1. PHD PROJECT DESCRIPTION (4000 characters max., including the aims and work plan)

Project title:

Factors of variation in grasslands on heavy metal polluted waste heaps left by historical ore mining

1.1. Project goals

The project deals with the problem of plant-soil interactions in the context of formation of heavy metal
grassland. The aim of this project is to:
(1) Compare parameters of vegetation, soil physicochemical properties and heavy metal concentrations,
between stands of high metal concentrations and non-metalliferous stands in relation to the quantity and chemical quality (heavy metals and other elements) of plant tissues under field conditions.
(2) Assess the above-mentioned parameters of vegetation and soil between non-metalliferous stands
and sites with high metal concentrations and compare them in the gradient of heavy metal concentrations (see point 1).
(3) Relate parameters of vegetation with physicochemical variables.
I hypothesize that: (1) Taxonomic composition of vascular plant communities and soil elemental composition in the metal contaminated sites would differ from those in the not contaminated and vary depending on the content and type of metals. Taxonomic composition of plant communities in the contaminated sites would differ from that in the not contaminated sites. (2) Taxonomic composition of vascular plant communities, available element concentrations in metal contaminated sites would differ from those in the not contaminated due to toxicity and type of heavy metals. Microbiome parameters would be lower and available element concentrations in soil would be higher in the not contaminated sites than in those with not contaminated. The above parameters may be influenced by the type of metals and geochemical diversity of polymetallic waste rocks.

1.2. Outline

The project deals with the problem of plant-soil interactions in the context of formation of heavy metal grassland. Dating back to the early Middle Ages activities related to ore mining and processing have led to soil contamination with heavy metals in large areas of Europe. Large amount of heavy metals, such as lead, cadmium, cobalt, cuprum, arsenic, lead and zinc enter the soil environment through mining and smelting, causing soil and groundwater contamination. So far, little research has been carried out on old metal rich heaps. In the case of Lower Silesian metal-bearing areas, such studies are still few or fragmentary. Historical sources indicate that metal ore deposits have been extracted intermittently since at least the 10th century. Strong environmental contamination with heavy metals in these places is associated with both mining and processing of ores. Often, the soils of many places, in addition to non-metalliferously occurring metals, were also contaminated with other metals used in ore enrichment and metallurgy, such as arsenic, zinc, lead and mercury. Old mining left behind characteristic objects that are the remains of old workings - depressions left by shafts, open pits and heaps of waste rock heavily contaminated with metals. They are characterized by high concentrations of heavy metals, may therefore pose a threat to the environment and human health. For this reason, they should be subjected to identification and environmental monitoring. It can be expected that the variability of the physicochemical properties of the soil, and above all metal contamination, may be particularly high within old heaps due to mining activities (digging and spreading material), as well as between them. The old heaps located in the field are highly diversified in terms of flora, which is probably due to the variability of both the pool of heavy metals contained in them (geological diversity of deposits) and their concentrations on these surfaces. The species composition, ranging from the dominance of calamine flora in some areas to its complete absence in others, may be not only the result of a gradient in the concentration of heavy metals in the substrate.

1.3. Work plan

The study will be conducted at Sudety and Sudeten Foreland. In this area, the location of all objects potentially being traces of former mining activities (old heaps) will be determined. Their identification will be based on the observation of features such as micro-relief, ground structure, and the presence of certain plant species. After preliminary chemical analyses twenty five sites (consisting of plot pairs on metal contaminated old heaps and neighboring patches of non-metalliferous communities as pseudocontrols) will be selected along the a series of old heaps creating a regular gradient of metal content in the soil from the lowest to the highest. Additional importance will be attached to ensuring that individual study sites are located as far from each other in the field as possible. Five soil samples will be taken from all heaps to determine the concentrations of metals and other physicochemical properties of the soil. Determining the diversity of these soil parameters within and between heaps will facilitate the selection of optimal areas for the second stage of research, as well as determine the size of these areas. In the second stage of the research, samples will be taken for microbiological analyzes and detailed botanical data will be collected. It is planned to collect at least a dozen soil samples (0-30 cm deep) on each plot, which will then constitute a mixed sample for microbiological and physicochemical analyses. Floristic analyzes will be carried out on the entire area from which soil samples will be taken for microbiological analyses. Vegetation will be characterized in terms of species richness, cover and composition. At each site, in the patches of both the metalliferous and non-metalliferous communities, soil samples (organic and mineral horizon) will be collected. Aboveground and belowground plant tissues will be harvested, dried and weighted. Field botanical data will be collected in 2025 and again in 2026 to avoid the impact of seasonal variability. This field study will allow for comparisons between vegetation and soil properties in the contaminated sites and in non-metalliferous vegetation.

