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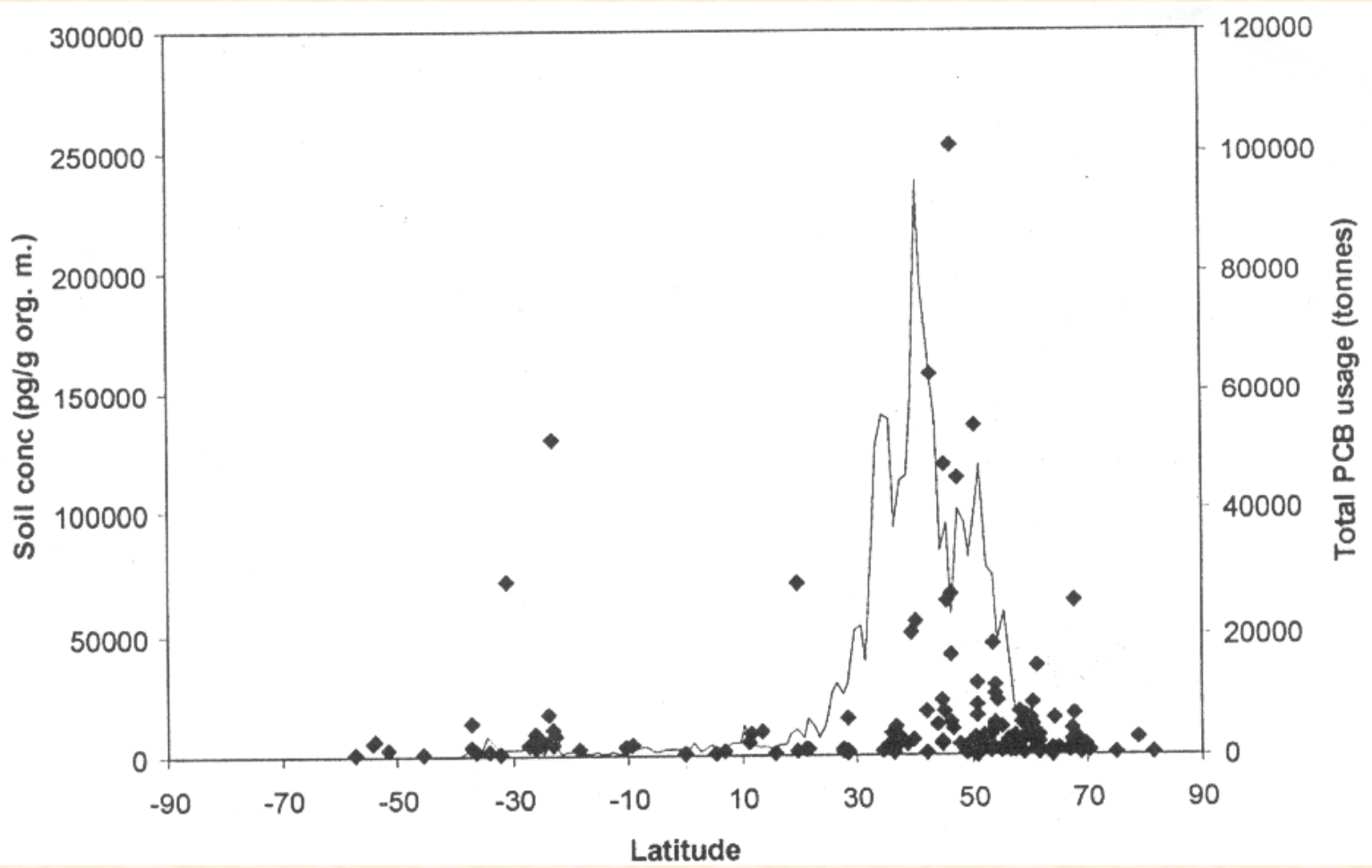
PCBs in SOIL

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10th EU Common Forum on Contaminated Land, Larnaca, 2-3 June 2003

Brief history of PCBs

- Developed in 1930s as heat transfer fluids
- Trade names: Aroclor, Phenoclor, Fenclor, Clophen
- Applications: 50% in capacitors and transformers
20% as plasticizers
hydraulic fluids, lubricants,
adhesives, inks
- Total global production ~1,3 million tons
- Peak production in 1970s
- Banned in late 1970s
- Not used in new equipment since 1986



