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Interreg Europe

European Union
European Regional
Development Fund

TANIA:
REVIEW ON CURRENT *IN SITU* REMEDIATION TECHNIQUES

MUTKU-PÄIVÄT 2019

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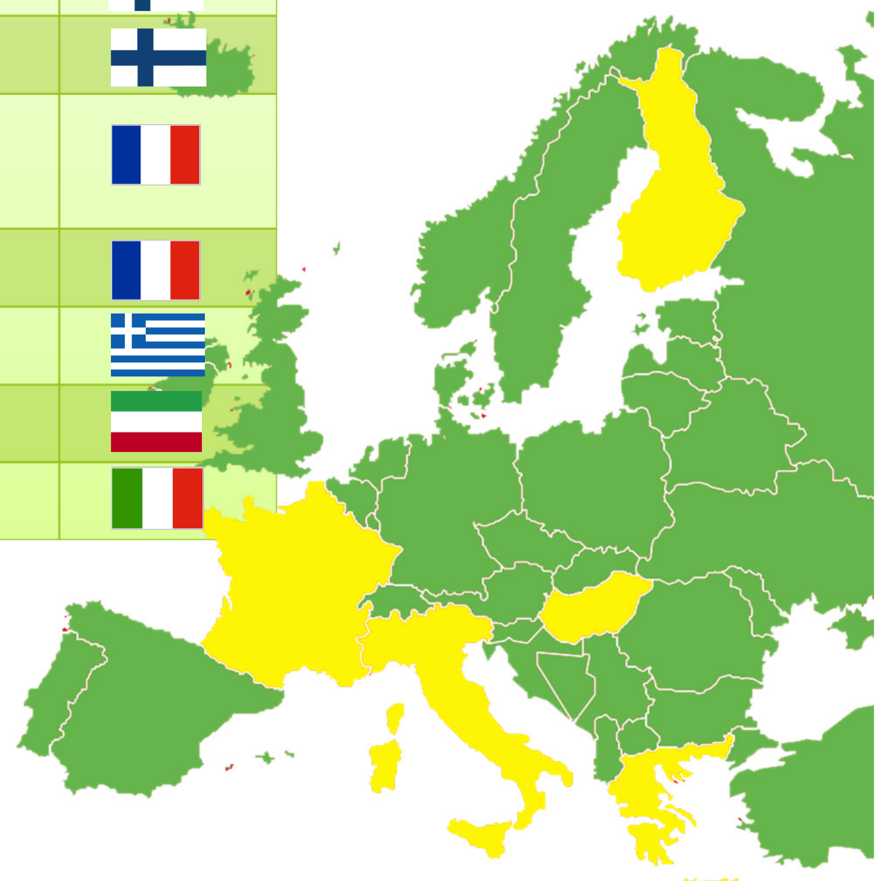
TANIA Context

- TANIA: TreAting contamination through NanoremedIAtion
- Priority Axis 4: "Environment and resource efficiency"
- Specific Objective 4.2: "Improve the implementation of regional development policies and programmes, in particular programmes for Investment for Growth and Jobs and, where relevant, ETC programmes, aimed at increasing resource-efficiency, green growth and eco-innovation and environmental performance management"

TANIA partnership

N	Partner	Country
1	Agency for the development of the Empolese Valdelsa	
2	Regional Council of Pajat-Hameen	
3	University of Helsinki	
4	Regional Council of Grand Est - Alsace Champagne-Ardenne Lorraine	
5	University of Lorraine	
6	Region of Crete	
7	Government of Baranya County	
8	Regional Government of Tuscany	

Project period:
January 2017 – December 2021



TANIA Objectives

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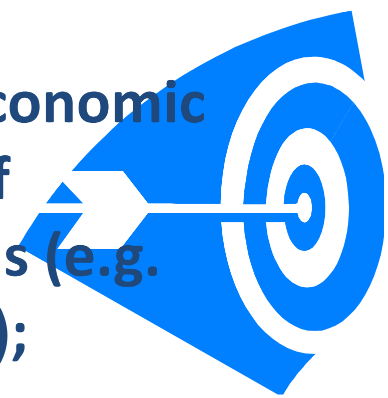
Overall objective: improve treatment of the ever-increasing number of contaminated sites in European regions, by improving design and implementation of policy measures capable of supporting uptake and diffusion of nanoremediation. Specifically:

