



## Book review

### **Principles and Practices of in situ Chemical Oxidation Using Permanganate**

Robert L. Siegrist, Michael A. Urynowicz, Olivia R. West, Michelle L. Crimi, Kathryn S. Lowe, Battelle Press, Columbus, OH, USA, 2001, US\$ 75.00, 367 pp., ISBN: 1-57477-102-7

In situ chemical oxidation is, the authors state, a viable remediation technology for certain organic contaminants mass reduction in source area as well as for plume control. The oxidants most commonly employed in this remediation process are hydrogen peroxide, ozone and permanganate. Alkanes, alkenes and explosives are compounds successfully oxidized with chlorinated organics being a common target contaminant.

The choice of in situ chemical oxidation over other source treatment methods (e.g. surfactant flushing, thermally enhanced recovery, etc.) has been motivated (in at least 100 completed or design stage applications) by the ability of chemical oxidation to (1) be engineered to accommodate site specific conditions, (2) be implemented quickly with commercially available equipment and materials, and (3) yield measurable results in a few months. Of the oxidants available, permanganate is often the preferred one because of the wide pH range over which it is effective, because it oxidizes by electron transfer rather than via a free radical process and thus, has a slower reaction enabling delivery and transfer and, finally, permanganate has lower gas and heat evolution and a lower risk for release of fugitive emissions.

The book appears to have resulted from a US Department of Energy (DOE), Office of Science and Technology sponsored project through their Subsurface Contaminates Focus Area Group. The book has eight well-written, well-illustrated and very well-referenced chapters.

Chapter 1 contains, not surprisingly, an overview of the problem of subsurface contamination of toxic chemicals (especially chlorinated organics) in soil and groundwater at industrial and military sites in US and abroad. The evolution of in situ chemical oxidation (ISCO) as a site remediation topic is reviewed, followed by a description of the chemistry of hydrogen peroxide and Fenton's reagent, ozone chemistry and reaction rate equations, and finally permanganate (both potassium and sodium varieties). As evidenced by the thoroughness of literature cited, I note the authors referenced 70 papers/reports.

In Chapter 2, the authors describe in detail the principles underlying permanganate oxidation of organics. The properties and characteristics of both potassium permanganate (sold as a solid) and sodium permanganate (sold as a liquid 40 wt.% permanganate) are given. Also detailed are permanganate reaction chemistry and reaction kinetics.

Chapter 3, entitled “Permanganate effects of metals in the subsurface”, discusses the impact on heavy metals (of alteration in pH and Eh), changes in ionic composition, removal in alteration of natural organic matter and production of MnO<sub>2</sub> solids. The concern is that destruction of natural organic matter yields increased heavy metal contamination/mobility.

Chapter 4 also discusses their concern for subsurface changes as a result of permanganate use. Described are potential effects of (1) altered behavior of organic contaminants of concern, (2) changes in permeability due to particle genesis and gas evolution, (3) geochemical and microbial perturbations, and (4) introduction of toxic contaminants of concern from impurities and reaction byproducts thereof.

The next three chapters (5–7), deal with the practical details of the design and use of permanganate remediation. By title, the chapters are as follows:

- Oxidant delivery and subsurface distribution
- Design of permanganate systems for ISCO
- Field applications and experiences

The book ends with a final chapter on “Status and future directions” and a very useful appendix containing manufacturer’s information on potassium and sodium permanganate and material safety data sheets for both of these oxidants.

In review, I note that my examination of Battelle’s book brochure reveals that, I have reviewed no less than eight of their listed books (in that brochure) on pollution related topics. All of the other books were good. So is this one.

Gray F. Bennett