

Andrzej Białowiec, Eng., PhD, DSc, Prof.

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Wrocław University of Environmental and Life Sciences

Department of Applied Bioeconomy

37a Chelmońskiego Str., 51-630 Wrocław

e-mail: andrzej.bialowiec@upwr.edu.pl

THE REVIEW OF DOCTORAL DISSERTATION

written by **Danuta Drózdź MSc. Eng.**

entitled „**Production and use of organic soil enhancers and growing media from agro-residues**”

prepared under the scientific supervision of

prof. dr ir. Erik Meers

and

dr hab. inż. Krystyna Malińska, prof. PCz

1. The basis for the preparation of the review

The formal basis for the preparation of the review is a letter from the Head of the Scientific Discipline of Environmental Engineering, Mining and Energy, Czestochowa University of Technology, Iwona Zawieja, Eng., PhD, DSc, dated October 03, 2022.

Following Article 187 of the Law of July 20, 2018. - Law on Higher Education and Science (Journal of Laws 2018, item 1668, as amended), the doctoral dissertation is to present the candidate's general theoretical knowledge in a discipline or disciplines and the ability to conduct scientific or artistic work independently. In addition, the subject of the doctoral dissertation is to be an original solution to a scientific problem, an original solution to the application of the results of one's scientific research in the economic or social sphere, or an original artistic achievement. A doctoral dissertation may be a written work, including a scientific monograph, a collection of published and thematically related scientific articles, a design, construction, technological, implementation, or artistic work, as well as an independent and isolated part of a collective work. According to the guidelines of the Council for Scientific Excellence¹, "the opinion on a given dissertation should include the following elements:

¹ Rada Doskonałości Naukowej. 2022. Recenzje w postępowaniach o awans naukowy. Poradnik.

- 1) an assessment with a justification of whether the doctoral dissertation demonstrates the general theoretical knowledge of the applicant for the doctoral degree in a specific discipline or disciplines;
- 2) an evaluation with a justification of whether the doctoral dissertation demonstrates the ability of the applicant to conduct scientific or artistic work independently;
- 3) an assessment with the justification of whether the doctoral dissertation represents an original solution to a scientific problem, an original solution to the application of the results of one's scientific research in the economic or social sphere, or an original artistic achievement."

The review was prepared following the above recommendations to the extent specified in the contract for the preparation of the review in the doctoral proceeding.

2. Ph.D. Candidate description

In 2016, Danuta Drożdż MSc. Eng. obtained an engineering degree in wastewater biotechnology, while a master's degree in industrial biotechnology graduated in 2017 at Częstochowa University of Technology. She started doctoral studies at the Częstochowa University of Technology in 2017. however in 2018 she started a Joint Ph.D. (a joint Ph.D. within the Nutri2Cycle project) at Ghent University and the Częstochowa University of Technology, and up to date, she did not apply for the Ph.D. at another scientific unit. During that time, she accomplished 4 internships including a 15-week visit to Ghent University. MSc Danuta Drożdż published 8 scientific papers indexed on the Web of Science and Scopus databases. The number of citations of her works counts 133, and the H-index reached 5, which is a significant value at the early stage of the researcher's development. She participated in 5 international conferences and 3 summer/winter schools. MSc Danuta Drożdż was involved in the 2 research projects financed from H2020 funds. She received 3 awards. Up to date, her scientific achievements and activity are high and bring a significant contribution to the development of environmental sciences.

3. Thesis characteristics

The dissertation submitted for review is a written work - a scientific monograph entitled "Production and use of organic soil enhancers and growing media from agro-residues ". The doctoral student also prepared an abstract in Polish, English, and Dutch.



4. The significance of the research topic undertaken for the development of the discipline of environmental engineering, mining, and energy

In my opinion, the research problem undertaken, in the reviewed work, is an important and topical issue, falling within the discipline of environmental engineering, mining, and energy. One of the identified problems of waste and biomass management, including residuals from agriculture and animal husbandry, is the implementation of environmentally safe recycling, especially in terms of the recovery of biogenic elements. Many organic residuals, including poultry manure, have a high potential for recycling due to their organic nature and biogenic element content. One of the new scientific, developmental, and commercialization trends is the use of residuals to produce organic soil enhancers. This is a solution that meets the goals of sustainable development, by returning biogenic elements to primary production and replacing fossil fertilizers (phosphorus) and those produced using natural gas (nitrogen fertilizers). Biowaste from agriculture, including manure from poultry production, has characteristics that hinder its direct use in the environment. These characteristics include high biodegradability, which can cause odor nuisance and oxygen deficits in the soil. It has also high moisture content, which can disrupt soil-water relations. Another problem is the potential content of pathogens and parasites, which can pose a sanitary threat. In addition, the presence of antibiotics and other pharmaceuticals used in animal husbandry can adversely affect the environment. Therefore, a necessary measure is to pre-treat the manure, eliminate the above-mentioned characteristics, and give additional features that favorably affect the quality of the produced organic soil enhancers. Ms. Danuta Drożdż, M.Sc. Eng., proposed such a strategy by using a physical process - drying, a biological process - composting, and a thermochemical process - pyrolysis. The result of the applied processes is the production of dried, compost, and biochar, as well as their mixtures, which can meet the conditions for recognition as organic soil enhancers. The proposed solutions represent a new approach to the problem and can be developed in the future at higher TRL levels.

