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Review of the empirical equations to estimate mobile or available Cu content in soils and applicability at the European scale for risk assessment

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Soil contamination by trace elements (TE) due to anthropogenic activities is an ongoing issue. But knowledge of the soil total contents in TE cannot describe the risk for contamination of the different ecosystem compartments. Large soil survey allows the measure of total TE but not TE in solution or free TE values despite their better adequacy for environmental purpose. From the knowledge of total TE contents, soil parameters like organic matter (OM) content or pH can be used in empirical equations to calculate either TE in solution (about to reach freshwater and mimicking mobile forms) or free forms of TE (taken as a proxi of bio-available TE). However, empirical equations were rather provided at a small, local scale, and were never tested to a larger scale despite their relevance for risk assessment. Here, we focused on copper (Cu) as TE of particular interest because largely used in the agricultural sector. We collected from literature the empirical equations allowing estimation of the amount of Cu in solution and of free Cu from the knowledge of total soil Cu contents and of various soil parameters. Then, based on a total soil Cu map over Europe and the most accurate equation, we provided European maps of Cu in solution and of free Cu to identify specific areas linked to risks of Cu mobility or availability. Our results confirmed the strong effect of soil pH and OM content to explain soil Cu availability or mobility but showed a stronger pH effect to explain free Cu compare to Cu in solution. Depending on the Cu estimated forms, different areas were identified corresponding to potential high risks. Italy, South East and West of France and South of Spain were regions with higher Cu in solution associated to total Cu concentrations while highest levels of free Cu were calculated in west Iberia, East Europe, Scandinavia and central France regions due to the combined effect of low pH and moderate total Cu concentrations. Our results point out the usefulness of empirical equations at the continental scale to define environmental guidelines for mobility or availability of contaminants.

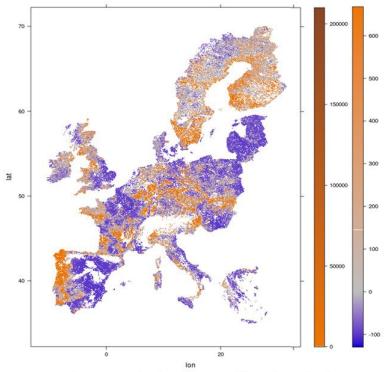

Fig. Map of European at 0.01° resolution of percentage difference for Cu with median between soil total concentration and estimated free Cu.