



REVIEW

on a dissertation for the degree of Doctor of Science in: field of higher education 4 Natural Sciences, Mathematics and Informatics professional field 4.4. Earth Sciences, scientific specialty Ecology and Ecosystem Conservation

Author of the dissertation: Desislava Gospodinova Angelova part-time PhD student at the Department of Microbiology and Ecological Biotechnologies, Agrarian University-Plovdiv, Bulgaria.

Thesis: Utilization of sludge from wastewater treatment plants by composting and vermicomposting

Reviewer: prof. PhD Violina Angelova Rizova, Department of Chemistry and Phytopharmacy, Agrarian University-Plovdiv, field of higher education 4. Natural Sciences, Mathematics and Informatics, professional field 4.4. Earth Sciences, scientific specialty "Ecology and Ecosystem Conservation" (Ecochemistry of Heavy Metals),

appointed as a member of the scientific jury by Order No. RD-16-1173/20.10.2021 of the Rector of the Agrarian University - Plovdiv.

1. Brief introduction of the candidate.

Desislava Georgieva Angelova was born on 2. 04. 1982. She graduated with a Bachelor's degree in Ecology and Environmental Protection from the Agrarian University - Plovdiv in 2006 as an ecologist. Desislava Angelova successfully obtained two master's degrees at the same university, specialty agronomist - plant protection in 2008 and agronomist - ornamental plants and landscape design in 2010.

From 02. 2009 to 07. 2009 she worked as a technician in agrochemistry and plant protection at ET MIKA-90, Plovdiv. From 08.2012 to 05.2021 she worked as an ecologist at Bulplod Ltd., Plovdiv. Since 04.2018 till now she works as an ecologist at Bulver Ltd., Plovdiv. Since 01.03.2014 Desislava Angelova is a part-time PhD student at the Department of Microbiology and Ecological Biotechnologies at the Agrarian University of Plovdiv with the scientific specialty "Ecology and Conservation of Ecosystems" (Ecology of Microorganisms).

2. Relevance of the problem.

The topic of the dissertation is extremely relevant as it concerns a significant problem related to the utilization of sewage sludge in agriculture. Sludge accumulation from wastewater treatment plants (WWTPs) is a serious problem in Bulgaria and

worldwide. The application of sewage sludge on agricultural land, in EU Member States, complies with Directive 86/278/EU "Environmental Protection Directive". The issue of sludge recovery from wastewater treatment is an important socio-economic and environmental problem in Bulgaria and the European Union. Its importance is determined by the fact that the amount of sludge generated in the country is constantly growing. Utilisation of sewage sludge in agriculture may pose risks to the environment, as sludge may contain heavy metals and pathogenic micro-organisms. In the European Union, there are strict regulations on the recovery of sludge in agriculture, established by the European Union Directive of 1986 (Directive 86/278/EEC) and other documents to protect the environment and human health. In Bulgaria, there is a lack of in-depth research on the recovery of agricultural sludge after composting.

Composting and vermicomposting of sewage sludge at the site of its generation is an innovative approach for our country. The possibility of treating sludge at source is essential for solving the problem of sludge from small and medium-sized wastewater treatment plants, where no significant investment is required and the final product is suitable for use in agriculture.

3. Purpose, tasks, hypotheses and research methods.

The main purpose of this dissertation is to optimize the utilization of sludge from urban wastewater treatment plants through composting and vermicomposting and its conversion into a product useful for agriculture and the environment.

In order to achieve the above purpose, 4 tasks were set, the sequential solution of which is presented in the experimental part of the thesis. Four specific tasks subordinate to the main objective of the study are indicated. They include co-composting and vermicomposting of WWTP sludge with other biodegradable wastes from agriculture and from parks and gardens of settlements, investigation of the presence or absence of phytotoxicity of the resulting composts and vermicomposts with respect to the seeds of some plants, investigating the possibilities of using the composts and vermicomposts obtained in tomato and pepper cultivation and analysing the compliance of the quality of the composts and vermicomposts with the requirements of the Ordinance on separate collection of bio-waste and treatment of biodegradable waste.

The methodological part is well planned to achieve the set aims and objectives. A large amount of work has been carried out, including precise field and laboratory experiments. A large number of indicators have been tracked and analysed with very well chosen statistical analyses.

The influence of the resulting composts and vermicomposts on seed germination, growth and development of cress (*Lepidium sativum* L.) and garden pea (*Pisum sativum* L.) in vascular experiments was evaluated. Experiments were also conducted under field conditions with tomato (*Solanum lycopersicum* L.) cv. 'Miliana' and pepper (*Capsicum annum* L.) cv. 'Kurtovska kappia'.

4. Visualization and presentation of the results.

The dissertation is 273 pages long, well-structured and balanced, and contains all the generally accepted sections for this type of scientific work.

The research results are very well illustrated and presented in 37 tables and 97 figures. The literature cited is related to the problem under consideration and includes 481 sources, 9 of which are in Cyrillic and 472 in Latin.

The literature review corresponds to the topic and the main directions of the thesis. The literature review is divided into subsections, which address issues related to types of biodegradation, aerobic thermophilic composting, the dynamics and stages of the composting process, the role of microorganisms involved in the composting process and factors affecting the composting and vermicomposting processes and national legislation related to the recycling of sewage sludge and its use in agriculture. The conclusion at the end of the section determines the necessity of conducting this study.

