



UNIVERSITY "PROF. D-R ASEN ZLATAROV"

SCIENTIFIC OPINION

Prepared by: assoc. prof. Dr. Bogdan Stoyanov Bonev,
external member of the Scientific Jury
Professional field 5.10. "Chemical Technologies"

Object of the scientific opinion: **Ph.D thesis in the doctoral program "Water Purification Technology", Professional field 5.10. "Chemical Technologies" at the Department of Chemical Technologies of the Technical Faculty at Burgas University "Prof. Dr. Asen Zlatarov".**

Prepared on the ground of: **Order No. UD-28/ 26.01.2023 of the Rector of Burgas University "Prof. Dr. Asen Zlatarov".**

Author of the Ph.D thesis: **Mag. Eng. MAYA BOGDANOVA STANCHEVA**

Title of the Ph.D thesis: **TECHNOLOGICAL OPPORTUNITIES FOR RECOVERY OF RESOURCES FROM WASTE STREAMS**

Mag. Eng. Maya Bogdanova Stancheva was born on 18.12.1982. She graduated from the University of Food Technology in Plovdiv as a bachelor, majoring in "Biotechnology" in 2006, and after that in 2012 she obtained her master's degree with specialization "Analysis and control of food products".

During the period from March 2018 to 2021 Maya has been a full-time doctoral student at the University "Prof. Dr. Asen Zlatarov" - Burgas in the Doctoral Program "Water Purification Technology", within professional field 5.10. "Chemical Technologies".

The dissertation work of Maya Bogdanova Stancheva covers 145 pages and is structured in 9 chapters: Introduction (2 pages), Literature review (60 pages, with 7 subchapters), Aim and tasks (1 page), Materials and methods (15 pages, with 6 subchapters), Results and Discussions (32 pages, with 4 subchapters), Main Conclusions (2 pages), Contributions (1 page), and Bibliography (27 pages with a total of 240 sources). The dissertation work is illustrated with 45 figures and graphs and contains 25 tables.

The topicality of the thesis is well outlined and substantiated in the introduction of the dissertation and the literature review.

The problem developed in the dissertation work is relevant in a scientific and scientific-applied sense due to the fact that reactors such as BES, ion exchange reactors, as well as membrane reactors are the object of research here. It was found that their applicability in field conditions still has not been achieved and seems far away. The reviewed articles show the great importance of struvite, produced in the treatment of waste and wastewater, as a fertilizer for the growth of many types of plants and vegetables. It is concluded that struvite precipitation is a profitable approach in the removal and recovery of biogenic elements from waste streams.

The formation of the struvite product is mainly influenced by temperature, pH, the type of reagent and their dosage, as well as the presence of competing ions. As the solubility of struvite increases with increasing temperature, it is usually operated below 25°C. Regarding the other parameters, the values considered optimal are reported in the literature found by the doctoral student. For example, pH values in the range 7.6-10.5 have been reported to be suitable for promoting MAP formation. For the formation of struvite crystals, the molar ratio of N:Mg:P with the values (1:1:1) must be guaranteed.

I have no doubt that the doctoral student has entered the problem very well. In the 286 literary sources cited by her, an attempt was made to gather information on the subject from 1933 to the present.

It has been established that currently, as a result of numerous and diverse researches, a serious volume of information has been accumulated on the work of extracting biogenic elements and obtaining struvite. All this information provides various opportunities for its exposition, analysis and interpretation and is a real challenge for every young researcher. I dare to say that the doctoral student Maya Bogdanova Stancheva successfully coped with this challenge by creatively considering the existing scientific data and problems described in the literature available to her, which she managed to present briefly and clearly in the 6 sub-chapters of the review. In a very well-arranged and succinct enough for the purpose of the dissertation conclusion of the overview, the directions in which work is currently being done are indicated. on the extraction of phosphorus from waste water.

In the conclusion of the review, the PhD student has emphasized the importance of the problem of phosphorus accumulation in soil and water and to assess the progress of struvite precipitation processes, considering the theoretical basis, operating conditions, type of reagents, reactor configurations and industrial applications. Attention is paid to the identification of unconventional, inexpensive reagents used for struvite precipitation.

The purpose of this dissertation is to investigate the possibilities of recovering biogenic elements and energy from waste streams during their processing and treatment. To achieve this goal, the following research tasks were formulated:

- 1) Selection and characterization of waste streams with high potential in terms of biogenic elements.

- 2) Investigation of anaerobic degradation as an approach for primary treatment of waste streams and increasing the concentration of chemically accessible forms of nitrogen and phosphorus, and energy recovery.

- 3) Treatment of waste streams to improve the subsequent extraction of

biogenic elements in them.

4) Processes for precipitation and recovery of biogenic elements.

