



Electronic Waste: Potential Sources of Toxic Chemical Contaminants?

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U.S. Geological Survey

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www.cerc.usgs.gov



**U.S. Department of the Interior
U.S. Geological Survey**

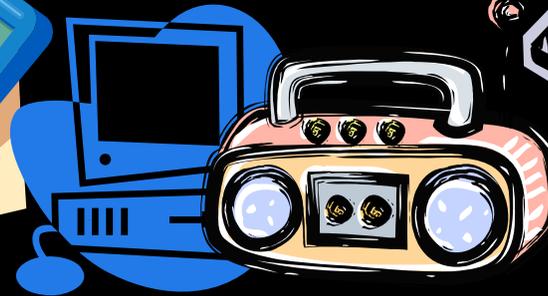
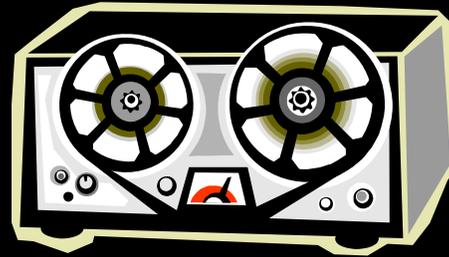
Waste Electric and Electronic Equipment (WEEE)



Metals



Plastics



Cadmium

Resistors, IR detectors semiconductors

Lead

Lead solder, computer monitor glass

Mercury

Relays, switches, lamps, batteries...

Hexavalent Chromium

Corrosion inhibitor for steel plates



Cadmium: Persistent, bioaccumulative, toxic.
Effects kidneys. Exposure via respiration & food.

Lead: damage nervous, blood, & kidney systems.
Drinking water supply contamination from landfill leaching

Mercury: transformed to methyl mercury which is
neurotoxic and bio-magnifies up the food chain.

Chromium VI: linked to DNA damage &
asthmatic bronchitis. Landfill leachate & incineration ash



PLASTICS

ABS resins

Wire & cable
insulation

Coatings

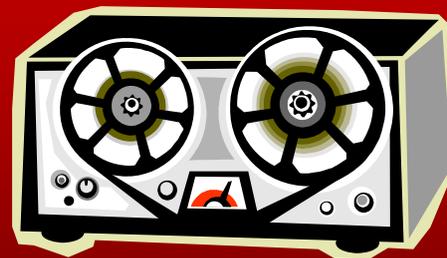
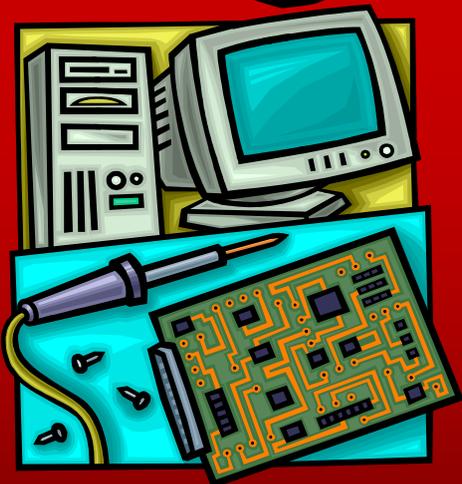
vinyl

Paints

Polyamides

Polyurethane
foams

Polystyrene
HIPS



 USGS

Combustible without...

...Flame retardants

physical & chemical actions that
reduce flammability

**Coating,
cooling,
Dilution**

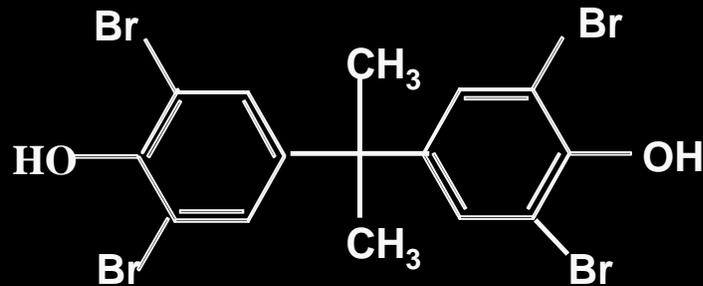
Phosphorous salts,
Antimony oxides,
Aluminum compounds

