KATEDRA CHEMII ANALITYCZNEJ

Professor Piotr Konieczka
Department of Analytical Chemistry
Faculty of Chemistry
Gdańsk University of Technology
e-mail: piotr.konieczka@pg.edu.pl

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Review Report

on Ph.D. Thesis of Claver NUMVIYIMANA

entitled: "Struvite precipitation from processed dairy wastes"

Supervisor: dr hab. inż. Jolanta WARCHOŁ, prof. uczelni

The world's phosphorus mines are rapidly being depleted, which is why phosphorus recovery methods are being developed. As phosphorus is recognized as a strategic raw material it becomes necessary to look for new sources from which it can be recovered and reused.

One of the groups of such sources are post-production waste, from which phosphorus can be recovered before their disposal. This allows, on the one hand, to obtain the desired raw material, and on the other hand, to purify the generated waste.

The research objective of this study was to determine the optimal process conditions for the recovery of phosphorus from processed dairy waste by precipitation of struvite and to assess the quality of the obtained product as a fertilizer.

The editorial layout of the dissertation is typical for this type of work and consists of:

- a list of acronyms used,

- introduction,

- theoretical part consisting of subsections concerning the description of the method of recovery of phosphorus from wastewater with particular emphasis on the method of phosphorus recovery by struvite precipitation,

Politechnika Gdańska
Wydział Chemiczny
Ul. G. Narutowicza 11/12,
80-233 Gdańsk

Tel. 58 347 10 10 - Kierownik Katedry
Tel. 58 347 19 10 - Sekretariat

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- experimental part, which begins with the presentation of the purpose of the work and then contains a list of reagents, analytes, apparatus and a description of the analytical procedures used in the research; in the following subsections there is a description of the obtained research results along with their discussion, and in the next ones there are conclusions and recommendations for the continuation of research in the subject of the dissertation.

The culmination of the work is a list of literature, tables and figures and its summary.

The theoretical part of the work contains all the necessary preliminary information related to the subject of the dissertation. Mgr Claver Numviyimana used numerous sources of literature in its elaboration, the vast majority of which were published in the last 10 years. This undoubtedly testifies to a very accurately conducted literature study in the field of the subject of the doctoral dissertation. It is certainly the most up-to-date and reliable study.

The main research objectives, which are the basis for the realization of the doctoral dissertation, the doctoral student included:

- literature review on the decrease in the level and consequently lack of phosphorus content in individual elements of the environment,

- chemical characterization of sewage and sewage sludge arising from dairy production,

- study of the struvite depletion process – process optimization,

- study of the level and impact of the content of interfering ions,

- thermochemical treatment of milk sludge through hydrothermal carbonization and phosphorus recovery in the form of struvite from HTC process water,

- determination of the influence of the initial parameters (pH, Ca, Mg and NH_4^+ content) on the quality of the struvite depletion process using mathematical models,

- assessment of the impact of the natural addition of the zeolytic material clinoptilolite on the processes of struvite precipitation and sorption of ammonium ions,

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- assessment of the usefulness of the obtained product as a fertilizer - use of kinetic models of nutrient release in in-vitro tests

- estimating the economically optimal model of valorization of chemically produced sludge for both phosphorus recovery and iron recycling.

Taking up the research subject by the Doctoral Student is certainly in line with the development trends of research in the field of optimal use of post-production waste, especially in the case of recovery of deficit substances.

The doctoral student's scientific achievements, which are reflected in the so-called "Scientometry parameters":

- 5 published papers in journals from the JCR list,

- H-index – 2,

- 11 independent citations,

- Summary IF – 27.019, which in terms of one work gives an average value of 5.404.

Out of the duty of the Reviewer, I would ask for a comment and clarification of the following issues.

1. How, according to the PhD student, would it be possible to transfer the proposed optimal method of phosphorus recovery to an industrial scale, i.e. its practical use?

2. What deserves, also according to the Doctoral Student, to be called a scientific novelty realized as part of the dissertation?

3. In Chapter 4.4. the Doctoral Student provided estimated values of the so-called "economic effects". I would ask for a more detailed algorithm for performing these calculations. Which of the process parameters were taken into account? What scale (amount of raw materials used) was taken to provide the estimation?

4. Page 53 provides information on the trace content of heavy metals in wastewaters. It is known that during the recovery of phosphorus, as it were, the content of other ions in the final product is enriched. Have you tried to label these contents in the final product obtained?

5. Numeric data presentation – in many cases, the results of analysis are presented in numerical notation. Why such a different and inconsistent number of significant digits

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in their writing – e.g. charts in Figures 14, 19 or Table 11. As a graduate of the EMQAL (European Master on Quality in Analytical Laboratories) project, should a Doctoral Student take this type of record?

6. Table 12 summarizes the kinetic parameters. What do the values after the ± represent? Are they presented correctly? Does 3335.64 ± 91 make sense? Please make a critical comment.

7. What is the reason to use the point graph at Figure 21 b instead of box one? That one from the thesis is not clear at all.

8. According data presented in Table 14 – recovery of phosphorous in one case is presented as 99 % whereas in other one as 99.05 %. There were any reason for that?

The above mentioned comments and questions do not change my very positive assessment of the substantive work.

On the basis of the above discussion, I conclude that the presented doctoral dissertation meets the conditions set out in Article 187 of the Act of 20 July 2018 – Law on Higher Education and Science (Dz.U. of 2020, item 85, as amended) and I request that Claver Numviyimana, MSc, be admitted to the further stages of the doctoral dissertation.

KIEROWNIK
Katedry Chemii Analitycznej

prof. dr hab. inż. Piotr Konieczka