Layman's Report

Evaluation and Management of Arsenic Contamination in Agricultural Soil and Water

AgriAs

AgriAs project

1.4.2017 – 31.3.2019

http://projects.gtk.fi/AgriAs

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Water JPI

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In the old days, we enjoyed food grown in our own village fields. Now our diet contains a vast range of exported foods from all over the world. We eat rice and pasta from countries with different regulations on air, soil and water quality. The question is whether this has changed the load of potentially harmful elements and compounds in the diet and whether our own fields are free of contaminants.

The main sources for As in the agro-ecosystem are contaminated soil, anthropogenic contamination via air and a naturally As-rich geochemical background. Arsenic-rich irrigation water may create problems in rise fields. A long history of agricultural activity has contaminated the soil in some places. Fertilizers and pesticides have increased the load of arsenic to soils.

Photos: H. Valkama, University of Oulu

Arsenic is a toxic and carcinogenic semi-metal. As-rich drinking water causes worldwide health risks (WHO, 2016) but another significant route is via crop since As may accumulate in plants. High As concentrations reduce crop yields as well. Rice is well-known as a potentially As-rich agricultural product but also other crop may contain in excess of arsenic.

WHO (2016, June). Arsenic Fact sheet. [Online]. Available: https://www.who.int/mediacentre/factsheets/fs372/en/

Loukola-Ruskeeniemi, K., Battaglia-Brunet, F., Elert, M., Le Guédard, M., Devau, N., Hatakka, T., Hellal, J., Hube, D., Jones, C., Jordan, I., Joulian, C., Kaija, J., Keiski, R., Pinka, J., Reichel, S., Tarvainen, T., Thouin, H., Turkki, A., Turpeinen, E., Valkama, H. 2019. Layman's report of the AgriAs project 'Evaluation and Management of Arsenic Contamination in Agricultural Soil and Water' 2017-2019, financed under the ERA-NET Cofund Water-Works 2015. 24 pages.

Graphical design: Elvi Turtiainen Oy

The AgriAs project followed two EU projects coordinated by the Geological Survey of Finland on the risk assessment and risk management of arsenic.
ASROCKS received a Best LIFE project award.

1) RAMAS 'Risk Assessment and Risk Management Procedure for Arsenic in the Tampere Region' EU's LIFE Environment programme, 2004–2007.
http://projects.gtk.fi/ramas/
2) ASROCKS 'Guidelines for sustainable exploitation of aggregate resources in areas with elevated arsenic concentrations' EU's Life+ Environment Policy and Governance programme, 2011–2014.
http://projects.gtk.fi/ASROCKS_ENG/index.html

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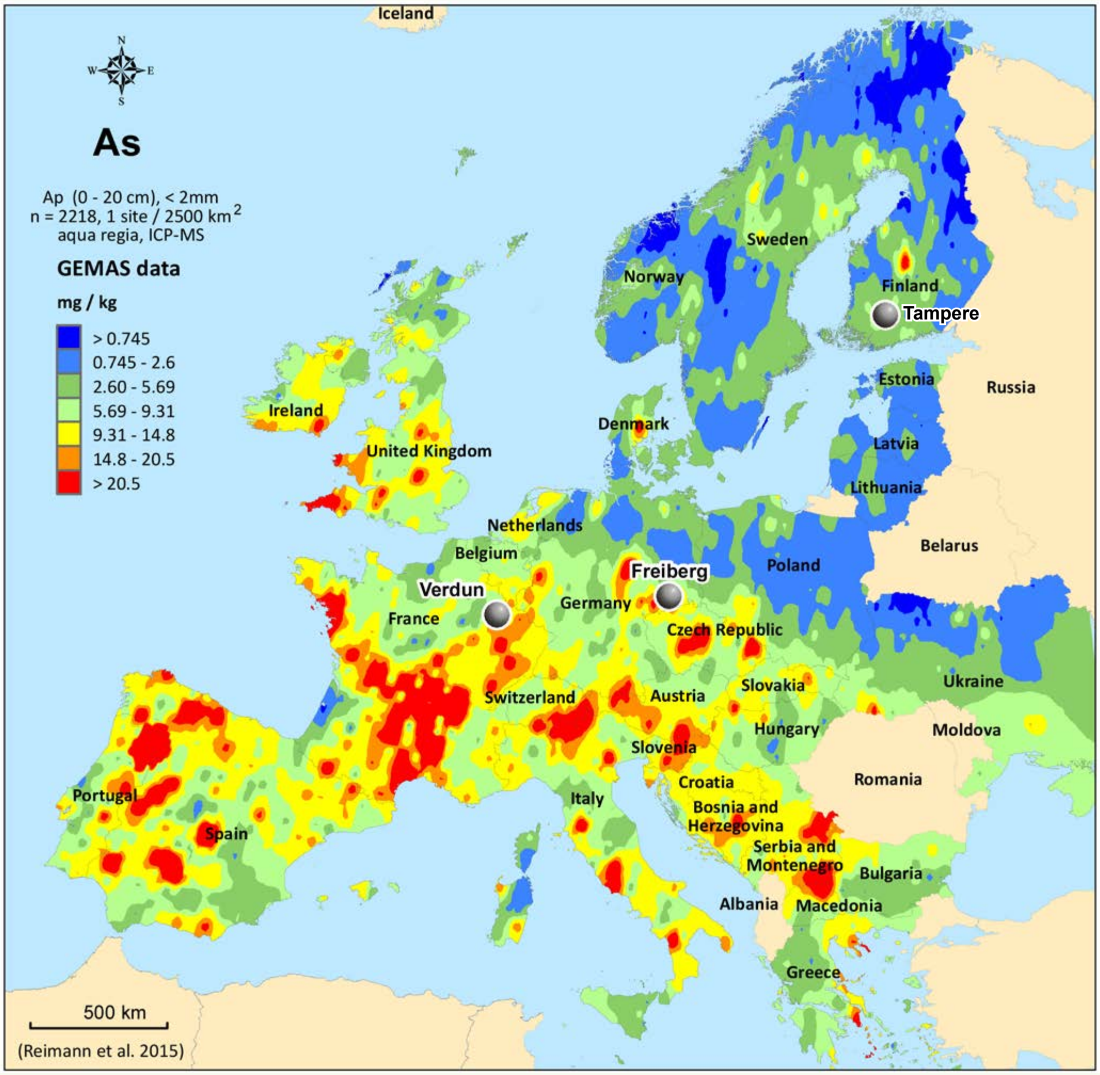
AgriAs summarized national and European databases to assess the scale of arsenic contamination in the agricultural soil and water in Europe.



Arsenic concentrations in European agricultural soils and the study areas in Freiberg, Germany, and in Verdun, France. The Tampere area provided geochemical background levels under natural conditions in Finland. Arsenic concentrations are higher in Central and Southern Europe compared with Northern Europe due to both geological and anthropogenic reasons.

Colour scale: Spatial distribution of arsenic in European agricultural topsoil (0 – 20 cm), Aqua regia extraction on the <2 mm size fraction, source: GEMAS Data Set. Reimann, C., Birke, M., Demetriades, A., Filzmoser, P. & O'Connor, P. (eds.) 2014. Geochemistry of Europe's Agricultural Soils. Part B. Geol.Jb. B 103.

Test sites

The two study sites of the AgriAs project represent anthropogenic contamination: 1) The French site at Verdun is a historical area of destruction of World War I chemical ammunition located in a sensitive zone both for agriculture and groundwater; and 2) The German site at Freiberg is characterized by 800 years of mining and ore processing.

For comparison, previous EU projects in the Tampere region in Finland represent a geological terrain with higher than average As concentrations in glacial till.

Verdun, France

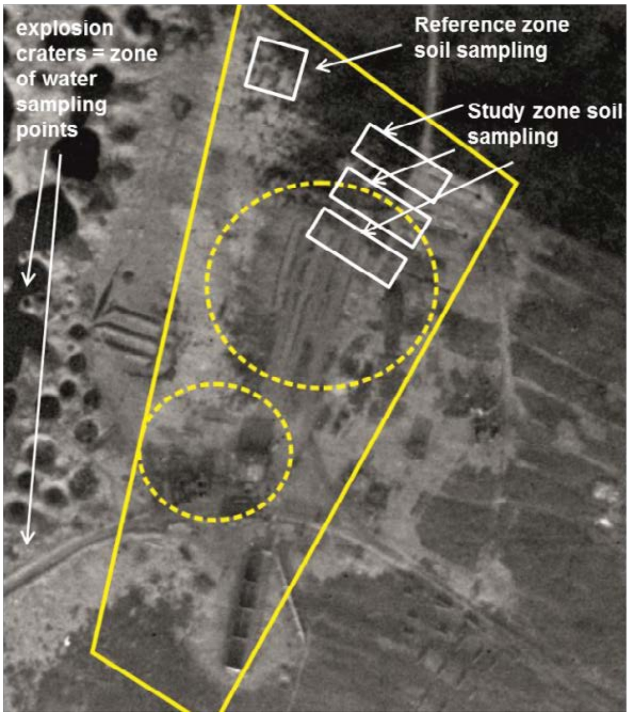
A former chemical ammunition treatment facility converted into agricultural land

One of the most important historical areas of chemical ammunition destruction of World War I, containing arsenical chemical warfare agents, located in a sensitive zone for agriculture and groundwater.

The site was used to assess the impacts of agricultural practices on arsenic speciation, bioavailability and mobility through water.

The French national soil monitoring network determined that arsenic concentrations in soils are generally higher than the threshold (5 mg/kg) proposed by the Ministry of Environment of Finland. The lower of two other guideline values indicating risks to ecology or health is exceeded in less than 5% of the studied points. These points are found in local areas influenced by mining and mineralization.

In groundwater, values acquired in 2017 indicate that 4250 wells were monitored for arsenic concentrations, and among them 134 presented an average As concentration higher than the drinking water standard of 10 µg/L. In terms of exposure to arsenic, the average values are for French adults (ANSES) between 0.24 to 0.28 µg/kg of body weight/day, and for French children (ANSES) from 0.30 to 0.39 µg/kg of body weight/day, which are close or exceeding the toxicological standard (EFSA) which is 0.3 µg/kg of body weight/day.



In 1922 (source D. Hube, BRGM)


Photo: F. Battaglia, BRGM

AgriAs applied biological tools to manage ecological, environmental and human risks.

