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Reflections from the “Assessing Risk in Soil: Challenges and Opportunities” Webinar

Cláudia Lima, Wageningen University; Juliska Princz, Environment and Climate Change Canada; Björn Scholz-Starke, Darwin Statistics; Paola Grenni, Italian National Research Council; Bonnie Brooks, Washington Department of Ecology; Mike Simini, U.S. Army DEVCOM Chemical Biological Center; Ulrich Menke, Bayer AG; Mathieu Renaud, Mireia Marti, Swiss Centre for Applied Ecotoxicology; Amy Gainer, Advisian; Vera Silva, Wageningen University; Matty P. Berg, Kees van Gestel, Vrije Universiteit Amsterdam & University of Groningen; Tiago Natal-da-Luz, University of Coimbra; Diana Vieira, European Commission; Silvia Pieper, Pia Kotschik, German Environment Agency

Introduction

Essential land-use activities, such as settlement, mining or agriculture, affect soil ecosystems in different ways (e.g., chemical or nutrient input, alteration of soil structure), which may lead to loss of soil organic matter and micro-habitats for soil invertebrates up to the point of no recovery. These activities have short- and long-term consequences for soil biodiversity and ecosystem services, such as disrupting soil structure formation, nutrient cycling or water infiltration. The question remains how we can maintain or implement sustainable land use activities while supporting biodiversity and a healthy soil ecosystem. With regards to chemical input, soil protection has legal bases in different frameworks established for plant protection products (PPP), biocides, human and veterinary pharmaceuticals, and industrial chemicals; however, chemicals are often assessed in isolation and multiple threats can occur on the same spot. Indeed, according to recent soil surveys, it is common to find residues from multiple pesticides across European agricultural sites, contributing to added risks for soil ecosystems.

Therefore, how can the toxic effect of pollutants on soil organisms be assessed more realistically? In soil, we often use single indicator species, such as the springtail, earthworm or predatory mite, in laboratory assays, using artificial soil, through the application of single or multiple concentrations of, normally, one single active substance to derive toxicity endpoint values (e.g., LC50, EC50, EC10, etc.). Although used ubiquitously, this approach does not allow scientists to answer relevant questions, such as:

- Are the results generated using artificial soil representative for the effects of different soil types in the field?
- How are native species or communities likely to be affected?
- Are species responses in these assays reflective of multiple exposures and cumulative stress?
- What are the impacts of multiple exposures on soil biodiversity and soil processes?

Together, these questions ask for a deeper understanding of the potential threats to soil biodiversity and ecosystem services, which in turn support our path towards defining realistic regulatory soil protection goals.

Assessing Risk in Soil: Challenges and Opportunities

Aiming to contribute to the already ongoing discussion on the future of soil risk assessment and bringing the debate to a broader audience, the Soils Interest Group steering committee coordinated a webinar, held 18–19 October 2022, titled “Assessing Risk in Soil: Challenges and Opportunities.” Each day, invited speakers addressed critical issues, followed by a focused panel discussion. The first day’s goal was to understand our knowledge and discuss the current state of European soils: types, physical–chemical properties, impacts and soil biodiversity. David Russel, Senckenberg Museum, described the occurrence and distribution of in-soil organisms within Europe based on data gathered in the Edaphobase database.

He noted that given the diversity of communities and the impact of possible environmental stressors, such as chemicals or drought, a deeper understanding of the distribution and influence of different soil types and their properties on chemical fate and effects on in-soil organisms is vital. Russel also pointed to the characterization and/or mapping of different soil types as important. This type of mapping is currently being accomplished for Europe by the Joint Research Council, which will allow for the assessment of the state of soil over time. This topic was elaborated by Diana Vieira, Ispra, who emphasized that up to 70% of European soils are unhealthy. Vieira highlighted the need for harmonized data collection strategies as well as the need to include landscape and land use when creating soil health criteria. To end the day, Vera da Silva, Wageningen University, discussed pesticide use and soil contamination in agricultural landscapes. She presented more integrative risk assessment approaches as used in the H2020 SPRINT project, specifically on sustainable plant protection transition. These approaches can accommodate complex multiple-stressor scenarios for which environmental and human health must be accounted for and balanced.

