

## **Performance evaluation of unactivated and activated persulphate oxidation for in-situ contaminated soil remediation applications**

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### **ABSTRACT**

There is a legacy of contaminated land spread across the UK and the world, created by long-standing, ill-regulated use of land resources. To achieve sustainable land use, there is a shift in policy from development on virgin land to construction on contaminated land. Consequently, there is an increased demand for efficient and faster remediation techniques. In-situ chemical oxidation presents a viable land remediation technique due to its ability to deliver effective remediation in fast time scales. However, this method often alters the physical, mechanical and geotechnical properties of treated ground. Hence, there is need to develop chemical oxidation techniques which degrade contaminants effectively and delivers improved post-remediation ground conditions.

In the light of the above, this research investigated three aspects of in-situ persulphate oxidation of contaminated soils. The first part involved the review and analysis of data generated from previous lab studies on the natural oxidant demand (NOD) exerted as a result of the interaction between persulphate and natural constituents of soil and groundwater materials. Correlation studies were performed to examine the relationship, if any, between the NOD and select chemical species and minerals in the soil and groundwater. The second part of the research involved experimental studies on ferrous iron- and cement- activated persulphate oxidation of artificially contaminated model soils and real contaminated site soils. Model sandy soils spiked with dodecane was treated using sodium persulphate dosages ranging from 5g/kg - 60g/kg catalysed by ferrous iron at various mole ratios under low water to soil conditions. For the cement-activated persulphate oxidation experiments, dodecane-spiked model soils and real contaminated site soils were treated with 5% and 10% cement respectively in addition to persulphate dosages ranging from 5g/kg to 50g/kg of the dry weight of the soil. The third part of the study reported field trials on a contaminated site in the UK, using ferrous iron-activated persulphate techniques developed in the lab treatability studies. The performance of the treated soils was assessed using organic leachability, persulphate consumption profile, heavy metal mobility and leachate pH. Cement-activated persulphate treatments were subjected to additional mechanical and microstructural tests including bulk density, unconfined compressive strength, X-ray diffraction, scanning electron microscopy and thermogravimetric analysis.

The investigation revealed that  $NOD_{clay} > NOD_{silt} > NOD_{sand}$ . Correlation analysis showed that there is no significant association between the NOD exerted by persulphate and the amount of iron minerals, carbonates, chlorides and sulphates present in the soil and groundwater samples. It was shown that ferrous iron-activated and cement-activated persulphate oxidation successfully reduced contaminant mass in model and contaminated site soils. Ferrous iron-activated persulphate treatments of the contaminated site soils led to mobilisation of heavy metals, although the percentage of metals leached out were low compared to the total mass of heavy metals present in the soils. On the other hand, cement-activated persulphate treatments led to the immobilisation of heavy metals within the contaminated site soils. The results suggest that soils treated with cement-activated persulphate oxidation can achieve suitable physical and geotechnical post-remediation

properties if the oxidant is utilised in moderate amounts. High oxidant dosages yielded low post-remediation unconfined compressive strengths. This was attributed to the copious presence of sulphate-bearing minerals in the soil. Field trials using ferrous iron-activated persulphate treatments resulted in significant reduction of the contaminant mass in the site soil.