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1.4. **Literature** *(max. 10 listed, as a suggestion for a PhD candidate)*

1. Ernst W.H.O., Verkleij J.A.C., Schat H. 1992. Metal tolerance in plants. Acta Bot. Neerl. 41: 229-248.
2. Grodzińska K., Szarek-Łukaszewska G. 2002. Hałdy cynkowo-ołowiowe w okolicach Olkusza – przeszłość, teraźniejszość i przyszłość. Kosmos 51 (2): 127-138.
3. Kools S. A. E., Boivin M.-E. Y., Van Der Wurff A. W. G., Berg M. P., Van Gestel C. A. M., Van Straalen N. M. 2009. Assessment of structure and function in metal-polluted grasslands using Terrestrial Model Ecosystems. Ecotoxicology and Environmental Safety 72: 51-59.
4. Mitchell R. J., Hester A. J., Campbell C. D., Chapman S. J., Cameron C. M., Hewison R. L., Potts J. M. 2010. Is vegetation composition or soil chemistry the best predictor of the soil microbial community? Plant and Soil (in press; DOI: 10.1007/s11104-010-0357-7).
5. Orłowska E., Zubek Sz., Jurkiewicz A., Szarek-Łukaszewska G., Turnau K. 2002. Influence of restoration on arbuscular mycorrhiza of *Biscutella laevigata* L. (Brassicaceae) and *Plantago lanceolata* L. (Plantaginaceae) from calamine spoil mounds. Mycorrhiza 12: 153 – 160.
6. Rodríguez-Loinaz G., Onaindia M., Amezaga I., Mijangos I., Garbisu C. 2008. Relationship between vegetation diversity and soil functional diversity in native mixed-oak forests. Soil Biology and Biochemistry 40: 49-60.
7. Wierzbicka M., Rostański A. 2002. Microevolutionary changes in ecotypes of calamine waste heap vegetation near Olkusz, Poland: a review. Acta Biologia Cracoviensia, Series Botanica 44: 7-19.
8. Woch M.W. 2015. Tereny metalonośne Dolnego Śląska, in. Ekotoksykologia: rośliny, gleby, metale. Warszawa: Wydawnictwo Uniwersytetu Warszawskiego, s. 189-206.
9. Woch, M.W., Kapusta P., Stefanowicz A.M. 2016. Variation in dry grassland communities along a heavy metals gradient. Ecotoxicology 25, 80–90.

10. Woch M.W., Stefanowicz A.M., Stanek M., Waste heaps left by historical Zn-Pb ore mining are hotspots of species diversity of beech forest understory vegetation. Science of The Total Environment 599–600: 32-41.

10.1. Required initial knowledge and skills of the PhD candidate

Knowledge of biology and ecology, MSc (mgr or mgr inż.) in biology/environmental protection/environmental engineering/chemistry/agriculture forestry.

10.2. Expected development of the PhD candidate's knowledge and skills

The doctoral student will receive practical knowledge of modern interdisciplinary scientific research in the environmental sciences from the investigations planning stage, through their implementation, analysis and interpretation of results, to their presentation at conferences and leading international journals. The PhD candidate's knowledge will be large extended, especially in biology, ecology and chemistry.