Karl-Winnacker-Institut Electrochemistry

In situ process for improvement of microbiological ground water and soil remediation by electrokinetic dispersion effects

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Introduction

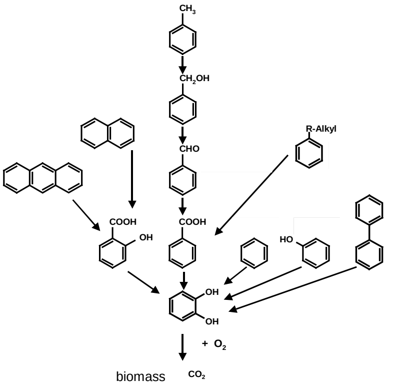

Fig.1: Reaction scheme of BTEX and PAHs degradation.

BTEX (Benzene, Toluene, Ethylbenzene and Xylene) and PAHs (polycyclic aromatic hydrocarbons) are typical pollutants of groundwater in the surrounding of gas plants. The aerobic degradation of aromatic hydrocarbons by micro-organisms takes place in a multi step process by successive degradation of each ring. Degradation under consumption of oxygen starts with building of dihydrodiol followed by an cleavage into acids and smaller fragments. The last ring will be degraded by building of salicylic acid and pyrocatechol. At last a mineralization into biomass and carbon dioxide takes place. Toluene will be degraded by formation of benzyl alcohol and benzyl aldehyde (Fig.1). The anaerobic degradation process will be supported by anions like nitrates and sulphates. For the degradation in the soil the bioavailability of each component like pollutant, nutrient and micro-organisms in the same place is very important. Dispersion of the components perpendicular to the flow direction of groundwater is very weak, so that the support of transport in this direction by electro-kinetic processes like, electro-osmosis and electrophoresis and migration of ions (Fig.2) is necessary. In that case coincidence of all components takes place to optimize the degradation process.

Objective

Aim of this project is the stimulation of microbiological groundwater and soil remediation by electro-kinetic dispersion effects to overcome mass transport limitation of the natural degradation process. The nutrients will be transported in the depleted regions to get bioavailable for the remediation process to shorten the contaminated downstream region.

Electro-kinetic processes and migration of ions

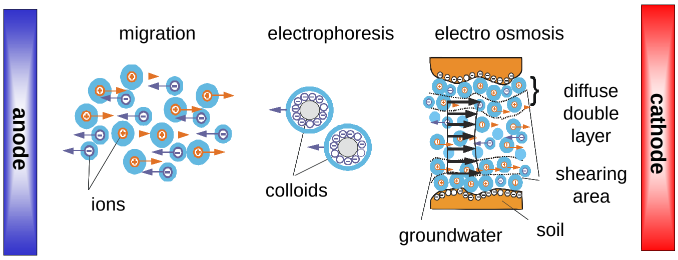

Fig.2: Electro kinetic processes and migration of ions.

Possible redox-reactions of BTEX and PAH were tested, taking Naphthalene-1,5-disulfonic acid as an example. In cyclovoltammetric measurements no oxidation or reduction at BDD (fig. 3) or Pt-electrodes is observed.

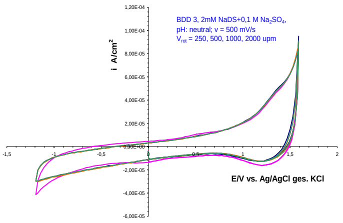

Fig.3: Cyclic Voltammograms of Naphthalene-1,5-disulfonic acid.

Migration of MnO_4^- ions in silica sand and normsand®

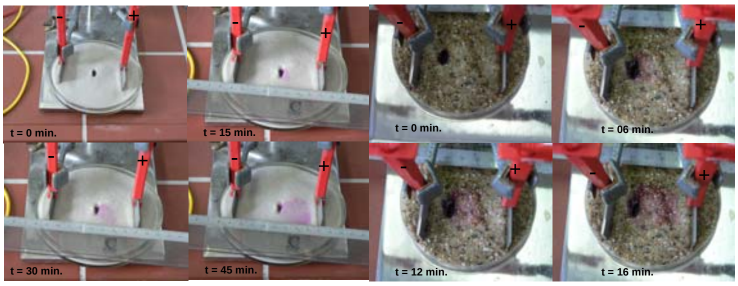

Fig. 4: Migration of MnO_4^- - Ions as dyer in silica sand (left) and normsand® (right). Cell voltage: 15-30 Volt; $I_{init.}$ = 0,38 – 2,20 mA; water/sand ratio: 0,25; h_s= 5 mm; v_m = 4-10 cm h^{-1} . Anode and cathode material: stainless steel.

Measurement of local field parameter in an aquifer

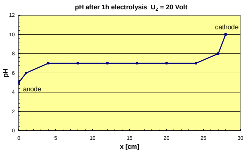

Fig. 5: Local pH in aquifer without clay

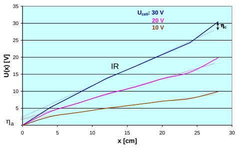

Fig. 6: Cell voltage in aquifer without clay

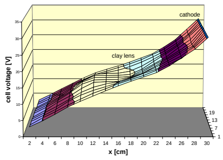

Fig. 7: Cell voltage (3 D) in aquifer with clay

At the anode the pH decreases due to the oxygen evolution electrode reaction and at the cathode the pH increases owing to the hydrogen evolution reaction (Fig.5). The cell voltage must be further divided into its components: anodic and cathodic overvoltage η_c ,η_a and the IR drop (Fig.6). Heterogeneities like clay lenses could be detected by the change of cell voltage due to the change of local conductivity in the aquifer (Fig.7). The change of the local electric field E(x) and the deviation of field lines could be measured with a double electrode with two platinum wires (Fig.8-10). The distribution of local currents in the aquifer shown in (Fig. 11) has been calculated from E(x) and the local resistant ρ(x).

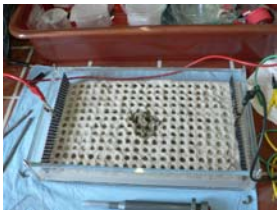

Fig. 8: Aquifer with clay lens

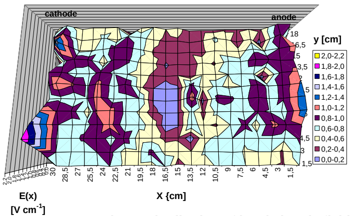

Fig. 9: Distribution of local electric field

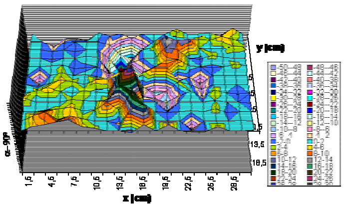

Fig. 10: Deviation of field lines

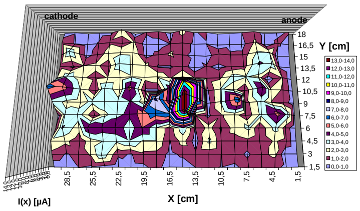

Fig. 11: Distribution of local current