AgriAs developed a biogeochemical model able to simulate and predict the behaviour of arsenic according to fertilization practices and redox conditions.

Photos: J. Hellal from BRGM

Freiberg, Saxony, Germany

Centre of mining industry

The region of Freiberg is characterized by widespread arsenic contamination due to the geochemistry of bedrock and soil in Ore Mountains (Erzgebirge) and mining and ore processing activities to produce silver, lead and zinc for over eight centuries. According to the Saxon State Office for Environment, Agriculture & Geology (LfULG), arsenic contents are high in agricultural land containing up to several hundred mg/kg of arsenic in soil.
Elevated arsenic concentrations in German topsoil are mostly related to arsenic-rich bedrock or ore deposits with arsenic containing minerals (geogenic background concentration). Besides, historical mining activities especially the pyrometallurgical industry emitted arsenic and lead to arsenic enrichment in soil. Despite the restriction of the use of arsenic containing insecticides in the 1940´s there are still elevated arsenic concentrations in soil in some winegrowing regions in Germany.

In the Erzgebirge in the southern part of Saxony As concentrations are elevated and reach interpolated mean values of approx. 320 mg/kg. In this region, about one thousand km² of agricultural soils show metal contamination with an area of 288 km² where arsenic concentration exceeds the German action value of 50 mg/kg.

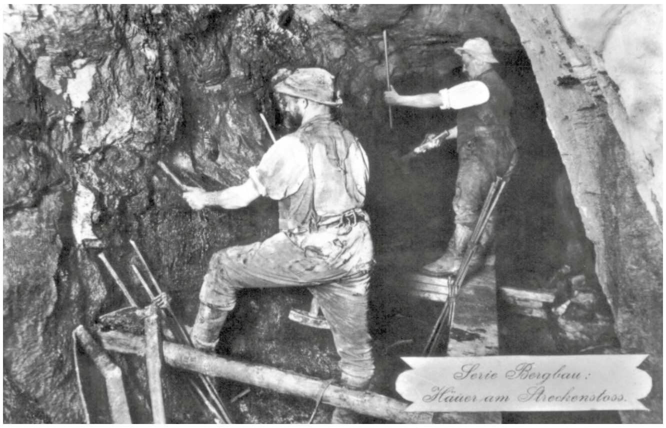


Photo: Ernst Oehme, Freiberg

Photo: Arno Heinicke, Freiberg

Saxon State Office for Environment, Agriculture and Geology (LfULG) (2009, accessed 08 January 2018). Geochemische Übersichtskarten des Freistaates Sachsen (Geochemical maps of Saxony). [Online]. Available: https://www.umwelt.sachsen.de/umwelt/boden/11646.htm

LfULG (2001, accessed 08 January 2018). Boden-Sondermessnetz Freiberg (Special soil monitoring grid, Freiberg). [Online]. Available: https://www.umwelt.sachsen.de/umwelt/boden/19150.htm#article19153

The ore of the Freiberg mining area contains not only silver and lead in galena, but also zinc and cadmium in sphalerite and arsenic in large quantities in arsenopyrite. All these compounds were mined and melted together, and the residues were deposited in heaps until the end of mining activities in 1969. Thus, over 800 years of mining and ore processing in this region also means over 800 years of environmental pollution. Beside tailings and former mining and ore processing sites, large areas of agricultural land and alluvial plains were affected by huge quantities of trace elements, especially arsenic, cadmium and lead, at a distance of hundred kilometres.

As mining, industrial ore processing, agriculture and settlement areas are located close together, the impact of exposure to arsenic and other pollutants on the environment and human health had to be assessed. That is why comprehensive studies were initiated by the local authorities (especially the Saxon state office of environment, agriculture and geology, short: LfULG). Contaminants in soil and water have been monitored regularly for many years up to today. In areas with high amounts of contaminants, permanent soil monitoring systems were installed, that allow an early-alert in case of harmful changes of soil characteristics. Recommendations have been given by local authorities for the treatment of contaminated soils for agriculture and gardening.

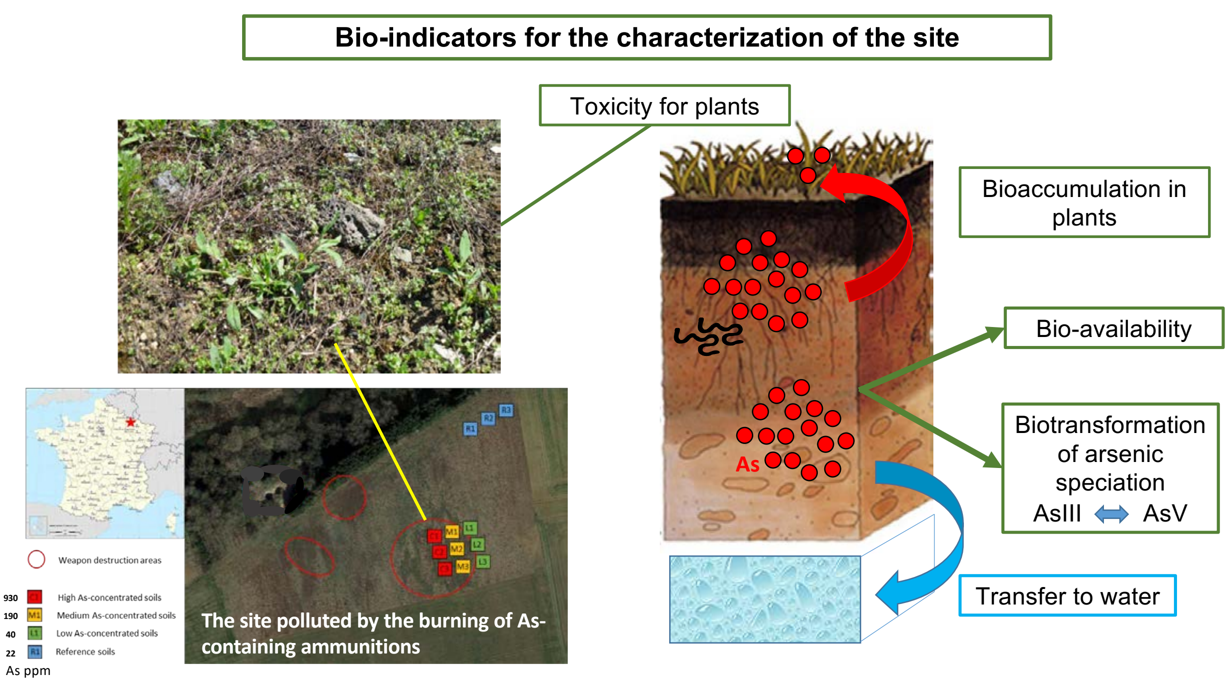
Nowadays arsenic concentration is measured at a regular basis in dust at several locations in Germany and it was found that the highest measured arsenic emissions occurred in industrial environments, e.g. 4 ng/m³ (2017), while lower emissions were measured related to urban traffic or in regions with high geological background concentration. Arsenic emissions decreased significantly (by ~90%) during the last 25 years. At present the highest arsenic emissions in Germany are caused by coal fired power plants and waste incineration plants.


Photo: H. Forberg, LfULG

Effect of agricultural practices on arsenic concentration, bioavailability and toxicity in water and soil

The main results of the work carried out in the AgriAs project:

- Globally, the amendments, applied at the real average dose used on site, did not significantly influence the arsenic leached from the soil. Microcosm and pot experiments performed in non-saturated conditions showed that (1) PK amendment increases As uptake by lettuce; (2) ammonium sulfate amendment (applied on Verdun site) decreases As transfer to water and phytotoxicity; (3) ammonium sulfate may increase As concentration in grains; (4) AsV remains the main As species in soil and water, but AsIII is present in significant proportion in grains. Lime ammonium nitrate fertilizer (applied on Freiberg site) did not modify the mobility of As towards water nor influenced arsenic phytotoxicity.
- Slurry and column experiments, performed with soil from Verdun, allowing a change from oxic to anoxic conditions, showed that saturation combined with organic substrates mobilizes arsenic in water. In these conditions, arsenic is reduced from AsV to AsIII in both water and solids. Results showed that even slightly reducing conditions promotes the reduction of iron and arsenic and the mobilization of arsenic, which concentration reached nearly 30 mg/L in the outlet of the 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. 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. 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.



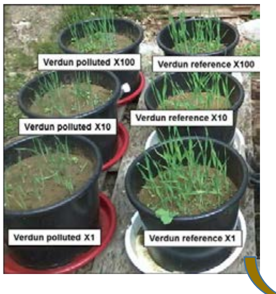
Effects of agricultural amendments

Microcosm experiments, not saturated, without plants:
Transfer to groundwater

Ecotoxicological tests Omega3-index with *Lettuce*:
Transfer to leaves and phyto-toxicity

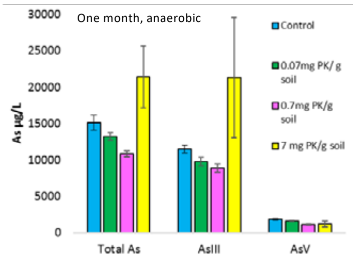
Results:

- PK amendement increases As uptake by lettuce
- Ammonium sulfate amendment decreases As transfer to water and phyto-toxicity
- Ammonium sufate may increase As concentration in grains
- AsV remains the major As species



Pot experiments with barley:
Transfer to water and crops

Effects of redox conditions coupled with amendements



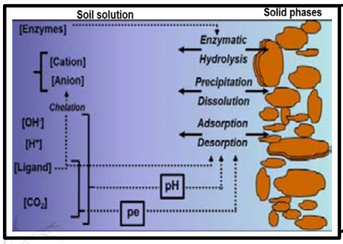
Results:

- Saturation combined with organic substrates mobilizes arsenic in water,
- Complex behavior is observed with KP fertilizer according to incubation time and redox conditions,
- Arsenic is reduced from AsV to AsIII in both water and solids

Column experiments:

- Saturation
- Organic substrates supply
- Variations of redox conditions
- Amendments (phosphate, ammonium)

