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NorthPestClean - Demonstration of *in situ* alkaline hydrolysis as a new technology for remediation of pesticide contaminated soil and groundwater



Drilling in progress

In the period September 2010 to July 2014 a large European Commission funded demonstration project, **NorthPestClean**, was conducted. The project was carried out at the site, Groyne 42, located at the west coast of Denmark. The primary objective was to determine the efficiency of the soil remediation method "*in situ* alkaline hydrolysis" and to demonstrate, in side-by-side field experiments, various techniques to enhance delivery and contact between the reagent (caustic soda) and the contaminants (pesticides) in the subsurface.

The main objectives of

the project were to;

1. Document the efficiency of *in situ* alkaline hydrolysis
2. Test and compare "enhancement" technologies (delivery and contact)
3. Risk assessment-based "stop-criteria" for clean-up

The results from the pilot testing were used to design a full-scale remediation at the site.

A test site consisting of 3 test cells and 3 test pipes were constructed. In each of the 3 test cells separate technologies (acoustic vibration, recirculation and surfactant flushing) were



Soil sampling

implemented to enhance contact between caustic soda and the pesticides.

The efficiency of the *in situ* alkaline hydrolysis method and the performance of the enhancements were monitored throughout the project by analysing water and soil samples and calculation of contaminant mass removal and degradation rates.

Project results

The over-all results of the demonstration project showed that *in situ* alkaline hydrolysis can be used as an effective tool in the remediation

of pesticide contaminated soil and water. The efficiency of the method varied for the different pesticides at the test site. The

method was most effective in removing malathion, methyl parathion and sulfotep. The main contaminant at Groyne 42, Ethyl-

Planned dissemination

- Continual up-date of web; www.northpestclean.dk
- Site visits
- Usage of results in future remediation of the site
- Implementation of procedures
- Workshops and presentations
- Scientific articles

Project results - continued

	E-Sulfotop	MP3	Malathion	EP3	Total
TC1 Baseline	19	40	27	354	446
TC1 After Cycle 3	7	5	1	253	267
TC1 Removal	62%	88%	93%	29%	40%
TC2 Baseline	31	94	71	508	704
TC2 After Cycle 3	4	4	0	199	208
TC2 Removal	88%	99%	99%	61%	71%
TC3 Baseline	41	105	73	469	688
TC3 After Cycle 3	12	16	4	370	402
TC3 Removal	72%	85%	94%	21%	42%

The calculated removal of pesticides from the soil.

parathion, is the compound that has the lowest degradation rate. The table shows the removal of the pesticides from the soil after 2,5 years of treatment. The effect of the different enhancements was also been monitored. Test cell 3 (TC3) was used as a control/blind here no enhancements were applied. In TC1 the enhancement "acoustic vibration" was tested. It did not have a sig-

nificant effect on the rate of alkaline hydrolysis. The enhancement "recirculation" in TC2 had no significant effect on the rate of alkaline hydrolysis but had a positive effect on the distribution of caustic soda in the sediment. The "surfactant flushing" in TC2 also had no significant effect on the rate of alkaline hydrolysis but it greatly increased the dissolution of the pesticides in

the groundwater and thereby enhanced the removal of the pesticides from the soil.

The stop-criteria based on risk assessment shows that no removal of mercury is necessary (from a risk point of view) but ethyl-parathion has to be almost fully removed from both the water and soil phase.

Dissemination strategy

The strategy for dissemination is differentiated to the defined target groups.

- 1) local stakeholders,
- 2) politicians,
- 3) national professionals,
- 4) international professionals etc.

Different media has been applied. Such as pamphlets, presenta-

tions, workshops, radio, videos etc.

Within the project period the objectives for dissemination defined in the proposal have been met and there has been an extensive interest wherever the project has been presented.

The after-life strategy

will be similar to the strategy from the project. The different target groups will be reached through the relevant media, e.g. international professionals are reached through articles in international papers or presentations at conferences.

"The strategy for dissemination is differentiated to the defined target groups"

After-Life communication activities

Numerous activities have been planned to be carried out during the coming years.

- 1) the **web-page** will be maintained and kept up to date with the newest information.
- 2) the results of the

project and the method of *in situ* alkaline hydrolysis will be included as an option in the **future remedy selection process for Groyne 42**. It may be developed further to be combined with other methods.

