Topic 5 - abstracts

This document contains the abstracts for topic 5. Topic 5 contains the sessions listed below. The abstracts are ordered by poster & session.

The complete programme and session overview can be found on our website at: https://aquaconsoil.com/aquaconsoil-2023/scientific-programme/

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5b1	*Governance and management (long term land stewardship, includes landfills, formerly contaminated sites) - session 1*
5b2	*Governance and management (long term land stewardship, includes landfills, formerly contaminated sites) - session 2*
5d1	*Advancing Sustainable Soil and Underground Solutions*
5sps1	*A Soil Deal for Europe – how far are we with determining soil needs, sustainable land management practices, soil literacy and Living Labs and Lighthouses?*

5sps2	*Transitions in soil quality management 'Look differently, think differently and act differently,' the EU SOIL strategy in perspective*
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5sps4	*Application of innovative technologies for site characterization and treatment in the Superfund Program*
5sps5	*A series of sustainability assessment case studies of enhanced bioremediation across Europe*
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Posters

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118	Francesca Motta	AECOM	Analysis of the Economic, Environmental and Social Sustainability of Soil Remediation Technologies with AECOM Sustainable Remediation Tool
146	Cécile Le Guern	BRGM	Questioning usual monitoring protocols of groundwater contaminated plume: example of a former landfill (Nantes, France)
183	Cécile Nouet	University of Liege	Waste2bio, a network of Belgian stakeholders for the economic and environmental redevelopment of brownfields
246	David Kwesi Abebrese	Czech University of Life Sciences	A comparative study of conventional tillage and multi-tillage treatments under multiple soil physicochemical characteristics
374	Mónica González-González	Instituto Canario de Investigaciones Agrarias (ICIA)	Evaluation of the capacity of the organic matter hydrophobicity as an indicator to assess soil health

Session 5a1

Wednesday 09:00-10:30

Room D222

ID	Name	Organization	Title
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100	Ilse van Keer	VITO NV	A multi-criteria approach to explore the remediation of contaminated sediments
176	Peter van Breemen	RIVM	The Groundwater Risk Assessment Toolbox – a quality assessment system

256	Yevheniya Volchko	Chalmers University of Technology	Comparison of PFAS Soil Remediation Alternatives at a civilian airport using Cost-Benefit Analysis
378	Virginie Derycke	BRGM	Bringing soil multi-fonctionnality into contaminated soil management : an enhanced cost-benefit analysis
108 – Backup	Karen van Geert	Arcadis Belgium	Managing soil contamination in green areas using nature-based solutions – a manual

Session 5b1

Thursday 11:00-12:30

Room D218

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102	Hebah	Arcadis	A case study of a complex site-specific risk assessment on an industrial landfill site: presenting the conceptual site model and methodology for assessing fate and transport modelling
149	Shaswati Chowdhury	Leibniz-Centre for Agricultural Landscape Research	A framework for upgrading of contaminated urban land and soil by nature-based solutions: possibilities and challenges
178	Willem Havermans	TAUW BV	Long term groundwater monitoring of natural enhanced molybdenum precipitation
232	Michele Remonti	ERM	Numerical groundwater models: the quantitative support to water stewardship and risk management of contaminated sites
76 – Backup	Jay Hall	Arcadis	Sustainability at every stage: UN Sustainable Development Goals as a framework for industrial improvement

Session 5b2

Wednesday 11:00-12:30

Room D218

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238	Hilde Passier	Deltares	A healthy groundwater system as guiding principle in planning and management of water, soil and subsurface in the Netherlands
247	John Flyvbjerg	Capital Region of Denmark	The impact of soil pollution on surface water quality

266	Luca Sacilotto	Ramboll Italy S.r.l.	Permanent safety measures implementation for industrial redevelopment
376	Johan Ceenaeme	OVAM (Public Waste Agency in the region of Flanders)	Prospecting redevelopment opportunities with the Cedalion tool to enhance dynamic landfill management
395	Daniël Rits	Witteveen+Bos	Exploring feasibility of an area-based approach for contaminated soil and groundwater in the port of Antwerp

Session 5d1

Tuesday 14:00-15:30

Room D218

ID	Name	Organization	Title
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24	Dominique Guyonnet	BRGM	Risk-based imprecise soil concentration remediation objectives
169	Cécile Le Guern	BRGM-IRSTV	Tomorrows soil quality indicators to promote vegetation within urban development and planning
298	Paul Iturbe-Espinoza	VU Amsterdam	Correlating the succession of microbial communities from Nigerian soils to petroleum biodegradation
348	Cynthia Alcántara	Kepler, Ingeniería y Ecogestión, S.L.U.	Molecular biology as a key tool to demonstrate natural attenuation: first evidence of thermal oil removal via denitrification

Session 5sps1

Wednesday 14:00-15:30

Room D216

ID	Name	Organization	Title
231	Jenny Norrman, Dominique Guyonnet	Deltares, BRGM	A Soil Deal for Europe – how far are we with determining soil needs, sustainable land management practices, soil literacy and Living Labs and Lighthouses?

Session 5sps2

Tuesday 16:00-17:30

Room D222

ID	Name	Organization	Title
272	Margot de Cleen	Ministry of Infrastructure and Water Management, Rijkswaterstaat	Transitions in soil quality management 'Look differently, think differently and act differently,' the EU SOIL strategy in perspective

Session 5sps3

ID	Title
	cancelled

Session 5sps4

Thursday 09:00-10:30

Room D216

ID	Name	Organization	Title
422	Vanessa van Note	United States Environmental Protection Agency	Application of innovative technologies for site characterization and treatment in the Superfund Program

Session 5sps5

Thursday 09:00-10:30

Room D226

ID	Name	Organization	Title
66	Paul Bardos	r3 environmental technology ltd	A series of sustainability assessment case studies of enhanced bioremediation across Europe

Session 5sps6

Wednesday 11:00-12:30

Room D216

ID	Name	Organization	Title
427	Martin Doeswijk, Margot de Cleen	TAUW, Ministry of Infrastructure and Water Management, Rijkswaterstaat	The urgent necessity of healthy soils

Posters

Session 5 poster / Abstract title: Analysis of the Economic, Environmental and Social Sustainability of Soil Remediation Technologies with AECOM Sustainable Remediation Tool

ID: 118

Key words: sustainable remediation

Submitter: Francesca Motta

Organization: AECOM

Co-authors: AECOM

Session: 5 poster

Abstract

Objectives. A range of different technological solutions for the remediation of saturated and unsaturated soil were evaluated to be applicable to two contaminated sites located in Italy, to reach the remediation goals, based not only on the efficiency of the remedial technologies, but also implementing Economic, Environmental and Social Sustainability (EESS) assessment in the decision-making process for the selection of a suitable solution.

Approach. By considering the environmental site-specific context, a wide range of different technological solutions were selected in order to: i) remove the source of contamination (i.e. off-site Dig and Disposal). ii) to treat and reuse the excavated contaminated soil (i.e. Soil Washing, Biopile, Landfarming) and iii) to treat directly the contaminated soil without excavation (i.e. Direct Soil Mixing with ISCO, Bioventing, MPE, SVE) iv) to manage the risk posed by the contamination prior the final the remediation project, wich follows the decommissioning of the area. The choice of one or more effective technical solutions could not be defined solely on the magnitude of the soil-volume to be treated, but each different Remediation Scenarios (i.e. combination of different technologies implemented together to reach the remedial objectives) was evaluated in terms of the different impact of Economic, Environmental and Social Sustainability. The current increasing awareness in sustainability and sustainable-related solutions is a matter of concern and it must be considered when remediation actions shall be implemented, and public community is involved. Within this framework, an Economical, Environmental and Social Sustainability Assessment was performed to select the sustainable solutions within the environmental remediation procedures for two sites located in northern and southern Italy, one for the remediation of

both unsaturated and saturated soil (perched aquifer) and one for unsaturated soil remediation. The study was developed through the application of the AECOM Sustainable Remediation Tool© (SRT). The AECOM SRT© allows for a Multi-Criteria Decision Analysis (MCDA) based on sustainability indicators, weights and measurement criteria selected by considering the site-specific attributes. As a decision-making tool, it provides a ranking of the alternatives examined by calculating a sustainability index (or score), which does not represent an absolute value of the individual solution but a relative value, as result of comparing different remedial strategies in a specific context.

Results. The tool allowed to take into consideration the site-specific attributes of relevance, for the stakeholders, including the local community, such as: 1) site located in a mixed land use area with presence of neighbouring residential houses; the redevelopment plan of the site for industrial use; the need to minimize the use of natural resources; 2) part of the site located in a natural reserve area, close to the sea and close to the city; presence of native plant (‘’Macchia Mediterranea’’). The EESS Assessment performed with the AECOM SRT© lead to the selection of the most sustainable remediation strategy applicable to the sites. These applications confirmed the suitability and the flexibility of the tool that might be readily implemented in a variety of different Remedial Projects taking into consideration the site-specific constraints and allows to guide the choice toward the most sustainable one. The value of the Sustainability Assessment was intended as a support before the Authorities for the selection of the applicable Remediation Scenario with qualitative and quantitative measurable approach that could be easily communicated and integrated within remediation projects.

Session 5 poster / Abstract title: Questioning usual monitoring protocols of groundwater contaminated plume: example of a former landfill (Nantes, France)

ID: 146

Key words: groundwater, quality, monitoring, climate change, landfill

Submitter: Cécile LE GUERN

Organization: BRGM

Co-authors: Pauline Radigois Univ. Gustave Eiffel, field campaigns, data storage, data treatment ; Bernard Flahaud, Univ. Gustave Eiffel, field campaigns ; Alexandra Lépinay Msc, OSUNA, Nantes University, field campaigns, data storage, data treatment ; Laetitia Pineau Dr, Univ. Gustave Eiffel, database management ; Antoine Lefèvre, BRGM, data treatment ; Pauliana Courbier, BRGM, data treatment ; Gwenaëlle Bodéré, BRGM, field campaigns ; Suzanne Schomburgk Msc, BRGM, hydrogeologist ; Dr. Béatrice Béchet, Univ. Gustave Eiffel, IRSTV, transfer of contaminants

Session: 5 poster

Abstract

Questioning usual monitoring protocols of groundwater-contaminated plume seems to be necessary in the frame of climate change. Point-source contaminated sites like landfills frequently impact groundwater quality. The evolution and degree of impact is usually observed thanks to point sampling in conditions of low and high groundwater table, when the concentrations of contaminants are supposed extreme. Feedback on existing monitoring appears useful to try and understand the origin and period of peaks and to question the representativeness of groundwater monitoring downgradient of contaminated sites.
Here, we focus more particularly on one pilot site: a former landfill located in Nantes (western France). The underlying alluvial groundwater is contaminated by leaching of waste due to rainwater infiltration. The monitoring data include daily monitoring of groundwater table, electric conductivity, and temperature, and point sampling in early spring and autumn to check the impact of the site on the alluvial groundwater quality. A network of 5 piezometers located along a contamination gradient (upstream, landfill leachates, near and further downstream) is used for sampling. The data, available for several years and including extreme periods, are interpreted in detail: we compare the sampling dates with the evolution of the leachates and groundwater table, looking in particular at lowest and highest levels, the evolution of concentrations and observation of peaks, and the rainy and dry climate events. We assume indeed that important concentration fluctuations are associated with extreme climate periods such as heavy droughts, floods or rainy periods. In a context of climate change, these periods are becoming more frequent in Europe and worldwide.

A clear correlation occurs between contaminant concentrations in the leachates, the landfill groundwater table, perched in the waste deposit, and climate events. Recharge of the landfill groundwater leads to contaminant dilution, whereas higher concentrations and electric conductivity occur in early autumn (usual end of discharge). The same occurs in the alluvial groundwater downstream of the site, with a delay between the two signals. This delay seems to increase with distance from the site. Peaks observed in leachates are more difficult to interpret. Some seem correlated to heavy rain events, leading to a higher than usual landfill groundwater table. This could be linked to the unusual leaching of contaminated waste located usually above the leachate table. For 10 years, the high levels appear at different times of the year (from January to April), depending on very heavy rainfall. This questions the representativeness of the sampling period. The sampling carried out on the pilot site, is not always representative of higher and lower groundwater table as was targeted. The calculated time of transfer of contaminants downstream of the contamination source shows that it is improbable to observe peaks at the same time along the contamination plume. Understanding the origin of peaks anywhere in the system requires a better understanding of the dynamics of the system.