- Support R&I on identification and production of eco-compatible and eco-sustainable solutions for treatment of contaminated soil and water;
- Exchange methodologies to evaluate effectiveness, economic sustainability and environmental safety and impact of nanoremediation, within the context of EU regulations (e.g. REACH) and strategies (e.g. EU Soil Thematic Strategy);
- Provide incentives for in-situ use of NM and NP to treat contaminated soil and water; communication tools.



Objectives of the review

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- **Assess the current use of available *in situ* techniques**
- **Identify novel methods and upcoming trends in soil and groundwater remediation.**
- **Map the field experience in global scale**
- **Map the future prospects of consultants, scientists, contractors, and public authorities working in the field of soil and groundwater remediation.**

Executors:
Ramboll Finland Oy
Pöyry Finland Oy
Insinööritoimisto Gradientti Oy

Questionnaire

A webropol survey was spread to global contact networks related to contaminated area remediation.

The questionnaire contained questions about:

- Used remediation methods
- Addressed contaminants
- Duration of the treatment

These subjects were divided into four parts:

1) Background information of the responder
2) Information regarding the methods used in the field (method, contaminant, year, the success of the treatment)
3) Evaluation of the methods
4) Future prospects

The questionnaire was carried out in Finnish, English and Russian. The material presented here is based on 28 replies to the questionnaire.

Questionnaire

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Survey respondent data

	Field of operation				Number of remediation projects			
	Consultant	Constructer	Authorit y	Researc h	Soil	Ground -water	Soil and ground-water	In situ projects from all remediation projects (%)*
Finland	5	1	3	1	59	10	15	17 %
United Kingdom	5				10	20	4	30 %
Germany				1	4	4	4	
Italy	2				3	0	7	
Spain				1	0	1	0	
Belgium	1				2	6	2	
United States	5				7	10	17	55 %
Brazil	1				0	4	0	
Australia	1				3	1	1	
Russia		1			4	0	19	
Total	**20**	**2**	**3**	**3**	**92**	**56**	**69**	**56 %**

Affiliation:

69,5% consultants
11% researchers
12,5% public authorities
7% contractors

Geography:

79% Europe
17% North America
Single answers from South America and Australia and Oceania.
No answers from Asia or Africa.

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Results: commonly used *in situ* methods

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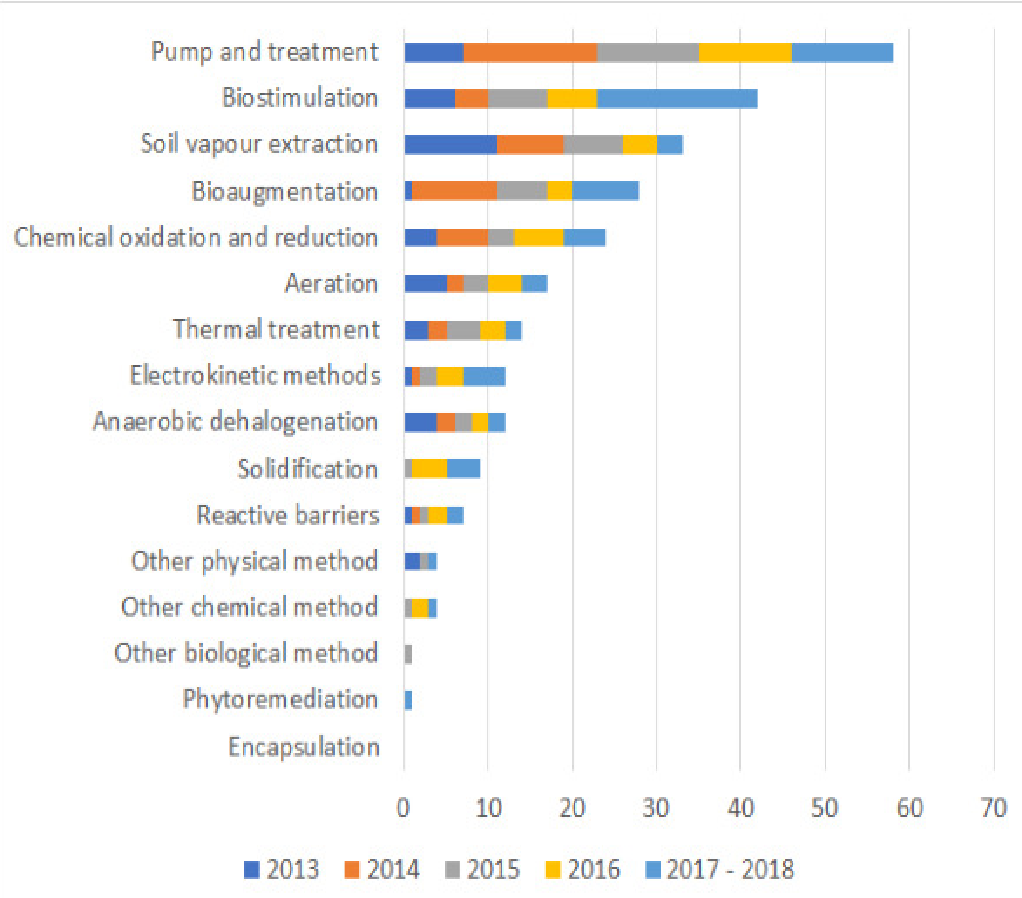