Batch experiments:
Aerobic or anaerobic
Organic substrates supply
KP supply



Arsenic removal technology & innovation

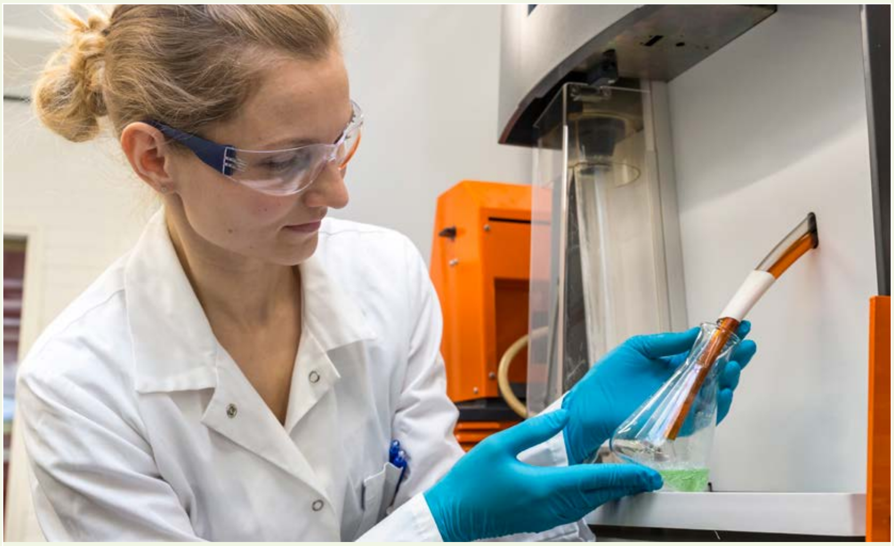
The water purification methods studied were membrane technologies, *i.e.* nanofiltration (NF) and low-pressure reverse osmosis (RO), adsorption, combined RO-adsorption, and advanced oxidation-coagulation-filtration (AOCF). The membrane-adsorption experiments were carried out with real contaminated natural water samples from the pilot area in Verdun, France.

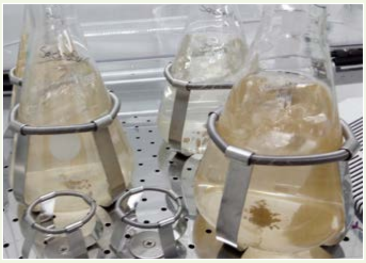
The soil remediation experiments were done with a novel biologically synthesized schwertmannite (iron-oxy-hydroxysulfate mineral) based adsorbent (sorpP). Bioindicators were used to assess the successful application of adsorbents on agricultural soils. Omega-3 Index of plants was determined during the experiment as an indicator for the oxidative stress of the plants caused by soil contaminants. The tests were done with contaminated soil samples from the pilot areas in Saxony, Germany and Verdun, France.

The aim of the sustainability assessment was to give an overview of sustainability of technologies available for arsenic remediation in aquatic environment. The assessment was based on multi-criteria approach having criteria concerning technological, economic, environmental and social aspects.

Main results of the experiments in water and in soil

- In water arsenic concentration below 10μg/L was achieved with advanced-oxidation-coagulation-filtration (AOCF) method.
- Sustainability assessment showed that the coagulation-filtration and adsorption processes are competitive options for the treatment of high arsenic concentrations in surface waters.
- Reverse osmosis membrane system provides high water quality.
- In soil experiments with iron-based adsorbent sorpP and its buffered modifications sorpP + chalk and sorpP + ash were successful.
- Arsenic mobility in soil and arsenic concentration in crops were reduced.
- Addition of buffered iron-based adsorbents can help to immobilize cadmium (Cd) and lead (Pb) as well.





Photos: H. Valkama, University of Oulu

AgriAs developed arsenic removal technologies and assessed their technological and economic feasibility.

Risk assessment

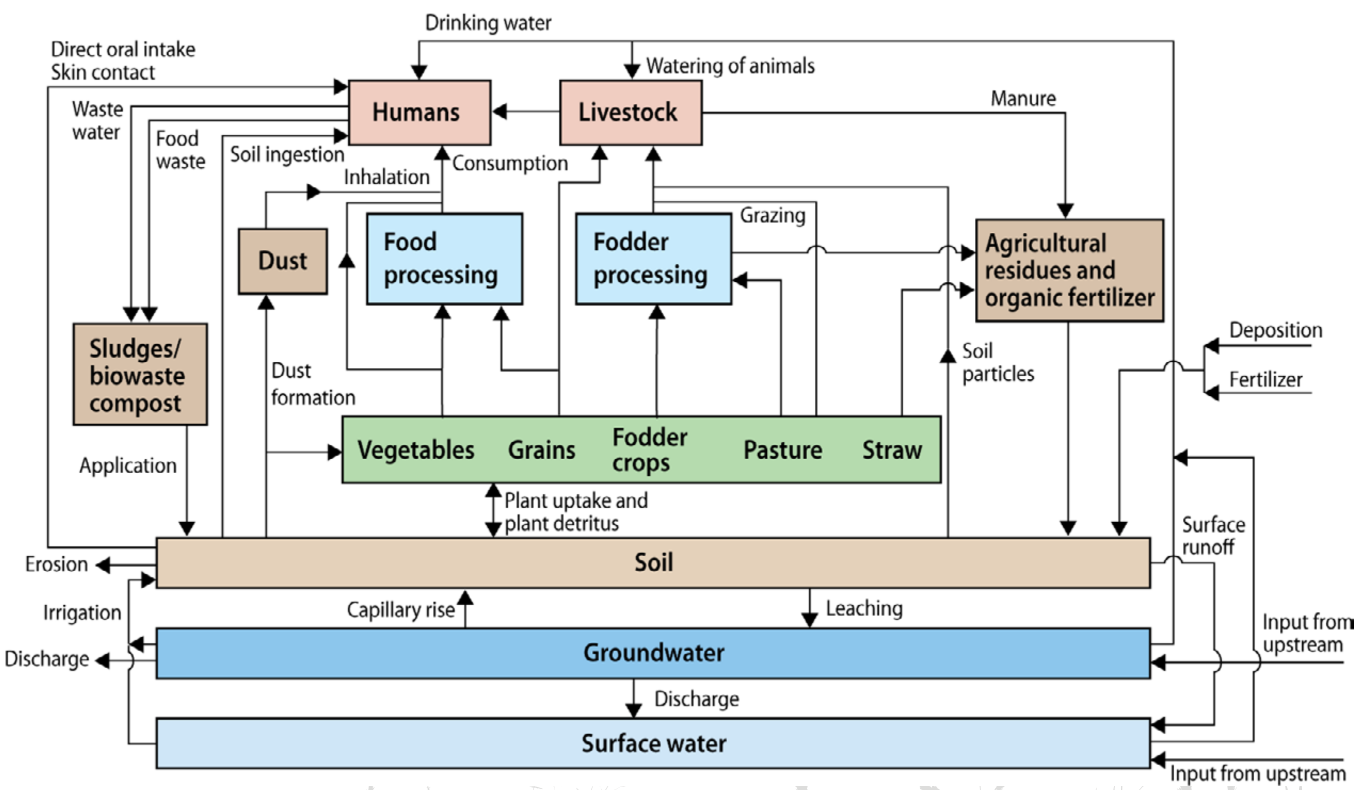
Both inorganic and organic As compounds occur in food and water, of which inorganic As has been considered to be more toxic to humans. Chronic exposure to As may cause health impacts, including As poisoning and cancer. Since the most significant exposure to arsenic is in most countries from food, contamination of agricultural soils is of utmost importance.

Risk management refers to actions aimed at avoiding or minimizing risks to a generally acceptable level, which in the AgriAs project is restricted to human health, excluding occupational health.

A model was developed in the AgriAs project to estimate the exposure of people to arsenic in agricultural soils. The model considers that adults and children are directly exposed to arsenic in the soil in several ways; through direct contact by getting soil in the mouth and on the skin, or by inhalation of soil dust. Persons can also be exposed to arsenic when eating food grown on arsenic contaminated soil or eating meat dairy products and eggs from farm animals raised in the contaminated area. Furthermore, groundwater contaminated with arsenic can be an important pathway for exposure, if it is used as drinking water. How much arsenic people are exposed to, depends on their habits and consumption patterns. The model allows for the use of site-specific description of human habits.

In addition to the exposure to arsenic coming from the contaminated site there is an additional exposure of arsenic due to its presence in foodstuff coming from other regions or countries with elevated levels of arsenic. This exposure to off-site arsenic is calculated based on country or region- specific measurements. The model makes it possible to compare the on-site and off-site arsenic exposure.

For site specific estimates, the model can use measured concentrations of arsenic in soil and water, and



A model for the pathways and exposure of people to arsenic in agricultural soils.

measured concentrations in foodstuffs and animal fodder. If measured concentrations in foodstuffs and fodder are not available, they can be calculated from the concentrations of arsenic in the soil using site-specific data about uptake in plant and animal products. If there are no site specific uptake data, generic factors taken from the scientific literature, or generic concentrations in foodstuffs (from European Food Safety Authority, EFSA) can be used.

