aquilogic

Email: info@aquilogic.com
Telephone: +1.714.770.8040

Brominated Flame Retardants

The PBDE Experts

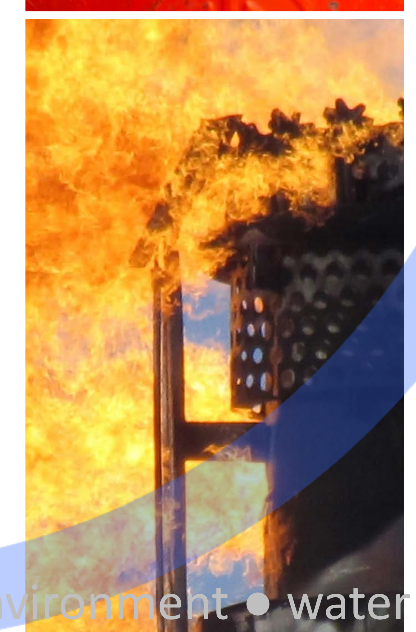
Responsible Party Identification
GIS and Geomatics
Contaminant Hydrogeology
Fate and Transport Modeling
Risk Assessment
Remediation Feasibility Studies
Soil and Groundwater Remediation
Natural Resource Damage Assessment
Water Resources Assessment
Source Water Assessment and Protection
Drinking Water Treatment
Environmental Risk Management
Litigation Support/Expert Witness
Forensic Engineering
Stakeholder/Public Participation
Regulatory Strategy

environment • water • strategy

To contact us, or sign up for our newsletter, please scan here.

www.aquilogic.com

aquilogic



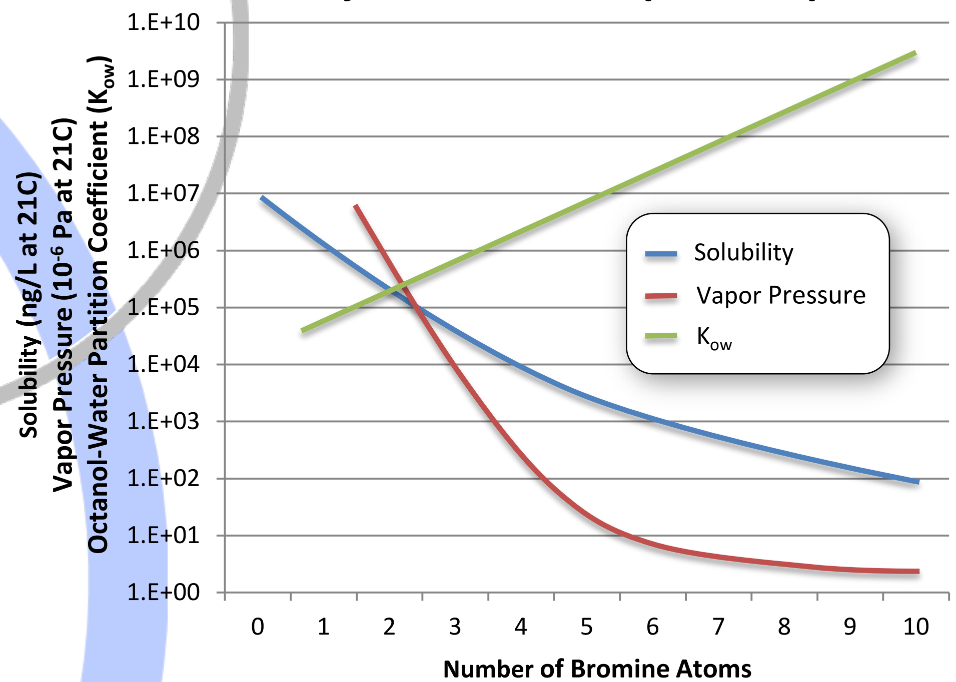
Email: info@aquilogic.com
Telephone: +1.714.770.8040

Brominated Flame Retardants

Flame retardants are, chemically speaking, a group of very diverse substances which may strongly differ in their chemical and physical properties, toxicology and environmental behavior. They have only one effect in common – they reduce the flammability of materials. Flame retardants are generally classified according to their chemical makeup. The most common classes of flame retardants are: Brominated, Phosphorus, Nitrogen, Chlorinated and Inorganic.

PBDE's interact with the fire cycle in the gas phase to stop the chemical chain reaction that leads to flame formation and a self-sustaining fire. In essence, brominated flame retardants either prevent a fire from starting in the first place, or significantly slow a fire down. PBDEs are used in a variety of materials including: textiles, electronics, building materials, plastics, and foams.