- **The most common method to treat contaminants in situ was groundwater pumping and treating (58%) and biostimulation (24%).**
- **Reactive barriers, solidification and phytoremediation were amongst the less used techniques (less than 10 cases in five years)**
- **Electrokinetic methods were used in 14 cases**

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Results:contaminants remediated by *in situ* methods

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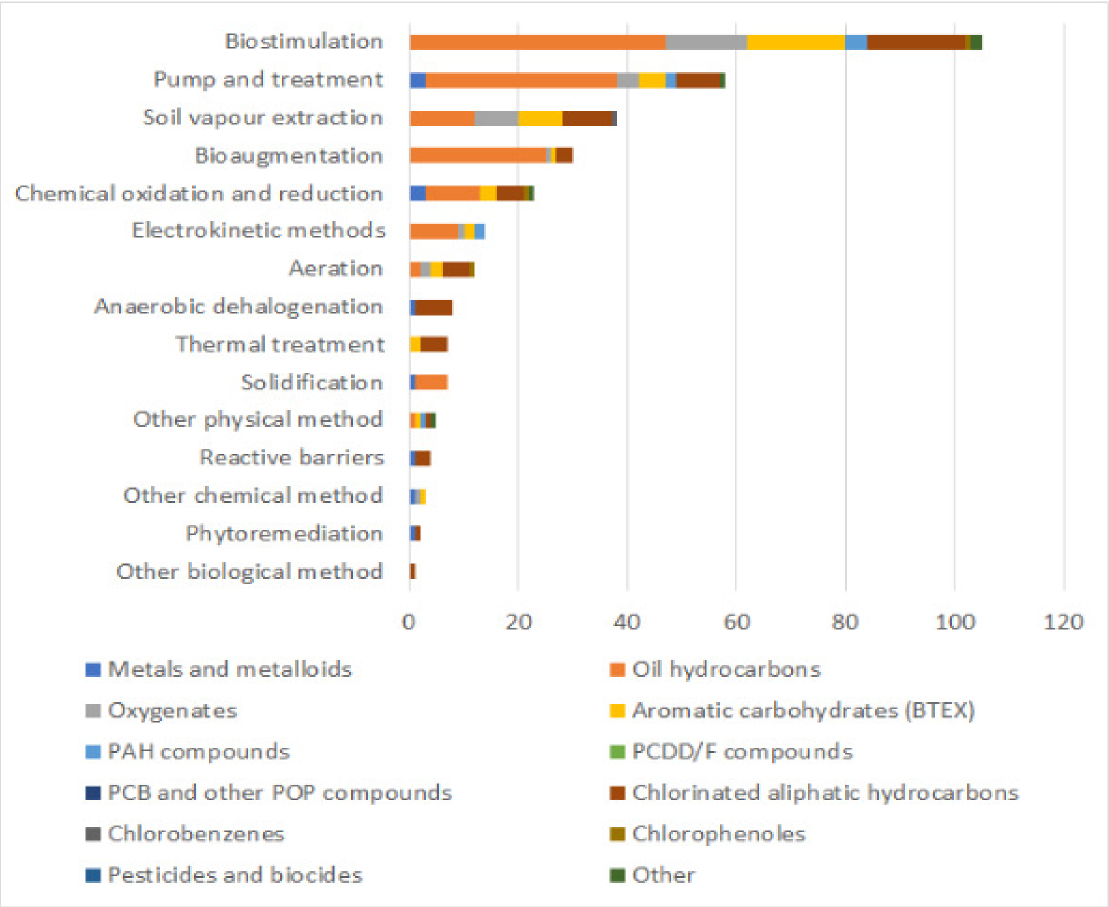