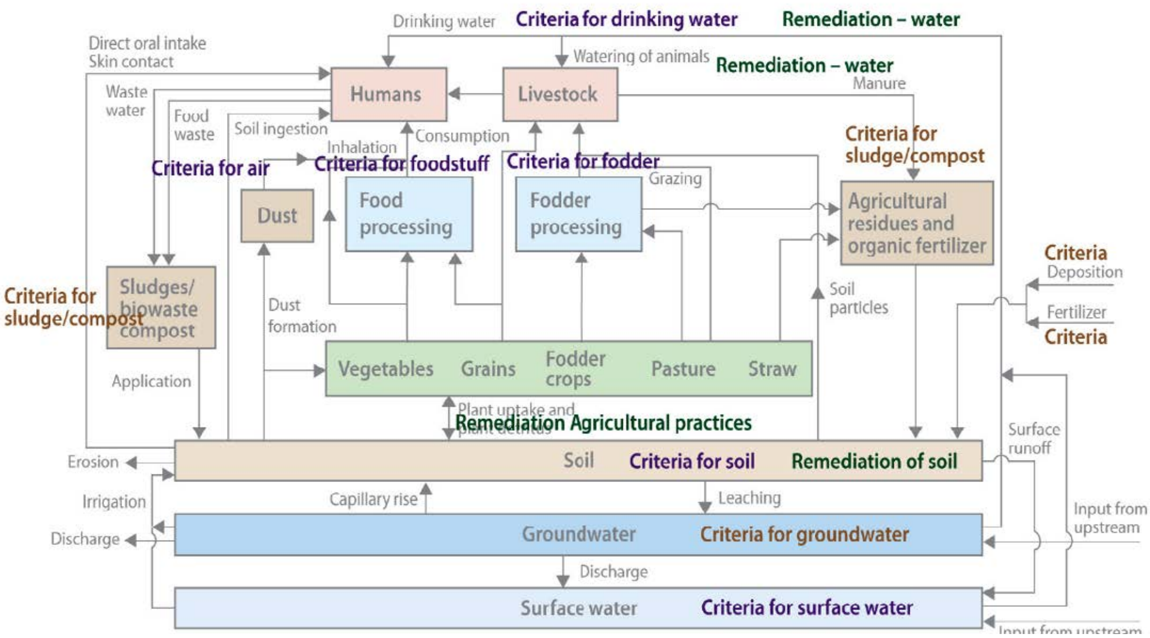
Risk assessments of the test sites

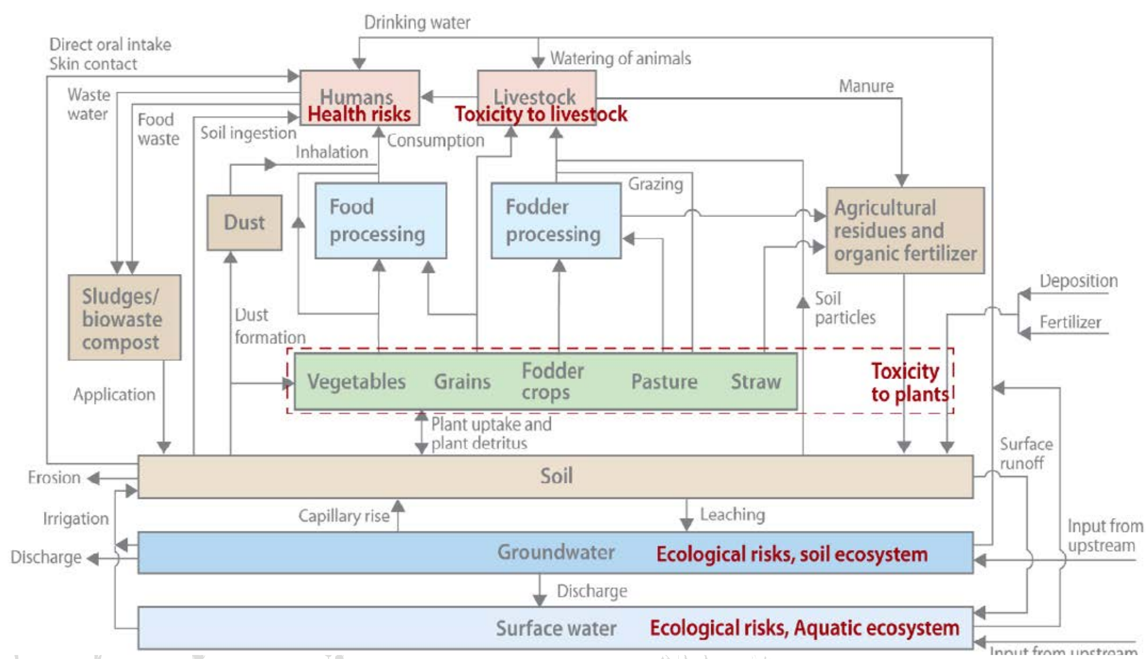
The AgriAs model was used to estimate the health risks from arsenic in agricultural soils at the two test sites in Saxony, Germany and Verdun, France. Site-specific input data were used as far as possible. For both sites the assessments showed that the risks from arsenic at the contaminated site dominated over the exposure due to consumption of foodstuffs coming from other areas.

The most important exposure pathways were intake of vegetables and fruit, but the intake of animal products also gave a significant contribution. Since groundwater was not used for drinking water at either of the sites, consumption of water was not an important exposure pathway. However, at sites where groundwater containing arsenic is used as a drinking water source, this pathway would become important.

The risk assessment gives conservative estimates of the risk and should only be considered as an illustration of the use of the model. For a small site, such as the Verdun site, the scenario considered is unrealistic because it is not possible to grow all the different types of crops considered and raise animals on a contaminated site of limited size. Other conservative assumptions that were made concerned the bioavailability of arsenic in the soil, and the extent that people living on or near the sites have direct contact with soil.

Risk assessments were made for a situation with and without applying the remediation measures investigated in the other work packages. The soil amendments studied for the Verdun site were estimated to reduce the lifetime exposure to arsenic by about 30% when applied to the production of all crops. For the Saxony site, the studied soil amendments were estimated to reduce the lifetime exposure to arsenic by about 40% when applied to the production of all crops, and by about 30% when applied to the production of grains.





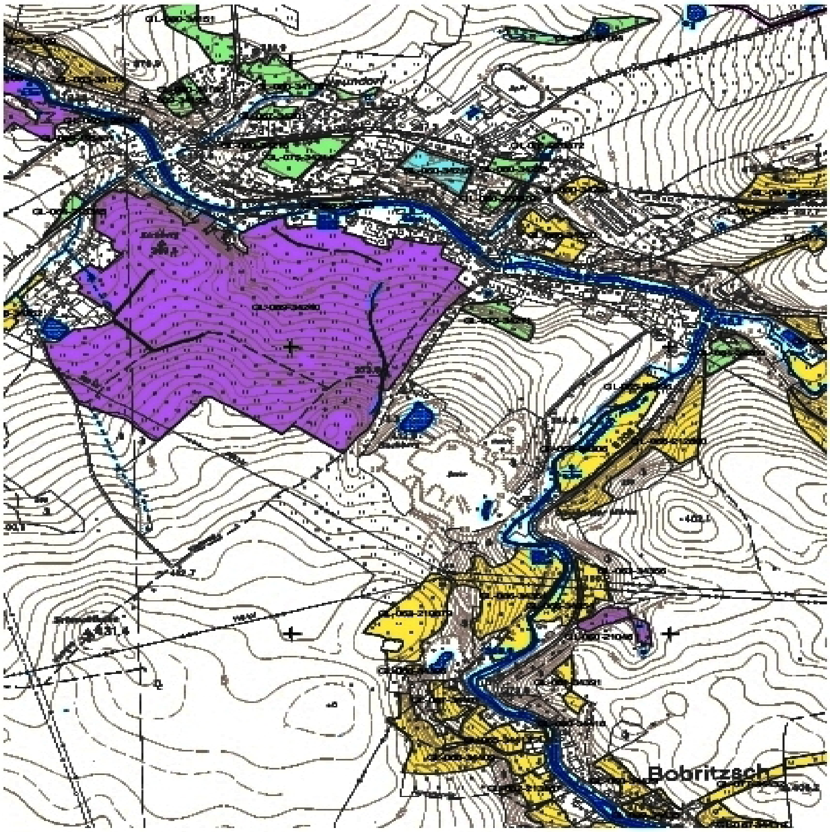
Risk management in Germany

A lot of test work has earlier been carried out at the German study site to investigate the transfer of As as well as heavy metals Cd and Pb into agricultural crop. Based on the data, guidelines for farming and gardening were developed to optimize the farming procedure and even the choice of suitable varieties of plants that are characterized by a lower potential of As uptake. (e.g., Serfing and Klose 2008; Klose 2017). Depending on land use and transfer pathways different measures can be proposed for an adaption of agricultural practices.

Since most arsenic contamination in agricultural crops is caused by adhering soil particles and not by systemic uptake by the roots, measures can be taken to ***reduce soil particles*** on harvested products. This can be done by cleaning procedures of harvested crops and the removal of husk as they contain a large part of contaminants that

Recommendation for grassland use

https://www.umwelt.sachsen.de/umwelt/download/12_Schuerer.pdf



class	colour	crop analysis	content (AR) [mg/kg
1	green	not necessary	no limit exceeded
2	yellow	As	As > 50
3	light blue	Cd	Cd > 2
4	dark blue	Pb	Pb > 1200
5	red	As, Pb	As >50 Pb > 1200
6	violet	As, Cd	As > 50 Cd > 2
7	brown	Cd, Pb	Cd > 2 Pb >1200
8	purple	As, Cd, Pb	As > 50 Cd > 2 Pb > 1200

Müller, I. (LfULG) (2017): Bodenbelastungen in Sachsen. Regelungen zur Bewertung und Sanierung. AgriAs Workshop. Freiberg: 18.09.2017

A. Serfing, and R. Klose, "Arsentransfer Boden - Pflanze: Entwicklung von Maßnahmen zur Verhinderung des Arsentransfers im System Boden- Pflanze", (Arsenic transport from soil to plants: development of measures to avoid the transport of arsenic in the system soil-plant) Edited by LfUG, 41 p., 2008.