**Quenching of
the flame**

**Brominated Flame
Retardants (BFRs)**

Various Brominated Flame Retardants

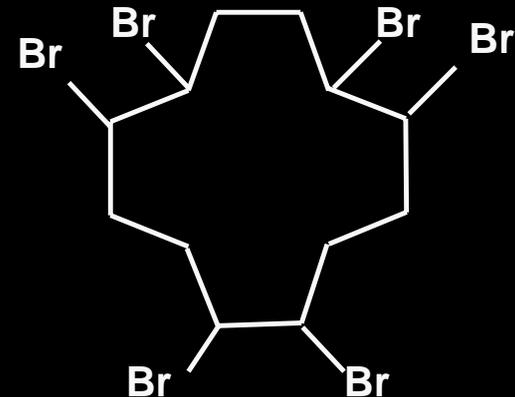
Polybrominated biphenyls



Tetrabromo-bisphenol A

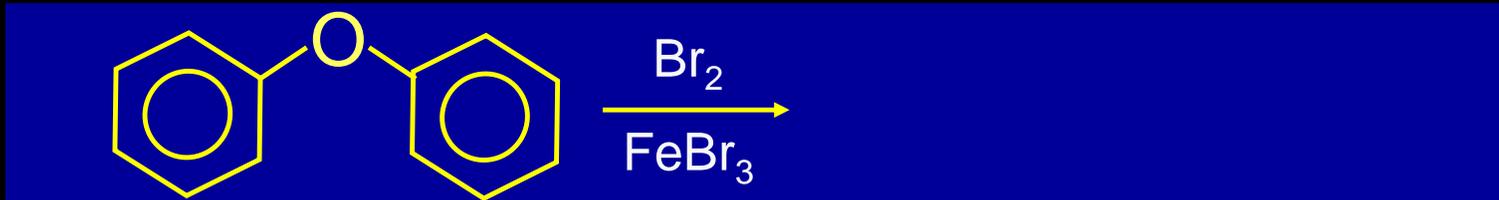
Covalently bound or added to polymer

Hexabromocyclodecane additive



PolyBrominated Diphenyl Ethers

Bromination of diphenyl ether



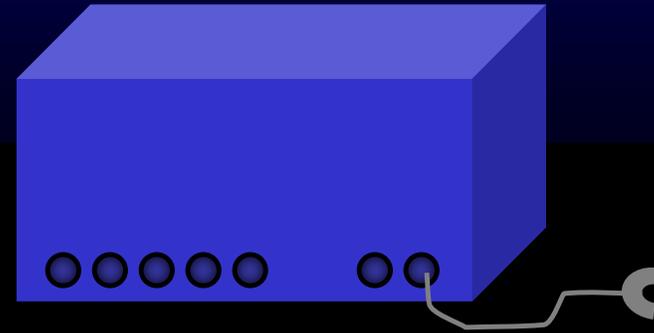
produces 3 major technical mixtures

deca, octa & penta PBDEs

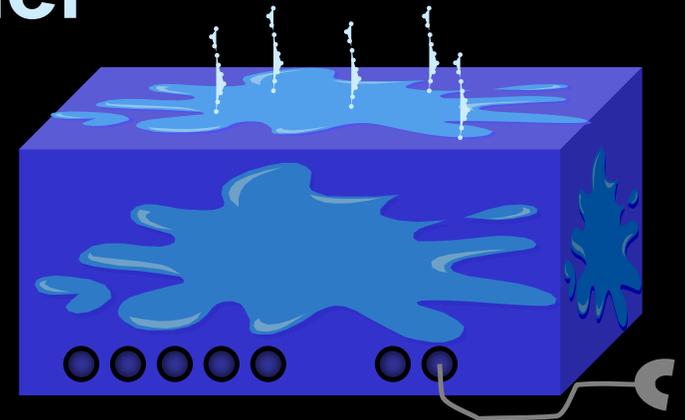
Differ in physical and chemical properties

Brominated Flame Retardants: Incorporated into plastic during manufacture

- either chemically bonded to the plastic

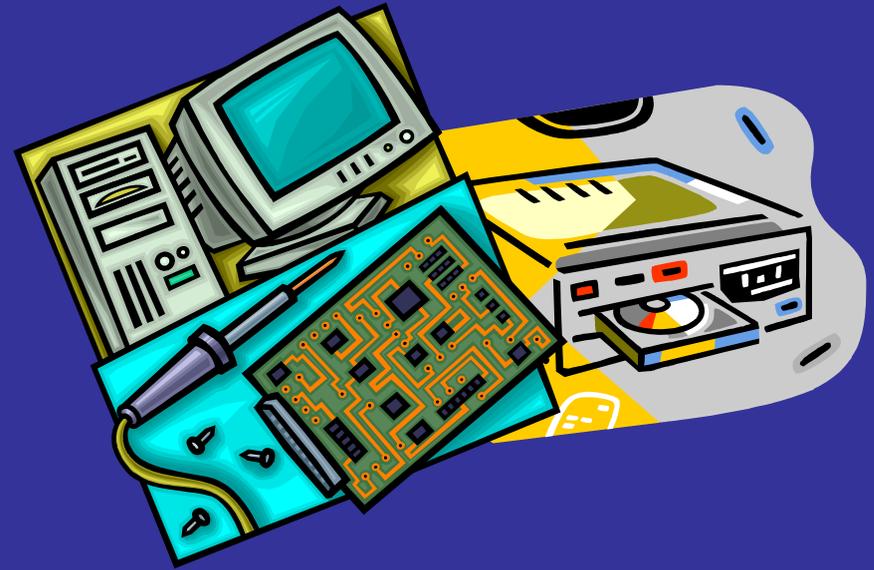


- or dissolved in the polymer
*potential to leach
and volatilize (“bloom”)
from the plastic product*