The results obtained on the pilot site underline the need for more effective protocols to improve monitoring strategies. Continuous monitoring using multi-parameter sensors appears useful. Piezometric registration helps knowing when the sampling occurred in the dynamic of the groundwater table evolution. Electric conductivity registration informs on the evolution of the global concentration of contaminants. This is more particularly interesting in case of contamination with major elements, which is the case of landfills. Threshold alert values could also be produced, for groundwater table and electric conductivity, to trigger additional groundwater sampling. Such threshold values would be particularly helpful to build warning systems for sites located upstream of vulnerable receptors such as drinking water catchments.

Session 5 poster / Abstract title: Waste2bio, a network of Belgian stakeholders for the economic and environmental redevelopment of brownfields

ID: 183

Key words: phytomanagement, soil health, multi actor approach

Submitter: Cécile Nouet

Organization: University of Liege

Co-authors: Jeroen Meermans, University of Liège, soil scientist ; Thérèse Torrekens, Espace Environnement, Collective intelligence tools dedicated to environmental issues ; Olivier Decocq, Duferco Wallonie, Brownfield manager

Session: 5 poster

Abstract

As part of the new Walloon Smart Specialization Strategy (S3), the Waste2Bio initiative launched in November 2021 aims to create a Living Lab deploying innovative nature-based solutions to give brownfields a second life.
The presence of 40,000 hectares of degraded soil in Wallonia, i.e. 2.3% of the territory, is the starting point of our Initiative. Contaminated and abandoned sites are ecosystems to be considered because they provide, like forests and agricultural lands, multiple services and functions that can be improved by appropriate management. Depollution is not a solution for all polluted sites due to the very high cost estimated at 2.5-5 billion euros for the 2000 most polluted sites in Wallonia. Currently, these lands remain abandoned for many years. Instead, they could be managed by permanent or temporary revegetation until the land is recycled for a new use. Appropriate revegetation improves the physical, chemical and biological properties of soils and sustainably manages water and soil resources, but also improves aboveground biodiversity, acts on the climate through carbon storage and the presence of green infrastructure in areas urban. areas, to reduce the risk of flooding, to promote the health and well-being of citizens and to provide economic value (creating jobs, increasing real estate prices and producing valuable plant biomass).

The Waste2Bio initiative relies on a consortium of more than 100 Walloon stakeholders in the rehabilitation of brownfields and the bioeconomy involved at all levels of the value chain: land managers, public authorities, service providers, farmers, biobased product companies, non-profit organizations, training and research organizations. The Waste2Bio initiative is coordinated by researchers from the University of Liège with the support of the Walloon Region.
The Waste2Bio initiative aims to restore soil health to abandoned sites through site

management with site-appropriate resilient land cover that provides multiple ecosystem services. These nature-based solutions will also help address other societal challenges such as climate change, biodiversity loss, net zero land take and increasing competition for land allocation to different uses in the framework of the Sustainable Development Goals, the EU Green Deal and the Soil Mission.

Our objective is to set up pilots to validate the innovations and demonstrators to inform the actors of the reconversion of industrial wasteland and allow the deployment of adapted solutions. About thirty abandoned sites have been identified as potential pilot sites. They represent different types of contexts: NATURA 2000, rural, urban areas, polluted and depolluted. The solutions proposed are based on feedback from projects developed around the world but also by key players in the Walloon Region (such as WallPhy, New-C-Land and ECOSOL) and on innovations to be developed within the framework of Living Lab. The Living Lab will be designed to:

- Offer spaces for co-creation between actors (public authorities, private sector, academics and citizens),
- Develop site-specific nature-based solutions restoring urban ecosystem services,
- Offers various land management uses: temporary/multiple/permanent,
- Contribute to the circular economy by developing molecules and products from degraded land,
- Share knowledge with land managers and policy makers,
- Raise awareness in society about the importance of soil health for food quality and human life and educate about soil health.

The communication will present the missions, stakeholders and activities proposed by our Living Lab in the process of co-construction.

Session 5 poster / Abstract title: A comparative study of conventional tillage and multi-tillage treatments under multiple soil physicochemical characteristics

ID: 246

Key words: Conservation tillage, Conventional Tillage, Soil physicochemical properties, Sustainability

Submitter: David Kwesi Abebrese

Organization: Czech University of Life Sciences

Co-authors: Prof. Dr. Svatopluk Matula, CZU Prague, hydrologist. Dr. Kamila Báťková, CZU Prague, hydrologist. Kara Recep Serdar M.Sc., CZU Prague, soil scientist. Dr. Miháliková Markéta, soil scientist.

Session: 5 poster

Abstract

Purpose of the study
Topsoil physical and chemical properties can vary subject to different soil treatment approaches. Tillage especially has been historically followed as an approach to improve these properties. The question of how sustainable or even how much of a significant improvement tillage results in, is highly debated. In Europe, conventional tillage practices involving intensive ploughing are common relative to other tillage approaches mainly because comparative studies within the region are lacking. This study looks at a comparison of physicochemical properties under a 27-year long term tillage approaches namely: 1. Reduced Tillage (RT), 2. Strategic Tillage (ST), 3. No Tillage (NT) and 4. Conventional Tillage (CT)
Methodology
The study adopted judgmental sampling to cover the variability of soil surfaces as representative samples for each tillage treatment. 57 samples in total were taken, and soil moisture content was measured for all these sampling points. Analysis of variances for soil organic carbon, soil moisture content, soil organic matter, pH, EC, and bulk density was done, and the inverse distance weighting (IDW) interpolation technique was adopted to explain the spatial distribution of the soil properties both within and amongst the tillage options.
Summary of findings
Generally, the results reflect a variation in the soil properties subject to tillage. Statistically, a significant variation in soil organic matter was observed for the tillage options in the order NT > ST > RT > CT. Volumetric water content was higher on all the plots under conservation tillage (RT, ST, and NT) compared to the CT field. Bulk density did not vary by tillage, while

EC and pH varied but rather not statistically significant. The IDW maps for all the soil properties analyzed could describe the spatial distribution within the tillage plots and between the different tillage systems and explain some relationships between the soil parameters tested.

Conclusion

Under long-term tillage practices, conservation tillage practices have the potential of improving soil parameters affecting sustainability by being able to produce outcomes comparable (in some cases better) to those fields under conventional tillage, even on soils like this silty clay loam known for its natural compactness.

Significance of the study

The outcome of this study serves as one of the bases to explore the usefulness of conservation tillage options in Europe, especially the Czech Republic and expand the knowledge base for enhanced adoptability and increased sustainability.

Session 5 poster / Abstract title: Evaluation of the capacity of the organic matter hydrophobicity as an indicator to assess soil health

ID: 374

Key words: Soil health; Indicator; Organic matter; Hydrophobicity

Submitter: Mónica González-González

Organization: Instituto Canario de Investigaciones Agrarias (ICIA)

Co-authors: Marta Selma Garzón-Molina, Gladys Arteaga-Clemente, María Araceli García-González

Session: 5 poster

Abstract

Soil is a regulatory center for many processes that occur in agrosystems and is a critical component of the biosphere; for these reasons, soil degradation is a problem on a global scale that is jeopardizing food security and the ecosystems health. The European Commission (EC) has identified that the main threats to soil are erosion, organic matter decline, contamination, sealing, compaction, biodiversity decline, salinization and landslides. “Caring for soil is caring for life” is the title of the mission proposed by the EC, whose goal is to ensure that at least 75% of soils in each European Union member state are healthy by 2030 and are able to provide food and other biomass, support biodiversity, store and regulate water flow or mitigate climate changes. Soil health is defined as the continued ability of the soil to function as a vital ecosystem that supports plants, animals and humans. From an agricultural and environmental point of view, the multifunctionality and diversity of a soil requires the use of multiple indicators to characterize its health, that include physical, chemical and biological properties. One of the six indicators for soil health quantification, proposed in the EC soil mission, is the soil organic matter (SOM) content. SOM is important for nutrient adsorption, water retention and for improving soil structure, as well as plant productivity. Soil hydrophobicity is a phenomenon characterized by the loss of affinity to water in a soil, which resists being temporarily wetted. In general, repellency increases with increasing SOM and decreases with increasing clay and silt content of soils. However, because all carbon is not hydrophobic, global indicators such as total or oxidizable SOM do not serve to explain the relationship between SOM and hydrophobicity, and the type of organic carbon must be considered to explain this relationship. The aim of this study was to evaluate the capacity of SOM hydrophobicity as an indicator to assess soil health. To this end, four soils with different health conditions were sampled in the Canary Islands (Spain). To extract SOM components selectively, a sequential solvent extraction of SOM was carried out by using four organic solvents of increasing polarity. The extract components, related to the SOM hydrophobic/hydrophilic character, were separated by ultra-high performance liquid

chromatography and diode array detection (uHPLC-DAD), by using a linear acetonitrile gradient in water. Two statistical techniques, cluster analysis and principal component analysis, were used to evaluate the separation of soils according to their hydrophobic character. Different physical and chemical properties were found on the soils, characterized as: water repellency; sand, silt and clay content; total and oxidizable SOM; extracted SOM amount; humic and fulvic acid fractions; nitrogen and iron contents; cation exchange capacity; electrical conductivity; pH; and luminosity, hue, and saturation chromatic attributes. As it was expected, the more hydrophobic components in the SOM were extracted by the non-polar solvent n-hexane and it was observed that more hydrophilic components appeared gradually in the chromatograms of SOM extracted by dichloromethane, ethyl acetate and methanol, in accordance to the order of their increasing polarity. Moreover, the relative abundance of peaks on the chromatographic profiles discriminated the SOM quality well, on the basis of the extracted organic compounds polarity. As a conclusion, the combination of the information from the physical and chemical properties and the hydrophobic and hydrophilic profiles acquired uHPLC-DAD enabled greater accuracy in judging the health of the evaluated soils. SOM hydrophobicity may represent a powerful indicator of the soil health, because of it has substantial bearing on the formation of stable aggregates and the whole soil structural stability.

Session 5 poster / Abstract title: Framework for Risk Management and Communication using Gentle Remediation Options (GRO) for Phytomanagement of Contaminated Sites

ID: 86

Key words: Risk communication; Gentle remediation options (GRO); Ecosystem services; Risk-based land management (RBLM); Phytomanagement

Submitter: Paul Drenning

Organization: Chalmers University of Technology

Co-authors: Shaswati Chowdhury, Chalmers University of Technology, PhD student; Yevheniya Volchko, Chalmers University of Technology, Researcher; Lars Rosén, Chalmers University of Technology, Professor; Jenny Norrman, Chalmers University of Technology, Professor

Session: 5 poster

Abstract

Purpose: The aim of this poster is to present a risk management and communication framework for gentle remediation options (GRO), including its broader use to facilitate phytomanagement as a contaminated land management strategy to provide risk management via gentle remediation options (GRO) and other wider benefits like ecosystem services.

Methodology: The risk management framework is derived based on conceptualizing the various risk mitigation mechanisms attributable to specific GRO strategies to manage specific risks according to the source-pathway-receptor risk management approach. A literature study was carried out to provide scientific backing to the framework and the risk mitigating effects of GRO.

Summary of findings/results: Key take-home messages will include a strategy for risk communication to various stakeholders, including decision-makers, to emphasize the utility of GRO for reducing risks posed by contaminants at brownfields, even if some strategies do not ultimately lower total concentrations or entail leaving the contaminants at the site (i.e. stabilization). This approach will stress viewing soil as a resource and restoring or preserving ecological function in order to provide ecosystem services.

Conclusion: Gentle Remediation Options (GRO) are valid risk management strategies for a variety of applications and can be tailored along pollutant linkages (source-pathway-receptor) to effectively manage risks to both human health and the environment and enable

a 'soft' reuse of a brownfield for green land uses that provide ecosystem services. Phytomanagement is highly suitable to bring into the conversation as a proactive land management strategy that can serve multiple purposes. This contribution will present recent research outputs to derive a risk management framework for GRO to use in risk communication and planning to manage contaminated sites (see link below to published article) as well as discuss the broader implications of such strategies for providing ecosystem services and other desirable co-benefits such as climate change resilience and green infrastructure as a nature-based solution.

