

All in One Oxidants for the Treatment of Difficult Geologies

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All in One

Persulfate

Activator

Single Blended Product

 **KLOZUR**[®] CR

 **KLOZUR**[®] ONE



- Intended as easy of use product
- Activator is pre-mixed with persulfate
 - Good overlap in subsurface between activator and oxidant
 - One design value, mix tank, and injection pump
 - Less onsite storage
- Advantage of separate activators with persulfate
 - Site specific ratios
 - Customized approach
 - Not all activation methods are available in All-in-One product
 - Cost

- Based on environmental grade sodium persulfate

KLOZUR[®] SP

- Based on environmental grade potassium persulfate

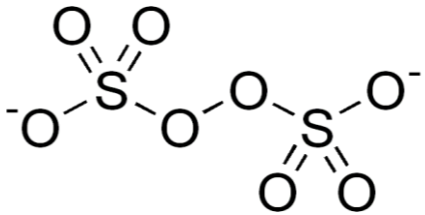
KLOZUR[®] KP

- “All-in-One” products based on Klozur SP

KLOZUR[®] ONE

KLOZUR[®] CR

All Klozur persulfates release the persulfate anion



Key Characteristics:

- A strong oxidant
- Activation results in the formation of oxidative and reductive radicals
- Applicable across a broad range of organic contaminants
- Extended subsurface lifetime (weeks to months)
- Little to no heat or gas evolution

KLOZUR[®] CR

- Klozur SP and PermeOx Ultra
- CR = Combined Remedy
 - Alkaline activated persulfate
 - Aerobic bioremediation
 - Potential for anaerobic oxidation
- Solid slurry applications (PermeOx is applied as a solid)

KLOZUR[®] ONE

- Klozur SP, but an “all in one” product.
 - 95% Klozur SP
 - 5% Activator
 - Iron-chelate, organic, and manganese
 - Oxidative pathway
- Simplified Klozur SP application
 - One solution, one pump, etc
- Totally soluble product

KLOZUR[®] CR

- Injected as solid slurry
- Petroleum hydrocarbon sites
 - Some mixed contaminants
- Coarse and fine grain geologies
- Excavation backfill
- Extended persistence of PermeOx Ultra

KLOZUR[®] ONE

- Injected as a dissolved liquid
 - 50 g/L to 200 g/L
- Source zone treatment
- Oxidative pathway:
 - Petroleum hydrocarbons
 - Chlorinated ethenes
 - Mono-, di-, and tri-chlorobenzenes

Challenging Geologies

- Establish contact by:
 - Injection
 - Recirculation
 - Soil Mixing
 - Excavation backfill amendment
 - Permeable reactive barriers

ISCO works by establishing contact between a sufficient mass of activated oxidant with the contaminant mass in the subsurface

Chemistry
Dose
Contact
Monitor

- Low permeable soils
 - Silts, clays, and other low permeable soils
- Fractured bedrock
- Heterogeneous soil types
 - Intervals of higher permeable and lower permeable soils