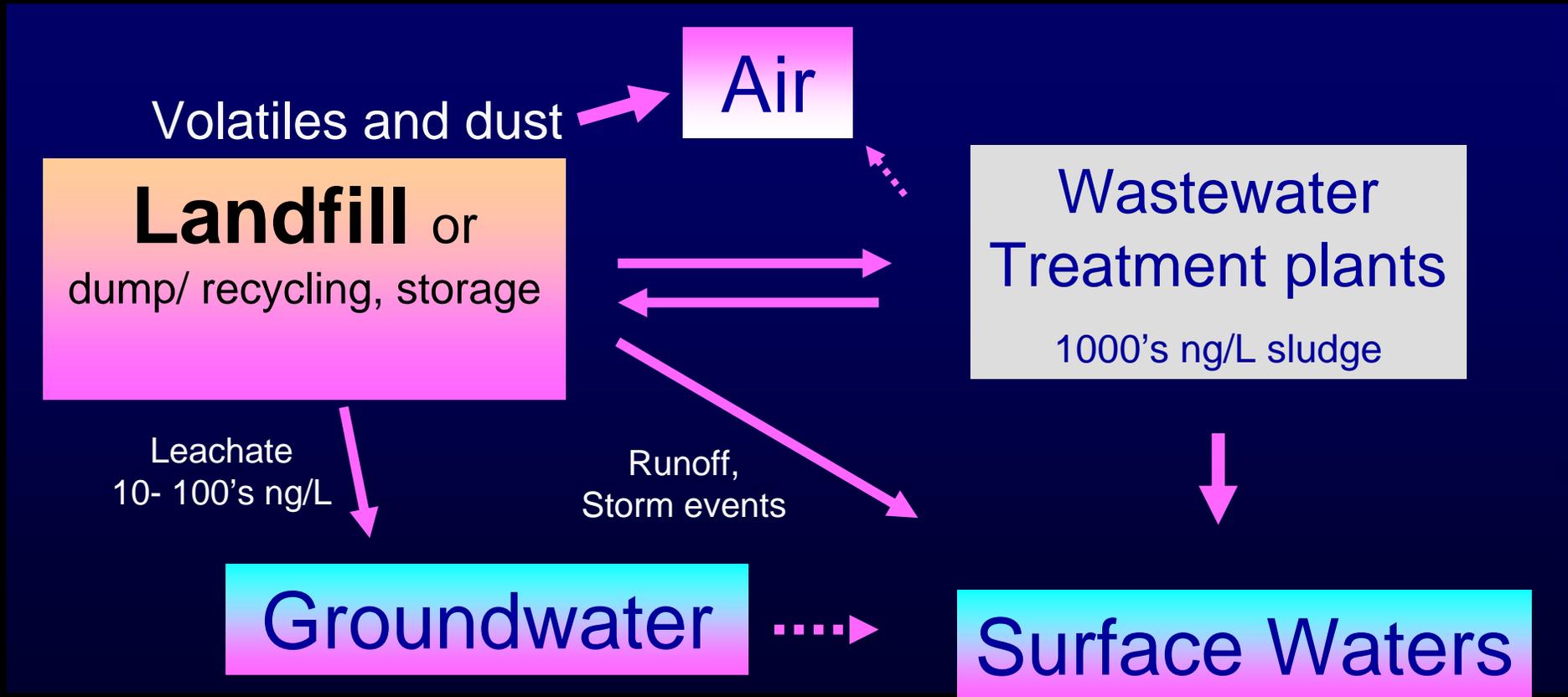
**plastic
parts of
WEEE
contain
an average**



**1% PBDE & TBBPA
flame retardants (1 lb / 100 lb)**

**scrap computers, office
& entertainment electronics**

PBDEs in the Environment !



Potential Releases of PBDE flame retardants

- PBDE production site -
- Polymer manufacture -
- Release from product during use -
- End of use: disposal, recycling -

Flame Retarded Plastics Recycling

PBDE flame retardant releases ?



