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REVIEW REPORT

on PhD thesis entitled

"Production and use of organic soil enhancers and growing media from agro-residues"

Submitted by Danuta Drożdż

The present document provides a review of the doctoral dissertation of MSc Ing Danuta Drożdż entitled "Production and use of organic soil enhancers and growing media from agro-residues". This PhD thesis was carried out as a joint PhD between Częstochowa University of Technology (Politechnika Częstochowska, PCz) and University of Gent, in the frame of the H2020 project Nutri2Cycle.

1. Context and Scope of the Thesis

The main objective of the thesis is to evaluate the potential of poultry manure to obtain fertilising products, mainly soil improvers. In that sense, the thesis is tackling a relevant topic considering the current context on fertilising products. The current energy crisis is alarmingly increasing the prices of the synthetic fertilising products, this, together with the limitation on certain raw materials for fertilisers productions, has made more attractive the use of secondary sources of nutrients for obtaining fertilising products. Moreover, animal manure is the main secondary source of nutrients in Europe and, currently, there is no relevant manure management strategies at EU level to properly valorise this waste, which is causing serious environmental problems in soils and waters. As stated in Danuta's work, in Poland, poultry manure is directly spread on the fields, whereas processed poultry manure is not commonly used in practice.

The thesis is presenting a wide range of results of poultry manure valorisation using different technologies: drying, pyrolysis and composting with the aim of obtaining different soil enhancers. The obtained products have been characterised in terms of compositions and also the application of these soil improvers have been assessed. Additionally, not only the products have been tested separately, but also different combinations with the different products have been produced with the aim of obtaining a tailor-made soil enhancer according to soil and crop needs, which is interesting.

In the framework of the thesis, the possible legal and regulatory aspects of the obtained products have been considered. Special attention has been put to the new EU Regulation 2019/1009 on fertilising products, which is good. However, given the scope of the work

and the importance that poultry manure has in Poland, it would have also been relevant to analyse the polish regulatory context.

Overall, the topic selected by the PhD candidate is relevant and provides valuable information not only to the scientific community but also to other stakeholders, such as farmers, fertilising industry and policy makers.

2. Layout and content of the Thesis

The thesis consists of a document of 145 pages, including 6 main sections and enriched with a good number of figures and tables that graphically represents all the work carried out, moreover, an index of Tables and Figures can be found at the end of the document. Just as a personal feeling, maybe it would have been better to include this list at the beginning of the dissertation, together with the list of abbreviations, which is also good and useful. The thesis is well written and in general it follows a good story-telling that it's easy to read. A relevant number of references have also been used and are well cited in the reference section of the dissertation.

Below there is a small summary and evaluation of the different sections of the dissertation:

I. **Introduction.** The first section gives the framework of the thesis, telling the main situation in the growth that the agriculture sector is facing, as well as the potential of poultry manure as a fertilising product. The content is good and clear, although some more extension, including some figures showing relevant data and statistics, would have also been relevant.

II. **Theoretical.** This is an extensive, comprehensive and complete section talking about soil enhancers, poultry manure characteristics and the current state of the art. When talking about the soil enhancers, the dissertation is providing a good overview of the different types of soil enhancers. Compositions of the substrates used to produce the soil enhancers are provided, based on several references, which is good. However, some more information about the types and properties of soils enhancers obtained would have been good to be described.

    The overview of the poultry manure potential is good and well structured, and it is demonstrated that the topic selected is relevant and of interest for Europe and specially for Poland. Moreover, a nice and comprehensive table collecting the different technologies used for processing poultry manure is also provided, giving more detailed explanations on the technologies that have been evaluated in the thesis.

III. **Goals and objectives:** The PhD thesis has set different goals and hypothesis to finally reach the objective of evaluating the potential of poultry manure to obtain soil enhancers. The objectives and hypothesis are coherent and clear.
    Also, a working plan of more than four years with many tasks have been presented. The amount of work done during the PhD is good and is also relevant that Danuta Drożdż have carried out this work between two institutions. This is always very positive and provides the candidate with more skills for her future professional growth.

IV. **Experimental**: A nice overview of all the materials and methods used for the execution of the thesis is provided. The explanations usually go with pictures which is always good to better show all the work done. Danuta has worked in different fields (i.e. technologies, agronomic testing, chemical characterisation), so she has performed a nice multidisciplinary work, which always provides more relevant information and have a higher impact.