Significance / contributions of study: We feel that this work could provide an important contribution to the discussion regarding the transition of how we think about managing contaminated sites and their corresponding risks. In particular, we have focused on a shift from full risk ‘elimination’ to ‘reduction’ while stressing the value of soil as a resource that can be fully exploited by multifunctional land management strategies such as phytomanagement via GRO.

https://www.sciencedirect.com/science/article/pii/S004896972104955X

Session 5a1 orals

Session 5a1 / Abstract title: A multi-criteria approach to explore the remediation of contaminated sediments

ID: 100

Key words: Remediation; Multi-criteria analysis; Cost-benefit analysis; Sullied Sediment; Policy tool

Submitter: Ilse Van Keer

Organization: VITO NV

Co-authors: Katrien Van de Wiele, OVAM, policy maker; Vermeiren Karolien, VITO, spatial modeller; Els Ryken, VMM, policy maker; Marleen Van Damme, DOV, data scientist; Ilse Van Keer, VITO, soil scientist; Steven Broekx, VITO, environmental economist

Session: 5a1

Abstract

Purpose of study: In line with the European Water Framework Directive, Flemish authorities have addressed major issues with respect to the impact of pollution from urban waste water and industry on surface and groundwater at the level of river basins. Historic contaminated stream sediments and those currently deposited are also known to negatively impact the water quality, and often spread gradually downstream causing damage to vulnerable ecosystems. Although the role of contaminated stream sediments has been acknowledged by authorities, an integrated approach to remediate and manage sediments is lacking. Such an integrated approach by means of a dedicated software tool is the topic of the current paper and has been put to practice in a collaborative project between VITO, the Flemish Institute for Technological Research, and OVAM, the public waste agency of Flanders. The project aims were twofold; 1) to identify potentially critical sites that allow decision makers to prioritize in efforts on further investigation, remediation and management of, and 2) to perform a cost-benefit analysis to inform the Flemish government about the societal costs and benefits of remediation in general and for specific areas as part of an integrated approach for sediment and water management.

Methodology: In Flanders, sediment quality data are collected by different local and regional authorities for different purposes. To support the decision making process on further examination, remediation and/or management of sediments, a web-based spatial tool called Sediment explorer (dutch. Waterbodemverkenner) was developed, that collects data from

these authorities and from publicly available sources. The tool considers data on the level of contamination (i.e. sediment quality) at measurement locations, spatial data mapping of the potential environmental risks (i.e. variables representing the quality of the aquatic ecosystem and riparian zones) and the potential for sustainable remediation (e.g. variables representing the chance for re-contamination) when contamination occurs. A weighted score is determined based on the relevant technical and environmental variables per stream in Flanders to derive the remediation priority of streams. A cost-benefit analysis is performed to compare costs for research and remediation with benefits for water quality, and reduced remediation costs downstream if complete or partial remediation of the identified contaminated sites is achieved.

Results/Conclusion: About 40% of measured sites show signs of physico-chemical contamination with significant ecological risks but also often high chances on sustainable remediation if appropriate measures are taken. The cost-benefit analysis indicates that only 60-90% of all costs can be compensated by the benefits of remediation. Best cost-benefit ratios are achieved when focusing on pollution hotspots near protected natural areas or urban settlements. Limited direct benefits of remediation suggest that additional incentives need to evoke remediation. It is therefore a strong plea for targeted prioritization and a location-specific approach. Consider it is an integrated project approach where sediment remediation is not an end in itself, but a necessary precondition to achieve or safeguard other functions. For example, during urban development in cities or river restoration projects within protected nature areas.

Significance: Local and regional authorities can consult, analyze and get insight in the prioritization and cost-benefit results through the web-based tool ‘Waterbodemverkenner’. It has proven to be a very useful instrument to not only involve different stakeholders in the decision making process but also help streamlining operational activities between different authorities.

Session 5a1 / Abstract title: Managing soil contamination in green areas using nature-based solutions – a manual

ID: 108

Key words: Soil Management, stewardship, nature-based solutions, soil care

Submitter: Karen Van Geert

Organization: Arcadis Belgium

Co-authors: Dorien Gorteman, Arcadis Belgium, consultant Karen Van Geert, Arcadis Belgium, senior consultant Nele Bal, OVAM Annelies Van Gucht, OVAM Froukje Kuijk, OVAM Kris Van looy, OVAM

Session: 5a1 backup

Abstract

Purpose of study
Soil provides us with essential ecosystem services. Soils are essential for functioning water- and nutrient cycles, a pleasant living environment and healthy food. This role is crucial for our society but happens 'underground' and thus often remains invisible. Many soils are unfortunately already contaminated. Management of soil contamination so far has been mainly focused on local contamination on high-risk land. However, this does not mean that other land cannot be contaminated. Diffuse contamination is often present. This is contamination with lower concentrations, for which there is no clearly identifiable source, caused by a variety of small-scale activities. For example, a busy road or railway can cause local pollution, both from exhaust fumes and from the wear and tear of tires, brakes, rails, etc. In addition, "residual contaminations" often remain after remediation which no longer pose an immediate risk to people and the environment but can again become a problem when conditions change.
Policymakers also aim to ensure that greenery and nature should be abundantly present in the built-up environment and to reduce paved areas. The creation of new green areas inevitably leads to encounters with diffuse or residual contaminations. Nature-based solutions can play a major role in managing these contaminations and limiting potential impacts, avoiding risks to people and ecosystems.
Methodology - results
A manual was created to provide local administrations and greenspace managers with information on available nature-based solutions for the management of soil green areas. Flowcharts and practical examples were included resulting in an accessible and practically usable tool.
Conclusion
The manual collects the key questions to ask when considering a nature-based solution for

soil contamination management. These solutions can be useful to mitigate effects of contaminations in green areas that do not need to be remediated.

Significance/contribution of study

The manual allows users to create or manage new green spaces in a low-threshold and cost-effective way, in areas where diffuse or residual pollution is present, taking into account competing policy objectives in densely built-up environments with scarce open space.

Session 5a1 / Abstract title: The Groundwater Risk Assessment Toolbox – a quality assessment system

ID: 176

Key words: Risk assessment toolbox, Groundwater quality, Protection targets, Sustainable groundwater use

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Organization: RIVM

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Session: 5a1

Abstract

Today, we find many compounds in groundwater that are toxic to humans and the ecosystem. The last decade, the number of compounds that does apply to this qualification increased, among them representatives of the notorious PFAS group. This phenomenon raises several questions, including:

1. Can I use the groundwater for, for example, drinking water? Or irrigation water?
2. Are there any risks involved with polluted groundwater, without making use of it, e.g., for humans through indoor vapour intrusion? Or for the groundwater ecosystem?

With the purpose to give answers to these questions, the National Institute of Public Health and the Environment has developed the Groundwater Risk Assessment Toolbox. This is an instrument that allows the impact of harmful compounds in groundwater to be identified. The instrument deals with the impact on human health, on the groundwater ecosystem, on drinking water extraction and on surface water. It can also be used to ascertain whether a specific type of groundwater usage is safe, such as groundwater drawn from a private well or irrigation from groundwater.

In terms of health, the toolbox assesses how and to what extent humans come into contact with harmful substances from groundwater through various exposure pathways. For example, when groundwater is used as drinking water, through the consumption of vegetables that have absorbed harmful substances from groundwater via their roots or through the consumption of vegetables that have been irrigated with groundwater. Substances present in the groundwater may also intrude into buildings, which may result in exposure of inhabitants.

The toolbox is a tiered approach, including three tiers to examine whether the amount of compounds present in the groundwater is harmful. The first simple step consists of a general

but stringent assessment to determine whether the quality of the groundwater meets critical concentration levels for each protection target. If this is not the case, the assessment is carried out in an increasingly more detailed manner in the two follow-up steps. This involves more calculations and measurements being carried out as well as making use of more specific information about the site. The second and in particular the third steps therefore require more knowledge on how substances are transported in the subsoil and how humans can be exposed to toxic compounds.

The Groundwater Risk Assessment Toolbox can contribute to a more appropriate use of groundwater and assessment of the risks involved.

Our presentation on the Groundwater Risk Assessment Toolbox will outline the theory behind the risk assessments in the toolbox. Moreover, a demonstration is given of the Groundwater Risk Assessment Toolbox software.

Session 5a1 / Abstract title: Carbon footprint calculations in the soil remediation sector: a comparative analysis

ID: 19

Key words: carbon footprint; soil remediation, emission factor

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Organization: KU Leuven

Co-authors: nan

Session: 5a1

Abstract

The CO2 Performance Ladder is a tool that helps companies in improving the environmental performance of projects and business operations. Since the summer of 2020, it can be applied to tenders for soil remediation projects commissioned by the Public Waste Agency of Flanders (Belgium). The CO2 performance ladder supports organisations in setting up a CO2 management system, calculating their CO2 footprint and achieving CO2 reductions. However, at present, little information is available about the application of this instrument to the soil remediation sector in Flanders. Carbon footprint calculators are already commonly applied to evaluate soil remediation projects, but have a narrower scope and system boundaries, as they are only meant to calculate the carbon footprint of soil remediation projects, and not of all business operations. Keeping these differences in mind, we compared the CO2 performance ladder with other evaluation tools (the CO2 calculator, the 'Sustainable Remediation Tool' (SRT) and the 'Spreadsheets for Environmental Footprint Analysis' (SEFA), which are used to calculate the CO2 footprint of soil remediation projects. The comparative analysis is composed of a qualitative descriptive analysis and a quantitative carbon footprint calculation based on data from two case studies in Flanders. The objective for the CO2 performance ladder is to achieve CO2 reductions on a continuous basis by establishing a CO2 management system. Calculating the carbon footprint of a soil remediation project is only one of the many elements to be considered. The results show that besides differences in objectives, scope and required input data, also the calculated carbon footprint of the remediation project can differ between the instruments. Use of different conversion factors by different tools can result in significantly different results. While some of these differences in the conversion factors are inherently related to regional differences, other differences cannot be explained unequivocally. Especially for more complex remediation projects, in which less conventional techniques/materials are used, CO2 conversion factors are not consistent, or they are simply lacking.
A systematic inventory a relevant emission factors, specifically for the soil remediation sector, would improve the application of carbon footprint calculations and support the implementation of these kind of evaluation instruments in the soil remediation sector.

Session 5a1 / Abstract title: Comparison of PFAS Soil Remediation Alternatives at a civilian airport using Cost-Benefit Analysis

ID: 256

Key words: Cost-benefit analysis (CBA); Per- and polyfluoroalkyl substances (PFAS); Gentle remediation options (GRO); Sustainable remediation; Ecosystem services; Decision-support

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Session: 5a1

Abstract

Purpose: The aim of this contribution is to present the results of a probabilistic CBA of remediation alternatives for managing PFAS contamination in soil at a civilian airport in Sweden.

Methodology: A probabilistic cost-benefit analysis (CBA) is used for evaluating five PFAS remediation alternatives for the Arlanda airport in Sweden. Both direct costs and benefits of these remediation alternatives as well as externalities were monetisied taking uncertainties into consideration. Different values of avoided cost of inaction were tested to find a breakeven point for making each alternative socially profitable. Two scenarios were considered to reflect the uncertainties in the spreading of PFAS at the site. Two different reference alternatives were used – (1) a modified business-as-usual case entailing 'total excavation' and (2) 'do nothing' as a common reference for economic analysis.

Summary of findings/results: In both the small and large PFAS spreading scenarios, excavation and S/S of the hotspot on-site combined with stabilization of PFAS at the rest of the site with activated carbon (AC) had the highest probability of being socially profitable compared to both reference alternatives.

Conclusion: The following main conclusions can be drawn from this study:
- Probabilistic CBA is demonstrated to be a robust method to account for uncertainties by creating multiple scenarios to test different model assumptions and parameter sensitivity.

- In general, excavation and stabilization/solidification of the hotspot on-site combined with stabilization of PFAS at the rest of the site with activated carbon has the highest probability of being socially profitable and highest ranking in all scenarios. All other alternatives, except for alternative that included thermal treatment of the hotspot, are socially profitable and entail reduced negative externalities to varying degrees compared to 'total excavation' of the entire site. The extent of PFAS spreading is shown be the most sensitive variable in the CBA model and affect the ranking of remediation alternatives.
- Costs of inaction to society from PFAS contamination are high but associated with uncertainties, in particular how much avoided damage to human health and the environment is attributable to remediation at a particular site like Stockholm Arlanda Airport. Simulations of different values for annual avoided cost of inaction as an aggregated benefit to society are useful to compare breakeven points for when a remediation alternative becomes socially profitable.