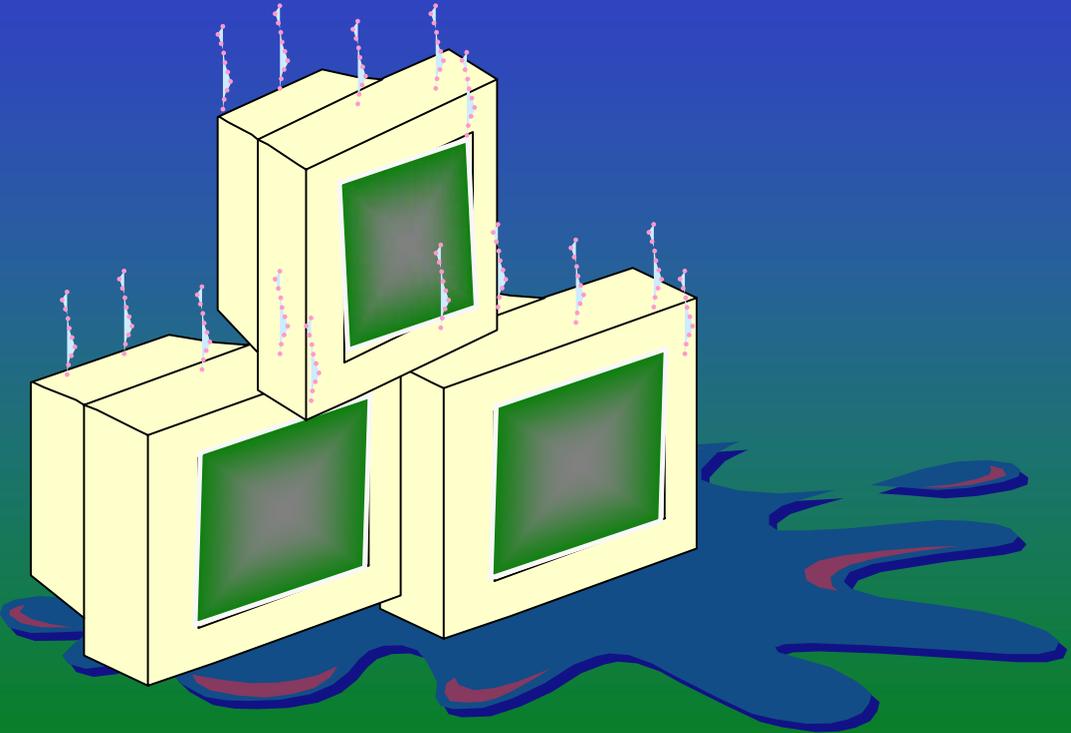
Automobile shredded residue
ASR

Waste Electric and Electronic Waste
larger flow of **PBDE flame retardants** than
Automobile Shredded Residue
and construction wastes

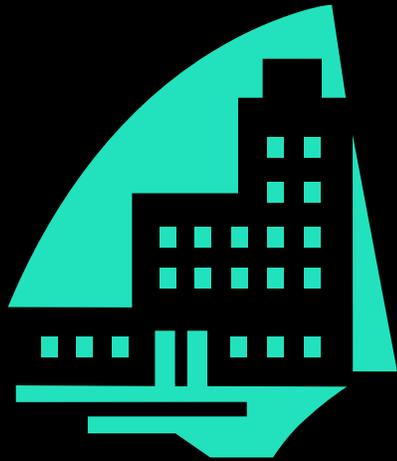


Weathered and land-filled WEEE

Potential
long term
release of
Flame
Retardants



Indoor air: Home and office dust Couch foam, carpets, electronics, etc



Web information,
including:

“ In the dust ”

[www.ewg.org/reports/
inthedust/index.php](http://www.ewg.org/reports/inthedust/index.php)