- **Pumping and treating,electrokinetic methods and biostimulation were used to degrade oil hydrocarbons and PAH compounds**
- **A lot of variation between results was seen in reactive barrier use, anaerobic dehalogenation and aeration**
- **No *in situ* solution was used for PCDD/F, PCB or other POP compounds, nor pesticides or biocides**

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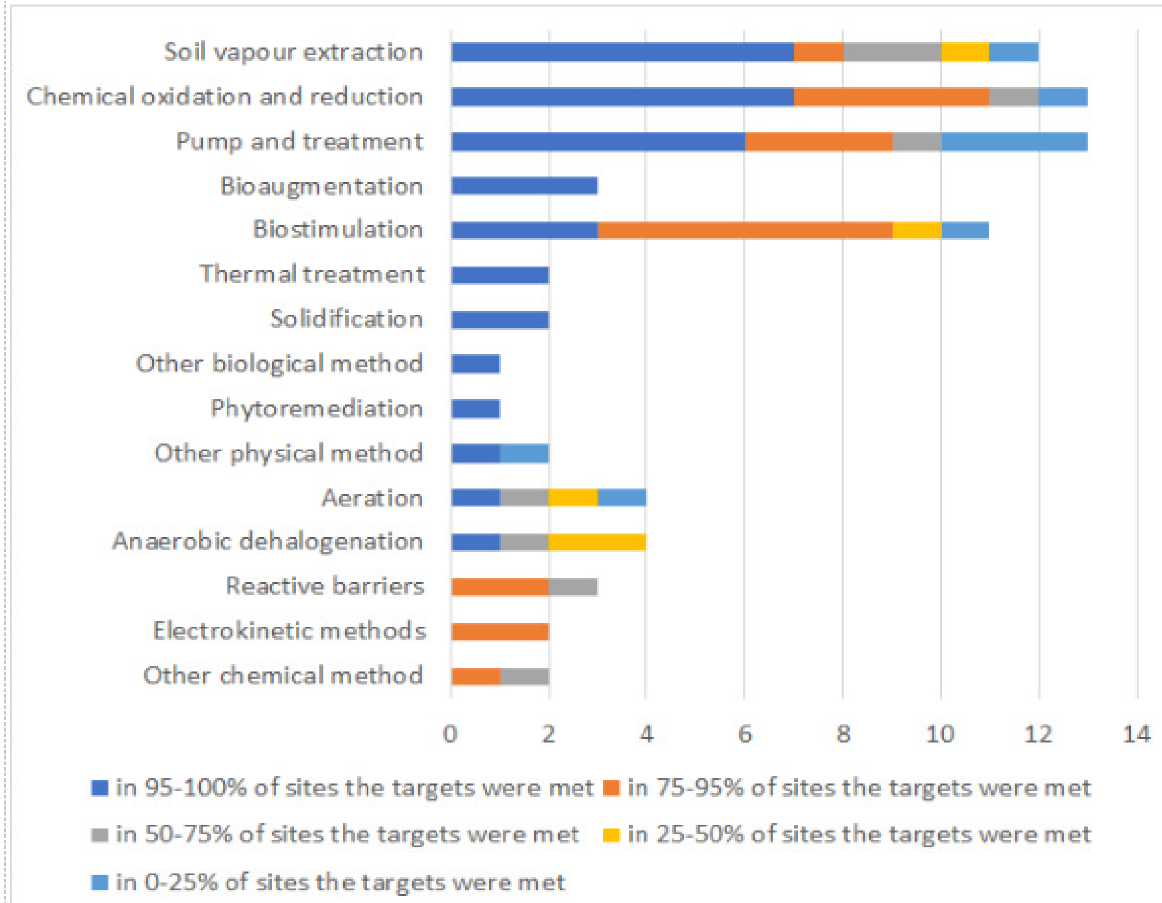
Evaluation of the methods