Significance / contributions of study: The novelty of this study lies in its systematic approach to evaluating feasible techniques for remediating PFAS in soil, according to prevailing literature, and estimating the economic impacts of each alternative while also including impacts to the environment and taking uncertainties into account. Given the scale of PFAS contamination and society's limited resources, demonstrating the use of CBA in a case study for a specific site also provides a valuable decision support.

Session 5a1 / Abstract title: Bringing soil multi-fonctionnality into contaminated soil management : an enhanced cost-benefit analysis

ID: 378

Key words: Contaminated land management, Soil multifunctionality, indicators, cost-benefit analysis, soil uses

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Session: 5a1

Abstract

Soils are a fragile and non-renewable resource, yet they can provide many ecosystem services (i.e. environmental, societal and economic benefits that humans can derive from the functioning of the ecosystem). Soil can be degraded, particularly as a result of soil sealing and urban or industrial contamination and no longer be able to constitute an ecosystem that support biodiversity and human beings. The last few years have marked a turning point in the management of degraded lands with an emerging desire to take into account the ecological functioning of soils. The design of decision-making tools, identification of bio-indicators, development of soil reconstruction method and also life cycle analysis. These tools make it possible to respond to the challenges of including soil as an ecosystem and and circular economy in territorial planning. The French methodology for contaminated sites management mentions taking into account biodiversity issues but does not details the precise methodology to do so, in particular due to the lack of a operational approach on these subjects. As part of one of its research and development programs, EDF, the French public electricity production and supply company, and BRGM, the French Geological Survey works on how to consider soil multi-functionality in the French methodology for contaminated sites management.

The present work focuses on the integration of soil multifunctionality into the cost-benefit analysis of remediation action plans. The cost-benefit analysis is enhanced in a practical yet precise way by taking into account soil multi-functionality while keeping in mind French methodology for contaminated soil practices. It brings into light soil functions and their vulnerability related to human activities they may endure during decontamination/rehabilitation phases. Based on a review of the existing literature we have outlined the main references that can be currently referred to and identified points of investigations that may be carried out to obtain further information on soil functionality. The

framework developed in this work encompasses reflexion steps and choices that are to be taken in the cost-benefit analysis in contaminated land management.
The consideration of soil multi-functionality in an upgraded cost-benefit analysis was tested on a practical site with a low level of pollution and with biodiversity issues (natural zones of ecological, fauna and flora interest (ZNIEF)). The contamination source is a former landfill discovered on a 30 year old industrial site. The landfill is 7 ha wide and the industrial site has been backfilled with 2 meters of sand to prevent flooding. Three areas were investigated to carry out a functional evaluation: two in the backfilled zone are 30 year old technosoils, one on the landfill and one away from the landfill. The third area is located away from the backfilled industrial site on non-artificialized soil, a fluviosoil. Investigations were carried out by manual auger sampling up to 20 cm (3 replicas and 9 samples/replica combined in a composite sample) and digging of soil pits up to 80 cm (2 to 3 horizons sampled on the profile). Analysis included metallic and organic compounds, nematode characterisation (abundance, diversity), bacterial activity (soil respiration, enzyme activities, quantification of functional genes) and diversity, and soil organic matter characterization by Rock-Eval analysis. Early results show that 30 year old technosoils have very different soil functions profile than the origin fluviosoils especially regarding soil carbon dynamics. These results also outline that evaluation of soil multifunctionality supports decision making related to contaminated land management by highlighting soil development trajectory and further uses of soils.

Session 5b1 orals

Session 5b1 / Abstract title: A case study of a complex site-specific risk assessment on an industrial landfill site: presenting the conceptual site model and methodology for assessing fate and transport modelling

ID: 102

Key words: Contaminated Land, Landfill, Risk, DQRA

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Session: 5b1

Abstract

Developing a robust conceptual site model (CSM) is the basis for all land contamination risk assessments. The defined CSM informs the method of risk assessment as well as the fate and transport modelling tools used to assess environmental risk and devise a remedial strategy. The process of producing a CSM is dynamic and must take account of the specific site conditions encountered for each site. When large and complex sites are encountered, potentially with rich industrial histories and complex geological / hydrogeological conditions, it can be difficult to ensure that the CSM meets the requirements of the assessment. As such, care must be taken in producing the CSM such that it is appropriate both for the site conditions as well as for the nature of the contamination present.

A case study will be presented on a detailed quantitative risk assessment that was undertaken for a landfill at a landmark and regionally important industrial site in the northeast of the UK. The landfill had accepted various types of waste material from the widespread surrounding industrial processes, potentially including a wide variety of different potential contaminants. The environmental setting of the site was unique in its nature, given the history, scale, and proposed regenerative redevelopment of the area. To add to this, the site is located in a complex hydrogeological setting due to the presence of sensitive surface water and groundwater receptors on and off site. The presentation will provide detail on the

methodology used when developing the CSM, including guiding the site investigation and interpreting the data generated, and will cover the specific geological, hydrogeological and hydrological conditions encountered. In addition, a discussion will be presented on the subsequent decision making behind the specific fate and transport models adopted for the assessment, how the required parameters were defined, and the results obtained. Finally, the case study will explain the conclusions arrived at by the assessment and how these were used to aid in the regeneration of this regionally important and well-known UK site.

Session 5b1 / Abstract title: A framework for upgrading of contaminated urban land and soil by nature-based solutions: possibilities and challenges

ID: 149

Key words: brownfield; urban greenspace; gentle remediation options; nature-based solutions

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Session: 5b1

Abstract

Soil contamination is a threat to well-functioning healthy soils which are fundamental for provision of essential ecosystem services. To move towards a circular economy and to meet the upcoming EU regulatory requirement on soil health, both contaminated land and contaminated soils should be understood as fragile and valuable resources that should be recycled. Contaminated land and soil form a potential resource which may be recycled and turned back into beneficial use as urban greenspace (UGS) while rehabilitating contaminated soil using gentle remediation options (GRO), a subset of nature-based solutions. These methods that rely on plants, fungi, bacteria, and soil amendments can both: 1) improve soil functioning and increase dwellers' access to ecosystem services as well as 2) manage the risks to human health and the environment. This study presents a framework for exploring opportunities for transforming brownfields to UGS using GROs to deal with soil contamination and demonstrates its application for a case study site. The framework and its associated tools and methods may support a transition of brownfields to UGS while recycling both land and soil, providing benefits during the long-term redevelopment and increase the market value of the site and its surroundings. Although the stakeholders found the suggested framework useful, they identified the main challenges for its practical implementation: (i) financial aspects, -e.g. estimation of costs and benefits over time, monetisation of ecosystem services, changes in ownership of sites over time, and limited possibilities for long term economic planning, and (ii) existing customary practice and level of knowledge, e.g. preference for business as usual, detailed soil investigations too late in the process, awareness about GRO, involvement of other experts in earlier development stages. The stakeholders also identified the need of additional practical tools to: i) make predictions of time requirements of GROs to reach acceptable risk levels; ii) monetise non-market benefits such as ecosystem services to communicate benefits to decision-makers; and iii)

support plant and soil amendment selection for various GROs and contaminants in a Swedish setting.

Session 5b1 / Abstract title: Long term groundwater monitoring of natural enhanced molybdenum precipitation

ID: 178

Key words: groundwater, metal precipitation, 3D interpretation

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Session: 5b1

Abstract

In order to investigate the extent and behavior of a soil and groundwater contamination with molybdenum, a groundwater monitoring at site X, was performed during an eight-year monitoring period from 2013 to 2020. Groundwater monitoring consisted of quantitative groundwater flow monitoring (divers) and qualitative monitoring (half yearly sampling for molybdenum and macro chemical characterization of the phreatic, intermediate and deep aquifer, 67 monitoring wells in total).

The competent authority requested to demonstrate the stability of the extent of groundwater contamination over time and to investigate whether:
Molybdenum actually precipitates and is bound to the soil matrix in the form of crystalline trimolybdenum octaoxide or in the form of molybdenum disulfide.

When the analytical monitoring results of the intermediate aquifer are compared with those of the shallow phreatic groundwater a transition towards more anaerobic conditions is observed, resulting in a decrease of molybdenum and sulphate to be adsorbed or fixed to the soil matrix. For the purpose of the additional investigations, this hypothesis needed to be confirmed.

Methodology
In addition to the regular groundwater monitoring, a soil investigation was conducted in 2020, focusing on locations where strongly elevated groundwater concentrations of molybdenum were present in the aquifer. At locations MW A, B and C the investigation was performed to take soil samples every 25 cm from a depth of 10 to 20 m bg. By means of regular soil analyses on molybdenum, it was confirmed that at this depth molybdenum is present in elevated concentration levels. The fact that at a depth of more than 10 m bg molybdenum has been detected in the soil, indicates that molybdenum in dissolved phase as

molybdate has reached this depth by diffusion through the groundwater and is then adsorbed or fixed to the soil matrix and/or precipitates there. To further investigate the specific binding form, 10 duplicate samples were then examined by the laboratory Z through sequential extraction.

Summary of findings
It is concluded that binding and precipitation of molybdenum occurs under sulfate-reducing conditions where molybdate is adsorbed and can subsequently precipitate via a transition of thiomolybdate compounds (mono-, di-, tri- or tetra-) to molybdenum disulfide. In the process, these molybdenum compounds are adsorbed and fixed to the soil matrix and by compounds with the organic matter present in the solid soil, calcium, iron, aluminum and manganese. Due to the fact that these substances are present in significant excess, the soil system has ample buffering capacity, more than sufficient to ensure the stability of the groundwater contamination.

The overall monitoring results over the period 2013 to 2020 showed the impacted soil volume > Dutch Intervention level to decrease with 27.5 % from 983,700 m3 towards a soil volume of 712,700 m3. The observed fluctuations, within the range of the contaminated soil volume, are caused by slight variations in the macro chemistry, causing differences in speciation varying from soluble molybdate (MoO_4^{2-}) to the precipitation of thiomolybdate ($MoS_xO_y^{z-}$) and crystalline molybdenum disulfide (MoS_2).

For the purpose of this investigation, the molybdenum monitoring results are interpreted using a 3D voxler model as visualization tool, using Inverse Distance Weighted (IDW). To be consistent over time, the soil volumes are calculated in the same way for each new monitoring round. This method therefore does not depend on manual interpretations but is based on numerical statistic interpolations of measured concentrations.

Session 5b1 / Abstract title: Numerical groundwater models: the quantitative support to water stewardship and risk management of contaminated sites

ID: 232

Key words: "water sustainability"; "water risk"; "water stewardship"; "groundwater modelling"; "contaminated sites"

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Organization: ERM

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Session: 5b1

Abstract

Purpose of the study
Water is an increasingly scarce commodity subject to growing global pressures. Water demand is continuously increasing, driven by economic and population growths. In many European areas, demand is already exceeding sustainable supply and, alarmingly, it is estimated that by 2030 the demand for water in Europe will exceed total supply by 40%. On the other hand, water supply is stressed by growing pressures and unpredictable weather patterns due by climate change. Summer 2022 was the hottest on record for Europe, fitting in a continuing warming trend. Droughts are one of the most apparent consequences of this warming trend, drying up rivers and lowering aquifers reservoirs. Water shortages can disrupt products supply chains, and plants may need to reduce production or shutdown if water becomes too scarce. In this context, water-related risks should form an inherent part of risk management strategies and the application of water stewardship practices, like those regulated and promoted by the Alliance for Water Stewardship (AWS), are becoming more and more frequent among the private sector.
The concept of water stewardship should be applied also in the field of sustainable remediation of contaminated sites. Water, in fact, is, and should be increasingly considered in future, one of the most sensible aspect in the evaluation of the sustainability of every human activity, remediation included. In this context, there is the need of predictive instruments to quantify the water mass balance of the aquifers. Numerical groundwater flow models have been for decades the tool of choice for this kind of quantifications.
This study will present how groundwater flow models may support the water stewardship of contaminated sites, both for characterization and remediation. The use of groundwater models may increase the water sustainability of the remedial actions, which is often key part

of the broader topic of sustainable remediation.
The study will also demonstrate how the more recent digital technologies represented by inverse modelling techniques may significantly increase the reliability of the numerical groundwater flow models, also embedding the possibility to quantify the uncertainty associated to model predictions, which is key in managing the risks associated to the remediation projects.

