ELECTRO-RECLAMATION:

A new technique for In Situ and On/Off soil remediation

Electro-Reclamation in practice — Anode-series with circulation system and electricity supply. Cathodes are installed horizontally in between anode rows. In the background are containers for conditioning and treatment of electrode-solutions.

Soil pollution is a subject which will preoccupy us for years to come. Numerous locations have been characterized as polluted and many have already been inventorized, but the actual clean-up operation lags behind, due to either financial and/or technical constraints. Especially heavy metals like Copper, Zinc, Chromium, Lead, Cadmium, Mercury, Arsenic, etc. are difficult to remove; more so when the soil is clay, sandy clay or clayey sand. The permeability of these soils ranges from almost zero (clay) to moderate (clayey sand), which makes it difficult, if not impossible, to "flush" the soil with watery solutions in order to get rid of the pollution.

During the past years, the company Geokinetics, based in the Netherlands, has been successful with a technology which has been called "Electro-Reclamation", which is based on a combination of Geochemistry, Geohydrology, Electrochemistry and Electrotechnology.

The method makes use of electrical current which is sent through the soil by means of alternating anode and cathode arrays. In case of shallow pollution (up to 1.5 m), the electrodes can be installed horizontally, otherwise vertical installation is necessary. The current starts a number of electrokinetical processes, which force the pollutants to collect around the electrodes. These electrokinetical processes are independent of the hydraulic properties of the soil, hence its application possibilities for clay and clayey soils. All pollutants which have a charge, or can get a charge, participate in the process. So it does not only apply for heavy metals, but also for cyanides, phosphates, nitrates, polar inorganics, etc. Recent laboratory research using different electrical parameters came up with promising results regarding the removal of a-polar PCA's and PCB's.

The pollutants are captured in a solution, which circulates around the electrodes. There are such circulation systems for both the cathodes and the anodes.

part from capturing the pollutants, the circulation systems are used to control the physical/chemical conditions around the electrodes like pH, redoxpotential etc., which is a major prerequisite for the process to continue successfully. Uncontrolled electro-reclamation will result in acidification of the soil around the anodes and precipitation of metalhydroxides around the cathodes.

The electrokinetic installation is mobile and built in two or three containers. When large areas have to be cleaned, a series of these units can be put together. A preliminary laboratory test with a representative soil sample gives information about time-duration and energy-consumptions. The more polluted the soil, the longer the operation will last, and the more energy will be necessary. The speed at which the pollutants moves depends a.o. on the potential drop which can be realized between anodes and cathodes. The energy supply is, however, bound to a maximum, not only because of safety risks, but also because of temperature rises in the soil to such values that a proper functioning of the installation is jeopardized.

In situ electro-reclamation lasts one to several months, or even years. Highly contaminated soils are more economically cleaned when using a relatively low energy supply over a longer period of time. Clean-up activities to date consist of the following projects:

Project 1	**In situ field test, year 1987**
Locality	*Site of a former paint factory in Groningen*
Size	*Length 70 m, width 3 m, depth 1 m (210 m³)*
Pollution type	*Copper (Cu) and Lead (Pb) in peat soil*
Conc. at beginning	*Cu > 5.000 mg/kg, Pb 500 - 1.000 mg/kg*
Conc. at end	*Cu 80• reduction, Pb 70• reduction*
Test period	*43 days of 10 hours*
Energy consumption	*38 kwh/ton*

Project 2	**In situ field test, year 1988**
Locality	*Site of galvanizing plant in Delft*
Size	*Length 15 m, width 6 m, depth 0.5 m (50 m³)*
Pollution type	*Zinc in clay soil*
Conc. at beginning	*Max. > 7.000 mg/kg, average 2.400 mg/kg*
Conc. at end	*Average 1.620 mg/kg, reduction 33•*
Test period	*53 days of 16 hours*

Project 3	**In situ remediation project, year 1989**
Locality	*Site of former timber impregnation plant*
Size	*Length 25 m, width 15 m, depth 1-2 m (250 m³)*
Pollution type	*Arsenic (As) in heavy clay soil*
Conc. at beginning	*Max. 500 mg/kg, average 115 mg/kg*
Conc. at end	*Max. 30 mg/kg, average 10 mg/kg, reduction > 90%*
Time period	*80 days of 18 hours*
Energy consumption	*150 kWh/ton*

Project 4	**Off site remediation project, year 1990-1991**
Locality	*Site of a temporary soil deposit*
Size	*Length 70 m, width 40 m, depth 2.6 m*
Pollution type	*Cadmium (Cd) in fine argillaceous sand*
Conc. at beginning	*Max.* >22.000 mg/kg, average 250 mg/kg
Conc. at end	Cd <22 mg/kg
Time period	Estimated on two years
Energy Consumption	Estimated on 200 kWh/ton

Remediation costs are competitive with conventional methods, but in most cases there is no other alternative than excavating and dumping the soil on a (controlled) soil disposal site. In that case, however, the soil is still constituting an environmental problem, as it is still (heavily) polluted.

In situ and off-site remediation is a first practical application of electro-reclamation. Other developments are on-site cleaning of (already) excavated soil in specially constructed containers (capacity 5-8 m³/hour), cleaning river, industrial and municipal waste sludges in (semi) permanent installations (capacity up to 60 m³/hour) and desalinization of arable land.

Additionally, the method can be used to fence off potentially hazardous industrial or waste sites, and when such a fence consisting of a row of alternating anodes and cathodes, spaced 5 to 10 m apart, is installed perpendicular to the general direction of groundwater flow, the groundwater passing through such an electrokinetic screen will also be cleaned.

Finally, a very interesting development seems the combination of biodegradation with electro-reclamation. It turns out that electro-kinetic processes can favourably influence and optimize the boundary conditions of biodegradation e.g. temperature and oxygen supply.

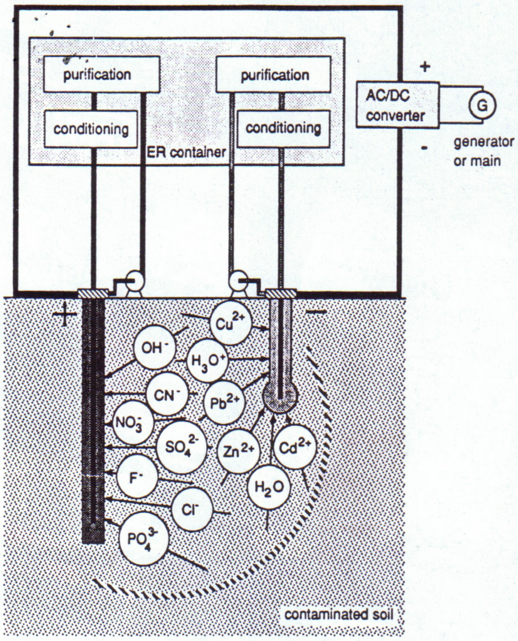

Fig. 1

circulation system

current supply

boundary of electrokinetical treatment

Schematic representation of ER-field unit and electrokinetical transport in the soil

Drs. R. Lageman
Geokinetics
Poortweg 4
2612 PA Delft
The Netherlands
Tel. 31-15-610637
Fax. 31-15-622056