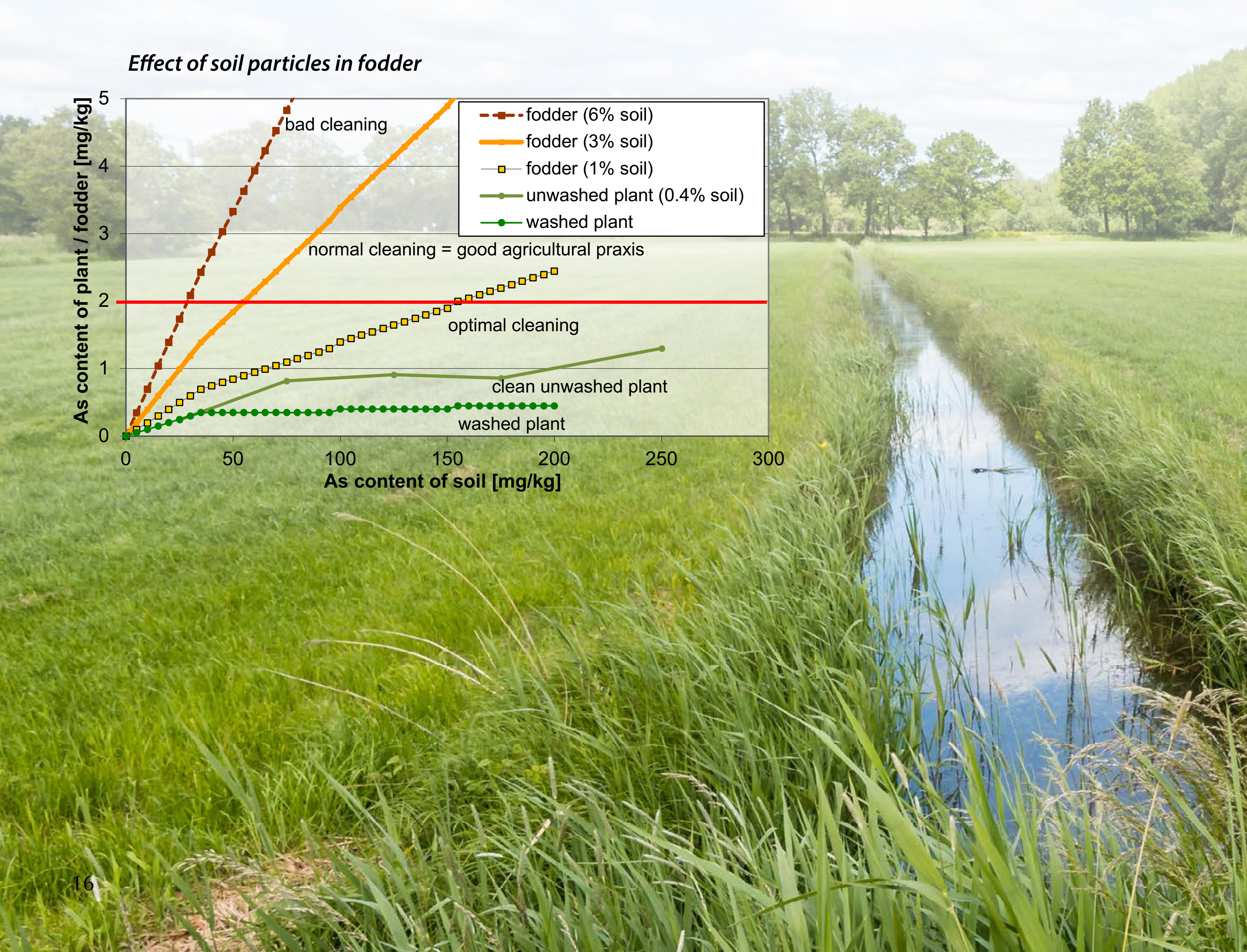
R. Klose, "Hinweise und Empfehlungen zum Umgang mit arsen- und schwermetallbelasteten landwirtschaftlich und gärtnerisch genutzten Böden," Böden (Tips and recommendations for the handling of arsenic and heavy metal polluted soils used for agriculture and gardening), Edited by Staatliche Betriebsgesellschaft für Umwelt und Landwirtschaft, GB Labore Landwirtschaft. 14 p., 2015.

reach grains. Especially in case that plants are intended be used as fodder an adaption of the operation of harvesting machines and the improvement of technologies is required to reduce the uptake of soil particles and subsequently of contaminants.

Due to high background concentrations of As and heavy metals in subsoil of the German study site, a ***deep dig up in subsoil*** should also be ***abandoned*** as this can release further contaminants. Based on the fact that As is especially mobile under reductive conditions, an aeration of wet soil is recommended. A well-functioning drainage system can prevent waterlogging and allows a sufficient aeration of soil.

The ***choice of fertilizer*** at an appropriate dosage is a relevant aspect that can easily be included in the routine of farmers. Fertilization with phosphorus at the beginning of the vegetation period can reduce the As uptake in plants, as As and P compete for uptake via the roots (Klose 2017). The interaction of P and N fertilizers and its impact on the As uptake of plants was also investigated. The dosage of P and N fertilizer affects the concentration of As in different parts of the plants. A high dosage of N at low dosage of P achieved lowered As concentrations, while for a low dosage N and a high dosage of P elevated As concentrations were found. It could therefore be assumed that the simultaneous high dosage of N and P would compensate the observed effect; however this was not evidenced within the study and needs to be verified in further examinations.

Liming aims at the establishment of an optimized pH value whereby As is immobile in soil and an agricultural land use is still possible. Therefore, a range of 5.5 to 7 can be recommended for arable land and 4.5 to 6.5 for grassland. The current pH value, the soil type and the



humus content are important for the dosage of lime as well as the land use as greenland, arable land or garden. Depending on the soil structure and nutrient availability, a certain amount of lime should not be exceeded, as too much lime can promote As uptake into plants (Klose 2017). Due to this, the applied dosage needs to be adapted based on the present mobility of contaminants. However, in case of an As concentration in soil that exceeds trigger and action values defined by law (see Table 2) it can be stated that liming will not be sufficient to successfully reduce concentrations in crops (Feldwisch et al. 2014).

In particular if contaminated sites are used as arable land for the production of food and fodder, ***cultures and varieties*** with a proven low As uptake rate should be used to ensure that limit values for food and fodder are not exceeded. Controls, *e.g.* regular harvest examinations, are needed to guarantee safe agricultural goods.

Additional ***pre-harvest-examinations*** allow a decision on the marketing of products as food or fodder or for incineration if the concentration of pollutants exceeds a limit value. Especially if an energetically utilization is the only option, farmers should know it beforehand in order to harvest the whole plant and not only the grains.

In case that concentration of contaminants in agricultural crops cannot be reduced by an adapted agricultural practice, the ***change of land use*** might be the only possibility. This can be the land use as short rotational plantations as well as the cultivation of plants for energy production by anaerobic digestion or combustion of produced contaminated biomass (Bert et al. 2017). An overview of summarized recommendations for an adapted agriculture aiming at the reduction of contaminants in crops was compiled by Müller et al. (2013) is given in the Table.

Recommendation for a sustainable agricultural practice on sites contaminated with arsenic in Germany

All agricultural used areas
- Reduction of contamination by adherent soil on plants - Choice of fertilizer - Fertilizing and liming adapted to mobilization potential of arsenic - Enhancing aeration of wet soils - Abandonment of (deep) dig up in subsoil/ underground - Change of land use

Greenland	Arable land	Garden
- Usage of harvesting technologies that avoid soiling - Change of vegetation composition - Examination of plants and harvested products	- Choice of types and varieties - Usage of cultivation procedures without or (with less) soiling - Pre-harvesting examinations	- Recommendations for cultivation, behaviour and consumption

N. Feldwisch, U. Herweg, G. Jacobs, R. Klose, I. Müller, J. Pollehn et al.,„Kalkung zur Qualitätssicherung." Edited by aifd Infodienst Ernährung, Landwirtschaft, Verbraucherschutz e.V. Available online at http://www.ble-medienservice.de/files/downloads/0389_2014_kalkung_x000-7057696.pdf. 2014.

V. Bert, S. Neu, I. Zdanevitch, W. Friesl-Hanl, S. Collet, R. Gaucher et al.,"How to manage plant biomass originated from phytotechnologies? Gathering perceptions from end-users." International Journal of Phytoremediation 19 (10), pp. 947–954. DOI: 10.1080/15226514.2017.1303814. 2017.

I.Müller, K. Kaufmann-Boll, S. Höke, S. Lazar, K. Brackhage, G. Dudel „Arsentransfer in Nahrungs- und Futterpflanzen – Gefahrenbeurteilung und Maßnahmen." 5. Sächsisch-Thüringische Bodenschutztage in Altenburg, 8 S. 2014.

AgriAs developed recommendations and guidelines for the sustainable management of arsenic risk together with the relevant stakeholders. We organized three stakeholder workshops: in Germany (2017), in Finland (2018) and in France (2018).

Dissemination and networking

The AgriAs project made a significant impact in Verdun and Freiberg where environmental issues and arsenic pollution have been of great concern of the local communities. Therefore, a lot of effort and resources were allocated to dissemination activities during the project. Local people, local and regional land-use authorities, environmental authorities and industrial parties as well as the Ministry of the Environment and scientific and technical community were the main target groups. Dissemination was required in French, German and English languages and in the stakeholder workshop organized in Finland, materials were distributed in Finnish as well.

During the project it appeared that AgriAs is the first project in the world which distributed guidelines for arsenic in agricultural soil and water with other crop than rice as the main product. Dissemination of the results to other countries both in Europe and globally was seen to be urgent resulting in several international conference presentations. The AgriAs results, guidelines and recommendations were presented to local experts and/or environmental authorities. An **Arsenic Workshop** was organized in association with the international SETAC conference in 2019 (Society of Environmental Toxicology and Chemistry).

AgriAs disseminated the results in numerous conferences and scientific journal papers. We organized the Arsenic Workshop in the international SETAC conference in Helsinki in 2019 (SETAC 'Society of Environmental Toxicology and Chemistry').

Main deliverables and publications of the AgriAs project

Deliverables

Below is a list of completed deliverables of each AgriAs work package.
Weblink to public deliverables and the public summaries of the confidential deliverables can be found here:
http://projects.gtk.fi/AgriAs/downloads/public_deliverables/

WP1. Arsenic concentrations in water, soil, crops
D1.1. Report on arsenic concentrations in agricultural soils and waters in European level, list of data gaps
D1.2. Report on arsenic contamination in European a gricultural soils, water & crop
D1.3. Introductory material on ecotoxicological tests, purification methods and risk assessment for stakeholder meetings
D1.4. Market study of low-cost arsenic removal techniques

WP2. Effect of agricultural practices on arsenic concentration and bioavailability in water and soil
D2.1. Effect of agricultural amendments on speciation and bioavailability of arsenic
D2.2. Effect of agricultural amendments on transfer and toxicity of arsenic toward plants and groundwater
D2.3. Mass balance of arsenic transfer according to agricultural amendment

WP3. Arsenic removal technology & innovation
D3.1. Report on the experimental work on arsenic removal from water
D3.2. Report on the experimental work on arsenic removal from soil
D3.3. Report on the sustainability assessment for arsenic removal technologies

WP4. Risk assessment in selected target sites
D4.1. Report on the collation of evaluation criteria for the health and environmental effects of arsenic
D4.2. Description of the model used for exposure of people and recipient waters to arsenic from agricultural soil
D4.3. Risk assessment report for the selected target sites

WP5. Sustainable management of arsenic risk & recommendations
D5.1. Report on the Baseline assessment and evaluation of existing recommendations and guidelines on As in the environmental systems
D5.2. Framework for management for compliance to the guidelines
D5.3. Report on recommendations for sustainable management of the risks linked to the land and aquatic environments in a generic perspective