Desislava Angelova shows a good awareness of the achievements on the problem treated in the thesis, and has developed skills for the purposeful use of previous scientific achievements in her work. The dissertation is written in a high scientific style and reflects the author's ability to independently analyze and summarize results.

5. Discussion of results and literature used.

The results of the study, their analysis and discussion occupy an essential part of the dissertation. They are presented in a well-structured logical sequence. The analysis of the results has been carried out thoroughly, in a logical sequence and in a high scientific style. The PhD student shows good theoretical background and mastery of modern methods of analysis. The literature used is well selected and gives an idea of the PhD student's level of knowledge of the issues under consideration. The comparison of the data obtained by her with those of other authors show the personal contribution to the development. All literature sources are correctly cited and bibliographically described.

The research carried out is in four main areas (i) composting and vermicomposting of WWTP sludge with different biodegradable wastes (from agriculture; from urban landscaping activities; and a combined approach), (ii) application of the resulting composts and vermicomposts in tomato and pepper cultivation under field conditions, (iii) analysis of the compliance of the quality of the composts and vermicomposts with the requirements of the Biodegradable Waste Separation and Treatment Ordinance of 2017. and (iv) the application of the developed sludge recycling technology in the WWTP-Hisarya, WWTP-Sopot and WWTP-Karlovo.

The conclusions are consistent with the experimental results.

6. Contributions of the thesis

The dissertation contains scientific and scientific-applied contributions, which in terms of content, significance and usefulness for science and practice are fully sufficient for obtaining the educational and scientific degree "Doctor".

Scientific contributions

1. For the first time in Bulgaria an integrated study of the treatment of sewage sludge by composting and vermicomposting has been conducted.
2. Models for the utilization of sewage sludge in agriculture, landscaping and land reclamation have been developed.
3. An approach to reduce the concentration of heavy metals originating from WWTP sludge in co-treatment has been established, resulting in an end product that meets the requirements set out in the Separate Collection of Bio-waste and Treatment of Biodegradable Waste Ordinance of 2017.
4. A way to reduce the loss of organogenic elements in the final products by returning the leachate to the system through dewatering has been established, for sludges with low heavy metal content.

Scientific and applied contributions

1. An improvement in vermicomposting technology has been made by using composters instead of so-called beds.
2. The operation of circular economy principles has been demonstrated by recycling production waste and converting it into compost and vermicompost end products applied in agriculture.
3. The developed technology for recycling of sludge from WWTP was applied jointly with VIK-Plovdiv at the place of generation in WWTP Hisarya, WWTP Sopot and WWTP Karlovo. As a result, the composted sludge amounts to about 1050 t per year, and the resulting in situ vermicomposts meet the requirements for a compost product set out in the Ordinance on Separate Collection of Bio-waste and Treatment of Biodegradable Waste of 2017 and are used as a quality complex fertilizer for maintaining green areas.

7. Critical comments and questions.

I have no significant critical comments regarding the thesis and the abstract presented by Desislava Angelova.

I have the following questions for the PhD student:

1. In your opinion, how can the content of basic organogenic elements, such as nitrogen and phosphorus, be increased in the final product of composting?
2. What are the most important conditions for obtaining a quality end product when composting sludge from WWTP?

8. Published articles and citations.

Desislava Angelova has submitted 4 scientific publications related to the development of her dissertation. In three of the publications she is the first author. One of

the submitted publications is in a reputable journal with impact factor (Journal of Environmental Protection and Ecology, 0.577). One of the publications is a published book chapter (Singh, D. P., Gupta, V. K., Prabha, R. (Eds.) Microbial Interventions in Agriculture and Environment, Vol. 2: Rhizosphere, Microbiome and Agroecology. Springer Singapore). The information in these articles is fully consistent with the data presented in this thesis.

In accordance with the Regulations for the Application of the PhD Law, the publications submitted constitute 50 points, which exceeds the minimum requirements (30 points) for admission to the defence of a thesis for the degree of Doctor of Education and Science.

The doctoral candidate has participated in 2 international and 2 national scientific conferences. The above information about the publication and presentation activities of Desislava Angelova and the scientific supervisor Assoc. Prof. Stefan Shilev show that they have presented the results of the research to the international and national scientific community.

No citations of the published results are given in the prepared report.

The presented abstract objectively reflects the structure and content of the thesis.

CONCLUSIONS:

On the basis of the different research methods learned and applied by the PhD student, the correctly derived experiments, the made generalizations and conclusions, I consider that the presented dissertation meets the requirements of the Agricultural University Regulations for its application, which gives me the reason to evaluate it **POSITIVE**.

I take the liberty to propose to the esteemed Scientific Jury also to vote positively and to award to **Desislava Gospodinova Angelova** the scientific degree "**Doctor**" in the scientific specialty "Ecology and Conservation of Ecosystems".

Data: 23.11.2021 г.
Plovdiv

Подписите в този документ са заличени във връзка с чл.4, т.1
от Регламент (ЕС) 2016/679 (Общ Регламент относно защитата на данни).