South pole

Equator

North pole

The latitudinal distribution of global PCB usage and PCBs in surface soils

(Ockenden et al., 2003)

EC Legislative Framework

Council Directives

On the disposal of polychlorinated biphenyls
and polychlorinated terphenyls

76 / 403 / EEC

96 / 59 / EC

On environment sound disposal / management
of waste

75 / 442 / EEC

91 / 689 / EEC

75 / 439 / EEC

96 / 2002 / EC

on waste

on hazardous waste

on waste oils

on waste electrical





and electronic equipment

Council Directive 96/59/EC

on the disposal of PCBs and polychlorinated terphenyls

- Preparation of inventories
- Labelling and treatment of all significant PCB holdings
- Stricter regulation of PCBs treatment facilities
- Thresholds set out for specific registration and consequent destruction are 5 dm³ of overall filling capacity for equipment and 50 ppm for contaminated substances within such equipment
- Decontamination or disposal of these PCBs material must be carried out by 2010.
- PCBs in transformers and ancillary equipment with contamination levels below 500 ppm, do not have to be removed until the end of the equipment useful life.

Characteristics of PCBs

-  Long term stability
-  Dispersion into the environment
-  Lipophilicity - biomagnification
-  Potential toxicity to humans and biota

Environmental Occurrence



Essentially ubiquitous

TEF values for 12 PCBs congeners

TOXICITY

- ✘ Structure similar to PCDD/Fs
- ✘ Binding with Ah receptor
- ✘ Elicitation of dioxin-specific responses / effects
- ✘ Persistent and bioaccumulative

