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Linking speciation and soil-water-plant transfers of natural radionuclides in a wetland impacted by a former U mine: recent advances from the pluri-disciplinary and multi-partners project INSPECT-NEEDSclides in a wetland impacted by a former U mine: recent advances from the pluri-disciplinary and multi-partners project INSPECT-NEEDS

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Main sources of radioactivity in the environment are natural radionuclides (RNs) which are ubiquitous in all Earth's surface ecosystems, i.e., in air, soils, waters, and living organisms including Humans, as terrestrial RNs (uranium-238, uranium-235, and thorium-232 from geochemical background and their radioactive daughters) or cosmogenic RNs (e.g. carbon-14). However, during last decades, numerous human activities in the fields of civil or military nuclear industries, or medicine, for example, have led to the production of technologically - enhanced natural radioactive materials (TE-NORM) as well as of artificial RNs that have been released or emitted in natural surface media. TE-NORM may occur typically in the Earth's "critical zone"which is the near-surface environment where interactions between rock, soil, water, air and living organisms control natural habitats and life-sustaining resources.

RNs are thus a main environmental issue owing to their increasing rate of release in aquatic and terrestrial biotopes, their potential radio-/chemical toxicity, and the complexity of the bio-physicochemical mechanisms that control their fate and eco-toxicity. For example, vegetated soils and / or wetlands that are located in vicinity of former uranium mines or U-mill tailing storage area are potentially long-term sources for increased transfers to surface waters and to biosphere of cocktails of potentially toxic RNs, which may undergo a biomagnification along trophic chains. Understanding and predicting the transfers of the RNs'cocktails and assessing their direct or indirect effects is mandatory and addresses major societal challenges of the 21st century: reduction of anthropogenic risks, sustainability of resources, and preservation of ecosystem's and Human's health.

When a RN is released into a soil-water-plant system, its transfers, bio-availability, and eco-toxicity is controlled by its chemical speciation (chemical states and forms), which depends on its ability to interact and to form stable chemical species with components within the aqueous, (nano-)mineral and (micro)biological compartments of the ecosystem or at the compartments'interfaces. The concept of chemical speciation is at the heart of the studies in environmental chemistry, where the priority is no longer to only measure concentrations of RNs but also to develop predictive speciation models allowing to apprehend transfers –and thereby eco-toxicity- of RNs in ecosystems. In order to develop these models, it is of crucial importance to make direct determinations of the speciation of RNs existing at trace levels in complex natural systems and to elucidate the relations existing between speciation, lability, mobility and transfers to trophic chains (bioavailability). To this regard, challenging and emerging research topics deal with elucidating the effects of mineral-solution interfaces, microorganisms, and complex natural organic matter. Meeting these challenges requires the use of powerful and advanced spectrometric, spectroscopic, and analytical techniques in order to carry out molecular-level investigations of the speciation of RNs, as well as to quantify transfers of trace RNs at the ecosystem scale by analysis of environmental and biological matrices.

This presentation will highlight new perspectives of innovative and pluri-disciplinary approaches developed

at the interface between chemistry and biology within the frame of the NEEDS-INSPECT project in order to elucidate the mechanisms of transfers of natural RNs in very complex systems, namely the soil-water-plants continuum of wetlands. Decisive and recent advances on our understanding of mechanisms of the bio-geochemical transfers of RNs in a wetland impacted by a former U mine in France (Rophin), which were obtained by mobilizing complementary expertise of scientists of eleven teams of CNRS, University, CEA and IRSN within the INSPECT project[e.g., 1], will be reviewed.

References

[1]. Del Nero, M., Montavon, G., L'Actualité Chimique. 2021, 460-461, 11-16. https://hal.archives-ouvertes.fr/hal-03452239v1

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