

Evaluation and management of Arsenic contamination in agricultural soil and water - AgriAs

Bio-hydrogeochemical model of arsenic speciation and transfer in soils

Title of the project:	Evaluation and management of Arsenic contamination in agricultural soil and water - AgriAs
Funding Scheme:	Water JPI Joint Call, ERA-NET Cofund WaterWorks2015
Start date:	01.04.2017
Duration:	24 months
Document title:	Bio-hydrogeochemical model of arsenic speciation and transfer in soils
Workpackage:	WP2, Task 2.4, D2.3
Lead partner:	BRGM, France
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Reviewed by:	Scientific Coordinator Kirsti Loukola-Ruskeeniemi (GTK)
Date of delivery:	31.3.2019
Dissemination level:	Confidential. Public Summary
Status of the document:	Final
Document location:	Intranet folder: AgriAs/Deliverables/WPX
Project web site:	http://projects.gtk.fi/AgriAs/index.html

Public Summary

Nicolas Devau, Hugues Thouin, Mickael Charron, Pablo Houlemare, Catherine Joulian, Fabienne Battaglia-Brunet, Jennifer Hellal, 2019. **Bio-hydrogeochemical model of arsenic speciation and transfer in soils.** The AgriAs Deliverable D2.3. 52 pages, 27 figures and 5 tables.

One of the main objectives of the AgriAs project is to develop recommendations and guidelines for sustainable management of As risk associated to agriculture. The behaviour of arsenic in agricultural soils depends on a range of biogeochemical processes. Previous steps performed in the frame of AgriAs project (characterization of the sites, microcosm and mesocosm experiments) provided data about the mobility and speciation of arsenic in solids and water when common fertilizers are added. In order to build a model taking into account both the effects of redox conditions and fertilization, complementary experiments were performed with the most contaminated Verdun soil. A range of biological and chemical parameters were monitored in batch and column experiments. In the outlet solution of both experiments, pH, and redox potential were measured daily and some major ions were quantified (NH_4 , NO_3 , NO_2 , FeII , S(-II) , AsIII , AsV , SO_4 , PO_4). At the end of the column experiment, arsenic speciation in the solids was determined. Oxidic and anoxic conditions were tested in the two experiments. These conditions were maintained through gas saturation, water saturation or supply of electron donor compounds (organic substrates). In the batch experiments, impacts of increasing amounts of KP fertilizer were tested in the two redox conditions over time by sacrificing batches after one week, one month and three months.

Batch experiments showed As speciation according to redox, i.e. AsV in the oxidic conditions and AsIII in the anoxic one, and a sequestration effect of increasing KP amounts on As, especially in the anoxic condition. Columns were then set up to measure the flow of As and other elements from the soils in different conditions. One column alternated oxidic/anoxic conditions while the other was always anoxic and received first a dose of PK then ammonium sulphate. Results showed that even slightly reducing conditions promotes the reduction of iron and AsV and the mobilization of As, which concentration reached nearly 30 mg/L in the outlet of the two column experiments. Mass balance calculations indicated that more than 30% of the total As from the solid phase had been mobilized in the column experiment whatever the redox conditions. Supply of fertilizers (in high dose compared with the field conditions) tended to attenuate the mobility of As.

Based on these experiments and the corresponding phenomenological hypothesis, a reactive transport model including transport and several biogeochemical models was developed to simulate As mobility monitored in column experiments. Ion transport was simulated using a standard advective-dispersive model. Specific biogeochemical models were used to simulate the following reactions: i) microbially-mediated redox reactions, ii) surface complexation reactions onto iron oxides and edge sites of clay minerals, iii) cation-exchanges reactions onto basal sites of clay minerals, iv) cation surface complexation onto solid organic matter, v) aqueous complexation reactions, vi) dissolution/precipitation of primary and secondary minerals. For microbially mediated redox reactions and some dissolution/precipitation of primary minerals, kinetic rates of these reactions were taken into account in addition to thermodynamic parameters. The simulated results are in agreement with the measured As concentrations in the outlet. Based on a partial sensitive analysis, predictive As concentrations have been calculated according to changes in soil properties.



The authors would like to thank the EU and Academy of Finland, L'Agence nationale de la recherche, Bundesministerium für Ernährung und Landwirtschaft and Forskningsrådet FORMAS for funding, in the frame of the collaborative international consortium (AgriAs) financed under the ERA-NET Cofund WaterWorks2015 Call. This ERA-NET is an integral part of the 2016 Joint Activities developed by the Water Challenges for a Changing World Joint Programme Initiative (Water JPI).