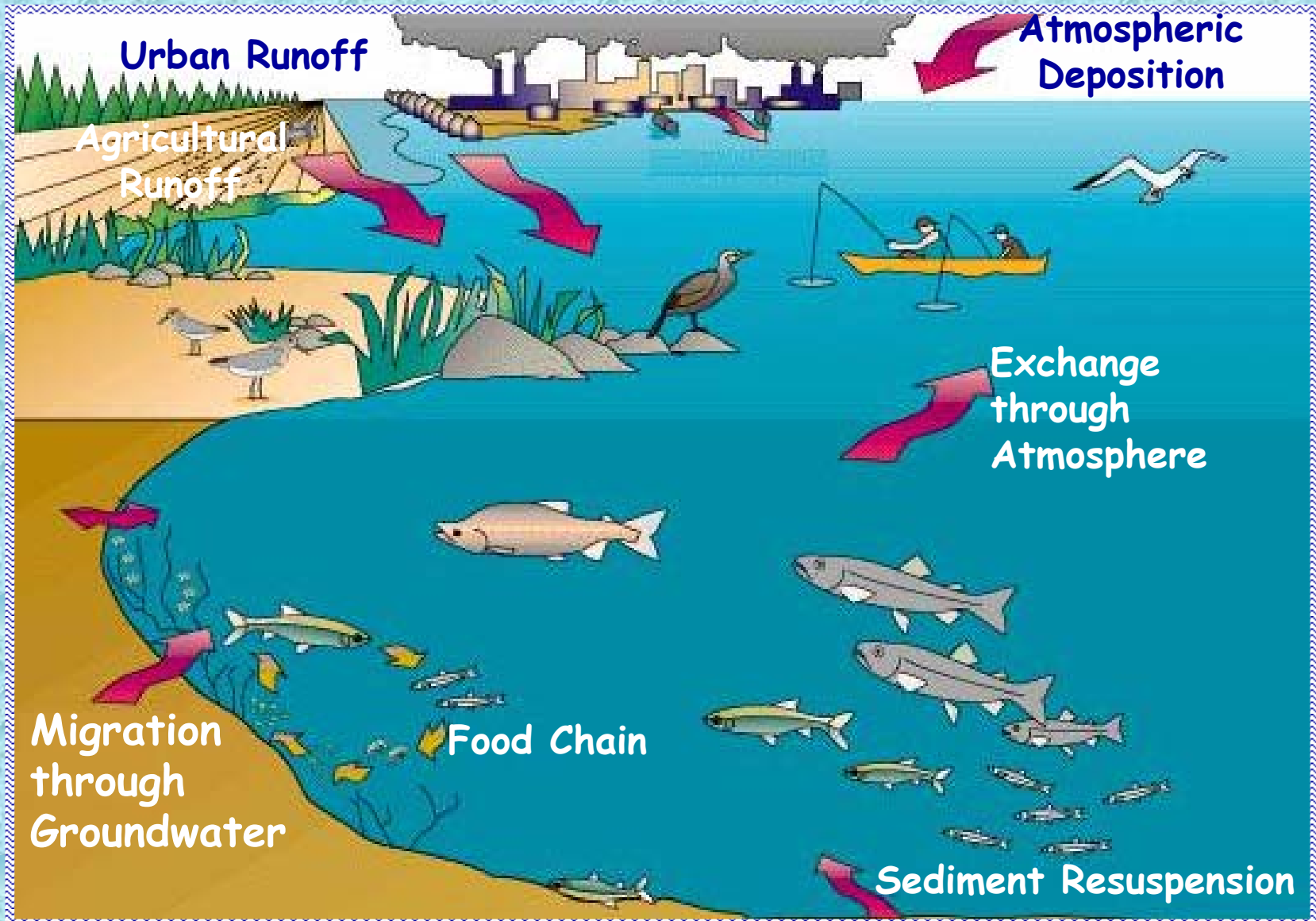
WHO TEFs for PCBs

Class	IUPAC No.	Structure	TEF
Coplanar	77	3,3',4,4'-TCB	0.0005
(non - ortho)	126	3,3',4,4',5-PeTCB	0.1
	169	3,3',4,4',5,5'-HxCB	0.01
Coplanar	105	2,3,3',4,4'-PeCB	0.0001
(mono-ortho)	114	2,3,4,4',5-PeCB	0.0005
	118	2,3,3',4,4'-PeCB	0.0001
	123	2',3,4,4',5-PeCB	0.0001
	156	2,3,3',4,4',5-HxCB	0.0005
	157	2,3,3',4,4',5'-HxCB	0.0005
	167	2,3',4,4',5,5'-HxCB	0.00001
	189	2,3,3',4,4',5,5'-HpCB	0.0001

PCBS

-  High priority pollutants - Black list (EC)
-  Persistent Organic Pollutants,
POP - Dirty Dozen (UNEP)
-  Endocrine disrupters (NRC)

PCBs in the environment



Sources

Commercial PCBs formulations

Unproper disposal

Accidental release

Industrial discharges