Methods success rates

- **Biostimulation, chemical oxidation and pumping and treating, had the best remediation success rates**
- **The least success was obtained using anaerobic dehalogenation**
- **Remediation targets were met entirely in 30% of the cases**
- **18% of the cases had less than 50% contaminants removed**



Evaluation of the methods

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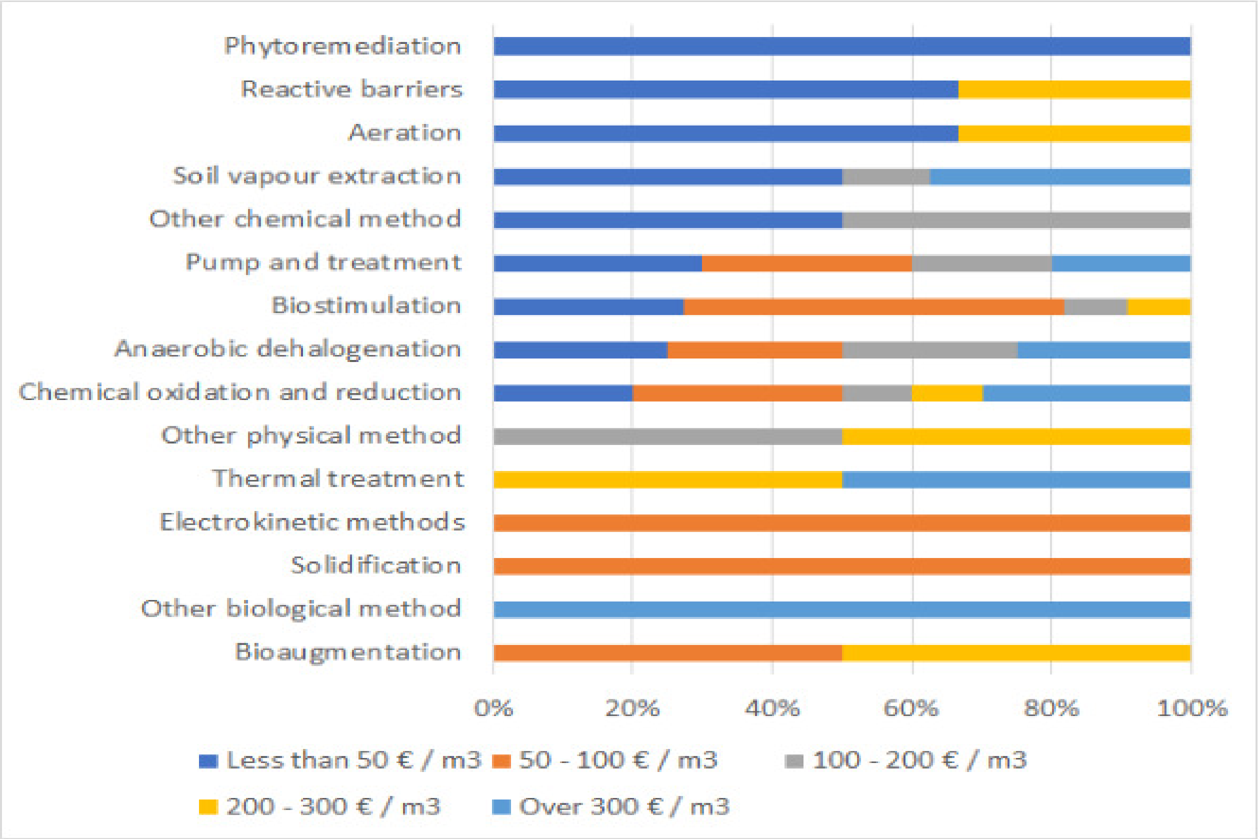
Costs