Considering the above remarks, I conclude that the problems undertaken by the author of the dissertation are topical, and justified, it is a new and necessary direction of research, and further development of these issues can make a significant contribution to the development of recycling of biogenic elements.

5. Substantive characteristics of the work

The goal of this work was to investigate the potentials of poultry manure as a source to produce organic soil enhancers such as dried poultry manure, poultry manure derived biochar and

poultry manure derived compost and to determine their physicochemical properties and effects on soil properties and growth of cherry tomato. The author formulated 3 research hypotheses; however, I missed the formulation of a technological hypothesis regarding the influence of the independent variable on the dependent variable, e.g., fertilizer properties or plant growth.

The dissertation is generally substantively well structured. In the first part, the author conducted a very extensive literature review including a description of the of organic soil enhancers and growing media; types and functions of organic soil enhancers; effects of organic soil enhancers on soil properties; legal and environmental aspects; application of poultry manure as a resource to produce organic soil enhancers; generation of poultry manure; characteristics of poultry manure; environmental risks related to the use of poultry manure; methods for processing of poultry manure including pyrolysis, composting, and drying, description of poultry manure based biochar, compost, and dried material. Danuta Drożdż MSc. Eng. also prepared the synthesis of the state of the art being the bibliometric evaluation of the main keywords of the thesis leading the determination of the novelty status of undertaken topics. The introduction section exceeded 50% of the whole thesis, what in my opinion is too much. However, this was not fault of too long introduction itself, but too short description of the used materials, methods, results, and discussion. The best part of the introduction and significant part of the theses are tables 12-16 summarizing the existing knowledge on poultry manure management and treatment. In my opinion, the selection of literature was accurate and recent. A total of as many as 383 literature items were cited in the dissertation. This demonstrates a very good and comprehensive understanding of the literature on the subject of the dissertation.

The result of the prepared literature review is the identification of the main objective and specific objectives, and the formulation of research hypotheses. The author then described the research procedures, successively discussing the materials used, such as poultry manure; bulking agents; soil; composting mixtures; growing media.

Next, the research procedures and test sites associated with the subsequent tasks are described:

- Physicochemical and microbiological analysis of poultry manure sampled from the cage breeding system.
- Conversion of poultry manure into soil enhancers through:
 - composting of poultry manure in laboratory composting reactors,
 - drying of poultry manure,
 - pyrolyzing of poultry manure,
- The analysis of C, N and P cycles during laboratory composting of poultry manure.

- Physicochemical analysis of the obtained soil enhancers (dried poultry manure, derived biochar, poultry manure derived compost).
- Preparation of the growing media with the investigated soil enhancers.
- Determination of the effects of the investigated soil enhancers on soil properties.
- Determination of the effects of the growing media on the cherry tomato growth in the plant growth experiment.
- Physicochemical analysis of plants and growing media after completion of plant growth experiment.

The layout of the research tasks is logical, starting with the characterization of substrates, the production of compost, biochar, and dried material, and their mixtures, and the study of their properties and their effects on soil properties and tomato growth. The research section concludes with analyses of the properties of soils with additives after the tomato growth experiment. The description of the methods used lacked a description of the statistical methods. Due to the variants used, it was possible to perform an analysis of variance.

The next chapter was a description and discussion of the results. The obtained results were collected in 12 tables and presented in 5 figures. Some of the results were included directly in the text. In general, the results were subjected to a scientific discussion, often of an in-depth nature, however, an uneven level of this discussion is noticeable. Some of the results were discussed too little and without due criticism.

Finally, the author formulates a summary and conclusions, which have been grouped concerning each of the research hypotheses.

Considering the above, I believe that the goal of the dissertation has been achieved.

I also believe that the dissertation presents the Doctoral Student's general theoretical knowledge at a high level in the discipline of environmental engineering, mining, and energy.

In my opinion, the dissertation demonstrates the Doctoral Student's ability to conduct scientific work independently. The experiments were designed correctly, although not fully all aspects of the experiments were presented. The application of statistical analyses was also lacking (only mean values and standard deviations were calculated), especially in terms of examining the significance of differences between the analyzed variants.

I believe that the dissertation represents an original solution to a scientific problem in the area of producing organic soil enhancers from manure processed by drying, pyrolysis, and composting, including an original solution to the application of the results of one's scientific

research in the economic sphere, due to the possibility of implementing these solutions into industrial practice.

6. Specific comments

Despite the relevance of the topic undertaken and the innovative approach, there are issues in the work, formulations that raise questions and doubts. These comments are arranged in the chronological order of reading the work.

Pages 12-13. The author wrote "These products, compared to raw poultry manure, have limited gaseous emissions, especially ammonia and carbon dioxide, are microbiologically stable...". What does it mean "microbiologically stable"? Sterilized or with a low rate of biodegradability?

Table 2. What is the difference between corn straw and maize straw?