V. **Results and discussion:** The results section is clear and with different tables and figures summarising the main outcomes obtained in the different experiments performed. The results are showing the properties and fertilising potential of the obtained soil enhancers obtained by pyrolysis, drying and composting; then the effects of these products on soil properties is evaluated and, finally, pot tests using cherry tomatoes have been executed to see the agronomical value. This is a nice set of data and information for farmers.

Attention has been paid to consider possible critical parameters established in the EU Fertilising Products Regulation and the analysis made showed that pathogenic microbials and heavy metals were under the limits stablished by the regulation.

The composting process has been analysed in more detail. A more exhaustive follow-up of the process has been made and a mass balance of the process has also been included. Critical parameters from the EU Regulation 2019/1009 (pathogenic microbials and heavy metals) have been analysed to check if the final compost could meet the requirements established by this regulation. The results obtained showed that the compost produced accomplishes with the quality required by the regulation.

With all the experiments and sample analysis made, and considering the importance that the thesis dissertation gives to the Regulation in the introductory part, I am missing a specific section discussing about the alignment of the obtained soil enhancers with the Fertilising Products Regulation EU 2019/1009. It's true that some critical parameters have been analysed and checked according to the regulatory limits, but could we conclude that the obtained products could somehow fit in some CMC and PFC of the new regulation?

VI. **Summary and conclusions:** The last section of the dissertation is presenting a nice summary of the main results obtained, and how the different hypothesis stated at the beginning have been confirmed. The conclusions presented are coherent and clear, providing relevant data of the properties of soil enhancers derived from poultry manure. Also, to close this section, possible future work to continue the research done by Danuta Drożdż is proposed, which is always positive.

3. Main contributions of the Thesis

Danuta Drożdż dissertation is providing new relevant data for the scientific community and also for farmers on new valorisation options of poultry manure, which is a relevant

environmental problem in Poland. The work performed in this thesis helps on enhancing the circular bioeconomy in Europe and, more specifically in Poland. The work performed is aligned with the needs of her country and will help on making this territory more sustainable.

From a scientific point of view, the most important achievement of the work developed by Danuta Drózdż is to produce "tailor-made" soil enhancers by mixing and combining different soil enhancers that usually are used separately. She is testing different potential combinations of biochar, compost and dried poultry manure in a % that fits with the soil and crop needs.

4. Candidate profile and main scientific contributions

During the period of her thesis, Danuta Drózdż has not only been focused on working in the experimental part of her thesis, but also has been building a nice and complete scientific curriculum. Danuta has finished her PhD with 8 publications in scientific journals, has participated in 5 conferences and has obtained 4 different awards. Moreover, she has also found time for doing teaching and for being involved in different commissions or working groups. The overall CV that Danuta has at the end of her PhD is excellent and it gives her a fantastic scenario for continuing her research career as a post-doctoral researcher.

5. Critical Remarks

The Dissertation of MSc Ing Danuta Drózdż is overall good and no major revisions or remarks would apply in this case. However, I would like to highlight some weak points that I detected when revising the document:

- Even though the work has considered not only the technological part but also the agronomic quality and the impact of the obtained product in soils, I think that the scope could have been broader. Only one poultry manure from one farm has been sampled, one type of soil has been considered and the pot tests only used one type of crop.
- It would have been relevant to do an analysis on how the soil enhancers produced are in compliance with the new European Fertilising Products Regulation 2019/1009. The same thesis specifies the importance of this regulation, and specific sample analysis have been made with this purpose, but the discussion and conclusions in that sense could have been much more detailed and extensive.
- The thesis is providing new and relevant results for the farming sector. However, to make it more applicable, it would have been interesting to discuss and talk about the real application of the research performed. The technologies used are well known and applied at full scale, but the thesis is only providing results at a laboratory scale. Having some discussion about scalability, potential application and use of the obtained products in Poland, some preliminary evaluation of the costs for obtaining these soil improvers, among others, could have give much more added value to the results obtained.

6. Final evaluation statement

My overall evaluation of the thesis dissertation presented by MSc Ing Danuta Drozdz is positive. She has made an intensive work, tackling different scientific aspects and covering a relevant topic at EU level. Moreover, the good work of the candidate is demonstrated by the scientific contributions that she made and the resulting CV.

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