Lead Scavengers Compendium: Overview of Properties, Occurrence, and Remedial Technologies

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Acronyms and Abbreviations

µg/L	Microgram per liter
1,2-DCA	1,2-Dichloroethane
ACIGH	American Conference of Governmental Industrial Hygienists
AEHS	Association for Environmental Health and Sciences
AS	Air sparging
ASR	Treatment Technologies for Site Cleanup: Annual Status Report, 11^{th} Edition
ASTSWMO	Association of State and Territorial Solid Waste Management Officials
ATSDR	Agency of Toxic Substances and Disease Registry
Avgas	Aviation gas
BEI	Biological Exposure Indices
BHC	Hexachlorocyclohexane
BTEX	Benzene, toluene, ethylbenzene, xylene
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CFR	Code of Federal Regulations
DDT	Dichlorodiphenyl-trichloroethane
DHHS	Department of Health and Human Services
DNA	Deoxyribose nucleic acid
EDB	Ethylene dibromide
EDC	Ethylene dichloride
EPA	United States Environmental Protection Agency
FRTR	Federal Remediation Technologies Roundtable
g/mol	Gram per mole
GAC	Granular activated carbon
H_2S	Hydrogen sulfide
HS^-	Bisulfide ion
HW	Hazardous waste
IARC	International Agency for Research on Cancer
IRIS	Integrated Risk Information System
KDHE	Kansas Department of Health and Environment
Koc	Soil organic carbon/water partition coefficient
Kow	Octanol-water partition coefficient
LNAPL	Light non-aqueous phase liquid
LUST	Leaking underground storage tank
MCL	Maximum contaminant level
mg/kg	Milligram per kilogram
mg/m^3	Milligram per cubic meter
mg/L	Milligram per liter
mM	Millimole
mm Hg	Millimeter of mercury
MMR	Massachusetts Military Reservation
MNA	Monitored natural attenuation
MSDS	Material safety data sheet
MTBE	Methyl tert-butyl ether

ND	Nondetect
NIOSH	National Institute of Occupational Safety and Health
NLM	National Library of Medicines
NPL	National Priorities List
O&M	Operation and maintenance
OPP	Office of Pesticide Programs
OSHA	Occupational Safety and Health Administration
OU	Operable unit
OUST	Office of Underground Storage Tanks
P&T	Pump and treat
PEL	Permissible exposure limit
POL	Petroleum, oil, and lubricant
ppb	Parts per billion
ppm	Parts per million
PR	Product recovery
PTA	Packed tower aeration
PWS	Public water system
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RfD	Reference Dose
ROD	Record of Decision
RPAR	Rebuttable Presumption Against Registration
SCDHEC	South Carolina Department of Health and Environmental Control
SDWA	Safe Drinking Water Act
SDWIS	Safe Drinking Water Information System
SGOT	Glutamic oxaloacetic transaminase
SGPT	Glutamic pyruvic transaminase
SVE	Soil vapor extraction
TCE	Trichloroethene
TEL	Tetraethyl lead
TLV	Threshold Limit Value
TML	Tetramethyl lead
URCIS	Unregulated Contaminant Information System
USGS	United States Geological Survey
UST	Underground storage tank
UV	Ultraviolet
VOC	Volatile organic compound
WQFS	West Quartermaster's Fueling System

Purpose

This compendium of materials about lead scavengers – in particular ethylene dibromide (EDB) and 1,2-dichloroethane (1,2-DCA, also known as ethylene dichloride or EDC) represents EPA's current state of knowledge (through 2005) on lead scavengers.

The compendium is the first of three phases of work EPA, along with state and regional UST programs, are undertaking to determine the scope and magnitude of lead scavengers at leaking UST sites nationwide. The two phases still to be conducted include:

- Collecting additional data to fill in information gaps identified during the first phase, and
- Developing an appropriate response based on the results of the first two phases.

With the phase out of leaded gasoline at the end of the 1980s, experts believed that alkyl lead compounds and associated lead scavengers from leaking UST systems would no longer occur in the environment. However, results published in summer 2004 of an investigation of leaking UST sites in South Carolina revealed that lead scavengers may persist for long periods of time in certain groundwater environments and, thus, may still be present at UST sites in operation through the end of the 1980s. Consequently, EPA and states are continuing their investigation into the potential presence of lead scavengers at UST sites.