Incineration of municipal solid wastes
chemical wastes, clinical wastes, sewary sludge

Combustion Processes

Burning of wood and coal

Traffic

Crematoria

Accidental fires / fires in landfills

Industrial Processes

Cement kilns

Sinter plants

Steal production

Sources of PCBs in soil

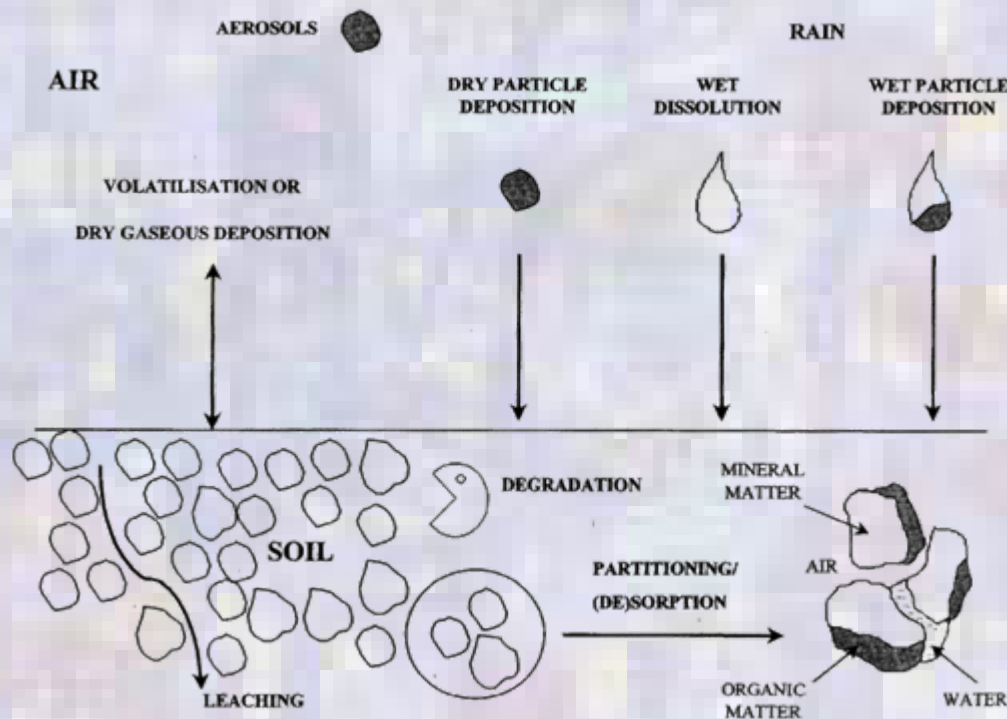
- Leackages from PCBs containing materials at waste dump sites/landfills
- Accidental release from waste containing PCBs
- Accidental fires of PCB containing equipment
- Illegal dumping of waste containing PCBs
- Accidental fires in landfills
- Agricultural activities / application of sewage sludge
- Emissions / wastes from industrial processes, combustion sources
- Atmospheric deposition