- Soil mixing—Alkaline activation

- High concentration-low volume application

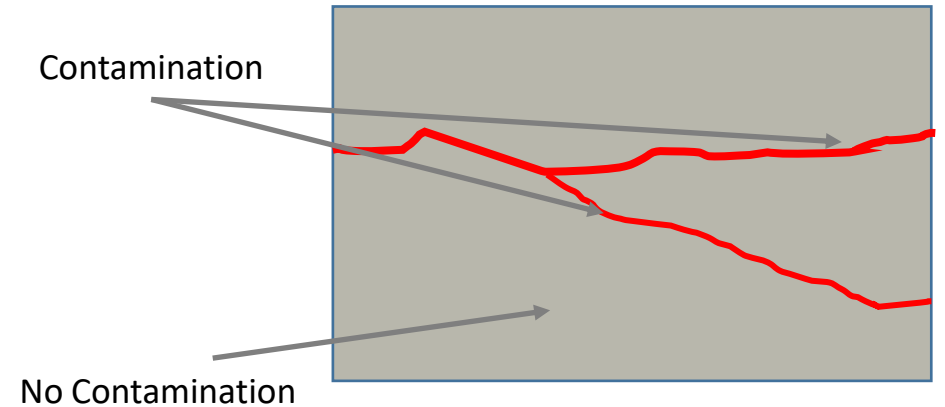
KLOZUR[®] ONE

- Fracture in extended release products

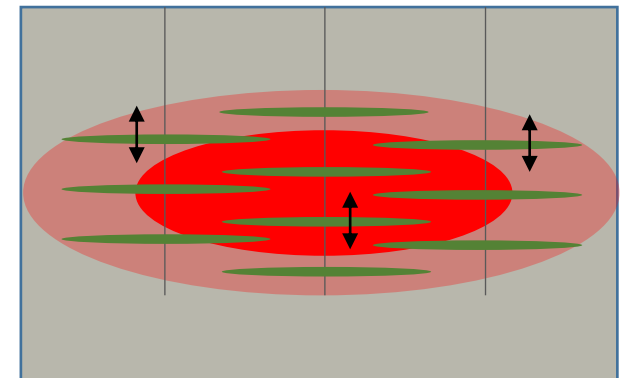
KLOZUR[®] KP

KLOZUR[®] CR

Contamination along Flow Paths



Contamination within Soil



- Similar to low permeable soils
 - No Soil Mixing
- Secondary fractures
- Competent rock vs low porosity rocks

