PT-1E and EC-199 organoclays remove organic hydrocarbons from water and fixate them in sediments.

PERCENT REMOVAL EFFICIENCY OF EC-199 FROM WATER

	25 ppm	125 ppm	250 ppm	1000 ppm	solubility
Phenol	78.2%	56.3%	58.3%	42.0%	86 g/l
2,4,6, Trichlorophenol	98.3%	99.9%	99.9%	41.0%	800 mg/l
3 Chlorophenol	89.8%	96.3%	83.8%	31.0%	27.7 g/l
Pentachlorophenol	87.0%		99.0%	62.3%	80 mg/l

	before filtration (mg/kg)	after filtration (mg/kg)
Chloroform	5.0	0.008
Chlorobenzene	2.0	<0.001
Methyl Chloride	0.8	<0.001
Anthrazene	2,000.0	<10.000
COD	16,084.0	202.000
BOD	429.0	120.000
OIL	12.0	1.000

CASE HISTORY FROM CLEANING A SUMP SLUDGE.

A sump sludge contained a wastewater that required cleaning before it could be discharged. The water was passed through 300 lbs of organoclay/anthracite (Oilsorb) and then discharged. The results were:

Contaminant	Inlet	Outlet	Solubility (mg/l)
TOC	29%	65 mg/kg	
Oil	12 mg/kg	1 mg/l	
BOD	429 mg/kg	120 mg/kg	
COD	16,084 mg/l	202 mg/l	
Anthrazene	2,000 mg/kg	<10 mg/l	0.073
Benzo (A) Anthrazene	5,300	<10	0.014
Fluorene	10,000	<10	1.98
Indeno (1,2,3,C,D) Pyrene	200	<25	0.62
Naphtalene	29,000	<10	1.29
Phenanthrene	40,000	<10	1.29
Pyrene	8,000	<10	0.14
TPH	172,000	<0.5 mg/l	

No change out of organoclay was required. The adsorber ran at 5 gpm.

Laboratory Test Results with 1,4 Dioxane. A batch test was conducted with PT-1E to determine the ability of a non-ionic organoclay to remove 1,4 dioxane from water. The testing method was:

Sorbent, 1,4 dioxane solution, and organic free, deionized (DI) water were combined in 10 ml glass tubes. The initial concentration of the contaminants was between 300-500 mg/l. The mass of sorbent used was between 0.5 and 1 gram. Tubes carrying the diluted contaminant, but no sorbent, were carried through the test and analyzed to determine losses due to reasons other than sorption to the sorbent. No significant losses were measured, and recovery in all tubes was determined to be greater than 95%. Tubes containing DI water and sorbent were carried through the test and analyzed to determine the possible presence of the contaminant on the sorbent. For each contaminant, negligible amounts were detected. The tubes were capped and shaken for one day at 23 degrees +/- C. After equilibration, the tubes were centrifuged at 2000 g and the supernatant was analyzed by gas chromatography with a flame ionized detector to quantify the concentration of the organic solute. The sorbed concentration of each solute was determined by difference assuming negligible losses of the solute. The results were:

Water was spiked with 958 mg/l 1,4 dioxane aqueous equilibrium concentration. The mass sorbed by 2 grams organoclay was 27.09 mg/l, or 2.709% of the organoclay's weight. These results confirm the ability of non-polar organoclays to remove chlorinated organic hydrocarbons from water.

Laboratory Test Result with Two Nitrobenzenes. Nitro aromatic compounds are used by industry in pesticides, explosives, solvents and intermediated in chemical synthesis (Boyd et al, 2001). These contaminants appear in soils and sediments and can be toxic to humans and animals. The ability of a powdered, non-polar organoclay to remove substituted nitrobenzenes from water was tested in the lab with the same method as 1,4 dioxane. The compounds tested for were 1,3-Dinitrobenzene and 1,3,5-Trinitrobenzene. The same testing method was used as for 1,4 dioxane (see above). The results were:

	Equilibrium Aqueous Concentration (mg/l)	Mass Sorbed (mg/l)	% by Weight
1,3-Dinitrobenzene	157.7	6.4	0.644
1,3,5-Trinitrobenzene	38.3	12.0	1.201

These results show that a regular organoclay can be used to fixate substituted nitrobenzene compounds, thus it is a viable component of permeable barriers.

