Carus Remediation Technologies
Remediation Report

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Customer: Matrix Environmental Technologies
3730 California Road
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Attention: Christine Curtis

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TECH # 22-038

Subject: RemOx® S ISCO Reagent Permanganate Natural Oxidant Demand

Summary
The overall average RemOx® S ISCO reagent permanganate natural oxidant demand (PNOD) at 48 hours for the soil samples was determined to be 8.5 g/kg. The average demands ranged from 4.2 g/kg to 13.2 g/kg. These values are calculated on a weight as potassium permanganate ($KMnO_4$) per dry weight of soil.

Background
Two soil samples were received from Matrix Environmental Technologies from the Lakeside Village Apartments project located in Lancaster, NY. The soil samples designations were LF1 (8'-9') and LF1 (10'-11'). The samples were analyzed for permanganate natural oxidant demand. The measurement of the permanganate natural oxidant demand is used to estimate the concentration of permanganate that will be consumed by the natural reducing agents during a given time period of 48 hours.

Experimental
The samples were analyzed for permanganate natural oxidant demand following ASTM D7262-10 Test Method A. A brief summary is as follows:

To determine the PNOD, the soil was baked at 105°C for 24 hours then allowed to cool to room temperature. The soil was then blended and passed through a U.S. 10 sieve (2 mm). Reactors were loaded with 50 grams of soil and 100 mL of 20 g/L $KMnO_4$ for an initial dose of 40 g/kg $KMnO_4$ on a dry soil weight basis at a 1:2 soil to aqueous reagent ratio. Each soil dose was performed in triplicate. The reaction vessels were inverted once to mix the reagents. Residual permanganate (MnO_4^-) was determined at 48 hours. The demands were calculated on a dry weight basis.

Results

The permanganate demand is the amount of permanganate consumed in a given amount of time. It should be noted that in a soil or groundwater sample, the oxidation of any compound by permanganate is dependent on the initial dose of permanganate and the reaction time available. As the permanganate dose is increased, the reaction rate and oxidant consumption may also increase. Some compounds that are not typically oxidized by permanganate under low doses can become reactive with permanganate at higher concentrations. The 48-hour PNOD results can be seen in Table 1 (on a dry soil basis).

Table 1: 48-Hour PNOD *

Soil Sample Identification	Average and Standard Deviation (g/kg)	Replicate 1 (g/kg)	Replicate 2 (g/kg)	Replicate 3 (g/kg)
LF1 (8'-9')	12.3 ± 0.95	13.2	12.4	11.3
LF1 (10'-11')	4.6 ± 0.57	5.3	4.5	4.2
Overall Average	8.5			

*Demands were calculated on a weight $NaMnO_4$/dry soil weight basis from an initial dose of 40.0 g/kg $NaMnO_4$ initial dose at a 1:2 soil to aqueous solution ratio.

Conclusions

For this application the amount of permanganate needed will be dependent on the reaction time allowed. On average, the soil samples had a 48-hour permanganate demand value of 8.5 g/kg. The average demands ranged from 4.2 g/kg to 13.2 g/kg. Generally, remediation sites with a soil demand of less than 20.0 g/kg at the time of interest are favorable for *in situ* chemical oxidation with permanganate (see Table 2 for additional information).

Table 2: Correlation of Permanganate Natural Oxidant Demand Results*

PNOD (g/kg)	Rank	Comment
<10	Low	ISCO with MnO_4^- is recommended. Soil contribution to MnO_4^- demand is low.
10-20	Moderate	ISCO with MnO_4^- is recommended. Soil contribution to MnO_4^- demand is moderate. Economics should be considered.
>20	High	ISCO with MnO_4^- is technically feasible. Other technologies may provide lower cost alternatives.

*Dry Weight Basis

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