Indoor air: recycling facility study

Waste electric & electronic equipment

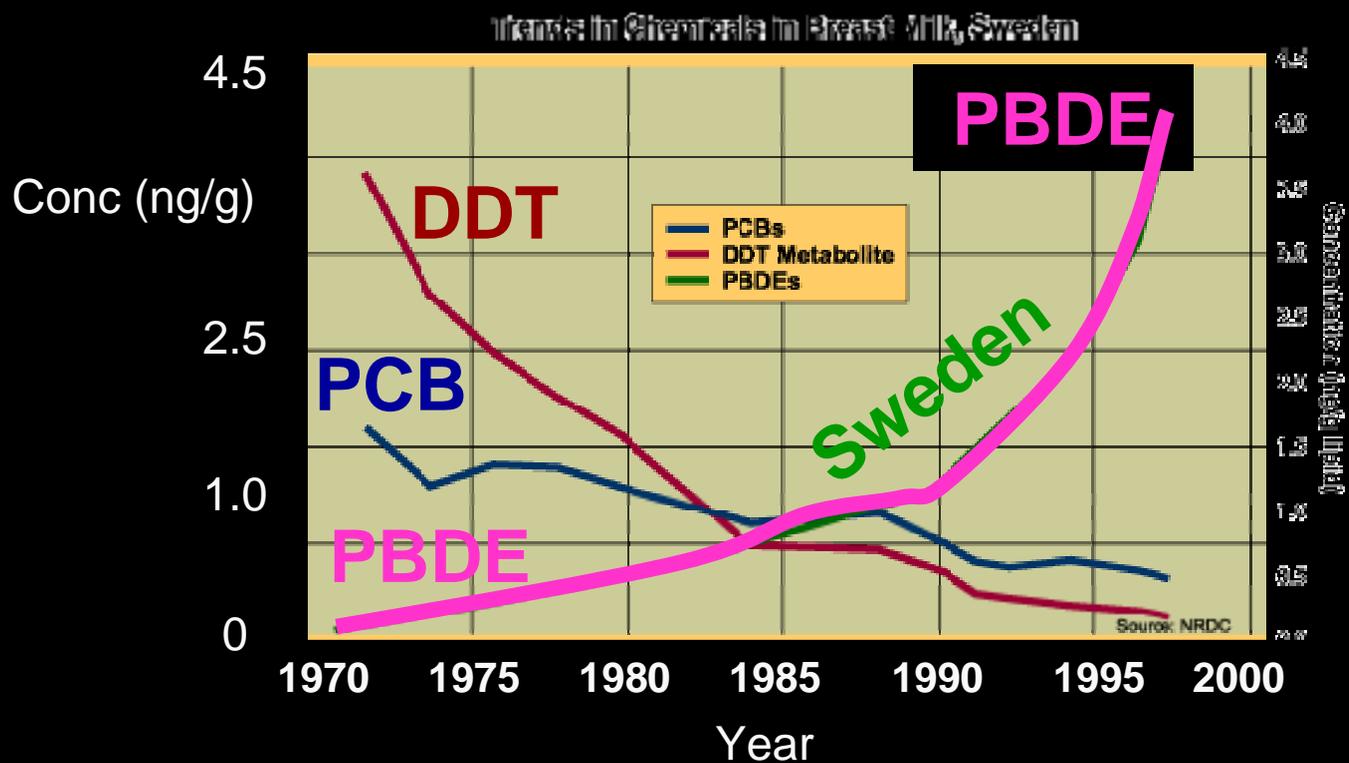


Higher PBDEs and TBBPA
compared to other work places

PBDEs in the inhalable dust
(Julander, Sci. Total Env. 2006)

Elevated serum PBDE levels
(Sjodin ES&T 2001)

Flame Retardants found in Breast Milk



From [Meironyté et al. 1998](#), NRDC

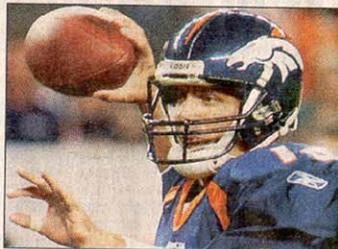
1998

LATE SPORTS

NFL Week 3

Broncos in a rout

QB Jake Plummer and Denver destroy rival Raiders ■ 1, 7C



By Ed Andrieski, AP
Plummer: 3 TDs in 1st quarter of 31-10 win.

USA TODAY

NO. 1 IN THE USA



Music

Listen up!

Dave Matthews, left, goes solo; Gloria Estefan returns; and Nickelback is no slug ■ CD reviews, 1, 6D

By Mark Mainz, Getty Images

Tuesday, September 23, 2003

Newsline

■ News ■ Money ■ Sports ■ Life

■ Dollar slides:— and stocks follow, 1, 5B

Index	Close	Change
Dow Jones industrial average	9535.41	↓ 109.41
Nasdaq composite	1874.62	↓ 31.08
T-bond, 30-year yield	5.14%	▲ 0.07
USA TODAY Internet 50	100.04	↓ 1.85

Sources: USA TODAY research, MarketWatch.com



Flame retardant found in breast milk

U.S. levels highest in the world, study says

By Elizabeth Weise
USA TODAY

A toxic chemical used to make furniture, foam and electronics fire resistant is turning up in high amounts in the breast milk of women in the USA.

Two studies, one out today, found that all of the women tested were contaminated with polybrominated diphenyl ethers. Their PBDE levels were the highest in the world: 10 to 20 times higher than those in Europe, where the chem-

icals are being phased out.

The Environmental Working Group, a non-profit environmental research organization, tested the milk of 20 women. It found levels ranging from 9.5 to 1,078 parts per billion. The women were recruited via EWG's Web site.

It is not yet known how this chemical affects people; no studies have been done on what a safe level would be. But "this is another wake-up call," says Linda Birnbaum, director of the Environmental Protection Agency's experimental toxicology lab. Levels of PBDEs in humans are doubling every two to five years, she says.

A University of Texas-Houston

What are PBDEs?

Polybrominated diphenyl ethers are among the most common flame retardants in the USA. Starting next year, they will be banned in Europe. In 2008, they will be banned in California.

■ Experts say it's still safe to breast-feed. Story, 10A

study by Arnold Schecter, professor of environmental sciences, and Birnbaum found levels in breast milk from 5 to 418 parts per billion in 47 American women. It was published last month in *Environmental Health Perspectives*. Breast milk is tested because it's the least invasive way to test fat, where PBDEs are stored.

In mice and rats, studies show PBDEs may cause cognitive and behavior changes during development; it also may lead to higher cancer rates. Peter O'Toole, of the Bromine Science and Environmental Forum, says human effects can't be extrapolated from rodents.