WP6. Outreach actions
D6.1. Communication, Dissemination and Exploitation Strategies
D6.2. Project Website & Corporate design & Brochures, Leaflets, Newsletter
D6.3. Social media channels
D6.4. Stakeholder workshops/road-shows
D6.5. Business plan for exploitation of the technology innovation
D6.6. Layman's report

WP7. Management
D7.1. Consortium Agreement
D7.2. Project handbook
D7.3. Gender action report
D7.4. Organization of project progress meetings incl. risk review
D7.5. Periodic reporting + Internal progress reports
D7.6. Progress review reports by Advisory Board

Publications

During the project, tens of conference presentations were given and four Master's theses were completed. The main output, the manuscripts for high-impact international journals are in progress:

- Participating organizations: BRGM/LEB. Preliminary title: Ecotoxicological characterisation of an agricultural soil highly contaminated by WW1 weapon destruction.
- BRGM/LEB. Influence of agricultural amendments on the mobility and toxicity of arsenic as revealed by microbial and plant bio-indicators.
- BRGM. Mobility of arsenic driven biogeochemical processes in contrasted redox conditions: effect of fertilizer.
- BRGM/LEB. Influence of nitrogen fertilization on the toxicity of arsenic, speciation and transfer in spring Barley.
- UOULU. Experimental and sustainability analyses for arsenic removal technologies from agricultural surface water.
- GTK/G.E.O.S./BRGM/LEB/KEMAKTA/UOULU. Risk management of arsenic contamination in the agricultural soils of Europe.
- GTK/G.E.O.S./BRGM. Arsenic in agro-ecosystems under anthropogenic pressure in Germany and France compared to a geogenic As region in Finland.
- GTK/G.E.O.S. etc. Risk management procedures for geogenic and anthropogenic As in agricultural soils (incl. comparison with North America and other continents - a short and general paper).
- KEMAKTA. A model for assessing health risks of arsenic in agricultural soil.

Networking

AgriAs has interacted with other projects including the following European Union, national and international projects.

- GTK: European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 776811: MIREU – Mining and metallurgy regions of EU. Coordinator: GTK + 30 partners including partners from the Saxony mining region.
- GTK: European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 776804: NEXT – New Exploration Technologies. Coordinator: GTK. 16 partners including partners from the Saxony mining region.
- BRGM national project funded by the Water Agency of the Rhin-Meuse Basin, focused on the environmental pollution on the large site near Verdun, were several former factories used to destroy chemical weapons. AgriAs benefits from several actions performed in the framework of this last project: surface and under surface mapping of pollution, digging of wells
- UOULU: EIT RM Advanced Material Doctoral Program, ADMA-DP KAVA. 1.1.2016-31.12.2018. University of Oulu.
- UOULU: HuJa - Enhancing the treatment of metal containing storm waters and wastewaters by using natural materials. 1.9.2015–31.8.2018.
- KTH: Swedish International Development Cooperation Agency (Sida) Project: "Aquatic Pollution and Remediation in the Titicaca, Uru Uru, Poopo High Altitude Lake Systems".
- KTH: Formas project (Sweden): Sustainable management of arsenic contaminated materials.
- KTH: Swedish International Development Cooperation Agency (Sida) Project: "Development of affordable adsorbent systems for arsenic and fluoride removal in the drinking water sources in Tanzania (DAFWAT)
- KTH: Sida-Unicef Project: Systems strengthening and scaling up drinking water safety in Bangladesh.

Future actions

In the future, the following activities will be carried out by the partners of the AgriAs project:

1. **Website.** The website of the project will be available at least until 2024 (http://projects.gtk.fi/AgriAs). Deliverables of the project will be available for industry, environment authorities and for general public free of charge. "Guidelines" subpages will be updated on a regular basis. The website of the AgriAs project is linked to the website of the Coordinating beneficiary. Therefore, the web pages will be taken care of by the web page administrator of Geological Survey of Finland.
2. The guidelines developed during the AgriAs project may be implemented into regulations of environment authorities in the participating countries and the European Union.
3. The results of the AgriAs project will be presented in near future in numerous conferences and workshops.
4. The results of the AgriAs project will be applied in the regional plan of the study regions.
5. The beneficiaries of the AgriAs project are eager to continue investigations and demonstration activities. Therefore, there will be ideas for new cooperative projects in the near future. Cooperation with other European countries having challenges with high arsenic concentrations will continue.

Recommendations for future research and development

Numerous data gaps were identified for future research. For example, no data were available in the European-wide mapping programmes from two countries: Moldova and Turkey, and Romania and Norway were missing from some of the surveys otherwise carried out on the European level. There is no up-to-date data on arsenic concentrations in European groundwater related to agricultural sites. More data should be collected from surface waters if they are closely related to As-rich soils in small catchment areas.

Development of risk assessment models is recommended so that the physical and chemical form of arsenic in of the releasing and receiving environments can be taken into account. This will allow the effect of important environmental factors, such as redox conditions, to be taken into account.

The exposure of people to arsenic in certain areas is equal to or exceeds the exposure which is considered as a low-risk level. Therefore, reducing exposure should be considered. We recommend that the authorities make efforts to keep As concentrations as low as reasonably possible in food and drinking water by applying effective soil and water treatment processes.

Treatment processes for soil can be divided into two main categories: methods for the removal of pollutants and methods for the immobilization of pollutants. The most commonly used technologies for the water treatment are precipitation, sorption and membranes processes. The most common treatment technologies for soils are immobilization of arsenic by soil amendments. The arsenic removal technology should be selected case-specifically considering the characteristics of water to be treated and design requirements for the treatment unit. Particular attention should be paid to sustainability when selecting the technology.

We recommend that the future research should pay more attention to the interrelation of different contaminants in soil and water systems. In our test sites, and in many other As-contaminated areas according to our experience and the literature, other metals and organic contaminants are present in concentrations that imply risks to health and the environment. The effects of emerging contaminants like medical residues, hormones, pesticides, herbicides and microorganisms on the behavior of arsenic are not fully understood yet. Other contaminants are also important with regard to amelioration techniques for soil, as the immobilization of arsenic can cause other contaminants to become more mobile.

Recommendations for policy actions

Healthy soils are the guarantee for healthy food. Even though the European Commission withdrew the drafts of the European Soil Protection Directive in 2016, the results from our project show that the need for coordinated management of the problems of As-contaminated soils remains. This could be achieved with guidelines and regulations developed in close cooperation with the stakeholders both in the national and at the EU level.

Soil contamination by As can be caused by various sources: e.g., residues of weapons, mineral occurrences, dust from smelters and pesticides. Soil contamination has consequences not only for agricultural products but also for the contamination of groundwater and air. Within the AgriAs project, solutions based on the German law are presented as examples.

List of dissemination activities

	Type of activities[1]	Main partner	Title	Date	Place	Audience	Size of audi-ence	Countries addressed
International communications (presentations and posters)								
1	Presentation	GTK	Loukola-Ruskeeniemi et al. 2017. AgriAs – Evaluation and Management of Arsenic Contamination in Agricultural Soil and Water. WaterJPI Joint Call, Projects Kick-off Meeting 6.4.2017 Stockholm, Sweden.	April 2017	Stock-holm, Sweden	Scientific & Water JPI Community	80	Europe
2	Presentation	GTK	Kaija, J. et al. 2017. Evaluation and management of arsenic contamination in agricultural soil and water. AgriAs Stakeholder Workshop - Informationsaustausch zur Bedeutung von Arsen in der Landwirtschaft.	September, 2017	Freiberg, Germany	AgriAs Stakehold-ers and Poli-cy makers	35	Germany
3	Conference presentation	GTK	Loukola-Ruskeeniemi, K., Kaija, J., Tarvainen, T., Hatakka, T., Keiski, R., Turkki, A., Pinka, J., Jordan, I., Battaglia-Brunet, F., le-Guedard, M., Jones, C., Bhattacharya, P., Kurppa, S., Muller, I., Siebielec, G. and Veliz, J. 2018. Risks of arsenic exposure through agriculture. **33rd Nordic Geological Winter Meeting**, Technical University of Denmark, Copenhagen, Denmark, **Jan. 10–12, 2018. Abstract volume, p. 213.**	January 2018	Online	Scientific Community	100	Europe
4	Conference presentation	GTK	Tarvainen, T. & Hatakka, T. 2018. European-wide data on arsenic concentrations in agricultural soil and waters. Pages 72-73 in: P. Skyttä & O. Eklund (eds.) 4th Finnish National Colloquium of Geosciences, Turku, 14–15 March 2018. Abstract Book. Espoo: Geological Survey of Finland.	March 2018	Online	Scientific Community	100	Europe
5	Conference presentation	GTK	Tarvainen, T. & Hatakka, T. 2018. Applying FOREGS and GEMAS as background data in the AgriAs project. Joint Annual Meeting of EuroGeoSurveys Geochemistry Expert Group and IUGS Commission on Global Geochemical Baselines, 16–18 May 2018, Madrid, Spain.	May 2018	Madrid, Spain	Scientific Community	29	Europe
6	Conference presentation	GEOS	Jordan I, Reichel S, Janneck E, Abbenseth A, Patzig A. Safe water systems in Arsenic polluted agricultural areas using a novel Schwertmannite-based adsorbent'. Emerging pollutants in freshwater ecosystems, Water JPI 2018 Conference 6–7th of June, Helsinki FINLAND	June 2018	Helsinki, Finland	Scientific & Water JPI Community	200	Europe
7	Conference presentation	GTK	Hatakka, T. & Tarvainen, T. Arsenic data availability in agricultural soils and waters in Europe. 7th International Congress & Exhibition on Arsenic in the Environment, Environmental Arsenic in a Changing World (As2018).	July 2018	Beijing, China	Scientific Community	500	International
8	Conference presentation	All part-ners	Battaglia-Brunet, F., Lions, J., Joulian, C., Devau, N., Charron, M., Hube, D., Hellal, J., Le Guédard, M., Jordan, I., Bhattacharya, P., Loukola-Ruskeeniemi, K., Tarvainen, T. & Kaija, J. Characterization of an agricultural site historically polluted by the destruction of arsenic-containing chemical weapons. 7th International Congress & Exhibition on Arsenic in the Environment, Environmental Arsenic in a Changing World (As2018).	July 2018	Beijing, China	Scientific Community	500	International
9	Conference presentation	GEOS, BRGM, LEB	Jordan, I., Reichel, S., Janneck, E., Hellal, J., Devau, N, Le Guedard, M. & Klose, R. Agriculture in mining-impacted regions- Investigations on the influence of soil amendments on As mobility. Goldschmidt 2018.	August 2018	Boston, USA	Scientific Community	5000	International
10	Conference presentation	UOULU, GEOS	Valkama H., Kursula K., Rathnayake B., Ainassaari K., Jordan I., Muurinen E., Keiski R.L. Removal of arsenic from natural waters by membrane technologies and adsorption. International Scientific Conference on Sustainability and Innovation – STEPsCON2018. December 6–7th, 2018.	December 2018	Lever-kusen, Germany	Scientific Community	100	International