Methodology
A summary review of some complex groundwater flow models developed for major contaminated sites will be discussed, identifying how these tools allowed to optimize the water abstractions used for the groundwater confinement, increasing the hydro-chemical efficacy and improving the water sustainability of the remediation activity.
A case study will be then discussed with greater detail. The model discussed has been developed with the public-domain numerical code MODFLOW-USG. It embeds a high complexity calibration and validation process, conducted with the inverse code PEST-HP, the state-of-the-art in groundwater model calibration. Various type of pilot points and calibration targets have been used to calibrate the model, to inform the calibration code about all the hydrogeological data made available by site characterization.

Summary of findings
PEST-HP allowed a sound reconstruction of the aquifer features. The model development was fundamental to understand the hydrogeological conceptual model, which in turn allowed to develop sound and safe remedial approaches, limiting the risks to develop wrong or not efficient remediation actions. The model was fundamental to guide new data acquisition, focalizing the characterization in the area where it was most needed, increasing the efficacy of the process. The use of PEST-HP also embedded the stochastic evaluation of the model predictions, allowing a risk-based evaluation of the remediation costs

Conclusion and Significance/contribution of the study
With this work, the groundwater models realized for a complex contaminated sites are presented under the broader context

Session 5b1 / Abstract title: Sustainability at every stage: UN Sustainable Development Goals as a framework for industrial improvement

ID: 76

Key words: Sustainability, Climate Change, Asset Resilience, UN SDGs, Industrial Site Lifecycle

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Session: 5b1 backup

Abstract

Industrial site operators across all sectors are expected to undergo considerable disruption in the next decade to meet the emerging challenges resulting from climate change and a pressure from governance and clients to improve sustainability. It is clear that operators need to understand not only the potential impact of their facilities on our environment but also opportunities for improving their future asset resilience.

Understanding the potential impact of industrial facilities on the environment and implementing changes is the key to success. Embedding sustainability best practice from the earliest possible stage in the asset lifecycle, gives the greatest opportunity to utilize the full spectrum of beneficial elements. These can range from incorporation of circular principles at the design stage; to sustainable soil management during construction; to reduced carbon emission during operation. However, the challenge for many industrial sectors is identifying an appropriate framework to follow and determining the decisions that will have the greatest positive impact. Guidelines aimed at residential or generic commercial properties may be difficult to apply to a specific set of industrial obstacles or provide little benefit in the context of wider operations.

New industry-specific guidance has been developed which embeds sustainability at every step, as an approach to help address these issues. The guidance provides specific examples of actions that can be implemented to directly affect sustainability goals throughout the asset lifecycle.

In this case study, we provide an overview of the process of developing new guidance to assist the energy and fuel retail sector in addressing this challenge. The presentation will

share the framework that has been developed to directly align with the UN's Sustainable Development Goals (SDGs) which include measurable targets related to all aspects of sustainability – from contamination and effects on soil-water-sediment systems, emissions and direct environmental impact to social factors and safety.

This guidance is intended to serve as a practical – and where possible future-proofed – document for all stakeholders involved in the energy station sector. It is intended to help demonstrate the changes and innovation that can be introduced at any stage of an energy station's lifecycle to support global targets for sustainable development. This approach highlights where industry-specific design, construction or operational decisions support the UN SDGs including – Climate Action and Life on Land – demonstrating that the effective integration of climate resilience goals into industrial land management can occur at any stage during the asset lifecycle, whether applied to development of a new site or redevelopment of an existing asset. An indexed summary provides a clear reference for targeting changes at any stage in the lifecycle and examples of improvements that can be made at key trigger points to contribute to sustainable development.

By linking the measurable UN Sustainable Development Goals with each stage of an industrial site's lifecycle this approach has great potential for replication across other industrial sectors that face disruption in the next decade. By assessing the lifecycle of a typical industrial site through the lens of the SDGs, we can create value and align business goals with the UN SDGs to improve industry-wide sustainability at all stages of the asset lifecycle.

Session 5b1 / Abstract title: A pilot study at a DDT-contaminated tree nursery in Sweden to assess the effects of gentle remediation options (GRO) on soil functioning

ID: 84

Key words: Gentle remediation options (GRO); Soil functions; Ecosystem services; Nature-based solutions (NBS); Soil quality index (SQI)

Submitter: Paul Drenning

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Session: 5b1

Abstract

Purpose: to present the results of a pilot study application of gentle remediation options (GRO) – i.e., nature-based risk management strategies/technologies that use plants, bacteria and fungi for effective risk management and improving soil functions – at a historically DDT-contaminated tree nursery site. This presentation will focus on GRO's effect on soil functioning as assessed through a soil quality index.

Methodology: To test the effectiveness of eight GRO strategies to manage risks due to DDT contamination and improve soil quality, a pilot-scale field experiment was established at the Kolleberga site in Ljungbyhed (Southern Sweden) by: (1) thoroughly homogenizing the soil, (2) using a randomized block design of test plots, and (3) planting suitable plants in each plot in a triplicate, either in combination with or without biochar as a soil amendment. Physical, chemical and biological indicators were selected via a 'logical sieve' to assess both the fate of the contamination as well as resulting impacts on soil functions. The indicators were aggregated into higher-level categories within specific ecosystem services (ES) to assess whether there resulted an increase or decrease in a particular ecosystem service's provisioning as result of GRO application. The ES assessment results are visualized with help of a radar chart.

Summary of findings/results: The results from the first two growth seasons indicate that biochar can have significant impacts on the quality of the soil in terms of improving soil fertility and improving microbial activity as well as reducing uptake of DDT in vegetation and earthworms. Effects of the different plants on soil functioning vary depending on the plant

species. The radar chart shows that different degrees of positive or negative effects from the treatments on ecosystem services compared to control measurements from the beginning of the experiment. In general, the mix of leguminous clover and alfalfa are shown to have the most positive effects, and the effects of biochar vary per the different ecosystem services.

Conclusion: Research results have shown that the tested GRO strategies can be used to manage the risks of DDT contamination at DDT-contaminated sites and are also highly relevant to preserve, and improve, the quality of the soil as evidenced by analysing biological parameters related to specific soil functions and ecosystem services. The results from this pilot study can provide valuable input into the ongoing work to manage DDT contaminated tree nursey sites in Sweden and beyond.

Significance/contributions of study: Historical use of dichlorodiphenyltrichloroethane (DDT) at tree nursey sites in Sweden has created a large contamination problem that much now be remediated. Many of these sites are large, diffusely contaminated areas and have good soil quality, which inhibits the use of more conventional excavation-based remediation techniques to intensively remove the contamination source. The sustainable and risk-based alternative proposed here instead is referred to as ‘phytomanagement’ – i.e., the long-term combination of GRO with beneficial land use (e.g., biofuel crop production) to gradually reduce risks at contaminated sites while also restoring ecosystem services. Phytomanagement is highly relevant to bring into the conversation as a proactive and multifunctional contaminated land management strategy for managing risks and improving soil functioning. There is also a clear connection to the recent initiatives relating to the EU Green New Deal and coming EU Soil Strategy. The method followed here to assess the treatments using a soil quality index provides valuable information that will be useful in communication with stakeholders.

Session 5b2 orals

Session 5b2 / Abstract title: A healthy groundwater system as guiding principle in planning and management of water, soil and subsurface in the Netherlands

ID: 238

Key words: groundwater, transitions, climate change, groundwater quality, energy transition

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Session: 5b2

Abstract

Purpose of study
Groundwater is under heavy pressure in large parts of the Netherlands. Both the quantity and the quality are deteriorating. As a result, nature reserves are drying up and becoming polluted. Moreover, the availability of sufficient pure water for drinking water preparation and other uses, such as for agriculture, cannot be guaranteed. The demand for groundwater for agriculture, drinking water and as a source for thermal energy is increasing and the different demands are conflicting.
The various groundwater issues and solutions can be visualized and combined. This creates initial insights for integrated solutions to restore the groundwater system in the Netherlands and to make it robust for future changes.

Methodology
The Integrated Groundwater Study in the Netherlands was carried out for the Ministry of Infrastructure and Water by Deltares, in collaboration with knowledge partners. In the

project, a picture of the existing and desired state of the groundwater on a national scale was sketched for a broad audience of policymakers, water managers and experts. Trends and points for attention were described and visualized for five themes: ‘desiccation of nature’; ‘protection of groundwater quality’; ‘energy transition and groundwater’; ‘urban area and groundwater’; ‘freshwater supply and groundwater'. The starting point for the solutions is that the natural groundwater system is leading.

Summary of findings/results

Nature areas in the higher Netherlands have gradually desiccated; the increase in the groundwater level that is necessary to restore this, is not possible without adjusting land and water use.

Good groundwater quality is of crucial importance, but is under pressure. First of all, reduction of emissions of pollutants and polluting sources will protect the groundwater quality. Also, by making use of the natural protecting barriers in the subsurface, the risks of pollution of groundwater can be reduced.

The use of groundwater as storage or as a source of thermal energy has potential, while care should be taken to prevent groundwater pollution.

Urban areas can be made future-proof by taking greater groundwater fluctuations into account.

In order to guarantee sufficient fresh groundwater supplies, use must be limited to high-quality applications and supplies must be replenished and protected.

Conclusion

A healthy groundwater system is valuable for humans and nature. Protection and restoration of groundwater resources require adaptation of water and land use. Taking larger fluctuations in the groundwater into account and combining measures for both quantity and quality are important. The agricultural and energy transitions and urban innovations offer opportunities.

Significance / contributions of study

This integrated groundwater study provides starting points for land management based on the water, soil and subsurface system. It provides input for regional elaborations and planning.

Session 5b2 / Abstract title: The impact of soil pollution on surface water quality

ID: 247

Key words: Soil pollution, surface waters, surface water quality, chemical status, Water Framework Directive,

Submitter: John Flyvbjerg

Organization: Capital Region of Denmark

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Session: 5b2

Abstract

The impact of soil pollution on surface water quality
Background
Surface waters such as rivers, streams, lakes and coastal waters are often polluted by chemicals above relevant water quality criteria. The sources of this pollution include wastewater discharge, urban and agricultural runoffs. Sites with contaminated soil from e.g. industrial activities or waste disposal may also contribute if polluted groundwater from these sites flow into surface waters.
According to the Water Framework Directive (WFD), EU member states must ensure that their waters achieve good chemical and ecological status by 2027. A prerequisite for designing effective management plans to meet WFD goals is sound knowledge about the pollution sources that contribute to the contamination of surface water bodies. In Denmark all 5 regions have carried out comprehensive risk analyses and field investigations to assess the impact of contaminated sites on water quality in Danish surface waters. The regions are the government authorities responsible for contaminated soil management in Denmark.
Purpose of study
To investigate the impact of contaminated sites on the water quality of surface waters.
Methodology
400 contaminated sites were selected for the study. All the sites posed a potential risk to nearby surface waters according to risk analyses based on existing data. Field investigations were carried out in 2021-2022 to assess the actual risks from the sites.
In streams and rivers, direct water quality measurements were carried out in the summer during low flow conditions where the dilution of contaminated groundwater flowing into the stream/river is expected to be at the lowest.

For lakes and coastal waters, the flux of contaminants into the surface water was assessed by measuring contaminant levels in groundwater wells situated near the lake- or seashore. Water and sediment analytical programs were tailored according to the contaminant profile of the sites.

Summary of findings/results

The results of an overall analysis of all collected data is not available yet. The analysis is carried out during winter and spring of 2023 and the main findings and conclusions will be presented at the conference in September.

At this point, the findings from our investigations of more than 100 streams/rivers in 2021 may illustrate the type of trends and conclusion we will present at the conference:

In approx. 50 % of the streams, one or several contaminants were detected in concentrations above water quality criteria. The sources of the contamination in the streams were evaluated as follows:

- In 30 % of the streams, a polluted site near the stream was the only source of contamination
- In 40 % of the streams, the source of contamination appeared to be a combination of a polluted site near the stream as well as other sources further upstream
- In 30 % of the streams, the contamination was caused by other sources than the polluted site close to the stream.

The contaminants found most frequently in concentrations above water quality criteria were: PFAS (including PFOS), ammonia and dissolved iron (near old landfill sites), pesticides and heavy metals. Chlorinated solvents in concentrations above quality criteria were found in surprisingly few of the streams potentially affected by sites contaminated with this group of compounds.

Most (but not all) of the contaminated sites with an impact of nearby streams are located less than 100 meters from the stream.

Conclusion

Contaminated sites may impact surface water quality and can be a significant source on the local scale. However, the study also shows that in many cases other sources also contributed to the contaminant levels found in the surface waters.