- **Biostimulation was deemed the most inexpensive method**
- **Remediation costs for different methods are difficult to compare, as certain methods are commonly used for easy sites and contaminants, and others are only used for inherently complicated cases. Costs are thus largely dependent on site properties**



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Evaluation of the methods

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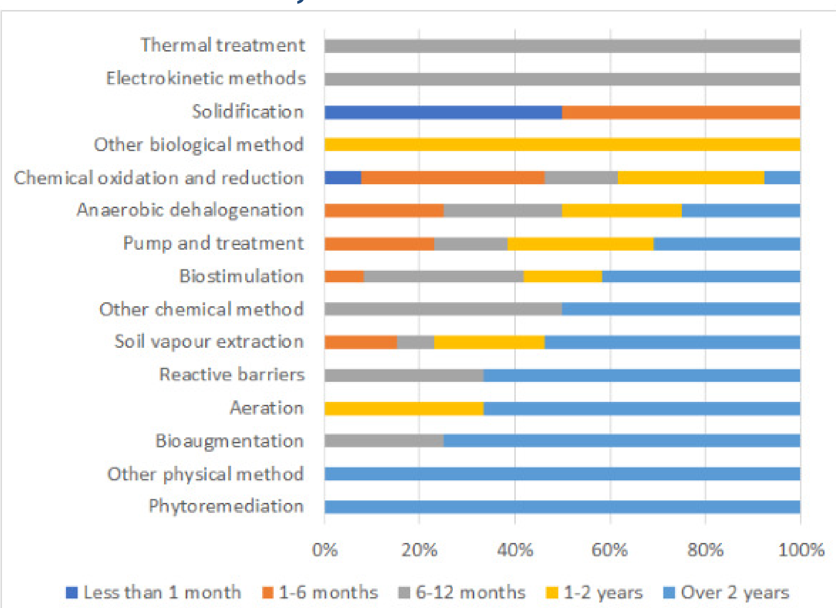
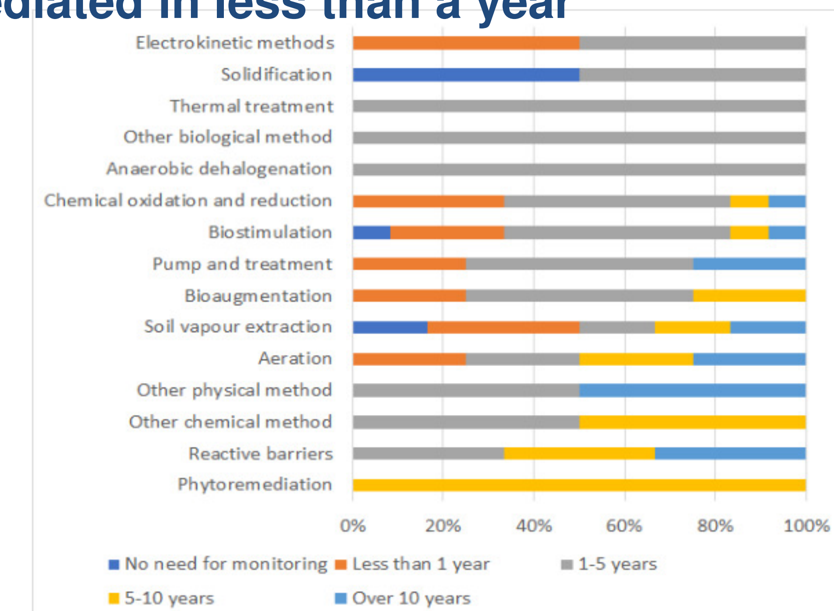
Time