- High Concentration-Low Volume

KLOZUR[®] ONE

- Fractured in extended release products

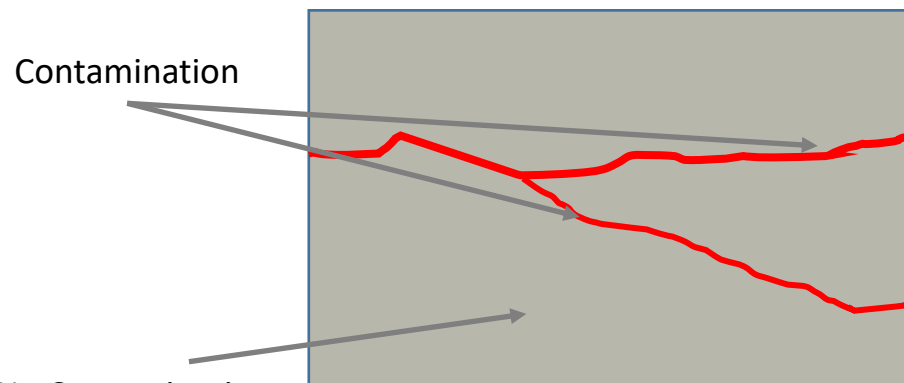
KLOZUR[®] KP

KLOZUR[®] CR

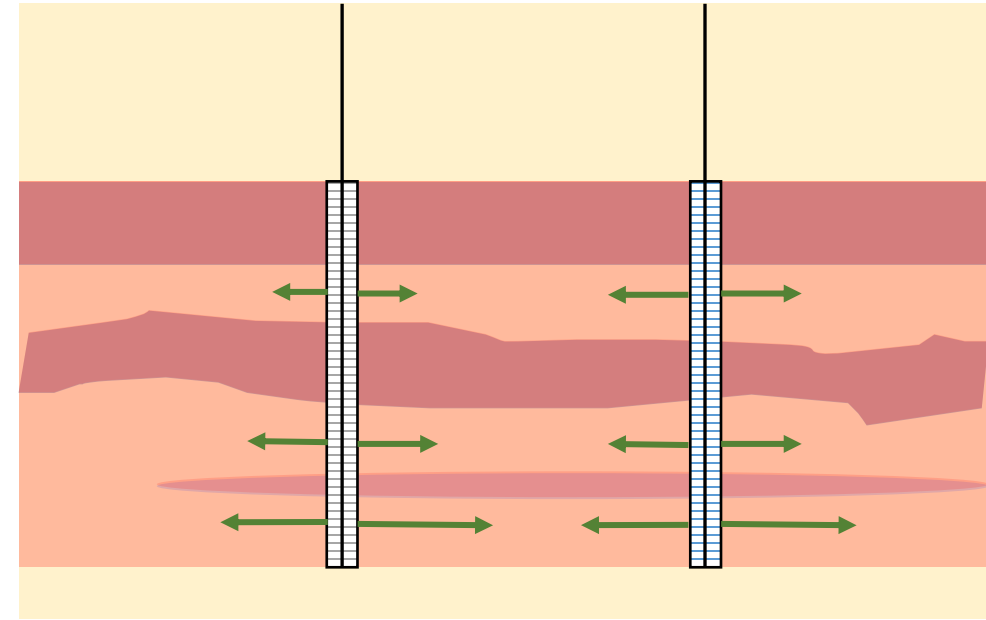
- Recirculation

KLOZUR[®] ONE

Contamination along Flow Paths



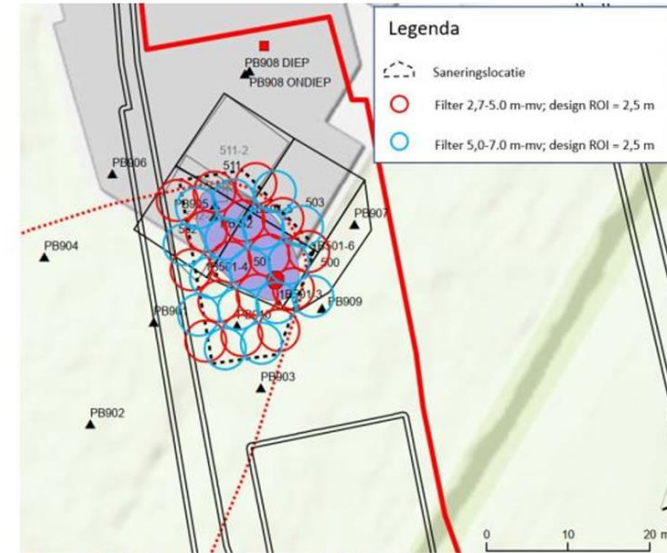
- Soils of different permeabilities
- Same soil type can have 4 orders of magnitude different permeabilities
- Injected reagents flow in and remediate higher permeable soils
- Less permeable soils become secondary sources



- Soil mixing
- Fracture in extended release oxidants
- DPT liquid reagents into lower permeable zones

Case Studies

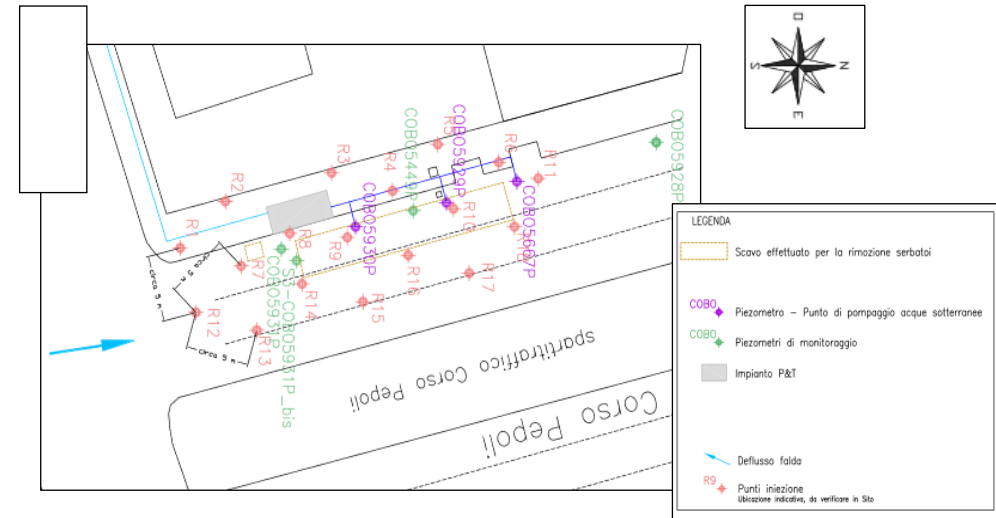
- Former Manufacturing Facility in The Netherlands
- 270 m² (2,900 ft²)
- 3 to 7 m bgs (10 to 23 ft bgs)
- 9,225 Kg Klozur One
 - 20,332 lbs Klozur One
 - ~4.9 g Klozur One/Kg soil



