Pore-water carbonate and phosphate as predictors of arsenate toxicity in soil

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Phytotoxicity of inorganic contaminants is influenced by the presence of competing ions at the site of uptake. Arsenic (As) is a major soil-borne toxicant globally and is well known to impact directly on human and ecological health. Yet, our ability to model and predict As toxicity in terrestrial systems is lacking. In comparison to cationic counterparts, such as lead, arsenic toxicity from solution culture has not been shown to be strongly dependent on pH. Furthermore, as there are presently no binding constants included in the WHAM speciation software for As and dissolved organic carbon, there are significant limitations in the application of biotic ligand or the WHAM-based Ftox models in soil. Since arsenate is taken up via the phosphate cotransport system, ions able to influence phosphate uptake may similarly influence arsenate (e.g. carbonate). In this study, interaction of soil pore-water constituents with arsenate toxicity was investigated in cucumber (Cucumis sativa L) using 10 contrasting soils.

Arsenate phytotoxicity was shown to be linked to soluble carbonate and phosphate. The data indicated that dissolved phosphate and carbonate had an antagonistic impact on arsenate toxicity to cucumber. To predict arsenate phytotoxicity in soils with a diverse range of soil solution properties, both were required. The relationship between arsenic and pore-water toxicity parameters was established initially using multiple regression. In addition, based on the relationship with carbonate and phosphate we successively applied a terrestrial biotic ligand-like model (BLM) including carbonate and phosphate. Estimated effective concentrations from the BLM-like parameterisation were strongly correlated to measured arsenate values in pore-water ($R2 = 0.92$, $P < 0.001$). The data indicates that an ion interaction model similar to the BLM for arsenate is possible, potentially improving current risk assessments at arsenic and co-contaminated soils.