

## SCIENTIFIC OPINION

On the materials submitted for participation in a competition for the academic position of "Associate Professor" for the needs of the Laboratory "Bioremediation and Biofuels", Department "Biotechnology", Institute of Microbiology, Bulgarian Academy of Sciences

in the field of higher education 5. Technical sciences

5.11. Biotechnologies (specialty: Biotechnology),

announced in the State Gazette No. 21/14.03.2025

Candidate: Chief Assistant Professor Elena Yordanova Chorukova, PhD,

prepared by Assoc. Prof. Ekaterina Krumova, PhD,

Institute of Microbiology, Bulgarian Academy of Sciences

The documentation submitted by Chief Assistant Prof. Elena Yordanova Chorukova, PhD, complies with the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria (LDASRB), the corresponding regulations for its implementation, and the rules governing the acquisition of academic degrees and academic positions at the Stephan Angeloff Institute of Microbiology, BAS.

### **Brief Biographical Information**

Dr. Elena Chorukova earned her Master's degree in Biotechnical Engineering from the Technical University of Sofia in 1994. From July to November 1994, she worked as a specialist engineer at the Central Laboratory of Bioautomation, BAS. Between November 1994 and December 31, 2010, she successively held the positions of engineer and research associate of third, second, and first rank at the Institute of Microbiology, BAS. Since January 1, 2011, she has held the academic position of Chief Assistant Professor in the Bioremediation and Biofuels Laboratory, Department of Biotechnology, Institute of Microbiology, BAS.

She obtained her PhD degree in 2009 from the Institute of Microbiology at the Bulgarian Academy of Sciences, Department of Biotechnology. Her dissertation was titled *"Neural and Hybrid Modeling and Optimization of Biotechnological Processes"* and falls within the field of Technical Sciences, specializing in Bioautomation.

### **General Overview of the Candidate's Academic Activities**

**Compliance with the National Minimum Requirements for the Academic Position of "Associate Professor" (as outlined in Section III of the Regulations for the Implementation of the Law on the Promotion of Higher Education and Research in the Republic of Bulgaria)**

**Criterion A:** A minimum of 50 points is required; 50 points have been submitted.

Dr. Chorukova obtained her PhD in 2009 at the Institute of Microbiology, Bulgarian

Academy of Sciences. Her thesis was titled "*Neural and Hybrid Modeling and Optimization of Biotechnological Processes*."

**Criterion B:** A minimum of 100 points is required; 142.57 points have been presented. A total of 10 publications have been submitted: 1 in a Q1-ranked journal, 4 in Q2, 3 in Q3, and 2 in Q4 journals. None of these publications overlap with those included in her PhD thesis.

**Criterion D** (scientific publications): A minimum of 200 points is required; 250.86 points have been submitted.

The candidate has presented 12 scientific publications indexed in internationally recognized databases such as Web of Science and Scopus. These include: 1 in a leading Q1 journal, 2 in Q2, 3 in Q3, and 4 in Q4 journals. Two publications appear in full-text conference Proceedings referenced in Scopus. Additionally, 11 of the submitted papers have been published in non-refereed journals with scientific peer review.

**Criterion D** (citations): A minimum of 50 points is required; 1001 points have been presented.

Dr. Chorukova reports 92 citations in peer-reviewed journals, monographs, collective volumes, and patents indexed in Web of Science and Scopus. She has also received 21 citations in peer-reviewed monographs and collective works, and 9 citations in Doctoral dissertations—substantially exceeding the required threshold for this criterion.

### **Fulfillment of Additional Criteria for the Academic Advancement of the Stefan Angelov Institute of Microbiology at the Bulgarian Academy of Sciences**

#### *Scientific Output:*

A minimum of 20 publications in journals with an impact factor (IF) or SCImago journal Rank (SJR), monographs, monograph chapters, or full-text publications in proceedings from international forums and patents (excluding those used for the acquisition of the PhD degree) is required, with at least five as first or corresponding author.

— Dr. Chorukova has submitted 33 publications, 12 of which list her as the first author.

