



Investigating bioremediation of petroleum hydrocarbons through landfarming using apparent electrical conductivity measurements

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Bioremediation of soil contaminated with petroleum hydrocarbons through landfarming has been widely applied commercially at large scale. Biodegradation is one of the dominant pollutant removal mechanisms involved in landfarming, but strongly depends on the environmental conditions (e.g. presence of oxygen, moisture content). Conventionally the biodegradation process is monitored by the installation of field monitoring equipment and repeated sample collection and analysis. Because the presence of petroleum hydrocarbons and their degradation products can affect the electrical properties of the soil, proximal soil sensors such as electromagnetic induction (EMI) sensors may provide an alternative to investigate the biodegradation process of these contaminants.

We investigated the relation between the EMI-based apparent electrical conductivity (ECa) of a landfarm soil and the presence and degradation status of petroleum hydrocarbons. The 3 ha study area was located in an oil refinery complex contaminated with petroleum hydrocarbons, mainly composed of diesel. At the site, a landfarm was constructed in 1999. The most recent survey of the petroleum hydrocarbon concentrations was conducted between 2011 and 2013. The sampling locations were defined by a grid with a 10 m by 10 m cell size and on each location a sample was taken from four successive soil layers with a thickness of 0.5 m each. Because the survey was carried out in phases using different georeferencing methods, the final dataset suffered from uncertainty in the coordinates of the sampling locations.

In September 2013 the landfarm was surveyed for ECa with a multi-receiver electromagnetic induction sensor (DUALEM-21S) using motorized conveyance. The horizontal measurement resolution was 1 m by 0.25 m. On each measurement location the sensor recorded four ECa values representative of measurement depths of 0.5 m, 1.0 m, 1.6 m and 3.2 m. After the basic processing, the ECa measurements were filtered to remove anomalies resulting from small metallic objects. Next, the ECa measurements were interpolated to average values for blocks of 2.5 m by 2.5 m using ordinary block kriging to meet the location uncertainty of the corresponding hydrocarbon concentration observations.

Comparison of the block ECa values representative of different depths with the petroleum hydrocarbons concentrations observed in the different landfarm layers suggested a relationship between ECa and the level of biodegradation. Zones with a large ECa corresponded to zones where high microbial degradation activity was expected and vice versa. This indicates that EMI-based ECa surveying can support the monitoring of the bioremediation process in landfarms and subsequent decisions on operating parameters. Furthermore, studying the relationship between ECa and the petroleum hydrocarbon concentrations can improve the understanding of microbial degradation processes.