European Distribution

Country	Transformers	Big capacitors
Belgium	10.000	<2.000
France	45.000	>2.500
Germany	30.000	12.000
U.K.	3.000	<6.000
Ireland	100	<250
Spain	22.000	3.000
Portugal	25.000	500
Italy	45.000	<7.000
Greece	2.500	500

Total amount > 200.000

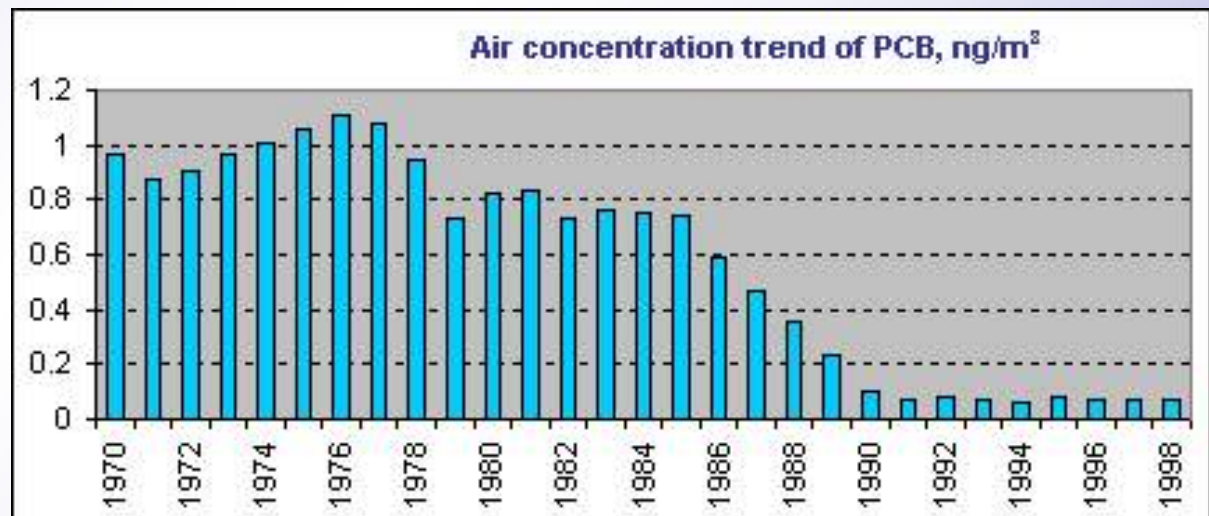
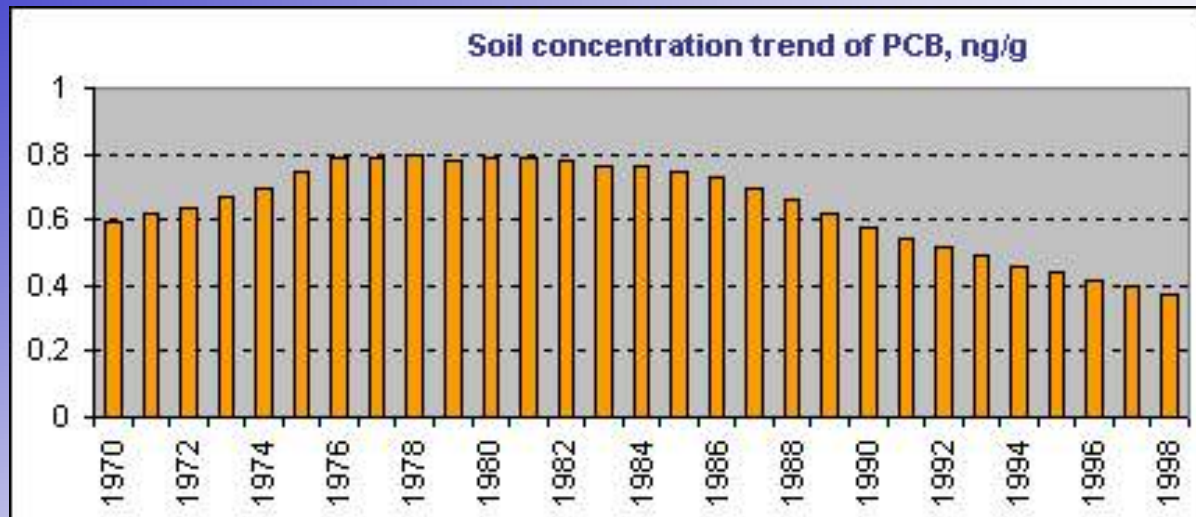
Fate Processes of PCBs



