Providing the evidence necessary to make informed decisions for contaminated land

The last 40 years of ‘environmental revolution’ in Europe and beyond has helped to establish comprehensive frameworks built around preventing pollution and risk-based management. After various lessons learnt, several countries, namely the United Kingdom, Netherlands, Belgium, the United States of America, and Australia have now a set of mature policy frameworks and successful track records of sustainable integrated remediation strategies. The risk-based approach of their contaminated land legislative regimes has further allowed more innovative and cost effective approaches to be applied elsewhere in the world. Nevertheless, tackling the protection and recovery of soils impacted by complex chemical mixtures such as among others, petroleum hydrocarbons, heavy metals (HM) and metalloids remain a key challenge because of its consequences for water resources and land use.

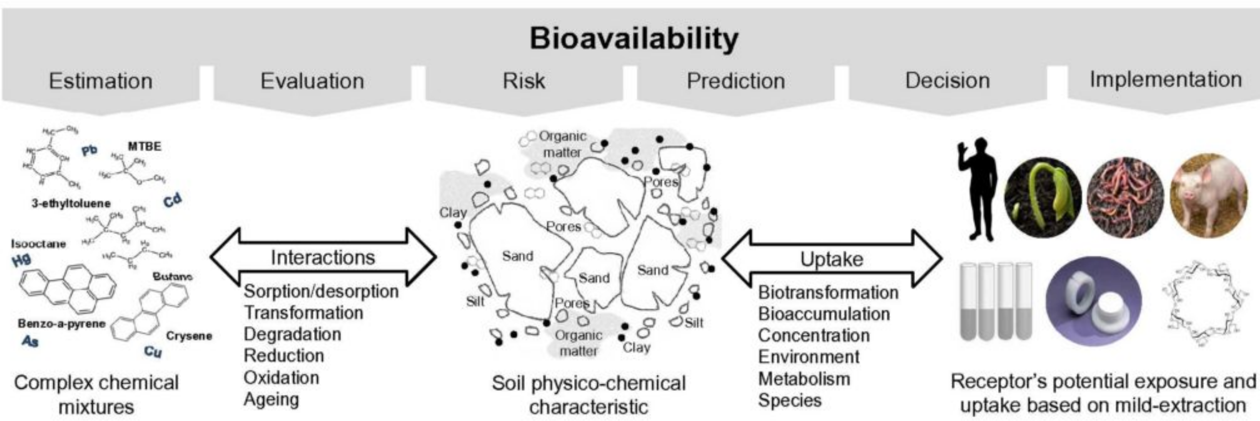

Fig. 1. Contaminants, soil and receptor interactions and uncertainties associated with estimation and implementation of bioavailability.

Petroleum hydrocarbons originate from incomplete combustion of organic materials, petroleum-based products, coke or aluminium production, and accidental spills, while heavy metals usually come from vehicle emission, industrial wastes, and mining activities. These contaminants are ubiquitous and persistent in soil. They can negatively impact both human and ecological receptors. Thus the importance of studying these groups of contaminant is related to their co-occurrence in polluted soils, which challenges the risk evaluation and complicates the achievement of site-speci?c remediation objectives.

Risk assessment (RA) is recognised as a robust process to support decision-making practice for contaminated land and to prevent further damage to the environment and human health. It has been further shown that measuring only the total concentration of contaminants in soil does not give a useful basis for the evaluation of the potential risks to human and the environment. Thus, in the last decade in the United Kingdom, and increasingly across the world, the end-point of remedial activity is defined not by the total concentration of the chemicals of concern but by the concentration likely to pose significant risk, the bioavailable concentration. In our study we discussed the challenges of assessing complex chemical mixtures bioavailability (Fig. 1) and its implementation in the contaminated land risk assessment framework.

While a number of physical, chemical and biological techniques have been developed to estimate bioavailable fraction and successfully applied on case-by-case scenario, doubts have been casted on their applicability, due to lack of standardisation. Unlike single contaminant, the physico-chemical interactions of chemical mixtures are still not fully understood as the additive, synergistic or antagonistic effects of mixtures will often yield bioavailability values that differ from those of individual contaminants. The review highlighted the role of biotic and abiotic factors affecting bioavailability measures, and how different mechanisms, partitioning, can affect the risk estimation. Moreover we provided an in-depth evaluation of advantages and disadvantages of different extraction techniques.

Understanding the distribution, behaviour, and interactions of complex chemical mixtures is key for providing the evidence necessary to make informed decisions and implement robust remediation strategies. Future work should focus on (1) defining relevant and standardised sampling strategies producing more reliable and accurate information; (2) providing convincing evidence that contaminants left behind in the soil do not pose a risk (low bioavailability = low harm), through establishment of standardised techniques (in vivo and in vitro methods) to assess bioavailability of complex mixtures; (3) considering toxicity implications of complex chemical mixtures vs. single contaminants for the estimation and application of revised environmental quality standards; (4) promoting better and more coordinated effort to implement multidisciplinary approach to contaminated land risk-based management.

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