#### *Citations:*

A minimum of 100 citations is required.

— A total of 122 citations of publications involving Chief Assistant Chorukova have been provided.

#### *Impact Factor:*

A cumulative IF of at least 20 is required.

— The cumulative impact factor of her publications over her scientific career is 30.822.

#### *H-Factor:*

A minimum H-factor of 5 is required.

— The candidate's H-factor is 5, meeting the criterion.

#### *Project Participation:*

Participation in at least 3 scientific projects is required.

— According to the submitted documentation, Chief Assistant Chorukova has participated in 14 projects, serving as principal investigator on two of them.

## Evaluation of the Candidate's Scientific and Applied Research Activities

According to the submitted documentation, Chief Assistant Prof. Elena Chorukova is participating in the current competition with **33 scientific publications**, none of which duplicate the works submitted during the procedure for acquiring her PhD degree. These publications are categorized as follows:

- **23 articles** published in journals indexed in *Web of Science* and *Scopus*
- **10 full-text publications** presented at international congresses

Dr. Chorukova is listed as the **lead author on 12** and as **second author on 9** of these works, underscoring her **key contribution** to a significant portion of the research.

She has been involved in **10 national scientific projects**—9 funded by the National Science Fund and 1 by the National Innovation Fund—as well as **3 international projects**, in which she has personally participated.

Her scientific contributions have been showcased at various forums through **22 oral presentations** and **26 scientific posters**.

Among her recognitions are:

- **Third Prize** for Best Presentation by a Young Scientist at the *3rd International Symposium "BioInfo '07"*, part of the *Automation and Informatics '07* Conference
- **Best Presentation Award** at the *Automation and Informatics '05* International Conference

Dr. Chorukova is co-author of the **patent** "*Biofilm reactor with submerged fixed filling for biogas production*" (Bulgaria, 2010) alongside Lyudmil Nikolov, Ivan Simeonov, Vyara Mamatarkova, Assen Mirkov, Rumen Marinov, and Snezhanka Mihaylova. She is also listed as co-author of a **Utility Model** titled "*Composition for biogas production*" (Bulgaria, 2013), developed with Ivan Simeonov, Dencho Denchev, Snezhanka Mihaylova, and Venelin Hubenov.

To further enhance her qualifications, Dr. Chorukova completed two specializations abroad:

- In **Germany** (Karlsruhe), at the *Department of Bioprocess Engineering*, Institute of Life Science Engineering, University of Karlsruhe, in **2008** (1 month)
- In **France** (Paris), at the *Laboratory of Signals and Systems*, Supelec, CNRS, in **2006** (3 months)

## Scientific, Applied Scientific, and Practical Contributions

Dr. Chorukova's research is dedicated to biotechnological processes, with a particular emphasis on **anaerobic degradation of various types of organic waste**. Her scientific interests are primarily centered on **mathematical modeling, control, and optimization** of such processes. Her work explores the integration of both **deterministic approaches** and **artificial intelligence (AI) techniques** to improve the design and efficiency of biotechnological systems.

Her original contributions can be summarized as follows:

### 1. Application of Deterministic Methods for Modeling, Control, and Optimization

Dr. Chorukova has developed numerous **mathematical models** for both one-stage and two-stage biotechnological systems, aimed at optimizing the **anaerobic degradation of organic waste**.

She has introduced and adapted **AI-based methods**—including neural networks and hybrid modeling techniques—for the **mathematical modeling, control, and optimization** of complex biotechnological processes.