- **Biostimulation treatment times vary, 60% of the sites were remediated in less than two years, with a lengthy monitoring period up to 5 years**
- **The duration of pumping and treating and the time needed for monitoring varies substantially**
- **Chemical oxidation and remediation is the least time consuming *in situ* method, 67% of the sites were remediated in less than a year**



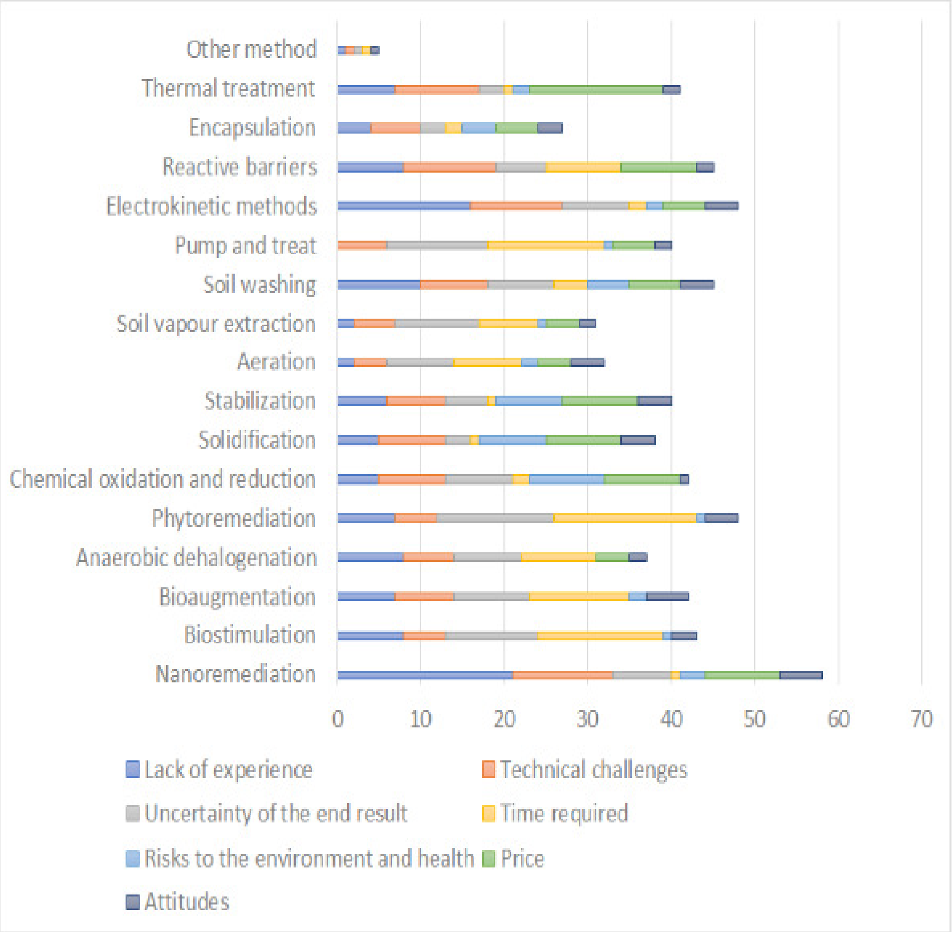
Remediation times



Monitoring times

Limiting factors

- **Choosing the correct method for the sites requires specific expertize**
- **All *in situ* methods have inherent unpredictability, and differences between treatment methods were small**
- **Physical methods, such as thermal treatment, encapsulation, stabilization and solidification were seen as less uncertain**
- **Stabilization and solidification, along with chemical oxidation and reduction were seen to contain the greatest risk to the environment**



Choosing the correct method

Method selection is always dependent on site properties

- **While interpreting the data one should keep in mind that the methods are not directly comparable. Site properties have a profound impact on the successfulness of the treatment**
- **Different methods have different requirements for the soil, the project should be planned accordingly**
- **Some methods, such as encapsulation, electrokinetic methods, and solidification suffered from poor availability. These methods have potential in the remediation of less degradable compounds such as chlorinated aliphatic hydrocarbons, PAH and BTEX compounds and metals and metalloids.**