	Type of activities[1]	Main partner	Title	Date	Place	Audience	Size of audi-ence	Countries addressed
11	Meeting presentation	GTK	Kirsti Loukola-Ruskeeniemi, GTK. The overview of the project. AgriAs Final meeting.	March 2019	Oulanka, Finland	AgriAs + WaterJPI Community	25	Europe
12	Meeting presentation	GTK	Timo Tarvainen, GTK. Arsenic concentrations in water, soil, crops. AgriAs Final meeting.	March 2019	Oulanka, Finland	AgriAs + WaterJPI Community	25	Europe
13	Meeting presentation	BRGM, GEOS, LEB	Fabienne Battaglia-Brunet, BRGM et al. Effect of agricultural practices on arsenic. AgriAs Final meeting.	March 2019	Oulanka, Finland	AgriAs + WaterJPI Community	25	Europe
14	Meeting presentation	UOULU, KTH/KWR	Hanna Valkama, Esa Turpeinen, Auli Turkki, Riitta Keiski UOULU, Arslan Ahmad, KWR. Arsenic removal technology & innovation. AgriAs Final meeting.	March 2019	Oulanka, Finland	AgriAs + WaterJPI Community	25	Europe
15	Meeting presentation	KEMAKTA, KTH	Celia Jones, KEMAKTA. WP4. Risk assessment in selected target sites. AgriAs Final meeting.	March 2019	Oulanka, Finland	AgriAs + WaterJPI Community	25	Europe
16	Meeting presentation	All AgriAs partners	Kirsti Loukola-Ruskeeniemi et al. Sustainable management of arsenic risk & recommendations. AgriAs Final meeting.	March 2019	Oulanka, Finland	AgriAs + WaterJPI Community	25	Europe
17	Meeting presentation	UOULU, All partners	Auli Turkki, UOULU. Outreach & Exploitation. AgriAs Final meeting.	March 2019	Oulanka, Finland	AgriAs + WaterJPI Community	25	Europe
18	Presentation	GTK	Loukola-Ruskeeniemi, K., Kaija, J. and the AgriAs team. Evaluation and management of arsenic contamination in agricultural soil and water. Mid-term Evaluation Meeting of RDI projects.	March 2019	Madrid, Spain	Scientific & Water JPI Community	40	Europe
19	Conference presentation	GTK	Tarvainen T., Hatakka T., Loukola-Ruskeeniemi K. 2019. European wide data on arsenic concentrations in agricultural soils, waters and crops (AgriAs project). GSG 2019: 15th International Congress of the Geological Society of Greece.	23 May 2019	Athens	Scientific community	50	Greece
20	Conference presentation	BRGM/LEB	Jennifer Hellal, Nicolas Devau, Pablo Houllemare, Catherine Joulian, Daniel Hube, Marina Le Guedard and Battaglia-Brunet. Microbial communities in As contaminated agricultural soils -How PK fertiliser can influence As speciation. SETAC Europe 29th Meeting	May 2019	Helsinki, Finland	Scientific & SETAC Community	2161	International
21	Conference presentation	LEB/ BRGM	Marina Le Guédard, Jennifer Hellal, Olivier Faure, Hube Daniel and Fabienne Battaglia-Brunet. Characterization of an agricultural soil polluted by As and its impact on plant species diversity and health. SETAC Europe 29th Meeting.	May 2019	Helsinki, Finland	Scientific & SETAC Community	2161	International
22	Conference presentation	GTK	K. Loukola-Ruskeeniemi, I. Müller, H. Daniel, R. Keiski, C. Jones, I. Jordan, M. Le Guedard, P. Bhattacharya, T. Tarvainen, J. Kaija, Geological survey of risk management of arsenic inherited from mining activities and World War I in the agricultural soils of Europe. SETAC Europe 29th Meeting.	May 2019	Helsinki, Finland	Scientific & SETAC Community	2161	International
23	Conference presentation	LEB/ BRGM/ GTK	F. Battaglia-Brunet, H. Thouin, M. Charron, N. Devau, M. Charron, C. Joulian, D. Hube, D. Breeze, J. Hellal, M. Le Guédard, Loukola-Ruskeeniemi K. Biogeochemistry of arsenic in a soil polluted by the destruction of chemical weapons: effect of agricultural amendments and redox conditions. ISEB Potsdam Germany	September 2019	Potsdam, Germany	Scientific Community	80	International
24	Poster	All partners	AgriAs Team. 2017. AgriAs – Evaluation and Management of Arsenic Contamination in Agricultural Soil and Water. WaterJPI Joint Call, Projects Kick-off Meeting 6.4.2017 in Stockholm, Sweden.	April 2017	Stock-holm, Sweden	Scientific & Water JPI Community	100	Europe

	Type of activities[1]	Main partner	Title	Date	Place	Audience	Size of audi-ence	Countries addressed
25	Poster	BRGM	Hubé D, Battaglia-Brunet et al. 2018. Destruction of old chemical ammunition of the Great War on the western Front The hundred-year-old forgotten contaminations". Emerging pollutants in freshwater ecosystems, Water JPI 2018 Conference 6–7th of June, Helsinki FINLAND.	June 2018	Helsinki, Finland	Scientific & Water JPI Community	200	Europe
26	Poster	LfULG/ GEOS	Müller I, Kardel K, Jordan I. Assessment of large-scale metal contaminated soils in Saxony (Germany) – is there an impact on the soil-to-water pathway? Emerging pollutants in freshwater ecosystems, Water JPI 2018 Conference 6–7th of June, Helsinki FINLAND.	June 2018	Helsinki, Finland	Scientific & Water JPI Community	200	Europe
27	Poster	UOULU	Valkama H, Kursula K, Rathnayake B, Muurinen E, Keiski R. Removal of arsenic from natural waters by low-pressure reverse osmosis. Emerging pollutants in freshwater ecosystems, Water JPI 2018 Conference 6–7th of June, Helsinki FINLAND.	June 2018	Helsinki, Finland	Scientific & Water JPI Community	200	Europe
28	Poster	UOULU, GEOS	Valkama H., Turpeinen E., Kursula K., Rathnayake B., Ainassaari K., Jordan I., Muurinen E., Keiski R.L. Experimental and sustainability analysis for arsenic removal technologies from surface water. SETAC Europe 29th Annual Meeting 26–30 May 2019, Helsinki FINLAND.	May 2019	Helsinki, Finland	Scientific & SETAC Community	2161	International, 64 countries
29	Poster	BRGM	H. Daniel, Industrial scale destruction of old chemical ammunition of the Great War on the western Front. Hundred-year-old forgotten contaminations?	May 2019	Helsinki, Finland	Scientific & SETAC Community	2161	International, 64 countries
30	Poster	All partners	AgriAs Team. 2019. AgriAs – Evaluation and Management of Arsenic Contamination in Agricultural Soil and Water. University Business Forum, October 16th, 2019, Oulu, FINLAND.	October 2019	Oulu, Finland	Industry, Scientific community, entrepreneurs	200	Finland
31	Poster	UOULU, GEOS	Valkama H., Turpeinen E., Kursula K., Rathnayake B., Ainassaari K., Jordan I., Muurinen E., Keiski R.L. Experimental and sustainability analysis for arsenic removal technologies from surface water. University Business Forum, October 16th, 2019, Oulu, FINLAND.	October 2019	Oulu, Finland	Industry, Scientific community, entrepreneurs	200	Finland
National communications (presentations and posters)								
32	Poster	UOULU	AgriAs. Älykäs erikoistuminen -seminaari 25.4.2017 Oulu, Finland	April 2017	Oulu, Finland	Scientific Community, stakeholders	60	Finland
33	Poster	KEMAKTA	Jones, J. Renare Mark (Cleaner Soils) spring meeting 2018. – AgriAs – Evaluation and management of arsenic contamination in agricultural soil and water	March 2018	Norrköping, Sweden	Scientific Community, authorities, entrepreneurs	65	Sweden
34	Poster	UOULU/ GTK	Loukola-Ruskeeniemi, K., Keiski, R. & AgriAs Team. AgriAs – Evaluation and management of Arsenic contamination in agricultural soil and water.	October 2017	Oulu, Finland	Scientific Community, authorities, entrepreneurs	50	Finland
35	Poster	G.E.O.S./ All partners	AgriAs Team 2019. AgriAs – Evaluation and Management of Arsenic Contamination in Agricultural Soil and Water. Saxon-Thuringian Soil Protection Days 19th – 20th June in Leipzig, Germany	June 2019	Leipzig, Germany	Scientific Community, authorities, entrepreneurs, Stakeholders	?	Germany

