

The Contamination Experts

- Responsible Party Identification
- GIS and Geomatics
- Contaminant Hydrogeology
- Fate and Transport Modeling
- Risk Assessment
- Remediation Feasibility Studies
- Soil and Groundwater Remediation
- Natural Resource Damage Assessment
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Petroleum Contamination

Contamination of soil and groundwater can result during all phases of petroleum production, transmission, refining, storage and marketing. The contaminants include the constituents of crude oil, oil field chemicals (e.g. produced water/brines, diluent, drilling fluids, arsenic biocide), refined products (e.g. gasoline), product additives (e.g. lead-alkyl additives or oxygenates), or other chemicals used in the processing of petroleum (e.g. sulfolane).

Crude oil and the major refined products (e.g. gasoline, kerosene, diesel #2, aviation fuels) are a mixture of hundreds of individual chemicals, notably paraffins (straight chained hydrocarbons), iso-paraffins (branched hydrocarbons), cyclo-hexanes (single-bond, ring hydrocarbons), aromatic hydrocarbons (with a single benzene-ring), and poly-aromatics hydrocarbons (PAHs). Crude oil also contains trace heavy metals, notably nickel, vanadium, copper, cadmium and lead, and naturally occurring radioactive materials (NORMs), notably radium 226 and 228. Sour-oil/gas also contains high concentrations of sulfur.

Refined petroleum products, notably gasoline, usually contain other additives, such as fuel oxygenates (e.g. MTBE, ethanol) and proprietary detergents. Historically, leaded gasoline contained lead-alkyl additives (e.g. tetra-ethyl lead) and anti-knock agents, such as 1,2-dichloroethane (1,2-DCA) and ethylene dibromide (EDB).

Most paraffins, iso-paraffins and cyclo-hexanes have low solubility in water, are relatively immobile in the environment, and have limited toxicological effects. However, aromatics and PAHs have higher solubility in water, are somewhat mobile in the environment, and have known toxicological impacts at relatively low concentrations. The aromatics of primary concern are the volatile organic compounds (VOCs) benzene, toluene, ethylbenzene and xylenes (BTEX). The PAHs of primary concern are naphthalene, chrysene, benzo(a)pyrene, benz(a) anthracene, benzo(b) fluoranthene, benzo(k)fluoranthene.

Most fuel oxygenates have higher solubility and are generally more mobile and persistent in the environment. In particular, MTBE and TBA releases can result in significant groundwater contamination and impact to water supplies. The anti-knock agents 1,2-DCA and EDB also have relatively high solubility and are also more mobile and persistent in the environment.

Aside from pure petroleum product found as a light non-aqueous phase liquid (LNAPL), BTEX, PAHs, lead-related additives and fuel oxygenates are the most common chemicals found in soil and groundwater at petroleum facilities.

Properties of Common Petroleum Contaminants

Chemical Type	Compound	Molecular weight (g/mol)	Boiling Point (°C)	Density (g/cm ³)	Vapor Pressure (mmHg)	Sorption (Log K _{oc}) (unitless)	Log K _{ow} (unitless)	Solubility (mg/L)	Henry's Constant (unitless)	Regulatory Levels		
										CA PHG (µg/L)	CA MCL (µg/L)	US MCL (µg/L)
Aromatic VOCs	Benzene	78.11	80.1	0.88	95	1.82	1.99	1,770	0.227	0.15	1/NS	5
	Toluene	92.14	111	0.87	28.2	2.15	2.54	530	0.276	150	150	1000
	Ethylbenzene	106.17	136	0.87	9.6	2.31	3.03	169	0.327	300	300	700
	O-Xylene	106.17	144	0.88	6.75	2.11	3.13	178	0.0007	1800	1750	10,000
PAHs	Napthalene	128.17	218	1.14	0.09	3.19	3.17	31.4	0.02	-	170 (AL)	-
	Benzo(a)pyrene	252.31	495	1.24	4.89x10 ⁻⁹	5.98	6.11	0.0016	0.000047	0.007	0.2	0.2
	Benz(a)anthracene	228.29	438	1.19	1.54x10 ⁻⁸	5.55	5.52	0.01	0.00014	0.07	-	-
	Benzo(b)fluoranthene	252.32	481	1.29	8.06x10 ⁻⁸	6.08	6.11	0.0015	0.0005	0.07	-	-
	Benzo(k)fluoranthene	252.32	480	1.29	9.59x10 ⁻¹¹	6.09	6.11	0.0005	0.0000004	0.07	-	-
Fuels	Gasoline	~100	40-200	0.75	47.9	3.6	-	5.4	50	-	-	-
	Kerosene and Jet Fuel	~160	150-250	0.80	0.48	5.4	-	0.034	120	-	-	-
	Diesel #2	~200	250-350	0.83	0.036	6.7	-	0.0008	520	-	-	-
	Fuel and Mineral Oils	~270	>150	0.88	0.0008	8.8	-	0.000002	4900	-	-	-
Lead-Alkyl Additives	1,2-DCA	98.96	84.0	1.25	81.3	1.24	1.83	8,700	0.053	0.4	0.5	5
	EDB	187.86	129	2.18	11	1.73	2.01	4,320	0.029	0.01	0.05	0.05
	TEL	323.45	84	1.65	0.15	3.69	4.88	0.8	3.31	-	15	-
Oxygenates	MTBE	88.15	55.2	0.74	249	1.15	1.43	48,000	0.024	13	13/5*	20-40
	TBA	74.12	82.4	0.78	31.42	0.62	0.69	Miscible	0.0003	-	12 (AL)	NS
	TAME	102.18	86.3	0.76	99.72	1.62	1.95	4,295	0.13	13	5*	NS
	ETBE	102.18	66.9	0.74	89.96	1.57	1.88	5,031	0.099	13	5*	NS
	DIPE	102.18	69.0	0.73	77.6	1.81	2.19	2,666	0.16	-	NS	NS
	Methanol	32.04	65.0	0.79	122	-0.74	-0.63	Miscible	0.00019	-	NS	NS
Process	Ethanol	46.07	78.4	0.79	32.6	0.08	0.002	Miscible	0.00028	-	NS	NS
	Sulfolane	120.17	285	1.26	0.0006	-0.79	-0.80	8370	0.000005	-	87.5 (AK)	-

PHG = public health goal MCL = maximum contaminant level AL = action level AK = Alaska * = secondary MCL
 Fuel carbon range equivalents for property estimation: Gasoline = C6-8; Kerosene = C10-12; Diesel #2 = C12-16; Fuel Oils = C16-C35