Variability in PBDE Transport Properties



The first commercial productions of PBDEs began in the 1970s in Germany and has continued until the present. There are three commercial PBDE products, penta-, octa-, and deca-bromodiphenyl ether. Decabromodiphenyl ether (DBDE) makes up the majority of these products manufactured globally (more than 80% of all PBDEs). Its main use is for electronic enclosures, such as television cabinets. Octabromodiphenyl ether (OBDE) product is used in plastics for business equipment. Pentabromodiphenyl ether (PnBDE) product is used in foam for cushioning in upholstery.

Two forms of PBDEs, DBDE and OBDE, are no longer produced within the United States; however, they continue to be produced elsewhere and are still present in products manufactured prior to the phase-out was completed in 2004. In June 2006, the State of California prohibited the manufacture, distribution, and processing of flame-retardant products containing either PBDE or OBDE. In 2009, both OBDE and PBDE were listed as persistent organic pollutants due to the properties of their pre-cursor components, heptabromodiphenyl and hexabromodiphenyl ether and tetrabromodiphenyl ether, respectively.

Fate and Transport Properties of Selected PBDEs

PBDE	Acronym	Molecular Weight (g)	Vapor Pressure (mmHg)	Sorption (Log K_{oc}) (unitless)	Log K_{ow} (unitless)	Solubility (mg/L)	Henry's Constant (unitless)
Tetrabromodiphenyl ether	TBDE	485.8	---	---	---	0.0109	---
Pentabromodiphenyl ether	PnBDE	564.7	3.5E-07	---	6.57	0.0133	4.44E-03
Hexabromodiphenyl ether	HxBDE	643.6	1.2E-08 – 3.5E-09	---	---	---	4.6E-05
Heptabromodiphenyl ether	HpBDE	722.3		---	---	---	---
Octabromodiphenyl ether	OBDE	801.4	4.9E-08	---	6.29	5E-04	4.29E-03
Decabromodiphenyl ether	DBDE	959.2	3.5E-08	6.3	6.27	<0.001	>1.28E-02

PBDEs can enter water and soil during their manufacture and from their use in consumer products. PBDEs become suspended in air as particulate matter that eventually settle back down to land or water and enter the water cycle through precipitation and subsequent infiltration through the soil. These characteristics also allow the chemicals to become a non-point source of contamination by potentially travelling great distances, resulting in difficulties in identification of the source of contamination. Upon the settling of the airborne contaminated particulate matter, PBDEs may not move great distances, at significantly elevated concentrations, once introduced to the groundwater system. However, at lower concentrations , commonly at the parts per trillion level, PBDEs can be as a marker for identifying source areas and the dating of groundwater plumes.

Once introduced into the subsurface, based upon the available fate and transport properties, notably the octanol-water coefficient (K_{ow}) and organic carbon partition coefficient (K_{oc}), PBDEs are expected to bind readily to soil particles . The anticipated concentrations of PBDEs in groundwater are typically low , as reflected in their respective solubility's. However, once introduced to groundwater, PBDEs are expected to remain in the liquid phase , due to each PBDEs low Henry's Law constants.

Nearly all people in the developed portions of the world have been exposed to low levels of PBDEs, notably PnBDE and TBDE. Research regarding the direct effects of PBDEs on human health are ongoing. However, based upon existing studies, exposure to PBDEs are suspected to cause learning, memory and behavioral disabilities. Studies have also found that PBDEs can disrupt the endocrine system by affecting the way the thyroid, reproductive system, and immune systems work. Once introduced to the ecosystem, PBDEs tend to bioaccumulate and persist for long periods of time. Despite these risks there are no federal guidelines or cleanup standards for PBDEs.

PBDE	Percent Composition of Selected PBDEs								
	PBDE Mixture	Tri-BDE	Tetra-BDE	Penta-BDE	Hexa-BDE	Hepta-BDE	Octa-BDE	Nona-BDE	Deca-BDE
No. of Br Atoms		3	4	5	6	7	8	9	10
DBDE	---	---	---	---	---	---	---	0.3 - 3	97 - 98
OBDE	--	--	--	--	10 - 12	43 - 44	31 - 35	9 - 11	0 - 1
PBDE	---	0 - 1	24 - 38	50 - 62	4 - 8	---	---	---	---
TBDE	7.6	--	41 – 41.7	44.4 - 45	6 - 7	--	--	--	--

Sources:
Environment Canada. (2006). Ecological Screening Assessment Report on Polybrominated Diphenyl Ethers (PBDEs). June.
U.S. Environmental Protection Agency (EPA). (2010). DecaBDE Phase-out Initiative. www.epa.gov/oppt/existingchemicals/pubs/actionplans/deccadbe.html
Agency for Toxic Substances and Disease Registry (ATSDR). (2004). Toxicological Profile for Polybrominated Diphenyl Ethers and Polybrominated Biphenyls. www.atsdr.cdc.gov/toxprofiles/tp68.pdf.
De Wit, C. A. (2002). An Overview of Brominated Flame Retardants in the Environment. Chemosphere. Volume 46. Pages 583 to 624.