Please note that the information in this compendium is based on data presented in source materials discussed in section 1. Also note that mention of trade names or commercial products does not constitute endorsements or recommendations for their use.

EXECUTIVE SUMMARY

Introduction

Ethylene dibromide (EDB) and ethylene dichloride (EDC; also known as 1,2-dichloroethane or 1,2-DCA) are synthetic organic chemicals used in leaded gasoline as "lead scavengers" to prevent the buildup of lead deposits that foul internal combustion engines. Even though leaded gasoline for on-road automobiles has not been used for more than a decade, leaded gasoline containing lead scavengers is still used as aviation gasoline (Avgas) and in some off-road applications such as automobile racing fuel.

Current Investigation

To determine whether lead scavengers pose a potential threat to human health or the environment, the U.S. Environmental Protection Agency's (EPA) Office of Underground Storage Tanks (OUST) teamed with the Association of State and Territorial Solid Waste Management Officials (ASTSWMO) to investigate the occurrence of lead scavengers in the environment. As a first step, readily available information was gathered from EPA Headquarters and the regions, various states, and the scientific literature to identify the properties and occurrence of lead scavenger compounds as well as remedial technologies for these compounds. This compendium represents the state of knowledge through mid-2005 of lead scavengers and their occurrence at LUST sites.

Historical Uses of Lead Scavengers

The use of EDB as a lead scavenger began in 1925. Beginning in the 1940s, EDB was partially replaced with EDC as a cost saving measure. In 1973, EPA initiated a "phasedown" program for leaded gasoline to reduce lead content from 2.0 grams per gallon to 0.5 gram per gallon in large refineries by 1980 and in small refineries by 1982. In 1982, EPA lowered the standard for lead in fuel to 1.10 grams per gallon and eliminated the provision that allowed refineries to average their total leaded and unleaded gasoline output to meet the standard. In 1986, the standard was further reduced to 0.10 gram per gallon. In 1996 on-road uses of leaded gasoline were banned entirely. However, leaded gasoline (that also contains lead scavengers) is still used in some off-road applications such as aviation gasoline (Avgas) and automobile racing fuel.

Other Uses of Lead Scavengers

Lead scavenger compounds have other uses besides leaded fuel additives. EDB was widely used in agricultural applications as a pesticide and fumigant. EDC was used as a fumigant, in varnish and finish removers, in soaps and scouring compounds, in organic synthesis for extraction and cleaning purposes, in metal degreasers, in ore floatation, and in paints, coatings and adhesives. EDB is also used as a chemical intermediate in synthesis and as a nonflammable solvent for resins, gums, and waxes. EDC is now primarily used to manufacture vinyl chloride. The last registered garment fumigant containing EDB and EDC was Tri-X-Garment Fumigant. Production of this fumigant was cancelled on September 8, 1993.

Environmental Transport and Fate of Lead Scavengers

Once released into the environment, the transport and fate of EDB and EDC in soil and groundwater is dependent on physical, chemical and microbiological processes. EDB and EDC can be expected to exhibit low to moderate adsorption to particulates in groundwater and show high mobility in groundwater. EDB readily undergoes aerobic biodegradation in surface soil, with the fastest degradation occurring at or near the soil surface. EDB is moderately persistent deeper in the soil, and a representative half-life has been estimated to be 100 days. Sorbed EDB slowly leaches from micropore sites to contaminate groundwater. Biodegradation of EDB in groundwater occurs aerobically with a half-life of 35 to 360 days and anaerobically with a half-life of 15 to 50 days. EDC is biodegraded in soil, and a representative half-life value of 52 days has been reported. Biodegradation of EDC in groundwater occurs aerobically with a half-life of 100 days and anaerobically with a half-life of 400 days.

Toxicology of Lead Scavengers

Based on the effects of EDC on the human central nervous system, lungs, and liver as well as on the cancer risk posed by the compound, EPA promulgated a maximum contaminant level (MCL) of 5 micrograms per liter (µg/L) in water for EDC in 1989. Based on the effects of EDB on the human stomach, adrenal glands, reproductive system, respiratory system, nervous system, liver, heart, and kidneys as well as on the cancer risk posed by the compound, EPA promulgated a MCL of 0.05 µg/L in water for EDB in 1992. EPA has determined that both EDB and EDC are probable human carcinogens. The U.S. Department of Health and Human Services has determined that both EDB and EDC may reasonably be expected to cause cancer. The International Agency for Research on Cancer considers EDC to be a possible human carcinogen.