	Type of activities[1]	Main partner	Title	Date	Place	Audience	Size of audience	Countries addressed
36	Poster	BRGM/ LEB/GTK	F. Battaglia-Brunet, M. Le Guédard, K. Loukola-Ruskeeniemi, N. Devau, D. Hube, H. Thouin, P. Houllemare, M. Charron, D. Breeze, C. Joulian, J. Hellal. Mobilité et phytotoxicité de l'arsenic dans un sol pollué par une activité ancienne de destruction d'armes chimiques de la première guerre mondiale. Rencontres Nationales de la Recherche sur les Sites et Sols Pollués (ADEME)	November 2019	Paris, France	Scientific Community, Stakeholders	300	France
37	Poster	BRGM / LEB	Jennifer Hellal, Nicolas Devau, Hugues Thouin, Catherine Joulian, Daniel Hube, Marina Le Guédard, Dominique Breeze, Mickael Charron, Fabienne Battaglia-Brunet. Biogéochimie de l'arsenic dans un sol contaminé par la destruction d'armes chimiques: impacts des amendements agricoles et des conditions d'oxydo-réduction. IXe Colloque de l'Association Francophone d'Ecologie Microbienne.	November 2019	Bussang, France	Scientific community	200	France/ French speaking countries
Dissemination initiatives (popular articles)								
38	Media article	UOULU	Älykkään erikoistumisen seminaari Pohjois-Pohjanmaalla http://mailchi.mp/edita/europa-uutiskirje-ajassa-52017?e=48b8f2beac	April 2017	Online;	General Public	N/A	Finland
39	Media article Website	KTH	Jordbruksaktuellt Internationellt forskningssamarbete kring vatten. http://www.ja.se/artikel/53578/internationellt-forskningssamarbete-kring-vatten.html	April 2017	Online	General public	N/A	Sweden
40	Media article	N/A	AgriAs project on arsenic contamination concluded. The Circonomist, WATER, FOOD & ENERGY IN THE CIRCULAR ECONOMY. https://www.circonomist.com/general/agrias-project-on-arsenic-contamination-concluded/	May 2019	Online	Scientific Community	N/A	International
41	Science Blog	GTK	K. Loukola-Ruskeeniemi. Do you get too much arsenic from your diet? http://geokatse.gtk.fi/2019/10/07/science-blog-get-much-arsenic-diet/	October 2019	Online	General public+ scientific community	N/A	International
42	Article	GTK	K. Loukola-Ruskeeniemi. Arseeniriskin hallinta Suomessa ja Saksassa. Ympäristö ja Terveys -lehti (popular article in Finnish, 'Risk management of arsenic in Finland and in Germany')	December 2019	Finland	Environmental authorities	1600	Finland
Dissemination initiatives (others)								
43	Stakeholder Workshop	GEOS/ LfULG	AgriAs Stakeholder Workshop - Informationsaustausch zur Bedeutung von Arsen in der Landwirtschaft.	September 2017	Freiberg, Germany	German speaking stakeholders	35	Germany
44	Stakeholder Workshop	GTK	AgriAs Stakeholder Workshop	June 2018	Tampere, Finland	Finnish speaking stakeholders	30	Finland
45	Stakeholder Workshop	BRGM/ LEB/GTK	Workshop of presentations and exchanges on the thematics of AgriAs project	September 2018	Orléans, France	French speaking stakeholders	50	French speaking countries
46	Website	BRGM	Evaluation et gestion de la contamination par l'arsenic dans les sols agricoles et les eaux – projet AgriAs. http://www.poledream.org/wp-content/uploads/2018/07/AgriAs_Workshop-Orl%C3%A9ans24sept.pdf	September 2018	Orléans, France	French speaking stakeholders	N/A	France

	Type of activities[1]	Main partner	Title	Date	Place	Audience	Size of audience	Countries addressed
47	Scientific Workshop	GTK/ BRGM/LEB-/G.E.O.S./ UOULU/ KEMAKTA	Arsenic Workshop with Learning Café – Recommendations and guidelines for arsenic in agricultural soil and water. SETAC Europe 29th Meeting.	May 2019	Helsinki, Finland	Scientific & SETAC community	30	International
48	Website	WaterJPI	AgriAs – Evaluation and Management of Arsenic Contamination in Agricultural Soil and Water. http://www.waterjpi.eu/index.php?option=com_content&view=article&id=553:agrias-2&catid=156:joint-calls	April 2017	Online	General Public	N/A	International
49	AgriAs website	GTK	http://projects.gtk.fi/AgriAs/index.html	April 2017	Online	General Public	N/A	International
50	Website	KWR	Evaluation and management of arsenic contamination in agricultural soil and water (AgriAs) https://www.kwr-water.nl/en/projecten/evaluation-and-management-arsenic-contamination-agricultural-soil-and-water-agrias/	July 19, 2017–	Online	Scientific & Water JPI Community, General public		International
51	Website	FACCEJPI	21 projects selected for funding in the ERA-NET Cofund with Water JPI. https://www.faccejpi.com/layout/set/print/FACCE-JPI-Home/FACCE-JPI-News/21-projects-selected-for-funding-in-the-ERA-NET-Cofund-with-Water-JPI	April 2017	Online	Scientific & Water JPI Community		International
52	Website	ERA-LEARN	Project: Evaluation and management of As contamination in agricultural water and soil. https://www.era-learn.eu/network-information/networks/waterworks2015/2016-joint-call-sustainable-management-of-water-resources-in-agriculture-forestry-and-freshwater-aquaculture-sectors/evaluation-and-management-of-as-contamination-in-agricultural-water-and-soil	April 2017	Online	Scientific Community	N/A	Europe
53	Website	KTH (FORMAS)	Utvärdering av hantering av arsenikföroreningi jordbruksmark och vatten (AgriAs) http://www.formas.se/Documents/Svenska%20projekt%20WaterJPI2016%20Joint%20Call.pdf	April 2017	Online	Scientific & Water JPI Community		Sweden
54	Research Gate	GTK + all partners	https://www.researchgate.net/project/Evaluation-and-Management-of-Arsenic-Contamination-in-Agricultural-Soil-and-Water	August 2017	Online	Scientific & Water JPI Community		International
55	Twitter Situation on 27.10.2019	GTK	@AgriAs_EU 244 followers, @AgriAs_EU follows 684 accounts, @AgriAs has tweeted 323 times	April 2017 – October 2019	Online	Scientific & Water JPI Community, Authorities, NGOs, Entrepreneurs, General public	~2000 AgriAs EU profile visits	International
56	Flyer	GTK	Bewertung und Management der Arsenbelastung in landwirtschaftlich genutzten Böden und Wässern	September 2017	Online + print	German speaking stakeholders	300 printed	German speaking countries
57	Flyer	GTK	Evaluation and Management of Arsenic Contamination in Agricultural Soil and Water	October 2017	Online + print	English, stakholders	500 printed	International
58	Flyer	GTK	Evaluation et gestion de la contamination par l'arsenic dans les sols agricoles et les eaux	October 2017	Online + print	French speaking stakeholders	300 printed	French speaking countries

	Type of activities[1]	Main partner	Title	Date	Place	Audience	Size of audience	Countries addressed
59	Website	BRGM	AgriAs Workshop 2019. https://www.brgm.eu/news-media/agrias-workshop-2019	May 2019	Online	Scientific community	N/A	Europe
Planned publications, accepted by the Governing Board of the AgriAs project								
60	International referee journal article	GTK/ G.E.O.S./ BRGM/ LEB/ KEMAKTA/ UOULU/ LfULG	Preliminary title: Risk management of arsenic in the agricultural soils of Europe (Journal of Environmental Management, Elsevier)	Submission in 2019		Scientific Community	N/A	International
61	International referee journal article	BRGM/LEB	Preliminary title: Ecotoxicological characterisation of an agricultural soil highly contaminated by WW1 weapon destruction	Submission in 2019		Scientific Community	N/A	International
62	International referee journal article	BRGM/LEB	Preliminary title: Influence of agricultural amendments on the mobility and toxicity of arsenic as revealed by microbial and plant bio-indicators	Submission in 2019		Scientific Community	N/A	International
63	International referee journal article	BRGM	Preliminary title: Mobility of arsenic driven biogeochemical processes in contrasted redox conditions: effect of fertilizer	Submission in 2019		Scientific Community	N/A	International
64	International referee journal article	BRGM/LEB	Preliminary title: Influence of nitrogen fertilization on toxicity of arsenic, speciation and transfer in spring Barley	Submission in 2019		Scientific Community	N/A	International
65	International referee journal article	GTK/ GEOS/ BRGM/ LfULG/ Luke (Finland)	Preliminary title: Arsenic in agro-ecosystems under anthropogenic pressure in Germany and France compared to a geogenic arsenic region in Finland	Submission in 2019		Scientific Community	N/A	International
66	International referee journal article	UOULU	Preliminary title: Experimental and sustainability analysis for arsenic removal technologies from agricultural surface water	Submission in 2019		Scientific Community	N/A	International
67	International referee journal article	GTK et al.	Preliminary title: Geogenic and anthropogenic As in agricultural soils: risk management procedures developed in Europe (a short and general paper)	Submission in 2019		Scientific Community	N/A	International
68	International referee journal article	KEMAKTA	Preliminary title: A model for assessing health risks of arsenic in agricultural soil	Submission in 2019		Scientific Community	N/A	International
Master´s theses								
69	Master's thesis (Tech.)	UOULU	Kalle Kursula: Removal of arsenic from contaminated natural water using membrane technology	October 2018	Finland	Scientific Community	N/A	International
70	Master's thesis (Tech.)	UOULU	Moaadh Benkherouf: Life cycle assessment of arsenic removal methods.	November 2018	Finland	Scientific Community	N/A	International
71	Master's thesis (Tech.)	KTH/ KEMAKTA	Supritha Vijayakumar: Developing a model for risk assessment of arsenic exposure in agricultural regions of Europe	December 2018	Sweden	Scientific Community	N/A	International
72	Master's thesis (Tech.)	KTH/KWR	Anna Christoforidou: Arsenic contamination in natural waters: a critical analysis on the role of Fe-oxides in As removal	May 2018	Sweden	Scientific Community	N/A	International

The Governing Board of the AgriAs project

Professor, Ph.D. Kirsti Loukola-Ruskeeniemi, Geological Survey of Finland (GTK). Chairperson of the GB. The Scientific Coordinator of the AgriAs project, Leader of WP5.

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Dr. Marina Le Guédard, LEB Aquitaine Transfert, France.

Professor Prosun Bhattacharya, Kungliga Tekniska Högskolan, Sweden. Leader of WP4.

The Advisory Board of the AgriAs project

The Advisory Board has been very active and participated in most of our project meetings strengthening our expertise:

Dr. Ingo Müller. Desk officer in the Saxon State Office for Environment, Freiberg, **Germany**.

Professor Sirpa Kurppa, Natural Resources Institute **Finland**.

Dr. Grzegorz Siebielec, Institute of Soil Science and Plant cultivation of **Poland**.

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Evaluation and Management of Arsenic Contamination in Agricultural Soil and Water

AgriAs project
1.4.2017 – 31.3.2019
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AgriAs developed risk management procedure for agricultural areas rich in arsenic.

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