Subsection 1.1.3. The author could mention the application of geocomposites as mineral-based soil enhancers.

The description of soil enhancers is not balanced. In some cases, the Author provided just a few sentences, while in the case of biopolymers spent more than 2 pages on that.

Page 27. The Author wrote that "The application of chemical fertilizers and pesticides has negative effects on soil. It causes difficulty in carbon sequestration, increases C/N ratio (>30:1)...". My question is how does the addition, for example, of NH_4NO_3 increase the C/N ratio?

Page 33. The Author presented some data about poultry production, but I had the impression that only egg production was included. What about the production of broilers?

In table 12 the Author included the description of some methods of poultry manure treatment including drying, anaerobic digestion, composting, pyrolysis, and others, however, I think that the application of the torrefaction process and hydrothermal carbonization/liquefaction could be discussed. There is literature about that.

Page 49. The description of the pyrolysis process could be more informative. The description of the composting process is prepared in a better way.

Table 17. Why is the C/N ratio not calculated everywhere where the values of C and N are given?

Pages 66-67. The Author derives 5 gaps in the state of the art. Danuta Drożdż MSc. Eng. could indicate which of the gaps is the origin of the scientific topic and the goal of the thesis.

Page 71. Information about the farms and feeding systems should be provided. Additionally, it should be stated how many times the samples of manure were taken – once (when and in what amount) or more.

Page 75. The Author did not provide any information about the feedstock composition for the composting process. Table 25 is missing.

Table 24. What is the justification for the application of enhancers doses: 0.5%, 3%? It should be stated according to which study these doses have been chosen. On page 76, there is a description of doses applied by other authors, but the correspondence used here is very weak.

Page 76. The first paragraph is redundant.

Page 79. The composting process is not well described. What is the difference between reactor C1 and C2? Air flow rate should be given in units referring to the mass of the feedstock. The conditions of the maturation should be described.

Page 81. I do not see any reason to show the picture of the drier. Only specific equipment or laboratory stands should be presented.

Page 83. The watering regime of plants should be given.

Page 85. How were plants organized in the phytotron: randomly or in blocks of the same variant?

Page 87. The yield of the biochar should be referred to dry mass.

Page 89. The Author stated that "Based on the presented properties of the obtained biochars: the biochar obtained at 475°C was selected as a soil enhancer to be used as an additive in the growing media.". This information should be provided in the methods section.

Table 28. Why did the content of P_2O_5 decrease from about 74 (Table 20) to 11.6 after drying?

Table 30. Why did the content of P double after the addition of the very small dose of the enhancers, especially in the case of biochar (0.5%)? It is not discussed.

Section 5 should be located just after the result of the biochar production. Same to pyrolysis, composting is a way of manure pretreatment, therefore it should be described together.

Page 105. The author wrote "The contents of P_2O_5 , MC, C/N ratio, pH, and EC increased during the 40 days of the composting process.". After studying table 34 I had the opposite opinion.

Section 5.6. The analysis of the kinetics of pollutants emission could be added on the base of the cumulative curve.

Tab. 38. The composting mass balance is based on wet mass. It could be better explained how the emission may be calculated on the wet mass. Should it be done on the base of mols of the specific compounds? I recommend using Synkey's diagram for the visualization of the mass balance of the process.

7. Final conclusions

The topic of the dissertation is topical and important both from a scientific and practical point of view. The results obtained contribute to the development of the discipline of environmental engineering, mining, and energy in the development of environmentally safe methods of manure management. The content of the dissertation is consistent with the title, the stated goal of the work has been fulfilled, and the hypotheses have been verified. The dissertation was edited correctly from the formal side.

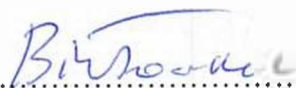
The dissertation confirms the author's very good knowledge of general theoretical knowledge in the analyzed area of the discipline of environmental engineering, mining, and energy. The dissertation also confirmed the author's ability to conduct scientific work independently, apply her experimental solutions and formulate conclusions, although the results obtained could have been subjected to statistical analysis.

The author's extensive previous experience and acquired knowledge allow me to believe that the research will be continued and developed to improve the technological readiness of the proposed solutions. This will allow, at a further stage of scientific development of the Doctoral Student, to supplement the presented results with specific studies on a semi-technical and technical scale.

I conclude that the issues taken up by the author of the dissertation are justified, it is a new and current direction of research, and further development of these issues can make a significant contribution to the development of methods of managing residuals from animal production.

When evaluating the doctoral dissertation of Danuta Drożdż, MSc. Eng., the following were considered: the significance and originality of the subject matter undertaken, the correctness of the formulation of the objectives and research hypotheses, the design of the research methodology, the description and interpretation of the results obtained, the structure of the dissertation and its technical side. Considering the above criteria and the comments made in the review, I conclude that, despite the listed shortcomings and doubts, the doctoral dissertation I have evaluated entitled "Production and use of organic soil enhancers and growing media from agro-residues" meets the requirements of the Law of July 20, 2018. - Law on Higher Education and Science (Journal of Laws 2018 item 1668, as amended) and I request that it be admitted to public defense.

Wrocław, 08.11.2022 r.

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