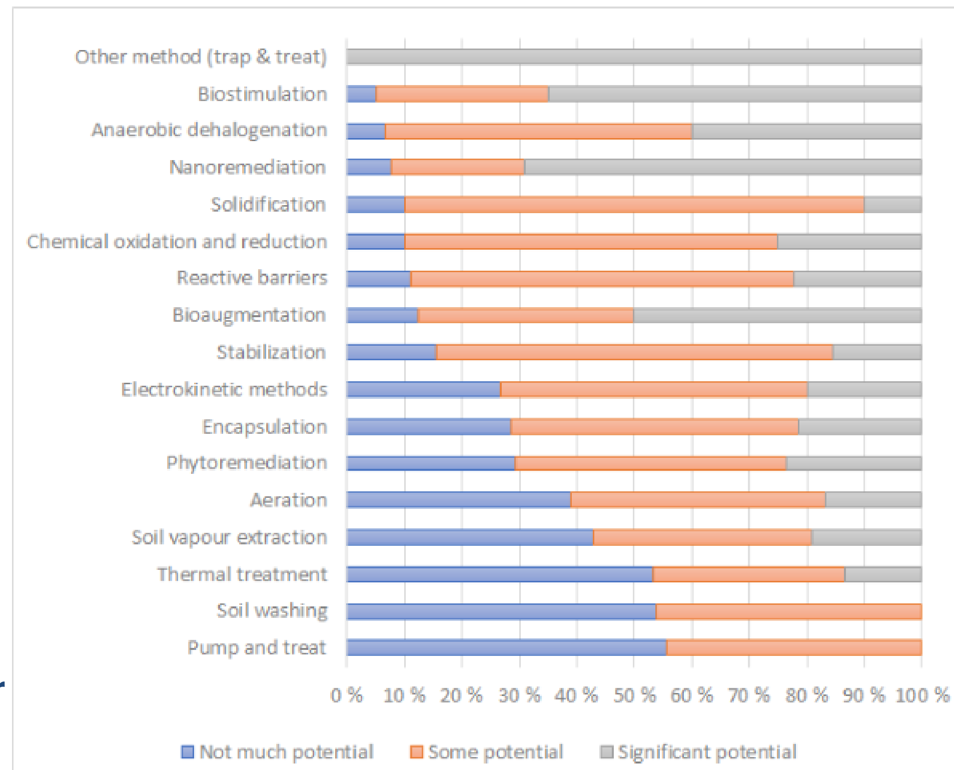
Future prospects

Potential

- **Many responders see a great potential in nanoremediation, biostimulation and coupled methods in the following years**

Nanoremediation

- **Nanoremediation is based on utilizing nanoscale materials in soil or groundwater remediation**
- **Nanoremediation is used by injecting slurry of nZVI in permeable reactive barriers (PRB)**
- ***In vitro* toxicity testing suggests that the reactive oxygen species released in treament can be harmful to soil micro- and macrofauna**
- **Several full scale remediation projects have been carried out in the USA using bimetallic and emulsified nZVI, but the precautionary attitude has hindered their application in Europe**



Future prospects

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Direct push injection

- The factor limiting several methods, e.g. bioaugmentation, biostimulation, chemical oxidation, as well as nanoremediation, is that the contaminant and the remediating agent do not physically meet
- In recent years, methods from geological surveys have been modified to overcome this shortcoming
- Biostimulation/bioaugmentation material are fed in the soil using drill rigs with a feeding system. In essence, remediation agent is injected in the soil using high pressure
- Direct push injection cannot be considered a novel technology in itself, but its application in *in situ* remediation has overcome some issues in older *in situ* techniques, such as biostimulation, chemical oxidation and reduction, and bioaugmentation, making them more feasible than before

Conclusions

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- **The results of the questionnaire highlighted, that most of the *in situ* treatment methods used in the past five years are the same that have been used for a long time. As such, no new methods were detected**
- **New applications of the old methods ensures good results**
- **A great deal of potential was seen in nanoremediation**
- **Coupling physical and biological methods has shown a great promise**
- **The shift from the use of single techniques to site-specific tailored solutions for each site has been a big trend in *in situ* remediation in the past five years.**

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Thank you!

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