TREATMENT OF ORGANIC CONTAMINANTS FROM WATER USING AN INTEGRATED SORPTION-OXIDATION SYSTEM

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Submitted in fulfilment for the degree of

Doctor of Philosophy

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Australia

2012

Certificate

I certify that the work in this thesis has not previously been submitted for a degree, nor has it been submitted as part of requirements for a degree. I also certify that this thesis is my own work and it does not contain any material previously published or written by another person except where due acknowledgement is made in the text.

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Abstract

In-situ treatment of chlorophenols using a permeable reactive barrier is still an emerging research area. A novel integrated sorption-oxidation barrier is proposed and systematically investigated in a neutral pH, very poorly buffered water. Intermittent injections of permanganate oxidise dissolved and sorbed chlorophenol as well as the woody sorbent with manganese dioxide formed as a by-product.

Common woody biomass (pine/hardwood) were evaluated as a cost effective sorbent. Chlorophenol uptake on these was relatively low (3–8 mg g^{-1}) with evidence of sorption hysteresis. Increased sorbent particle size and reactions with the oxidant did not significantly affect sorption. Under dynamic conditions non-equilibrium sorption occurred with higher flow rates.

Oxidation within the porous media was complex with multiple oxidation processes occurring simultaneously. An analytical method was developed to allow the quantification of chlorophenol in the presence of a quenching agent. This allowed the collection of kinetic data for the permanganate oxidation reaction. Oxidation of dissolved chlorophenol by manganese dioxide was found to be minimal. Early time data showed that the oxidation rate of pine (0.06 min^{-1}) was less than for chlorophenol sorbed on pine (0.07–0.12 min^{-1}) which was much less than for dissolved chlorophenols (0.4–1.48 min^{-1}). This suggests that the reaction between permanganate and pine materials is kinetically controlled and will dominate only after the oxidation reaction with chlorophenol. The rate of sorbed chlorophenol oxidation decreased with increasing contaminant hydrophobicity. In column studies the oxidation of the pine sorbent was

found to be both pH and residence time dependent. Some evidence of sorbent/column plugging and reduced sorbent oxidant demand due to manganese dioxide precipitation was found at pH 6.15 but not at pH 2.

The research has shown that a novel sorbent-oxidation barrier system that can treat chlorophenol contaminated water is technically feasible. Insights into the key mechanisms that would occur in the system have been given. Further work into operationalizing these processes is still needed.

Acknowledgements

TABLE OF CONTENTS

Abbreviations

2-CP   : 2-Chlorophenol

3-CP   : 3-Chlorophenol

4-CP   : 4-Chlorophenol

2,4-DCP   : 2,4-Dichlorophenol

2,6-DCP   : 2,6-Dichlorophenol

2,4,6-TCP : 2,4,6-Trichlorophenol

AOPs   : Advanced Oxidation Processes

BET   : Brunauer-Emmett-Teller

CP   : Chlorophenol

DOC   : Dissolved Organic Carbon

FC   : Filter Coal

GAC   : Granular Activated Carbon

HW   : Hardwood

ISCO   : In-Situ chemical Oxidation

LOD   : Limit of Detection

MDL   : Minimum Detection Limit

NPI   : National Pollutant Inventory

NOD   : Natural Oxidant Demand

PRB   : Permeable Reactive Barrier

PV   : Pore Volume

PVC   : Polyvinyl Chloride

Principal Notation

C_e : equilibrium concentration (mg L^{-1})

C_o : initial concentration (mg L^{-1})

D_{ow} : octanol-water distribution coefficient

K_{ow} : octanol-water partition coefficient

k_{th} : Thomas rate constant (L min^{-1} mg^{-1})

k_{yn} : Yoon-Nelson rate constant (min^{-1})

q_t : amount of sorbate at any time t (mg g^{-1})

q_e : amount of sorbate at equilibrium (mg g^{-1})

Q : volumetric flow rate (mL min^{-1})

r^2 : correlation coefficient

k_y : Yan rate constant (L min^{-1} mg^{-1})

LIST OF FIGURES

LIST OF TABLES