The research methodology described by the doctoral student in the fourth chapter is a function of the goal set in the dissertation and the resulting tasks. I find the way in which she presented the methods and work to achieve the set goals to be very logical and consistent and, as a result, fruitful in terms of the purely practical results obtained.

It is very important that the whole chain from the research, through the analysis of the available information, to the realization of the formulated tasks is on the face. Therefore, from a methodological point of view, the doctoral student has shown the necessary scientific culture and skills.

The presentation of the experiments conducted is very convincing. To solve the set tasks, the doctoral student examined five liquid and solid samples containing phosphate. All obtained samples were stored under conditions that maximally preserve their original characteristics.

The methods selected for the implementation of the dissertation work are scientifically based and standardized according to BDS and ISO. This fact has undoubtedly allowed the obtaining and publication of correct scientific results, which allow to meet the goal set in the dissertation work and the 4 tasks arising from it.

The obtained results of the analysis and characterization of four waste streams with high potential in terms of biogenic elements confirm that they are characterized by high organic concentration, high total mineralization and low pH, which is favorable for the precipitation of struvite crystals.

Very encouraging research results have been obtained in the application of anaerobic degradation as an approach for primary treatment of waste streams and increasing the concentration of chemically available forms of nitrogen and phosphorus.

The results of treating waste streams from livestock farms and dairies using chemical methods and the ultrafiltration membrane method to improve the subsequent

extraction of biogenic elements in them are very well presented. I am convinced that these are the first results in Bulgaria for the precipitation of struvite from the four waste streams mentioned in the dissertation.

The original and reliable results obtained are of a contributing nature and are obviously the personal work of the doctoral student Maya Bogdanova Stancheva.

The scientific and scientific-applied contributions of the doctoral student are formed in 7 points:

1. For the first time, the potential of waste streams from animal husbandry and the dairy industry as a potential source for phosphorus recovery has been investigated in detail.

2. Anaerobic degradation has been researched and analyzed as a process for processing and stabilizing waste streams to improve their performance as substrates for struvite precipitation, and also to recover part of the energy through methanation and obtaining biogas from organic impurities.

3. The behavior of the different starting substrates during the anaerobic degradation process was clarified, as well as the dynamics of the target ammonium and phosphate ions were tracked.

4. It has been established that waste streams from pig farms are not suitable for carrying out a full-fledged methanization process and are not subject to effective anaerobic stabilization.

5. An approach was applied to mobilize additional potential in terms of phosphates available for precipitation by treating the substrates with acids with high efficiency achieved.

6. It has been established that ultrafiltration is an effective method for further purification of working fluids in terms of organic impurities, while at the same time a significant part of the phosphate, ammonium and magnesium ions are preserved in the process.

7. Data from experiments with real waste streams have been obtained, which are a solid basis for creating hybrid technologies for the simultaneous treatment

of wastewater from animal husbandry and the recovery of resources from them.

and refers primarily to the category of obtaining and proving new facts that make the work extremely valuable.

The presented publications in connection with the dissertation are 6 and are from the period 2019 - 2022. In three of them she is the lead author, and the third is in a description with an impact factor. The obtained experimental results were reported at three conferences. This publication activity is sufficient according to the criteria of the Technical Faculty at Burgas University "Prof. Dr. Asen Zlatarov", under professional field 5.10, Chemical technologies.

The abstract is prepared according to the requirements and accurately reflects the main points and scientific contributions of the dissertation work.

I have a question for the doctoral student and recommendations for her future work:

- What clogging of the membranes has been reported in the process of the ultrafiltration process?

I suggest to the doctoral student to continue the experiments and to study the possibilities of using dolomite as an alkalizing agent and source of magnesium ions.

In order to obtain higher citability, I recommend the PhD student to translate this dissertation into English and publish it, because here we see all her scientific work, which she has published in parts in 6 publications, is collected and logically arranged.

All submitted documents, as well as the dissertation itself, have been prepared and formatted extremely precisely, correctly and responsibly.

In conclusion, I would like to note that the presented dissertation together with the publications of mag. Eng. Maya Bogdanova Stancheva fully meets the criteria of the Technical Faculty at Burgas University "Prof. Dr. Asen Zlatarov", under professional field 5.10 Chemical technologies. The entire work is very intelligently written based on appropriate methods predetermining the credibility of the obtained original results of a contributing nature.

Therefore, I give a positive assessment and consider that the work submitted

for review should be allowed to be defended and I recommend the members of the esteemed Scientific Jury to evaluate it on merit and **to award Maya Bogdanova Stancheva the educational and scientific degree “doctor”** in the scientific specialty "Technologies for water purification", professional field 5.10 Chemical technologies, within scientific field 5. “Technical sciences”.

Burgas, 1/02/2023

Signature:

(Assoc. prof. Dr. Bogdan St. Bonev)

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