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

Project title:

Microplastics in soils of the city of Toruń: Spatial distribution, characteristics, and environmental risks.

1.1 Project goals

(i) qualitative-quantitative analysis of microplastics (MPs) in soils of the urban area of Toruń city (Poland) using a complex approach based on geospatial analyses,
(ii) determination of links between microplastics and other soil parameters in lateral and vertical dimensions (soil maps and profiles),
(ii) identification of MPs contamination pathways of soils,
(iv) assessment of the environmental risk associated with contamination by MPs.

1.2 Outline

Microplastics (MPs), defined as particles with a size of less than 5 mm, became a threat of global concern due to their unknown, potentially negative impact on the environment (Kim et al. 2020). Due to their small particle size and slow biodegradation rate, they can be transferred through the food chain to organisms with a higher trophic level. Most of the studies have focused on the harmful effects of MPs on the aquatic ecosystem. However, the fact that about 80% of microplastic debris in the ocean has migrated from land has shifted attention toward terrestrial ecosystems but much less is known about microplastics in these systems (Horton et al. 2017). So far it is known that MPs may influence soil biogeochemical parameters and processes such as soil structure, hydrology, nutrient availability, and microbial communities. Moreover, the abraded surface of plastics can adsorb organic contaminants (e.g., PAHs and PCBs) and heavy metals, mediating their mobility, and bioavailability in the soil environment (Guo et al. 2020). Due to the scale of the problem, MPs are considered a worldwide ecological problem, along with global warming, water pollution, and smog (A European Strategy for Plastics in a Circular Economy, 2018). The implementation of this project will contribute to filling the gap in understanding the behavior of MPs in soils as well as the environmental effects of microplastic contamination. Following the results by Leitão et al. (2023) and Yoon et al. (2024), it is assumed that the land use and the presence of the technogenic materials can be the key factors differentiating the qualitative and quantitative features of MPs deposited in the studied soils. The research will be carried out in cooperation with the Department of Environment and Ecology of the City of Toruń which will also allow to propose recommendations for the urban soil monitoring strategy.

1.3 Work plan

To achieve the goals of the project the following research tasks were defined:
Task 1. Reconnaissance study of historical and current land use and its spatial context based on available cartographic materials and soil data. Analysis of the spatial distribution of technogenic soil materials in the city (*first year of the project*).
Task 2. Fieldwork (*first/second year of the project*).
Screening study. Soil sampling from 0-5 cm depth within a grid of artificial units - elementary fields (1x1 km). All sampling points (116) will be located based on the reconnaissance study.
Detailed study. In 10% of squares where the highest MPs content will be recorded, soil sampling density will be adequately increased, and the soil pits will be dug to a depth of 1 m (in total to about 100 samples).
Task 3. Laboratory analysis (*second/third year of the project*):

- basic soil characteristics: particle size distribution, the content of total organic carbon, total nitrogen, $CaCO_3$, and artifacts,
- content of heavy metals (Fe, Mn, Cd, Co, Cu, Ni, Pb, Zn) by atomic absorption spectroscopy (only for detailed study),
- density separation of MPs from the soil matrix (Choi et al. 2021; Hulisz et al. 2024),
- MPs quantification (number of particles, shape, color, and size) by stereoscopic microscopy,
- MPs identification by Fourier infrared spectrometry (FT-IR).

Task 4. Data analysis and interpretation (*second/third year of the project*):

- analysis of the lateral variability of MPs in the studied soils using mapping techniques,
- analysis of vertical variability of MPs in the soil profiles,
- statistical analysis of the relationships between MPs contamination, other soil properties, and land use,
- environmental risk assessment using collected geospatial data.

Task 5. Writing publications related to Tasks 1-4 (*third/fourth year of the project*).

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

- Choi YR, Kim YN, Yoon JH, et al (2021) Plastic contamination of forest, urban, and agricultural soils: a case study of Yeoju City in the Republic of Korea. J Soils Sediments 21:1962–1973. https://doi.org/10.1007/s11368-020-02759-0.
- Guo JJ, Huang XP, Xiang L, et al (2020) Source, migration and toxicology of microplastics in soil. Environ Int 137:105263. https://doi.org/10.1016/j.envint.2019.105263.
- Horton AA, Walton A, Spurgeon DJ, et al (2017) Microplastics in freshwater and terrestrial

environments: Evaluating the current understanding to identify the knowledge gaps and future research priorities. Sci Total Environ 586:127–141. https://doi.org/10.1016/j.scitotenv.2017.01.190.

- Hulisz P, Loba A, Chabowski M, Kujawiak K, Koźniewski B, Charzyński P, Kim KH (2024) Microplastic contamination in soils of urban allotment gardens (Toruń, Poland), J Soils Sediments: 1-12, DOI:10.1007/s11368-024-03797-8.
- Kim YN, Yoon JH, Kim KH (2020) Microplastic contamination in soil environment - A review. Soil Sci Annu 71:300–308. https://doi.org/10.37501/soilsa/131646.
- Leitão IA, van Schaik L, Ferreira AJD, et al (2023) The spatial distribution of microplastics in topsoils of an urban environment - Coimbra city case-study. Environ Res 218:114961. https:// doi.org/ 10. 1016/j. envres. 2022. 114961.
- Yoon JH, Kim BH, Kim KH (2024) Distribution of microplastics in soil by types of land use in metropolitan area of Seoul. Appl Biol Chem 67:15. https://doi.org/10.1186/s13765-024- 00869-8.

1.5 Required initial knowledge and skills of the PhD candidate

A candidate should have experience studying anthropogenic/technogenic environments (e.g., MSc thesis on this topic). She/he should have a basic knowledge in the field of soil science and the functioning of urban ecosystems. In addition, the following skills are expected:

- high efficiency in field and lab research,
- ability of analytical analysis and interpretation of scientific results,
- the candidate should be familiar with basic statistical methods and graphic computer software,
- team collaboration and communication skills,
- communication skills in Polish or English.

1.6 Expected development of the PhD candidate's knowledge and skills

- The candidate will gain expertise in soil science and laboratory methods.
- The candidate will gain knowledge about technogenic soil transformations in urban areas and environmental risk assessment.
- The candidate will be actively involved in fieldwork, laboratory analysis, and dissemination of the project results during seminars, workshops, and conferences.
- The candidate will be well trained in the field and laboratory work and writing scientific articles.