Though the USA has the world's

toughest flame retardancy standards, 3,000 people die in fires each year. The Chemical Manufacturers Association estimates the number would be up to 960 higher without such flame retardants.

PBDEs may enter the environment during manufacturing or when products break down, though no one yet knows for sure. Some experts say the major source is animal fat in food. One study found them in house dust.

Schecter advocates using less toxic alternatives: "These are our babies. Do we want them to be dumber than we are because their brains are being attacked by these toxic chemicals?"

North American PBDE Levels

10-20x European levels; Doubling every 2-5 years

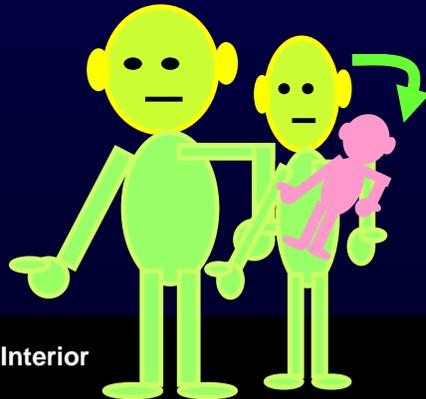


Human Exposure to PBDEs

**Indoors: dust
and vapors**

US dust: [PBDEs]
10's to 10,000's ppb (ng/g)
PBDEs 47, 99, 100, 209

Drinking water

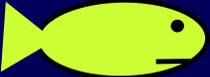


U.S. Department of the Interior
U.S. Geological Survey

Market Basket Survey (pg/g ww)