Literature Review of the Ability of Organoclays to Remove Pesticides. A comprehensive analysis of pesticide removal by organoclays, from water, is found in Sanchez-Martin, et al, 2006. The following pesticides were studied:

Common Name	Chemical Formula	Water Solubility
Penconazole	1-[2-(2,4-dichlorophenyl)pentyl]-1,2,4-triazole	73
Linuron	3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea	81
Atrazine	2-chloro-4-ethylamino-6-isopropylamino-1,3,5-triazine	30
Alachlor	2-chloro-2',6'-dietyl-N-methoxymethylacetanilide	240
Metalaxyl	methyl N-(2,6-dimethylphenyl)-N-(methoxyacetyl)-DL-alanite	8400
Lindane		10 ppm

(From Sanchez-Martin, et al, 2006)

Comparing these solubilities with organic hydrocarbons of known affinity to organoclays, we surmise that the first 4 and Lindane will be easily removed. Excellent results were also reported by Hermosin and Cornejo (1992) for adsorption of 2,4-D pesticide (2,4-dichlorophenoxy acetic acid) by standard organoclays. Tests conducted in our laboratory revealed good removal capacity by non-ionic organoclay for alachlor, diazinin, metalochlor, trifuralin and 2,4,5-T.

The authors of the pesticide article used a different organoclay, but the results when compared to the quaternary amine (octadecyltrimethylammonium bromide) used in this study will not be markedly different (di-methyl di-hydrogenated tallow ammonium chloride). Those authors concluded that soils containing organoclays provide barriers which drastically decrease the mobility of these pesticides.

The lab results obtained from a mini-column test are (Alther, 2004, 2002):

	Solubility	% By Organoclay Weight Removed
Benzene	1800 mg/l	39
Toluene	535	44
o-Xylene	insoluble	44
Naphthalene	34.4	24.3
PCB 1260	insoluble	52% by clay weight

Other case histories showed excellent removal capacity of organoclay for trichloroethene (sol. 1100 mg/l) and 1,1,1-dichloroethene (sol. 335 mg/l).

REMOVAL OF ORGANIC COMPOUNDS USING ORGANOCLAY/ANTHRACITE (OILSORB) SYSTEM

Organic Compound	Solubility (mg/l)	Inflow Concentration (mg/kg)	Outflow Concentration (mg/l)
Oil and Grease	12	1	
COD	16,084	202	
BOD	429	120	
Phenanthrene	1.29	40,000	<10
Naphthalene	34.4	29,000	<10
Fluorine	1.98	10,000	<10
Pyrene	0.14	8,000	<10
Benzo (A) Anthrazene	0.014	5,300	<10
Anthrazene	0.073	2,000	<10
Indeno (1,2,3,C,D) Pyrene	0.62	2,000	<25

REMOVAL EFFICIENCY OF ORGANIC COMPOUNDS IN COMBINATION ORGANOCLAY/ACTIVATED CARBON SYSTEM[1]

			Organoclay Unit	Activated Carbon Unit
Organic Compound	Solubility at 20-25˚C (mg/l)	Influent Concentration (mg/l)	Effluent Concentration (mg/l)	Effluent Concentration (mg/l)
1,1,1-Trichloroethane	480-4000	42,622	26,044	ND[2]
Trichloroethene	1,100	688	271	ND
1,1,1-Dichloroethene	335	285	ND	ND
Toluene	535	967	242	ND
pH	–	8.64	8.01	9.20