Significance / contributions of study

The results of the study show that to achieve the WFD goal of good chemical and ecological status in surface waters, the impact of contaminated sites need to be addressed along with other sources of surface water contamination.

Session 5b2 / Abstract title: Permanent safety measures implementation for industrial redevelopment

ID: 266

Key words: Green remediation, sustainability, reindustrialization, nature-based solutions, evapotranspiration cover.

Submitter: Luca Sacilotto

Organization: Ramboll Italy S.r.l.

Co-authors: Andrea Campioni, Ramboll Italy S.r.l.; Arianna Pantano, Ramboll Italy S.r.l.

Session: 5b2

Abstract

The present study was developed for an industrial site located in Sardinia (Italy), included in the remediation national priority list. The main environmental concern was related to the presence of fill materials characterized by an enrichment in fluorides, which volume was estimated to be more than 150.000 m3, ubiquitously distributed within the site. The site is a former primary aluminum production plant, acquired by a new owner, thus Ramboll developed the remediation strategy accounting for reindustrialization process needs, with particular reference to avoiding significant movement of contaminated material. With this target, Ramboll provided specific consultancy services for performing several stabilization and inertization tests on fluoride rich fill materials, with the aim of identifying applicable treatment techniques for in-situ or on-site treatment. However, the results of these tests indicated that no technologies applicable on an industrial scale were available, capable of reducing fluorides in eluate to the required regulatory limit (1.5 mg/l). According to this, the most sustainable solution, compatible with site reindustrialization resulted to be the implementation of a physical containment (i.e. capping, a permanent safety measure allowed by Italian law) to interrupt the exposure pathways between the source and the receptors (workers and groundwater). Avoiding the excavation of fluoride rich materials was particularly relevant, since in Sardinia there were no availability of hazardous wastes landfill, therefore the disposal would have involved long distance transportation of the excavated materials. Further enhancement on sustainability of the capping was achieved by realizing an evapotranspiration cover (multi-layer “green capping”, with top layer made of soil and indigenous grasses and shrubs), thus enabling also restoration of ecosystems.
According to the layering of fluoride-rich materials, their main potential interaction with environmental receptors is contaminants release due to rainwater seepage, and consequent impact on groundwaters. In order to avoid rainwater seepage, a site-specific hydrological balance was implemented with the aim of determining thickness and lithological characteristics of soils to be used for the cover. Based on the input data, the calculated

effective infiltration was null, thus indicating the effectiveness of the “green capping” in avoiding potential seepage of rainwater. Human health risk assessment simulation was also included in the evaluation of evapotranspiration cover applicability,. The “green capping” was planned to be realized with a clay layer at the base, overlapped by a cultivated layer aimed at optimizing evapotranspiration, minimizing surface erosion and obtaining hydraulic and mechanical seal of the capping. The vegetation cover was chosen to be realized with pioneer plant species, with good propagation capacity and aptitude for soil consolidation. The evapotranspiration cover was realized on an area of about 126.000 m2 according to the characteristics described above, and laterally confined by a shallow slurry wall (2 meters depth). This allowed to avoid the significantly more costly and less sustainable solution of “dig and dump” of an estimated amount of 150.000 m3 of fill materials. The vegetation cover was realized mainly with herbaceous and shrubby essences, including mainly autochthonous species. Shrubs were planted with a geometry aimed at facilitating their horizontal rooting.

Ramboll proposed a nature-based and sustainable remediation approach, compatible with the reindustrialization process of the site, which allowed to maintain a green area within the industrial site. Promotion of the restoration of nature and ecosystems was achieved by avoiding the use of traditional artificial products for the capping. This approach also allowed significant cost saving with respect to traditional remediation technologies, together with ecological benefits.

Session 5b2 / Abstract title: Prospecting redevelopment opportunities with the Cedalion tool to enhance dynamic landfill management

ID: 376

Key words: Landfills, dynamic, management, opportunity mapping, reuse of space

Submitter: Johan Ceenaeme

Organization: OVAM (Public Waste Agency in the region of Flanders)

Co-authors: Tom Behets, OVAM; Eddy Wille, OVAM

Session: 5b2

Abstract

Today, only a limited share of the produced waste is landfilled in Flanders (2%). However, this positive observation overlooks the many landfill sites that remind us of the linear economy. In view of the dispersed data collection over various data sources, the inventory of these landfill locations in the past proved not to be evident. The files were not systematically saved by the then licensing authority, let alone stored digitally to enable specific consultations. A systematic data collection was therefore necessary. Not so much because the current landfill volume was seen as a problem, as investigations on environmental risks pointed out that no urgent intervention was required. Actually, the position of former landfills in the circular economy was questioned. Moreover , doubts arose about the robustness of these static landfills in a strongly changing and dynamic environment.
The basis for a data structure was provided in the Enhanced Landfill Mining (ELFM) program that ran at OVAM from 2011 to 2015. The focus was mainly on locating landfill sites in view on possible mining, for which we needed a description of the content: the landfill volume and surface area, crucial data that is necessary for decision-making on the reclamation of landfills. However, landfill mining seemed not (yet) profitable for the majority of the landfill sites. Therefore, we shifted the focus to sustainable interim uses and other redevelopment processes. Think of recreation, a solar panel park, a 'hard' destination or (partial) mining/disposal of waste to enable water storage. In order to support informed decisions about this, the data management must be sufficiently extensive and we also need information about the context of the landfill. This overall concept is described as Dynamic Landfill Management and was approved by the Flemish Government on October 16, 2015. With this concept, we want to point out that we should take into account the dynamic nature of our environment when managing landfills: it is constantly changing and landfills are no exception. Just think of the increasing flood risks due to the climate crisis. When a landfill is flooded, it increases the risks of leaching out. Because our inventory, we know where the landfills are located, but because of our data management, we can also anticipate to such

patterns. We can either take protective measures to protect landfills in high-risk areas, or even use the landfill as a solution by designing it as a flood area.
To enhance the implementation of the concept of Dynamic Landfill Management, a first step was to share our landfill data with the public. Furthermore, a decision support tool was developed in order to achieve a sustainable long-term management of landfills. This resulted in the decision support model Cedalion. Cedalion forms the basic system in which all landfills are included and on which simple queries can be carried out. The link with the GIS environment allows specific spatial explorations and analyses. This type of prospecting translates into opportunity maps for afforestation, green energy, extraction of raw materials, opportunities for sustainable water management, etc. With our public map, we mainly want to inform others about the location of the landfills. But with our decision support tool, we can also provide new possibilities for the reuse of our old landfills. This form of reuse can be very valuable, especially in Flanders, where space is scarce.

Session 5b2 / Abstract title: Exploring feasibility of an area-based approach for contaminated soil and groundwater in the port of Antwerp

ID: 395

Key words: Diffuse contaminants. Threaten ecosystem services and national or European objectives. Area-based approach.

Submitter: Daniel Rits

Organization: Witteveen+Bos

Co-authors: Ellen Luyten, Public Waste Agency of Flanders (OVAM) / Nele Bal, Public Waste Agency of Flanders (OVAM) / Astrid Verheyen , Port of Antwerp-Bruges / Meta Van Heusden, Witteveen+Bos / Sophie Moinier, Deltares

Session: 5b2

Abstract

Ensuring future healthy soils as envisioned by the EU Soil Strategy has several challenges in the densely populated area of Flanders. Diffuse contaminants, significant residual pollutions in groundwater and emerging contaminants such as PFAS, threaten the ability of the soil and groundwater to deliver ecosystem services and surface water and may lead to national or European objectives being under pressure. These threats have a major impact on the development of the port and on national and European objectives such as the Water Framework Directive. Developed concepts for function-oriented land use and for the multiple reuse of different water types are thus under pressure.

The Port of Antwerp-Bruges (PoAB) entered into a partnership with the Public Waste Agency of Flanders (OVAM) in 2021. Working together on innovative approaches to counter the threats on these themes should, on a strategic and operational level, realize added value for both partners. The focus here is on a transition from opportunities rather than a regulatory-driven approach.

Two studies were launched in 2022. The first study explores the possibilities for area-based earthmoving in the port of Antwerp. The second study focuses on the feasibility of an area-based approach to deal with contaminated groundwater in the port of Antwerp (as a pilot case). The Port has great ambitions in the field of logistics and transport of goods. To realize these ambitions, PoAB wants to collaborate with OVAM to realize a circular and low-carbon economy, including themes such as management of waste, materials and soil. These themes should, on a strategic and operational level, realize added value for both partners. The focus here is on a transition from opportunities rather than a regulatory-driven approach.

The partners aim for an approach for soil movement and for mixed and diffuse groundwater contamination. Both studies show that different solutions arise at different scales. These are based on 1) protecting, 2) managing and/or 3) restoring soil qualities.

The feasibility of these scales and the feasibility of the solution options have been identified. To achieve these goals and results, the following process was followed:
1 environmental analysis of the area, soil and water system, topsoil activities and soil quality (soil and groundwater) at the site and area level;
2 inventory of stakeholders, existing knowledge, needs, gaps and opportunities for area-based approach;
3 development of scenarios for an area-based approach with short-term and long-term actions;
4 perform feasibility analysis with input from stakeholders and taking into account the context of the port area and current (technical) constraints.

We are currently finalizing these studies. At AquaConsoil, we would like to present in a session or in two presentations (both 15 minutes), the objectives, results and learnings of the projects as well as an outlook for the near future of both projects. We also would like to collect input from our colleagues in the field.

These projects were carried out by Witteveen+Bos and Deltares, on behalf of PoAB and OVAM and in collaboration with relevant stakeholders.

Session 5d1 orals

Session 5d1 / Abstract title: Multi-disciplinary spatial design: lessons for sustainable use of soil and underground

ID: 16

Key words: underground, spatial development, sustainability, design research, multi-disciplinary

Submitter: Geert Roovers

Organization: Saxion University of Applied Science

Co-authors: nan

Session: 5d1

Abstract

The importance of soil and underground for urgent societal matters – like energy transition and climate change - is still growing. For already several years in the Netherlands governments are working on embedding dealing with soil and underground in spatial developments, to effectuate this importance. Still, this dealing is difficult and early.

To support this development, several pilots and design research are executed in the Netherlands to explore the way in which soil and underground can play a substantial role in spatial development. Furthermore, research is conducted on how spatial design can contribute to develop comprehensive and multi-sectoral solutions that incorporate the potential of soil and underground. This research follows spatial concepts like planning as persuasive storytelling and planning as policy integration, and uses methods based on research design and design thinking.

This paper describes insights from these pilots and research, based on three perennial research programs in which Saxion University of Applied Science is participating. First it will address current barriers for sustainable use of soil and underground in spatial development, following desk study and case-studies. From this, it will present spatial designs for several cases on this in the Netherlands, such as the development of underground energy storage in salt caverns and gas stocks for sustainable regional energy transition, interactive area development with brownfields, and the contribution of soil to healthy urban development. From these cases it presents overarching principles and new urban design concepts for sustainable use of soil and underground, and gives recommendations to strengthen the

position of soil and underground in public and private organisations dealing with spatial planning.

This paper contributes to the fields of knowledge about the connection between soil, underground and spatial planning, and how knowledge about soil and underground in these developments can be used to substantially contribute to sustainable urban development.

Session 5d1 / Abstract title: Tomorrows soil quality indicators to promote vegetation within urban development and planning

ID: 169

Key words: soils, urban, functions, vegetation, decision aid tool

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Organization: BRGM-IRSTV

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Session: 5d1

Abstract

There is an increasing demand of nature in cities worldwide. However, urban soils can be degraded by, for example, diffuse or point-source pollution loss of organic matter. In addition, the European strategy to achieve no net land take by 2050 promotes the renaturation of artificialized soils. There is a lack of knowledge and tools to help optimise the management of urban soils within redevelopment and planning strategies. To address this lack, one of the objective of the R project SUPRA was to prepare a decision aid tool to help optimise the qualification of urban soils that could be considered for vegetation growth, including food production and other purposes. Within this framework, we developed a set of indicators to assess the soil functions linked to 3 services associated with vegetation growth: production of biomass, contaminants regulation and climate regulation.
This work is based on a literature review and a working group of experts on urban soils. The first step was to link services, functions and indicators of soil condition. A set of functions and subfunctions was then decided. For each of them, we listed the corresponding parameters, the existence or not of normative methods and the range of reference values. Discussions were held to select a set of minimum indicators. The existing range of reference values was used to set threshold that would allow the evaluation of each indicators. In case there was no reference, and the indicators were considered essential, new threshold value were proposed. A first version of decision aid tool was also developed and first tests allowed comparing the results obtained for some characterised soils.
The following 6 functions were selected: i) Storage, recycling and transformation of organic matter ; ii) Retention and supply of nutrients / Supply-recycling of nutrients (decomposition of organic matter) ; iii) Physical support – housing ; iv) Water retention, circulation and infiltration ; v) Retention, filtration, degradation of contaminants ; vi) Support of biodiversity.

