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Dr hab. Edyta Łokas
Institute of Nuclear Physics
Polish Academy of Sciences
Department of Mass Spectrometry
ul. Radzikowskiego 152
31-342 Kraków

Referee report on the doctoral thesis entitled „Biogeochemistry of chemical elements in Arctic soils: multi-factor effects on element concentrations from different locations in Billefjord, Svalbard” by Juliana Souza-Kasprzyk

The main subject of this work is to investigate the multiple factors that can affect the accumulation of chemical elements including Essential Elements (EEs), Potentially Toxic Elements (PTEs), Rare Earth Elements (REEs) and Other Elements (OTs) in soils from Billefjord (central Spitsbergen, Svalbard, Arctic). The west coast of the Billefjord experienced greater historical anthropogenic impacts than other areas of Spitsbergen, especially because of the past mining exploration by Swedish and Russian companies which for decades mined coal on Pyramiden Mountain. The east coast of Billefjord presents far less visible evidence of direct human impact, likely because of the greater difficulty of access.

This thesis was conceived and carried out in an integrated way to contribute to the increase of knowledge about the response of Arctic environments to inorganic contaminants and the factors that can affect their accumulation. The thesis also presents and demonstrates the application of two spectrometric techniques: Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and limitations/advantages of both methods.

The thesis is written in English, there is also an Abstract in Polish and English. The dissertation consists of six sections including a General Introduction and Conclusions, and an Appendix presenting scientific achievements of the candidate. The last section of the Thesis contains bibliography containing 173 items. There are 24 Tables in the text.



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POLISH ACADEMY OF SCIENCES**

Samples of environmental materials analyzed in this work were collected during six field campaigns in the northern part of Billefjord, Spitsbergen, Svalbard as a part of the project “Geochemical studies of deposits of central Spitsbergen” coordinated by the supervisor Prof. dr. hab. Przemysław Niedzielski with Ms. Juliana Souza-Kasprzyk participating in fieldwork in 2018. Additional soil samples were collected during sampling campaigns in 2019 and 2020. All expeditions were supported by the Adam Mickiewicz University (AMU) with the logistical support of Adam Mickiewicz University Polar Station “Petuniabukta” (AMUPS). In total, almost 600 samples were collected in areas with different levels of anthropogenic pressure.

The first chapter has 28 pages and outlines the general information about the Arctic and potential sources of pollution in Svalbard and points to the scarcity of data on the chemical elements in soils from Billefjorden area.

The second chapter presents in a clear way the main goals of the work and the importance of this study. In the third chapter, the author describes experimental methods and sample collection. The main part of this chapter is devoted to the presentation of different extraction/digestion methods and presents two spectrometric techniques applied in the analyses of collected samples: Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS). The author describes the strengths and limitations of these methods in the context of this study (Table 5) and also discusses detection limits and quality assurance procedures. This chapter clearly shows the enormous amount of work conducted by the author.

Chapter 4 presents measurement results and their discussion. The results are presented in tables 10 - 12 and figures 11 - 41. The results are presented in a very thorough way. The author extensively discusses the potential sources and possible routes of contamination to individual locations. The concentrations of essential, potentially toxic, rare earth and other elements are compared with organic matter, animal impacts and geographical locations separately for two soil layers. The authors showed that the majority of elements especially the potentially toxic and rare earth elements were enriched in Elsa valley indicating that the location has a strong influence on the elements concentration. It is very surprising that soils with greater vertebrate influence were characterized by lower concentrations of all chemical elements than soils without such influence. It is, however, not clear what was the basis of the categorization of soils as animal-influence and non-influenced.



I have several comments on the text of the dissertation:

- The author provides a detailed discussion of the potential sources and pathways of contaminants to specific locations. However, this discussion does not include several significant articles (Singh et al., 2013, 2015, 2017) despite the fact the literature on toxic metals in different environmental compartments in Svalbard is not very rich. For example, Singh et al., (2013, 2015, 2017) present data on toxic metal contamination of soils, marine sediments, lichens and cryoconite of Kongsfjord area. Łokas et al. (2019) describe the contamination of soil profiles and cryoconite of Kaffioyra. Similarly, subchapter 1.7 does not refer to publications discussing climatically induced release of elements from the retreating Hans, Waldemar and Irena Glaciers (Łokas et al., 2016, 2019). Works cited by the author (Rudnicka-Kępa i Zaborska, 2021 or Beard et al., 2022) are review papers that do not contain original data on metal contamination.
- Does the term „standard variation” used in table captions and in the list of abbreviations mean „standard deviation”?
- The text of Chapter 4 is difficult to follow because of large tables with data that should be moved to an appendix.
- Table 23 caption (Statistical analyses) should be supplemented by detailed information about the abbreviations of terms related to statistical tests.
- What was the basis for the categorization of soils as influenced or not influenced by animals? It is surprising that the soils indicated as influenced by animals do not have distinctly different chemical compositions including organic matter content.

In summary, I would like to stress that the comments mentioned above do not affect my very high opinion of this work. In general, the presentation of the arguments in the dissertation is consistent. There is a large number of tables and plots, which are generally clear. The language is typically appropriate. The author showed a deep understanding of the conducted research.

Based on the comments above, I conclude that Juliana Souza-Kasprzyk’s doctoral dissertation meets all the requirements and criteria of the Statute on degrees and scientific titles (Ustawa o stopniach i tytułach naukowych). Therefore, I am proposing to admit Juliana Souza-Kasprzyk to further steps in the procedure of the dissertation defence.



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I am happy to recommend this doctoral dissertation for distinction.

Best regards,