1 The oil content of the influent water is unknown. 2 ND = Not Detected.

% REMOVAL CAPACITY OF POWDERED ORGANOCLAY (PT-1E) AND ACTIVATED CARBON *(1 gram samples)*

Compound	Activated Carbon (% by carbon weight)	Organoclay (% by organoclay weight)
o-Xylene	45.1	44
Benzene	43	39
Toluene	45	44
Naphtalene	54	49
PCB 1260	50	52
Methylene Chloride	14	31
Humic Acids	23.4	54.6

(= 44 lbs xylene per 100 lbs clay)

Ternary Test (3 compounds in 1 sample)	Activated Carbon (% by carbon weight)	Organoclay (% by organoclay weight)	*Organoclay/ Carbon Combination
Benzene	13	12	13.5
Toluene	17.1	17.1	18.4
Naphtalene	22.5	24.3	25.2
Total Capacity for All 3 Compounds	51.3	52.2	55.7

(= 13.5 lbs benzene per 100 lbs clay/carbon)

**Date based on Micro-column Test. In clay/carbon combination, .05 gram organoclay was followed by .05 gram carbon.*

MINI-COLUMN TEST
ORGANOCLAY VS. ACTIVATED CARBON

(1 gram of media in a small column) (Combination means 0.5 gram Organoclay followed by 0.5 gram carbon)

Chemical	Solubility in Water (mg/l) (25˚ C)	Media	Concentration of Chemical (mg/l)	Sorbent Loading at Breakthrough (mg/g)	Equilibrium Sorbent Loading (mg/g)
Benzene	1800		900		
		Bit. Activated Carbon		117	130
		Nonionic Organoclay		108	120
		Organoclay/Carbon 1:1 Combination		121	135
Toluene	535		900		
		Bit. Activated Carbon		171	190
		Nonionic Organoclay		171	190
		Organoclay/Carbon 1:1 Combination		184	205
Naphtalene	31.7		900		
		Bit. Activated Carbon		225	250
		Nonionic Organoclay		243	270
		Organoclay/Carbon 1:1 Combination		252	280
Total Combined			2,700		
		Bit. Activated Carbon			513
		Nonionic Organoclay			522
		Organoclay/Carbon 1:1 Combination			557

MINI-COLUMN TEST
ORGANOCLAY VS. ACTIVATED CARBON

(1 gram of media in a small column)

Chemical	Media	Concentration of Chemical (mg/l)	Sorbent Loading at Breakthrough (mg/g)	Equilibrium Sorbent Loading (mg/g)
Benzene		900		
	Organoclay		340	390
	Activated Carbon		370	430
Toluene		900		
	Organoclay		390	440
	Bit. Activated Carbon		410	450
O-Xylene		220		
	Organoclay		400	440
	Bit. Activated Carbon		420	451
Naphtalene		10		
	Organoclay		420	490
	Activated Carbon		470	540
PCB-1260		10		
	Organoclay		480	520
	Bit. Activated Carbon		450	500
Methylene Chloride		900		
	Organoclay		261	310
	Bit. Activated Carbon		63	140
Motor Oil		5,000		
	Organoclay		3,500	3,900
	Bit. Activated Carbon		250	500

JAR TESTS OF WATER SPIKED WITH VARIOUS ORGANICS
SHOWING REMOVAL CAPACITY OF ORGANOCLAY AND CARBON POWDER

	TOC mg/l 6/8/98	TOC mg/l 6/10/98	TOC % Removal	TOC mg/g
Gasoline				
Non-ionic Organoclay	105	15	99.2	58.1
Coal Based Activated Carbon	120	25	98.7	57.8
Control	1,950	1,950		
Diesel Fuel				
Non-ionic Organoclay	90	10	99.5	59.4
Coal Based Activated Carbon	130	75	96.2	57.4
Control	1,990	1,990		
JP-4 Jet Fuel				
Non-ionic Organoclay	80	20	99.0	59.4
Coal Based Activated Carbon	120	65	96.8	58.0
Control	2,000	2,000		