- 3) the site, Groyne 42,

will be a part of a **"Danish Soil Tour"** and visitors will be introduced to the LIFE-project. Furthermore the site will be available for visits from foreign delegations on request.

- 4) parts of the project will be **implemented**



Test pipe before installation

After-Life communication activities - continued

in the regional procedures for managing of contaminated sites. The **stop-criteria based on risk-assessment** was based on a specific concept including different models for dilution and transport. The concept will be implemented in order to establish remediation stop-criteria at other contaminated sites within the region. The stop-criteria established in the project will be used in the future remediation of Groyne 42.

The **sustainability assessment tool** (spin-of project, to NorthPestClean). Is a tool to compare the sustainability of different remediation methods. The tool is a multi-criteria model, which includes five main criteria; a) effect, b) economy, c) time, d) environment and e) society. The tool/approach involves close collaboration with key stakeholders in every case. This approach for sustainability assessment will be implemented in the regional procedures to improve the basis for selecting the most "sustainable" remedy.

5) regularly dissemination activities at inter-

national and national **workshops and conferences** are planned to take place over the coming years. Below is a list for the planned activities, additional activities will be added later;

- NordRocs - Sep. 2014 - *5th Nordic Joint Meeting on Remediation of Contaminated Sites - Stockholm, Sweden.*
- AquaConSoil - June 2015 - *13th International UFZ-Deltares Conference on Sustainable Use and Management of Soil, Sediment and Water Resources - Copenhagen, Denmark.*
- Battelle - May 2016 - *Tenth International Conference on Remediation of Chlorinated and Recalcitrant Compounds - Monterey, USA.*
- Envina - Oct. 2014 - *Årsmøde Jord- og Grundvandsforurening, Horsens, Denmark.*
- ATV Vintermøde - Marts 2015 - *workshop on soil and groundwater contamination, Vingsted, Denmark.*
- Sustainable Remediation - Sep. 2014 - *The 3th International Conference on*

Sustainable Remediation, Ferrara, Italy

6) a **technical video** had been prepared and will be available by October 2014 at the website. The video will be used in presentations and at workshops.

7) results from the NorthPestClean project have been **presented** to Environmental government officials in Shanghai and Chengdu (**China**), with the purpose of sharing knowledge on the new method "In situ alkaline hydrolysis".

8) to ensure the exchange of knowledge through-out Europe several **scientific articles** are in preparation. Below is a list of the articles being prepared;

- Alkaline hydrolysis – *in situ* testing
- Surfactant - screening, choice and testing *in situ*
- Acoustic vibration
- Mercury - speciation and behaviour when using alkaline hydrolysis
- The effect from alkaline hydrolysis on the "natural chemistry"
- Quantification of NaOH demand during alkaline hydrolysis



Water samples

"...regularly dissemination activities at international and national workshops and conferences..."



On-line control of the recirculation system

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for further information



Central Denmark Region is one of five administrative units in Denmark. The primary responsibility of Central Denmark Region is healthcare, involving responsibility for hospital services, including psychiatry, health insurance, general practitioners and specialists. In addition the region operates a number of social institutions.

Furthermore, the region will ensure end coordinate regional development in areas such as nature, environment, business and tourism. The region must secure the overall strategy and at the same time a top quality of services. Around 30.000 employees work to carry out regional tasks at all levels.

The department of environment has the task of identifying, characterising and remediate contaminated sites. The objective is to protect groundwater resources, nature and to ensure human health within the private homes.



NorthPestClean
Pesticide Remediation



Danish Ministry of the Environment
Environmental Protection Agency



The project is supported through LIFE+, a program of the European Union. Since 1992, LIFE has co-financed some 3104 projects across the EU, contributing approximately €2.2 billion to the protection of the environment.

Project organisation

The NorthPestClean project was conducted by joint funding by the European Commissions LIFE+ programme, the Danish Environmental Protection Agency and the Central Denmark Region.

The Central Denmark Region was responsible for the implementation of the project.

The Danish EPA contributed through a Steering Committee. The Steering Committee was consulted in all matters that had fun-

damental influence on the projects objectives and economy.

The establishment of the test area were preformed by NCC, Denmark and the experiments were implemented by a consortium consisting of COWI A/S, Rambøll A/S, Kogsgaard Miljø and Geosyntec Consultants (USA).

All after-life activities are organised by the Central Denmark Region