Adapted from Schecter, et al 2003

Chicken liver 2835

 **616**

 **190**

 **180 – 680**

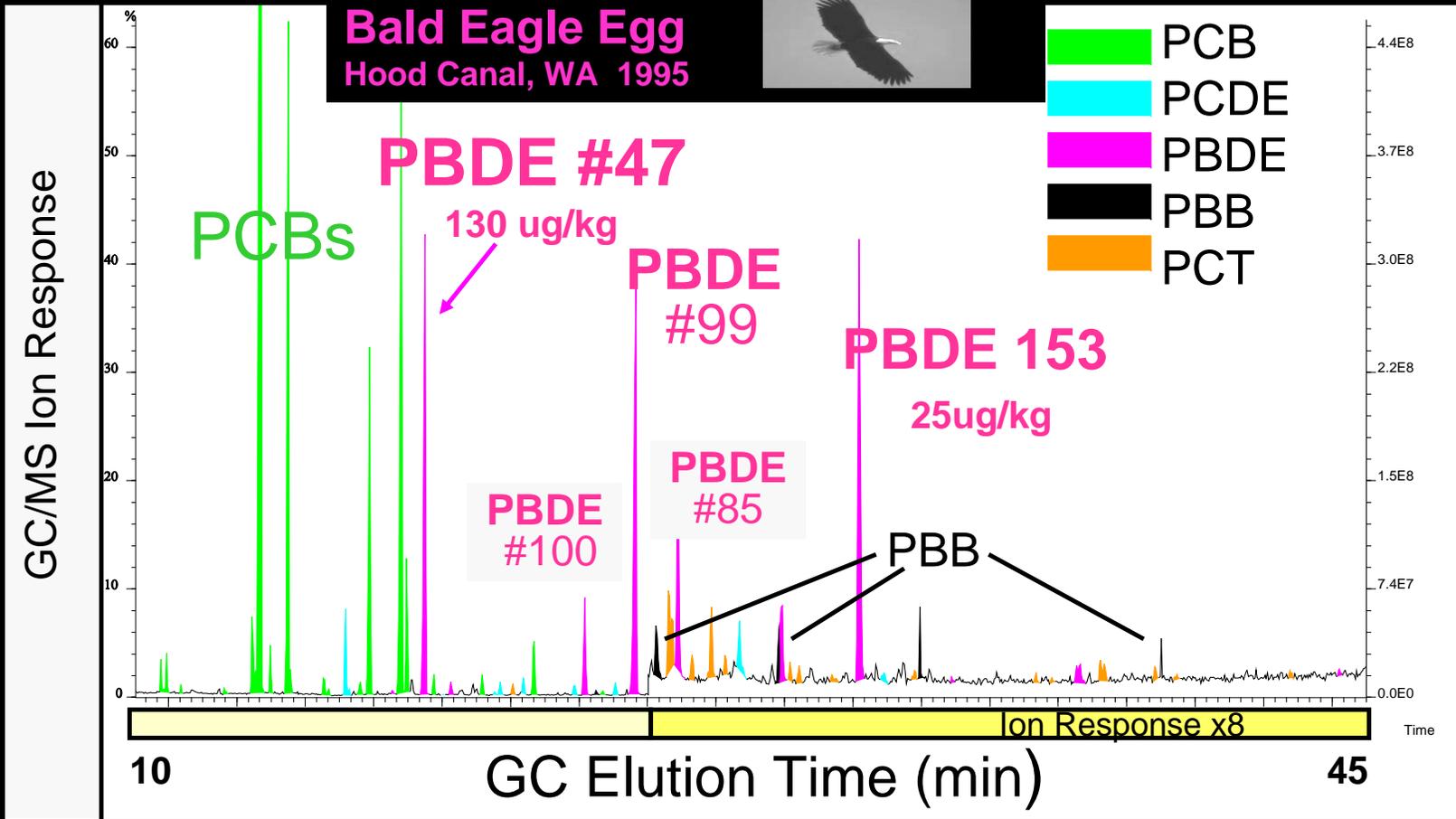
 **~ 10**

Breast milk

6 – 418 ng/g lipid

**630,000 pg/day
USA intake**

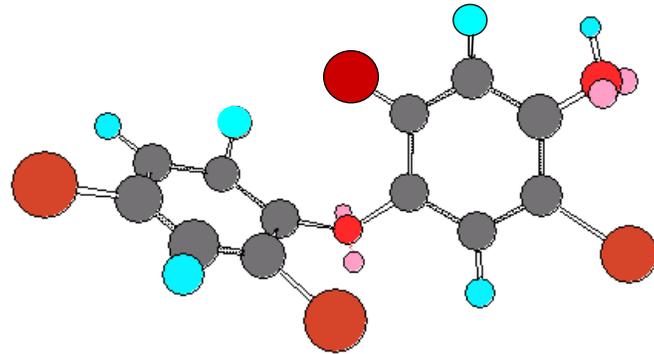
1996: PBDEs Found in Fish and Wildlife



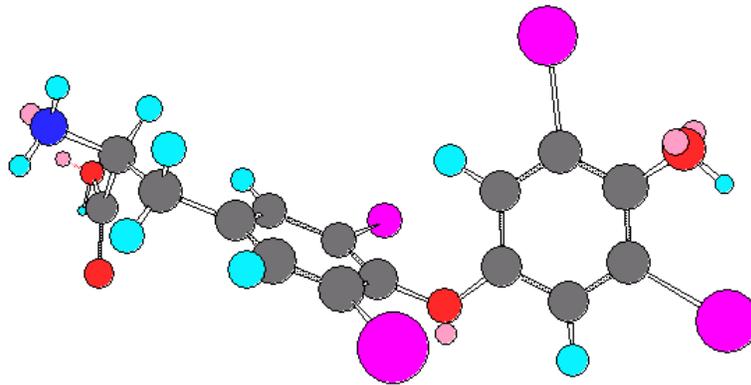
Peterman et. al, "Brominated Diphenyl Ethers Found in Aquatic Samples",

SETAC Annual Meeting, Nov 1996.

PBDE metabolites may compete with Thyroid Hormone



**Example of
Tetra-bromo-BDE
hydroxyl
metabolite**



Thyroxine (T4)

*Ubiquitous, bioavailable, **persistent**
environmental contaminants with rapidly
rising concentrations*

***Are PBDEs of concern now &
in the future ?***

**Are levels and kinds of PBDEs
being found in people,
environment, fish and wildlife at
*toxic levels?***

Summary of PBDEs' toxicities

According to EPA and other researchers, certain of the PBDEs are:

- likely carcinogens -
- induce liver enzymes -
- may impact neurological, developmental, and reproductive systems
- likely endocrine disrupters –

Toxic Substances Control Act (TSCA) enacted in 1976

**is main federal vehicle for controlling chemicals that
are potentially dangerous to living things.**

**Authorizes EPA to regulate manufacture, importation,
processing, distribution, use, and disposal**

Existing Industrial Chemicals

TSCA Section 4 authorizes EPA to require companies to conduct testing on health and environmental effects

EPA must show

- the chemical poses unreasonable risk
- and is produced in major quantities and a substantial # of people are exposed

**Section 6 authorizes EPA to ban it if...
it presents or will present and unreasonable risk of
injury to health or the environment
...only a handful of banned, i.e. lead in paint**

Worldwide Regulatory Activities

The European Union has banned Penta and Octa,
effective Aug 15, 2004.

Japan instituted voluntary phase out penta & octa.

California passed a statewide ban for 2008.

US EPA is working with PBDE manufacturers on a
voluntary phase out plan

US EPA Key Activities

Assess Substitutes for Penta BDE and Octa BDE

Assess and Evaluate Deca BDE

Assess Risks of Penta and Octa BDEs

Track Developments Concerning Other BFRs

PBDE State legislation introduced in last 2 years-

Regulating release

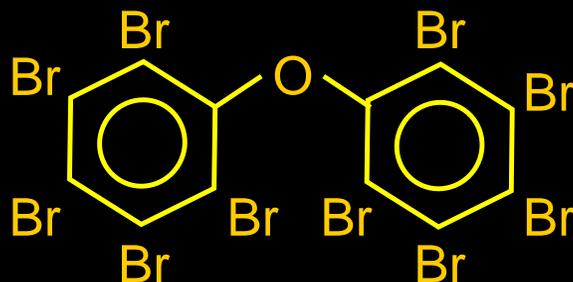
Phase out

Sentencing for environmental release of PBDEs

Incentives to recycle PBDE polymer wastes

ME, NY, HI, CA, MI, WA, WI, MA

Deca BDE Debate



Environmental Fate ?