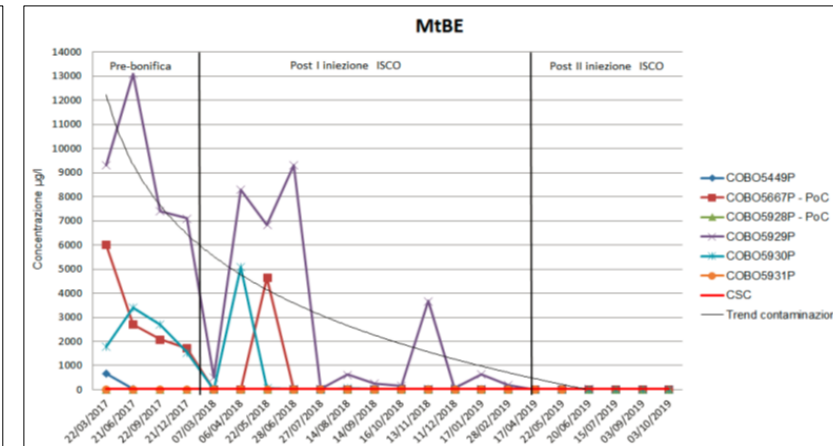
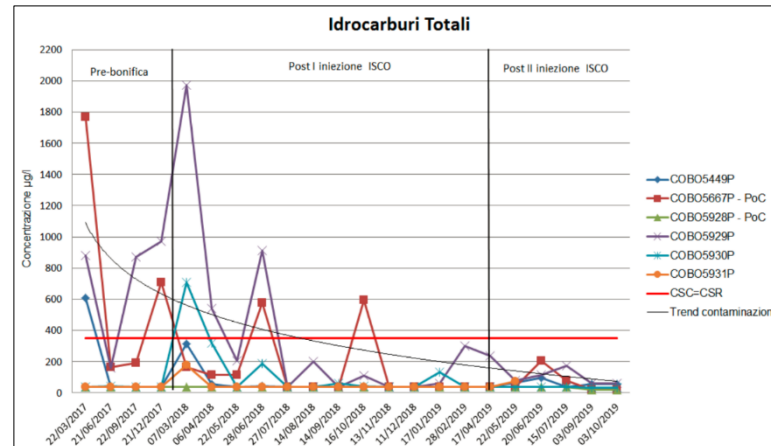
Monitoring well 2 depth: 4,5 m below ground level	Parameter	06-09-2019	24-09-2019	21-10-2019	21-11-2019
	PER µg/l	<50	<1	<1	<1
	TRI µg/l	14.000	2,4	<1	<1
	CIS µg/l	<50	1,4	1,4	1,4
	VC µg/l	<100	<2	<2	<2
	Sodium mg/l	13	n.a.	3.900	2.600
	Sulfate mg/l	30	n.a.	1.300	1.400

99.6% Reduction of TCE

- Former Petrol Station in Bologna, Italy city center
- 350 m² (3,800 ft²)
- 4 to 9 m bgs (13 to 30 ft bgs)



- 4,800 Kg Klozur CR
 - 10,579 lbs
 - 1.5 g Klozur CR/Kg Soil



**Remedial goals achieved
Site Closed**

- All in One: Klozur CR and Klozur One
 - Activator and persulfate together in single product
 - More convenient and easier to use
 - Highly effective
 - Not all activation methods available with All-in-One; customization; cost
- Complex geologies require matching treatment technologies with application methods to establish contact
- Chemistry, dose, contact and monitor.



Questions



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