## 2. Application of Artificial Intelligence Methods for the Mathematical Modeling, Control, and Optimization of Biotechnological Processes

- Using **artificial neural networks**, she has developed:
  - Neural and hybrid models of periodic and semi-periodic processes for the production of the intracellular enzyme *superoxide dismutase (SOD)*, using glucose as a limiting substrate
  - New neural models for the **anaerobic digestion of beef manure**
  - A neural model describing the **anaerobic digestion of activated sludge** in a cascade of two anaerobic bioreactors
- Through **metaheuristic algorithms**, she has created:
  - A mathematical model of **thermophilic anaerobic digestion of wheat straw** in a methane-producing bioreactor
  - A high-fidelity model of the **two-stage digestion of corn waste**, enabling the sequential production of hydrogen and methane
- By applying **inter-criteria analysis**, she has:
  - Synthesized the major theoretical developments in this field since its inception
  - Produced multiple **software implementations** and demonstrated the method's **broad applicability** across various scientific and technical domains
- With the use of **generalized networks (GN)**, Dr. Chorukova has:
  - Developed a GN-model that **mimics the foraging behavior of ants and their prey**, implementing the **ant colony optimization algorithm** to perform optimal searches
  - Contributed to the conceptual goal of representing **each major branch of artificial intelligence** through the framework of GN

## 3. Research and Implementation of Biotechnological Processes in Bioreactors

- Dr. Chorukova has conducted extensive research on biotechnological processes in **continuously stirred bioreactors** using various substrates, primarily focused on **organic waste treatment**. Her work has led to innovative approaches in **anaerobic degradation**, including the use of **biofilm bioreactors**. The outcomes of this research are protected by the **patent** titled "*Biofilm Reactor with Submerged Fixed Filling for Biogas Production.*"

## 4. Systems for the Automatic Control of Biotechnological Processes

- To support the **development and scale-up** of various **anaerobic digestion technologies**, Dr. Chorukova has played a key role in designing a **pilot-scale biogas plant equipped with integrated monitoring and control systems**.
- She has also developed a **control system for a cascade of bioreactors** aimed at the **production of hydrogen and methane** from organic waste, supporting the verification and scaling of **two-phase anaerobic biodegradation technologies**.
- Notably, **for the first time**, an **automatic operational mode** was implemented for a continuous process, enabling the **simultaneous production of hydrogen and methane**, made possible through a customized **computer-based monitoring and control system** for pilot bioreactors. This process yielded **over 40% more energy** compared to traditional single-stage methane production methods.

## Future Research Work

- Building on her expertise and ongoing scientific endeavors, Dr. Chorukova intends to focus her future research on the **modeling, optimization, and control of various biotechnological processes**. Her approach will integrate both **classical engineering methods** and **emerging artificial intelligence techniques**, aiming to enhance the precision and adaptability of process management. Additionally, she plans to **broaden her collaborations** with researchers in the field of bioprocess engineering, fostering interdisciplinary partnerships that will contribute to the **design and implementation of modern, robust control systems**.

## Conclusion

The documents and materials submitted by Chief Assistant Professor Elena Chorukova, PhD, fully comply with the requirements set forth in the *Law on the Development of the Academic Staff in the Republic of Bulgaria (LDASRB)*, the corresponding Regulations for its implementation, and the internal regulations of the Institute of Microbiology.

The candidate has presented a **sufficient body of scientific work**, all published after the defense of her PhD thesis. These works feature **original scientific and applied contributions** that have received **international recognition**, with many published in journals and proceedings issued by prominent academic publishers. Her theoretical developments demonstrate **strong practical applicability**.

The **scientific qualifications** of Chief Assistant Professor Elena Chorukova, PhD, are **undeniable**. The research outcomes she has achieved fully meet the **national minimum requirements** and the **additional standards** set by the Institute of Microbiology, BAS, in accordance with its internal regulations for the implementation of LDASRB.

After a thorough review of the materials and scientific works submitted for the competition, and following an in-depth analysis of their significance and the scientific, applied scientific, and practical contributions they contain, I find it fully justified to deliver a **positive assessment**. I therefore recommend that the **Scientific Jury prepare a report-proposal to the Scientific Council of the Stefan Angelov Institute of Microbiology**, proposing the election of **Chief Assistant Professor Elena Chorukova, PhD** to the academic position of **Associate Professor** at the Institute of Microbiology, in the field of higher education **5. Technical Sciences**, professional field **5.11. Biotechnologies** (specialty: *Biotechnology*).

..16.06. 2025...

Prepared the opinion:.....

(Assoc. Prof. Dr. Ekaterina Krumova )