The minimum data set includes 30 indicators of which 11 correspond to field observations and others to measurements (in situ or in the laboratory). The level of expertise and an assessment of the cost of acquisition are also described. The first tests of the tool need to be continued with more soils to verify the scoring of soil quality with the assessment of soil experts. A longer term objective would be to map the results of soil quality scoring that could be used within urban strategies for biomass production.

Session 5d1 / Abstract title: Risk-based imprecise soil concentration remediation objectives

ID: 24

Key words: Contaminated soil. Remediation. Risk-based. Remediation objective. Uncertainty

Submitter: Dominique GUYONNET

Organization: BRGM

Co-authors: Dominique Guyonnet (BRGM), Aline Coftier (BRGM)

Session: 5d1

Abstract

Uncertainty is a “fact of life” in contaminated land management. Taking into account uncertainty would seem important in order to faithfully convey information to end-users and to derive balanced decisions. This applies also to risk-based soil remediation objectives. Current sustainable and risk-based land management (SRBLM; Bardos et al., 2011) encompasses six remediation principles, the first of which stipulates that: “Remediation should remove unacceptable risks to human health and protect the wider environment now and in the future for the agreed land use, …” (CL:AIRE, 2010). This is consistent with ISO 18504 (2017) which states that sustainable remediation should be “limited to those strategies that are likely to achieve site-specific risk management objectives (i.e. eliminate and/or control unacceptable risks to human health, …).”

In order to design soil remediation action, the French national methodology for managing contaminated sites and soils (MEEM, 2017) includes a “predictive residual health-risk analysis” which defines the soil concentration levels, further to remediation, such that residual risks to human health are considered acceptable. While such an analysis involves significant uncertainties, the results are typically expressed in the form of a precise (i.e., single) residual soil concentration, that is used as a remediation objective. But previous research (e.g., Lee et al., 1994) suggests that, considering inherent uncertainties, it may be more consistent to express this objective in the form of a range, or interval, of values (i.e., imprecise remediation objective).

Such a range of values can be derived from the health-risk assessment methodology, while drawing from the theory of evidence of Dempster-Shafer (Shafer, 1976) to accommodate both stochastic (due to variability) and epistemic (due to imprecision) uncertainties relative to parameters that influence the risk (Dubois and Guyonnet, 2011). This leads to the identification of residual soil concentration values that are either acceptable, unacceptable or partially acceptable. If for example the analysis yields an interval [100-500 mg/Kg] for a specific contaminant, this interval could be used as a remediation objective as follows:

“Further to remediation, compliance analyses (number?) of soil concentrations should yield values □ 100 mg/Kg, while x% (to be defined) of values may exceed 100 mg/Kg while remaining □ 500 g/Kg”. This would be an alternative to the current practice whereby a certain proportion of compliance analyses results are allowed to exceed the precise risk-based residual soil concentration objective, but with no upper bound (i.e., no safeguard). This paper describes the procedure for estimating the bounds of the imprecise residual soil concentration objective, based on a practical example.

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Session 5d1 / Abstract title: Correlating the succession of microbial communities from Nigerian soils to petroleum biodegradation

ID: 298

Key words: Oil biodegradation, soil microbial communities, oil composition, degradation capacity, PAHs

Submitter: Paul Iturbe-Espinoza

Organization: VU Amsterdam

Co-authors: Dr. Paul Iturbe-Espinoza, Department of Molecular Cell Biology, VU Amsterdam, microbial ecologist

Session: 5d1

Abstract

Hydrocarbon components are ubiquitous in the environment as a result of both natural seeps and accidental spills of crude oil and related substances. Whilst biodegradation of different hydrocarbon components has been widely demonstrated to occur by specialist oil-degrading bacteria, less is known about the response of microbial communities as a function of oil composition. The objectives of this study were i) to assess the biodegradation capacity and succession of microbial communities isolated from Nigerian soils in media with crude oil or synthetic oil as sole sources of carbon and energy, and ii) to assess the temporal variability of the microbial community size. Community profiling was done using 16S rRNA gene amplicon sequencing (Illumina), and oil profiling using gas chromatography. Alkanes were degraded at much higher rates than aromatics, and the overall degradation rate was negatively correlated with the molecular weight of each type of molecule. Furthermore, biodegradation of high molecular weight hydrocarbons was more effective when incubated with communities from more-contaminated source soils. Variable community responses were observed during the degradation of alkanes and more simple aromatic compounds, but at later phases of growth they became more homogeneous. The degradation capacity and the size of the community from the more-contaminated soil were higher than those from the less-contaminated soil. Six abundant organisms isolated from the cultures (Gordonia sp. PT0S1a, Micromonospora aurantiaca P6MC1M3, Microbacterium oxydans P1MC1O1, Rhodococcus sp. P1MC1M3, Gordonia amicalis P1MC4M1, and Pseudomonas sp. P3MC4O1) were found to biodegrade oil molecules in pure cultures. Ultimately, this knowledge may contribute to a better understanding of how to improve the biodegradation of crude oil by optimizing culturing conditions through inoculation or bioaugmentation of specific bacteria during ex-situ biodegradation such as biodigesters or landfarming.

Session 5d1 / Abstract title: Molecular biology as a key tool to demonstrate natural attenuation: first evidence of thermal oil removal via denitrification

ID: 348

Key words: metagenomics, HTF-removal, denitrification, natural attenuation

Submitter: Cynthia Alcántara

Organization: KEPLER, INGENIERÍA Y ECOGESTIÓN, S.L.U.

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Session: 5d1

Abstract

KEPLER INGENIERÍA Y ECOGESTIÓN, S.L.U. periodically performs sampling campaigns at a site contaminated with heat transfer fluid (HTF), a thermal oil used in solar thermal plants. The results obtained showed that when the concentration of HTF decreased in piezometers nitrites (NO2-) production was detected in groundwater. This fact suggested a possible removal of HTF via biological denitrification of the pollutant where nitrate is used as an electron acceptor under anoxic conditions. The denitrification metabolic pathway consists of the reduction of nitrates (NO3-) to nitrogen gas. This process occurs in successive stages, catalyzed by different enzymatic systems, with nitrites (NO2-), nitric oxide (NO) and nitrous oxide (N2O) appearing as intermediate products. Thus, if HTF could be being used as a source of organic carbon during a denitrification process, an active natural attenuation process could be demonstrated in the aquifer.

To study this hypothesis, KEPLER carried out a metagenomics study in which the genomic region of the 16S ribosomal gene was analyzed to identify the autochthonous population of the aquifer and thus verify if there were denitrifying microorganisms. From the 16S sequences identified, a functional analysis was also carried out to infer the metabolic functions that could take place in the aquifer and check if denitrifying enzymes were present. After the metagenomics analysis, a laboratory treatability study was also carried out to evaluate a possible removal of HTF in the aquifer groundwater by this biological denitrification pathway. For that, a continuous test was performed in which a reactor under anoxic conditions was fed with HTF and nitrate for 6 months to evaluate the potential of the natural attenuation process.

Metagenomics study demonstrated that among the most abundant genera in the autochthonous microbial community were some that participate in denitrification processes using nitrate as an electron acceptor under anoxic conditions, such as the genus Thauera

spp. The ability of this genus to degrade aromatic compounds, as are HTF and its by-products, was also observed in denitrification reactors. Other microorganisms that play an important role in the nitrogen cycle were also identified, such as the genera Nitrosomonas spp. and Nitrospira spp. and, within the archaea group, the genus Nitrosarchaeum spp. Among the potential metabolic functions, enzymes described as denitrifying agents were identified such as nitrate reductase, nitrite reductase, nitric oxide reductase and nitrous oxide reductase. The presence of these microorganisms and these enzymes indicates that denitrification may occur in the aquifer and, furthermore, reinforces the hypothesis that HTF can be degraded by denitrification in an anoxic environment.

Treatability study in a continuous reactor confirmed the presence of a denitrification metabolic pathway. In this test it was observed that when HTF or NO3- were added separately, the concentrations of these two compounds did not decrease, however, when adding them simultaneously, HTF consumption and transformation of NO3- into NO2-, confirming that HTF can be removed from groundwater via biological denitrification.

In conclusion, this study provides the first evidence of the effectiveness of denitrification to eliminate HTF during groundwater treatment and demonstrates the potential of using genetic tools in the evaluation of soil and groundwater natural attenuation. In this case study, it was demonstrated to local authorities that there was a natural attenuation, excluding the need to apply an active remediation and being enough with a monitoring phase in the aquifer.

Session 5sps1 orals

Session 5sps1 / Abstract title: A Soil Deal for Europe – how far are we with determining soil needs, sustainable land management practices, soil literacy and Living Labs and Lighthouses?

ID: 231

Key words: Sustainable land management, Living labs, Lighthouses, ISLANDR Test Areas.

Submitter: Hans Groot

Organization: Deltares

Co-authors: Hans Groot MSc, Deltares, senior project manager; Linda Maring MSc, Deltares, senior project manager; Paul Bardos PhD, R3 Environmental Technology, environmentalist; Dominique Guyonnet ing, PhD, BRGM, hydrogeologist; Juha Kaija MSc, GTK, senior specialist; Jussi Reinikainen, Syke, senior advisor.

Session: 5sps1

Abstract

The main goal of the Mission 'A Soil Deal for Europe' is to establish 100 living labs and lighthouses to lead the transition towards healthy soils by 2030. Soil health living labs are defined as user-centered, place-based and transdisciplinary research and innovation ecosystems, which involve relevant partners in systemic research, co-design, testing, monitoring and evaluation of solutions, in real-life settings. This to improve their effectiveness for soil health and accelerate adoption. Lighthouses are defined as places for demonstration of solutions, training and communication that are exemplary in their performance in terms of soil health improvement.

Up to now, the mission is progressing well but focus on contaminated and brownfield land in running projects has been low compared to agricultural land. In this session, the ISLANDR project will be presented briefly to stimulate an exchange with the audience on the progress and importance of the Soil Deal for impacted soil-water-sediment systems under different land uses.

The Information-based Strategies for LAND Remediation (ISLANDR) project is cross-disciplinary and multi-actor and aims to promote the delivery of Green Deal objectives, particularly achieving Zero Pollution by reducing soil pollution and enhancing restoration in a socio-economic framework to foster the transition.

ISLANDR will provide a series of tools and methods to support:
(1) the delineation of soil pollution sources,
(2) the assessment of risks,
(3) the implementation of sustainable and risk-based land management (SRBLM),
(4) the inclusion of wider valuation approach in financial and investment cases,
(5) closer integration of land contamination and spatial planning decision-making and key policy-relevant findings related to the Soil Strategy.
For this ISLANDR is using 7 ISLANDR Test Areas (ITAs) to learn from their experience, and to co-create and test tools and strategies. All of this together with involved ITA actors.

These ITAs (listed below) form a crucial part of ISLANDR.
1 Outokumpu mining site Finland
2 Kolleberga forestry site Sweden
3 Toulouse Metropolis urban site France
4 Grójec rural site Poland
5 Larnaca oil refinery Cyprus
6 Kosovo - multiple sites
7 Soesterberg former airport site the Netherlands

This session focuses on presenting several of these ITAs in detail to drive an exploration of the transition of soil health from concept to practice for contaminated sites; and to further discuss the potential for setting up soil health-living labs and lighthouses for industrial and brownfield land. The session will bring together ISLANDR, stakeholders impacted sites and relevant EU networks and any interested AquaConSoil delegates.

After a 20 minutes introduction on the project and the ITAs, 3 roundtables (world café, 3 x 20 minutes) are setup with the audience to discuss around an ITA-setting to make the discussion more tangible:
- Soil health and research questions in different regions
  - What are the main soil needs and research challenges?
  - What does soil health mean, what are realistic objectives/indicators?
  - How to implement the concept of soil health?
- Elaboration and adoption of Best Practices for sustainable soil and land management
  - How to add value when regenerating impacted land? How to use this as leverage?
  - How to ensure effective uptake of novel methods, regarding national/regional specificities?
- How can we setup successful Living Labs and Lighthouses for contaminated and brownfield land?
  - What are success factors?
  - When does a LL site qualify as a lighthouse?

