Remediation of the pesticide-contaminated site "Groyne 42"

In situ alkaline hydrolysis – a new soil remediation technology

Børge Hvidberg (boerge.hvidberg@ru.rm.dk) and Morten Bondgaard (morten.bondgaard@ru.rm.dk)
Central Denmark Region, Soil and Natural Ressources, Lægårdvej 12, 7500 Holstebro, Denmark

Background:

- "Groyne 42" is a former chemical dump site located in the dunes close to the North Sea, at the western coast of Jutland, Denmark (photo 1 and 2).
- From 1957 to 1962 tons of chemical waste from the production of organophosphorous pesticides and other chemicals were deposited at the site.
- Today, the area is still heavily contaminated by approximately 260 tons of organic compounds, primarily the highly toxic insecticide ethylparathion.
- The contaminated area, encompassing 20,000 m², was in 2006 enclosed with a 14-meter deep steel sheet piling and a plastic membrane cap (photo 3 and figure 1).
- Since 2006, research into a novel treatment train consisting of enclosure, *in situ* alkaline hydrolysis and pump-and-treat has been carried out by the Central Denmark Region (Region Midtjylland) and the Danish Environmental Protection Agency.

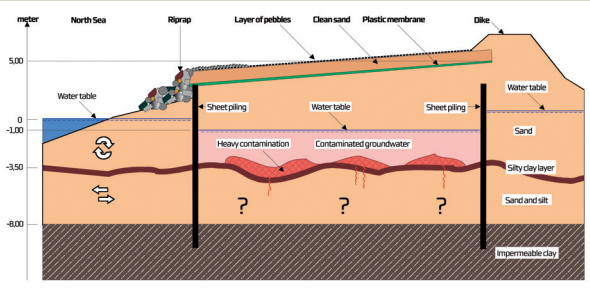

Figure 1: Principle sketch of the enclosed site.

Aims of the pilot test:

- To characterise the geochemistry, the redox conditions and the buffer capacity of the sediment at Groyne 42, and to determine infiltration rates of diluted caustic soda into the sediment, as well as determine the sediments' water retention properties.
- To demonstrate in the field that a solution of diluted caustic soda can be delivered effectively subsurface and soil pH can be raised and kept at pH >11 for a prolonged time.
- To demonstrate *in situ* that alkaline hydrolysis is a suitable method to remediate soil and groundwater contaminated by organophosphorous pesticides.

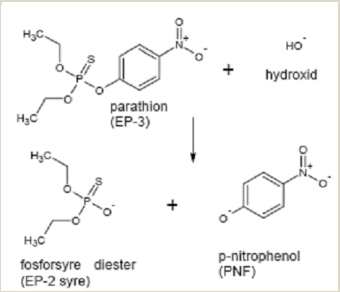

Figure 2. The process of alkaline hydrolysis shown with chemical structures

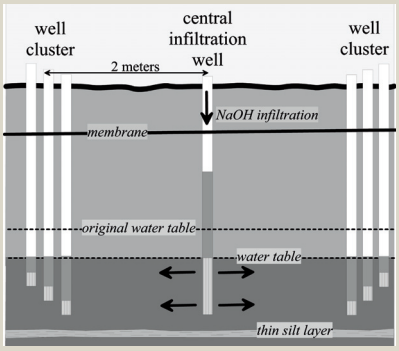

Figure 6. Principle sketch of the field test design

Principle of the treatment:

- Enclosure of the area by steel sheet piling (figure 1)
- Drain-off the groundwater (hydraulic control)
- Treatment cycle:
  a. Infiltration of the soil by diluted NaOH – pH in soil is raised to 12
  b. Incubation time /contact enhancements - to allow the alkaline hydrolysis to take place sub-surface.
  c. Pump and treat - the alkaline solution, containing the watersoluble breakdown products of ethyl-parathion, is pumped up and treated in a wastewater plant.
- Repeat treatment cycle 2-3 times.

Photo 1. The chemical dump site "Groyne 42" is located on the beach near the North Sea. The agrochemical factory Cheminova is seen in the foreground.

Photo 2: Location of the chemical dump site "Groyne 42" in the dunes close to the North Sea

Photo 3: The contamination at "Groyne 42" is enclosed by a 14 m deep steel sheet piling

Result:

- pH in the sediment was raised to >11, and kept at this level for over 17 months.
- *In situ* degradation of ethyl-parathion was demonstrated.
- The concentration of the ethyl-parathion degradation products (EP3 and PNF) in the water of the observation wells increases gradually for 17 months after NaOH injection.

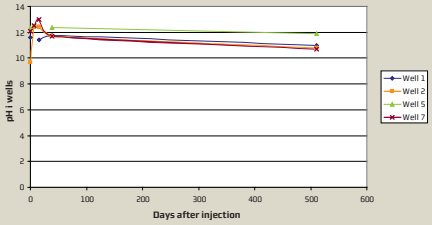

Figure 3. pH in the observation wells after NaOH injection

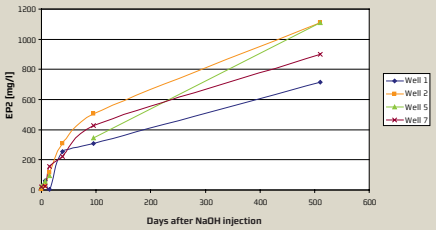

Figure 4. Concentration of the ethyl-parathion breakdown product "EP2" in the observation wells after injection with NaOH.

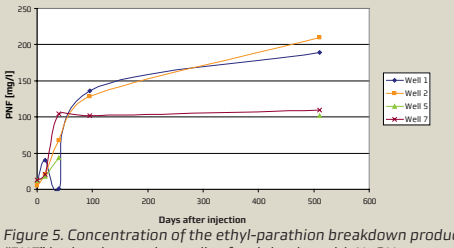

Figure 5. Concentration of the ethyl-parathion breakdown product "PNF" in the observation wells after injection with NaOH.

Conclusions

- Caustic soda was successfully injected into the sediment and soil pH raised to 12
- *In situ* degradation of ethyl-parathion was demonstrated.
- The effectiveness of the method (mass removal) needs to be quantified.

Field experiments planned for 2010- 2013

- The effectiveness of *in situ* alkaline hydrolysis will be quantified in field studies.
- Test cells (each 100 m²) will be constructed as areas encapsulated by a 14 m deep steel sheet piling.
- So-called "enhancement technologies" will be tested side-by-side in the test cells with the purpose of improving delivery of the diluted caustic soda in the soil and enhancing contact between the contaminants and the alkaline solution.
- Measurable remediation stop-criteria will be established based on an environmental risk assessment.