

Bench to Field: Testing Klozur® KP as a Permeable Reactive Barrier

Site Overview

A confidential former wood treatment site located in the Pacific Northwest region of the United States has a source area containing petroleum hydrocarbons including polyaromatic hydrocarbons (PAHs) and pentachlorophenol (PCP) and an associated groundwater plume, consisting of PCP. The potential use of an oxidative permeable reactive barrier (PRB) was investigated as a means of cutting off the PCP plume and preventing downgradient migration of the contaminants.



Site Information

Site: Former Wood Treatment Facility
Location: Pacific Northwest, USA
Consultant: ERM
Lithology: Silty Sand Confined Aquifer

Contaminants of Concern

Pentachlorophenol, up to 10 mg/L
Polyaromatic hydrocarbons

Approach

Emplaced Permeable Reactive Barrier (PRB)
Oxidant: Klozur® KP
Activation Method: Alkaline

Results

>99.9% reduction of PCP observed in both
Bench and Field Pilot Tests

Approach

A step wise approach was taken to assess the potential to use activated Klozur® KP (potassium persulfate) in a permeable reactive barrier to intercept and treat the contaminant plume. The first step included a series of bench scale column studies that evaluated different activation methods and assessed the longevity of potassium persulfate. Based on the results of the bench scale tests, a field pilot test was designed and implemented in the Fall of 2018. This field pilot study included the subsurface emplacement of solid slurry potassium persulfate and subsequent multi-month monitoring program.

Bench Scale Tests

Bench scale tests were set up at PeroxyChem's laboratory. The bench scale tests included evaluations of the soil oxidant demand (SOD), otherwise known as the Klozur Demand Test (KDT), base buffer capacity (BBC) and a series of column studies.

The test conditions evaluated included:

- Control, with sand replacing the reagents
- Klozur KP activated with Hydrated Lime with the reagents blended together
- Klozur KP activated with downgradient Hydrated Lime (separate zones)
- Klozur KP activated by downgradient ZVI (separate zones)

The system ultimately required spiking of the PCP in the inlet flow due to partitioning onto soils. Effluent PCP concentrations in the control columns varied between 60 and 110 mg/L. All three systems with activated Klozur KP resulted in effluent concentrations of less than 0.01 mg/L PCP, or approximately 99.99% reductions compared to the control. In addition, the Klozur KP persisted for the expected design duration of 25 pore volumes through the column.

Field Pilot Test

The field pilot test included the application of approximately 4,400 lbs of Klozur KP and proportional amounts of hydrated lime. The reagents were applied through twelve DPT points spaced approximately 5 to 10 ft apart from each other. The vertical target interval was approximately 10 ft. As stratification of the contamination had been identified and to provide information regarding the migration of the persulfate, three monitoring wells clusters each containing and well screened at the top of the target interval (shallow) and bottom of the target interval (deep) were installed within the PRB. The pilot test monitoring well network consisted of these 6 monitoring well locations as well as an existing monitoring well located approximately 40 ft downgradient of the pilot test area.

The site was monitored for multiple months and showed up to 3 orders of magnitude reduction in contaminants including pentachlorophenol and other petroleum hydrocarbons. The assessment of the groundwater flux at the site and observed longevity of the potassium persulfate suggests that full scale applications could be designed around multiple year longevity of the permeable reactive barrier.

Table 1. Pilot Test Results for Pentachlorophenol

Event	Pentachlorophenol													
	Downgradient		MW-1S		MW-1D		MW-2S		MW-2D		MW-3S		MW-3D	
	µg/L	% Reduction	µg/L	% Reduction	µg/L	% Reduction	µg/L	% Reduction	µg/L	% Reduction	µg/L	% Reduction	µg/L	% Reduction
Baseline	9,700		9		2		1,700		73		2,000		11	
6 Weeks	6,300	35	15	-69	0.4	78	5	99.7	ND	>99	800	60	13	-18
3 Months	330	97	7	18	0.4	78	2	99.9	ND	>99	1.7	100	13	-18
4 Months	140	99	ND	>99	0.7	59	1	99.9	ND	>99	0.2	100	ND	>99
5 Months	470	95	ND	>99	1.2	29	5	99.7	0.3	99.7	0.9	100	2	86

Summary

Klozur KP was successfully bench and field pilot tested as a permeable reactive barrier for this site. The pentachlorophenol concentrations observed at each of the monitoring wells within the target area decreased to below the 1 µg/L maximum contaminant level (MCL). While not directly targeted, the benefits were also observed in a monitoring location that was approximately 40 ft downgradient where concentrations of pentachlorophenol were observed to have decreased by up to 99 percent. In addition, the Klozur KP and hydrated lime were observed to persist in both the lab and field for the designed period of time.

References

1. Smith, B.A., Srirangam, R. and Pac, T. (2020) "Bench to Field: ISCO Based Permeable Reactive Barrier at a Former Wood Treatment Facility," 36th Annual International Conference on Soils, Sediments, Water, and Energy, A Virtual Conference

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