The roundtables give each 3 take home messages to the Soil Mission and its projects (10 minutes).

This session is being moderated by Deltares (NL), R3 (UK) and BRGM (FR), SYKE (FI) and other organizations participating in ISLANDR.

Session 5sps2 orals

Session 5sps2 / Abstract title: Transitions in soil quality management ‘Look differently, think differently and act differently,’ the EU SOIL strategy in perspective

ID: 272

Key words: soil health, EU soil strategy, soil quality management, soil policy transition, Theory of Change

Submitter: Margot De Cleen

Organization: Ministry of Infrastructure and Water Management, Rijkswaterstaat

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Session: 5sps2

Abstract

With the Green Deal for Europe, the EU Soil Strategy and the Soil Health Law, challenging ambitions for healthy soils and sustainable land management have been formulated. With the goal for healthy soils in 2050, Europe underlines the importance of soils for a healthy, sustainable, biobased and resilient society. This requires a broad and coherent vision on soil health, where soil ecosystem functioning is the core. We need a transformation in our attitude towards soil, not only in policy, but also in management concepts, business models, knowledge development and social contracts.

In this session we will challenge you to look differently and think differently and thus discover new pathways towards healthy soils, for a sustainable society and economy. This will be determined from the soil condition and the delivery of ecosystem services. Therefore we help you with building blocks we drew up to assemble a broad, integral soil policy for a multifunctional soil use, starting with a sustainable soil management. Such a broad strategy will make it possible to tackle the societal challenges ahead with regard to climate change and biodiversity decline in a coherent way. This is equally necessary to combat threats to soil quality, such as pollution, sealing, over-fertilization, erosion, soil biodiversity decline, organic matter decline and exhaustion.

Based on goals set by the EU to achieve healthy soils in 2050 we will discuss in this session with you, data collections, knowledge development and policy instruments already available or lacking to achieve the goals. To discover and unravel the complexity of new strategies for the soil-water system, we follow the concept of the 'Theory of Change' (ToC). The ToC method consists of a schematic representation of the activities required to achieve the desired goal, and the effects of these activities and measures. In the ToC, these are distinguished in activity, output, outcome and impact of measures. The outputs are the tangible results of the measures; the outcome is the effect of the measure in practice on the target group, and the impact is the effect of the outcome on society. With the ToC short term actions and measures can be connected to long term goals. The outcome of the ToC exercise will be reported and shared with all participants. We foresee ToCs on the topics ‘soil health and soil districts’, ‘soil data and monitoring’; ‘earthmoving and diffuse/emerging contaminants’ ‘no net land take and soil sealing’.

We start with three presentations on the following topics:

- The transition theory of Loorbach and building blocks for a futureproof soil policy drawn up by RIVM and the Dutch Soil Platform by Margot de Cleen (Ministry of Infrastructure and Water Management).
- An introduction and example of determining soil health condition and delivery of ecosystem services by Michiel Rutgers (RIVM)
- A discourse on soil quality management based on norms for contaminants or based on the functioning of ecosystem services and the valorisation of natural capital by Michiel Gadella (Ministry of Infrastructure and Water Management) and Piet Otte (RIVM).

In the ToC discussions we will get onto policy and management perspectives as well as lock ins, passing on, synergies and links with other domains. Policy and knowledge requirements as well as gaps and availability will be identified. The ToCs can be the step up towards a joint knowledge agenda, a collaboration on research or living labs and may provide insight in instruments, experience, practice and knowledge already available in the AquaConsoil network.

Session 5sps4 orals

Session 5sps4 / Abstract title: Application of innovative technologies for site characterization and treatment in the Superfund Program

ID: 422

Key words: delineation, subsurface contamination, real-time measurements

Submitter: Vanessa Van Note

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Co-authors: Lucila Dunnington, US EPA, geologist/environmental engineer; Carlos Pachon, US EPA, environmental protection specialist

Session: 5sps4

Abstract

CERCLA, the law under which the Superfund Program was initially created in the United States, generally requires that whenever practicable, contaminated groundwater be restored to its beneficial uses within a reasonable timeframe given site-specific conditions. Over its history, the program has successfully implemented treatment remedies at many of its sites, often restoring groundwater to beneficial use. Over the last 15 years, US EPA has seen a shift in major remediation strategies from ex situ (such as pump and treat and excavation) to in situ (such as bioremediation and chemical oxidation) remedies. In situ remedies theoretically reduce the environmental footprint and increase efficiency of contaminated site cleanups since they offer a targeted approach and can manage the waste on site, without added transportation for off-site treatment. However, to maximize efficiency of these in situ approaches, a more robust delineation of subsurface contamination is needed.

The United States Environmental Protection Agency's (US EPA) Superfund program partnered with practitioners to develop high-resolution site characterization (HRSC) to produce scale-appropriate measurements to better define contaminant distributions with increased certainty and to investigate the heterogeneities in the subsurface that control the contaminant distribution, transport, and fate at a site. The HRSC approach resolves groundwater flow and contaminant concentrations at a detailed level utilizing real-time measurement technologies, like x-ray fluorescence (XRF) and membrane interface probes (MIP), to generate data to support real-time decision making, including rapid turn-around from field-based measurement technologies. The application of HRSC as a best

management practice (BMP), not only refines the conceptual site model or functional description of a site to support faster and more effective cleanups but improves the delineation of the source zone leading to an overall reduction in the environmental footprint of a cleanup.

In this session, we will share how EPA applies a set of innovative tools and approaches to conduct field analysis, vertical profiling, and data interpretation and management to improve the characterization and treatment of contaminated sites. This session will include actual and hypothetical site examples to provide the audience with an understanding of how HRSC is implemented within the superfund program for sites of varying geologic and hydrologic properties, informs the CSM for a site (including contaminant fate and transport characteristics), addresses challenges and uncertainties in comparison to traditional sampling approaches, and contributes to green remediation.

The interactive portion of this session will involve knowledge checks throughout the technical presentation and breakout groups following the presentation. The breakout groups will be given an example remediation site and will work together to identify data gaps and opportunities for improved site characterization, as well as selecting the best possible real-time technology to enhance decision making. This activity will enable participants to familiarize themselves with HRSC approaches and innovative technologies.

Session 5sps5 orals

Session 5sps5 / Abstract title: A series of sustainability assessment case studies of enhanced bioremediation across Europe

ID: 66

Key words: case studies, sustainable remdiation, risk management, enhanced bioremediation, H2020

Submitter: Paul Bardos

Organization: r3 environmental technology ltd

Co-authors: This abstract is submitted under one name only because of constraints imposed by the submission timeline, but the free session will be multi-author and multi-actor.

Session: 5sps5

Abstract

This free session will present a series of case studies across sites in Europe (and possibly one from China) which consider the future deployment of enhanced bioremediation compared with more conventional remediation alternatives. The assessments all follow a common protocol and are compliant with ISO 18504:2017. This is the first time such a linked series of consistent case studies has been presented at any international conference.

These case studies are outputs of the EiCLaR project. EiCLaR (Enhanced and Innovative In Situ Biotechnologies for Contaminated Land Remediation, www.eiclar.org) is a €6.7 million international project developing the integration of in situ bioremediation with physical/chemical techniques to gain step change improvements in performance. It is funded under the EU Horizon 2020 programme and the National Science Foundation of China over 2021-24. EiCLaR expects significant gains in cost effectiveness and sustainability for the remediation of a wide range of problem sites from the deployment of these technologies. Its 18 partners are developing four technologies to field scale proof-of-concept, with a commercialisation plan for each technology led by a Private Sector SME champion.

Each case study will present three segments of decision information:
1. Ranking of technical fit to providing the desired risk management outcome over the S-P-R linkages of concern

2. Ranking of key cost drivers (capex, opex, wider value)
3. Ranking of sustainability assessment outcomes.

Each set of findings is based on the collaborative involvement of EiCLaR with the stakeholders for each site (variously site owners, consultants, regulators, developers depending on the site).

We anticipate presenting five of the more than ten case studies EiCLaR is working on, which will cover both technologies and their sustainability. Our intention is that the case studies will be presented by site stakeholders and/or technology providers, and that each case study will also describe what the decision information has been used for (e.g. implementation decision, proposal development) and how these activities were supported by the assessments made. Our hope is that this free session will give a platform for AquaConSoil delegates with interest in sustainability assessment, but limited exposure to its practical use, to hear about sustainable remediation in practice. It will also provide a show-case for the practical application of the four EiCLaR technologies (electro-nanobioremediation, monitored bioaugmentation, bioelectrochemical remediation and enhanced phytoremediation).

Engagement with the free session delegates will be primarily via question and answer sessions specific to each case study and a facilitated discussion to (a) draw out any key learning points for sustainable remediation in practice, and (b) open out opportunities for those interested in sustainable remediation to make contact with more established practitioners. Our plan encompasses about 60 minute talk time and 30 minutes interaction time. However, we are flexible and very open to suggestions from the AquaConSoil panel that they think could add value.

Session 5sps6 orals

Session 5sps6 / Abstract title: The urgent necessity of healthy soils

ID: 427

Key words: Healthy soils, EU policy

Submitter: Martin Doeswijk

Organization: TAUW

Co-authors: ir. Margot de Cleen, Ministry of Infrastructure and Water Management, dr. Hilde Passier, Deltares. Sophie Moinier Msc. Deltares

Session: 5sps6

Abstract

Everybody should be able to live in a healthy environment. Not only us, but also future generations. The soil – sediment – water system is the basis of a healthy environment and for a prosperous society. Therefore, we need to restore soil, protect it and manage it sustainably. How can the AquaConSoil community contribute to this mission and to the challenges and goals put forward in the EU Soil Strategy? In 2023, the Green Paper: 'The urgent necessity of healthy soils' was published by Margot de Cleen and Martin Doeswijk as outcome of discussions started during AquaConSoil 2021. In this special session we aim to:
• Show participants that healthy soils are vital for a healthy environment and show that we, as AquaConSoil community, all can contribute to healthy soils;
• Unite and inspire the AquaConSoil community to actively engage with the 10-point action plan listed in the green paper, and to contribute to healthy soils in Europe;
• Inventorize urgency and priorities;
• Conclude with a joint mission statement that everyone can spread in their own network.

Within the AquaConSoil community a lot of knowledge and experience of different disciplines is available, embodied in stakeholders of diverse plumage. Not only on sustainable remediation of contaminated land, but also on soil ecosystem services to tackle climate change, to comply to circular land and soil use or to manage soils for livable cities. This scope and network are further broadening in the future. The outcome of the sessions of AquaConSoil 2021 served as input for a green paper showing the urgent necessity of healthy soils for society. The green paper should be the starting point for discussion and network building on this important topic. The AquaConSoil community could be the beating heart of this community; it can help to become the vivid network which is in close contact not

only on the conference itself, but also between conferences. The green paper addresses why this is important, what challenges we need to tackle and how we can put focus into action. While drawing up this paper the EU Soil Strategy was published. With this strategy goals are set for healthy soils in the EU. A 10-point action plan will be discussed during AquaConSoil 2023:

1. Give soils a voice in decision making and actions
2. Acknowledge the intrinsic value of soils
3. Strive for a transition in mindset and actions
4. Take responsibility, take control
5. Set land degradation to zero
6. Adopt a programmatic approach soil remediation
7. Connect soil with other societal challenges
8. Create new business models
9. Develop new research and innovation models
10. Data, data and more data

Set up of the session:
• Welcome (session leader)
• Appetizer: 10 Minute screening of the movie 'Below the subsurface' ('Onder het Maaiveld', with English subtitles). The idea behind this is to inspire people, because for the first time the invisible world under your feet is made visible. After seeing this movie it's not possible to not think about healthy soils anymore
• Introduction of the green paper by Margot de Cleen and Martin Doeswijk.
• Reflection on the 10-point-action plan by the panel (panel members: to be decided). Two options (to be decided):
o 1: ask questions to panelists related to actions of the plan and approach to take up the actions
o 2: speed debate in which 3x2 speakers respond to certain statements.

Aim is to actively challenge the participants during the panel discussion to:
• Bring in their own practice into the discussion: how does your research, project or policy instruments contribute to healthy soils and what is lacking?
• How can they work together with others? How can different stakeholders/disciplines strengthen each other within the AquaConSoil community?

• Conclude session with key messages for mission statement
• Wrap up session and mission statement