Occurrence of Lead Scavengers in Drinking Water

As a preliminary step in evaluating the prevalence of EDB and EDC in drinking water, EPA reviewed several documents and databases for relevant information. According to the three EPA reports reviewed, EDB and EDC have been detected above the MCL in groundwater-supplied public water systems (PWS) across the country. One report, "Occurrence of Unregulated Contaminants in Public Water Systems – A National Summary," indicates that 12 PWSs out of 22,000 groundwater-supplied PWSs in 24 states had EDB concentrations above the federal MCL (0.05 µg/L), while 24 PWSs had EDC concentrations above its federal MCL (5 µg/L). The report also notes that the data suggest widespread occurrence of EDB with no apparent geographic pattern across the country.

Two other EPA reports ("A Review of Contaminant Occurrence in Public Water Systems" and "Occurrence Estimation Methodology and Occurrence Findings Report for the Six-Year Review of Existing National Primary Drinking Water Regulations") evaluate an eight-state subset for EDB and EDC occurrence. One report concludes that EDB is consistently ranked as among the most commonly occurring synthetic organic chemicals although their occurrence is relatively infrequent: EDB and EDC were reported above their MCLs by only 0.7% and 0.3% of the groundwater-supplied PWSs, respectively.

According to EPA's Safe Drinking Water Information System database, 62 MCL violations for EDB and 32 MCL violations for EDC were reported for 40 and 17 groundwater-supplied PWSs, respectively (from 1993 to 2004). Florida's Drinking Water Database indicated groundwater-supplied drinking water systems in Florida had EDB concentrations ranging from 3.8 to 272 µg/L and EDC concentrations ranging from 0.1 to 0.5 µg/L.

Presence of Lead Scavengers at Leaking Underground Storage Tank (LUST) Sites

The Association for Environmental Health and Sciences (AEHS) conducts a bi-annual survey of states' cleanup standards for hydrocarbon-contaminated soil and groundwater and these results are posted on their web site (*http://aehs.com/surveys.htm*). These data indicate that few states require sampling for EDB at LUST sites. Representatives of the Kansas Department of Health and Environment, the South Carolina Department of Health and Environmental Control, and Santa Barbara County in California provided information about the occurrence of EDB and EDC at LUST sites in their areas. Additional data for South Carolina were also obtained from Dr. Ronald Falta of Clemson University. Based on the limited data collected for South Carolina and Santa Barbara County (California), there seems to be no relationship between EDB, EDC, benzene, methyl tert-butyl ether (MTBE), and lead concentrations at these sites. Also, EPA Region 8 provided data from a few Federal-lead sites in Indian Country.

Remediation and Treatment Technologies for Lead Scavengers

Remediation and treatment technologies for EDB and EDC contaminants were evaluated using available data. According to EPA's Annual Status Report (ASR) for Superfund sites and site-specific data from the State of Kansas, the most common treatment technologies for EDB are air sparging, soil vapor extraction, and groundwater pump and treat with granular activated carbon. Four Superfund sites are treating or have treated soil or groundwater contaminated with EDB, and seventy Superfund sites have addressed EDC contamination. Three additional sites have identified EDB as a contaminant of concern. Thirty-one sites in South Carolina are using monitored natural attenuation to address EDB and other contaminants. Information obtained from ASR database indicates that 70 Superfund sites are treating or have treated soil or groundwater contaminated with EDC. The most common treatment technology for EDC is pump and treat, although the treatment was not specified in the ASR database.

Summary

Lead scavengers (and in particular EDB) appear to be persistent in some subsurface environments associated with releases of leaded fuel from leaking USTs. The magnitude of the potential problem, however, is as yet unknown but the subject of an ongoing investigation by EPA. Although EDB is acknowledged to be one of the common contaminants found in public drinking water supplies, it is present in very few systems and typically at very low concentrations. There is very little information on the occurrence of lead scavengers in domestic (private) wells and on the effectiveness of remediation and treatment technologies.