The second day focused on the regulatory framework for chemicals and soil protection and identifying new and different strategies to assess and regulate the impacts of chemicals on in-soil organisms and soil biodiversity. The discussion moved from examining biotic (e.g., biological communities) and abiotic (e.g., soil characteristics) diversity and pesticide occurrence to evaluating policies and tools to assess and protect in-soil communities and ecosystem processes. Silvia Pieper, German Environment Agency, discussed the implementation of the strategies developed by the European Union under the European Green Deal, such as the European Soil Strategy for 2030. These strategic activities target sustainable food production, consumption and growth, whereby the protection of soils and soil biodiversity are important components. Pieper acknowledged that the goal to attain 100% healthy soils by 2050 is a challenge because existing monitoring studies show declining trends for soil health targets, including (soil) biodiversity. To address current deficiencies, she pointed to the need to define the “good” and “bad” health status of different soils and a need for a shift in the environmental risk assessment for chemicals, e.g., inclusion of indirect effects and exposure to multiple pesticides in the field. She said it is crucial that a reality check via systematic soil monitoring can feed back into the prospective risk assessment of chemicals. Tiago Natal da Luz, Coimbra University, introduced a holistic approach to assess the impact of PPP on communities of soil invertebrates using Terrestrial Model Ecosystems (TMEs) through the testing of intact soil cores collected from the field. The approach merges elements of field and laboratory measures through the transfer and testing of the cores under controlled conditions for up to six months. This approach aims to answer relevant questions, such as the impact of direct and indirect effects of PPP mixtures on the soil community. Finally, Matty Berg, Vrije University, introduced a potential new approach assessing changes to soil biodiversity due to toxicant exposure using species traits rather than taxonomy. Together, these two latter presentations contributed innovative ways to integrate community-based assessments of toxicant exposure into the assessment and regulation of soil protection goals. The contributions of this session aimed at indicating pathways to support soil biodiversity and ecosystem sustainability for future generations in the assessment of chemicals by reflecting the goals of the European Soil Strategy with the upcoming Soil Health Law and the Biodiversity Strategy for 2030 with its

binding nature restoration targets.

Webinar Outcomes

Based on the panel discussions, it was clear that current tools used to map and monitor soil biodiversity, properties and pollution do not allow a complete assessment of soil health. Efforts to date demonstrate a strong will to start data collection and description of soil states, but there is much more collaboration and research needed to describe soil states correctly. It is important that researchers share data describing the physical, biological and chemical state of soils within existing and publicly available databases, for example, the European Soil Data Centre (ESDAC), for the consistent collection and evaluation of monitoring results. We also need to continue our efforts to communicate our transdisciplinary knowledge within soil science, and this webinar was an important first step. It will be through effective communication and partnerships among the scientific and regulatory communities that we can work towards an integrative approach to define and protect soil health, based on ecology, climate and soil properties, among other relevant variables.

Moreover, there is a need for a shift in the current risk assessment procedures to better fulfill the requirements of the existing legislative framework and the goals of the European Green Deal, specifically of the soil strategy. There is a need to cover potential indirect effects of toxicants on soil biodiversity. Towards this goal, more complex systems (e.g., TMEs), which assess the response of multispecies systems or communities and impacts on function, could help us understand effects under relatively realistic environmental conditions. For risk assessment, a system-based approach that integrates multiple exposures and monitoring for soils is needed to gauge long-term impacts under realistic conditions. Moreover, protection goals should be better aligned within different legislative frameworks dealing with protecting soil environmental targets to foster synergisms and to avoid conflicts when applying them to real situations.

Conclusion

Environmental risk assessments of chemicals need to address the reality of biodiversity loss and our changing landscape by integrating challenges, such as mixture toxicity, changes in bioavailability of chemicals due to different soil types, and effects on communities rather than single species. Our webinar, “Assessing Risk in Soil: Challenges and Opportunities,” contributed to understanding existing and new tools and their applications to broaden risk assessment to meet the needs and reality of current landscapes. After two days of interactive discussion, we were able to draw some conclusions:

- We need to define soil health despite its complexity
- It is necessary to centralize data collection and normalize the protocols and data sharing
- Current soil biodiversity and pollution monitoring efforts are not sufficient; some parts of Europe and some organism groups are more studied than others

- We need to recognize that different landscape features (e.g., land use, pedoclimatic zones, etc.) influence toxicity assessments
- Mixtures and cumulative effects of toxicants are the rule rather than the exception
- The outcome of standard laboratory tests can be calibrated by, e.g., higher tier testing with realistic assessments and enough replication
- We need to increase scientific collaboration across different soil disciplines in addition to ecotoxicology

A holistic risk assessment through collaboration with different stakeholders, the sound assessment of effects on soil biodiversity, and the acknowledgement of monitoring results will be required to ensure the implementation of protective regulation of chemicals.

Author's contact: Juliska.Princz@ec.gc.ca

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