Toxicity ?

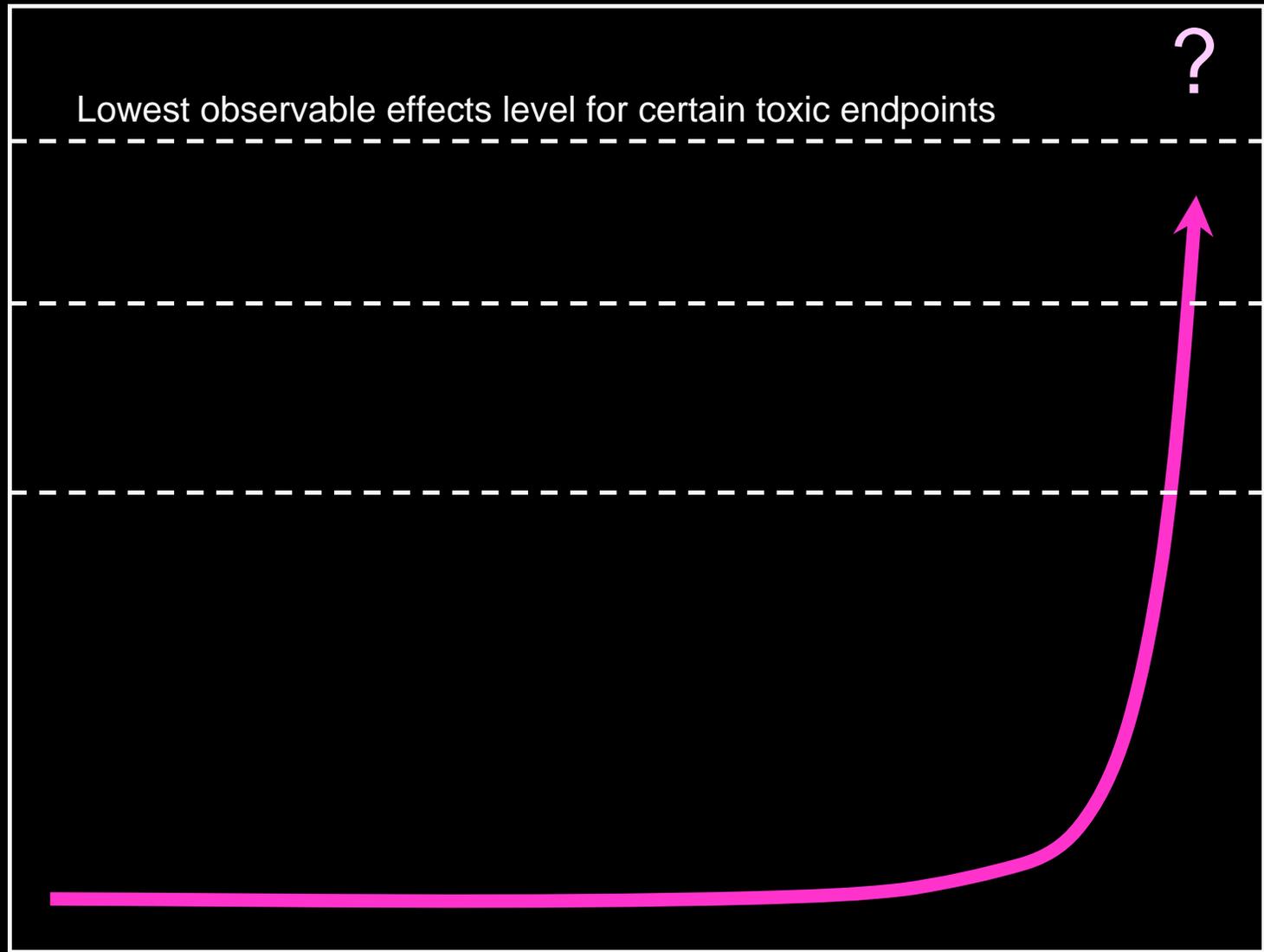
Replacements ?

**EPA Deca Assessment Under the
Voluntary Children's Chemical Action Program**

Continuing Research on PBDEs

- **Toxicities of PBDE congeners and mixtures**
- **Environmental degradation rates of various PBDEs**
- **Mobility of PBDEs in soils, leaching from landfills**
- **Occurrence and distribution in the environment**
- **Detrimental effects in fish and wildlife**
- **Incineration- produces halogenated dioxins/furans**

PBDE congener concentration



Thank you