Processes in soil:
Microbially mediated degradation
Occlusion into organic matter
Physical removal

Factors govern the presence of PCBs in soils

- Ambient temperature
- Soil properties (moisture, organic matter, structure etc)
- Physicochemical properties (subcooled liquid vapor pressure, log octanol-air)



Source: EMEP

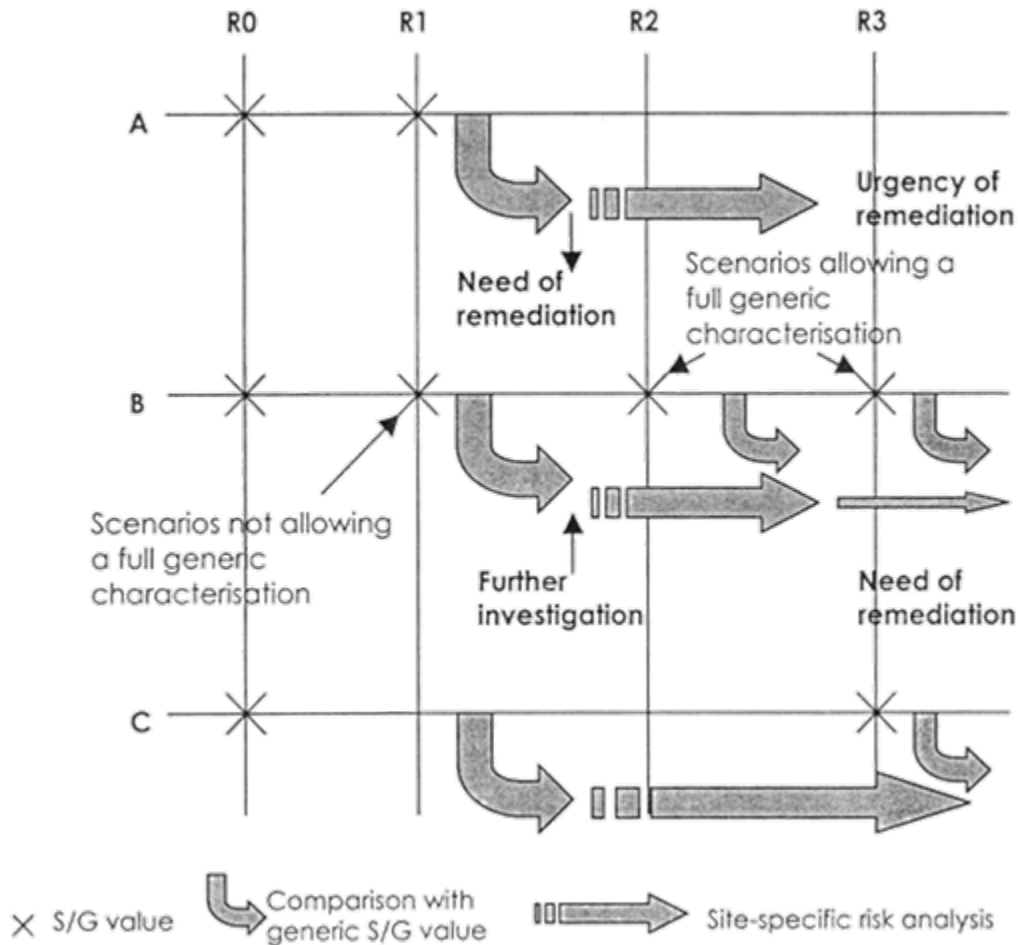
SOIL

*A secondary
emmission source
of PCB?*

Estimated annual releases of PCBs to the UK atmosphere

Source	Σ PCB (kg yr ⁻¹)
Volatilisation from soil	40.000
Capacitor leaks	3.500 - 4.200
Transformer leaks	200 - 300
Scrap metal recovering	240
Volatilisation from land applied sewage	85
Total	44.000 - 46.000

Different approaches in site characterisation



R₀: Background values

R₁: Upper limit of acceptable risk in a conservative derivation

R₂: Upper limit of acceptable risk in a realistic derivation

R₃: Upper limit of acceptable risk in a realistic derivation and exposure scenarios that are not affected by site specific variabilities

PCBs criteria for contaminated soil cleanup

**Level considered to be contaminated
(Quebec, Bernier, 1985)**

>0.5 µg/g dw

**Further investigation
Urgent remediation
(Holland, NMHPE, 1983)**

1 µg/g dw

10 µg/g dw

**Further investigation
Remediation (France,
Beaulieu, 1985)**

1 µg/g dw

5 µg/g dw

Environmental Pollution Control Laboratory

**Research activities
concerning PCBs**

Atmosphere

Wastewater / Sludge

Water / Sediment / Soil

Remediation of contaminated soil

Selection of PCBs for analysis

7 monitoring congeners
was proposed
by EC Community
Bureau of References

This selection was based
on their ...

- ◆ Abundance
- ◆ Persistence
- ◆ Representation
of each key
level of chlorination
- ◆ GC separation

PCB 28

2,4,4'-trichlorobiphenyl

PCB 52

2,2',5,5'-tetrachlorobiphenyl

PCB 101

2,2',4,5,5'-pentachlorobiphenyl

PCB 118

2,3',4,4',5 pentachlorobiphenyl

PCB 138

2,2',3,4,4',5'-hexachlorobiphenyl

PCB 153

2,2',4,4',5,5'-hexachlorobiphenyl

PCB 180

2,2',3,4',5,5'-heptachlorobiphenyl

Atmosphere

Possible sources

- ✓ Accidental releases of technical mixtures
- ✓ Improper disposal of PCB containing equipments
- ✓ Accidental fires
- ✓ Vehicles
- ✓ Combustion sources
- ✓ Redistribution from soil

Studies concerning the presence of PCBs in:

- ✓ Airborne particulate matter
- ✓ Emission from combustion sources (vehicles, oil and coal burning for health facilities)

 *Atmospheric concentrations relatively low*

Wastewater

Possible sources

- ✓ Atmospheric deposition
- ✓ Urban / agricultural runoff
- ✓ Domestic effluents (old devices)
- ✓ Industrial discharges

Leachability of PCBs from sludge using current leaching tests (MS6)

Soil - Water - Sediments

Possible sources

- ✓ Atmospheric deposition
- ✓ Urban and agricultural runoff
- ✓ Wastewaters
- ✓ Leackages from PCBs sources
- ✓ Uncontrolled burn of wastes/ biomass

Distribution of PCBs in aquatic environment

- ✓ Determination of PCBs in soil, water, suspended matter and sediments

Levels of PCBs in Greece

Atmosphere

Urban	0.5 – 30 pg/m ³ (TSP)
Semi-rural	0.5 – 16 pg/m ³ (TSP)

Waters

Sea water

Gulfs in N. Greece	15 – 92 ng/l
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River water

N. Greece	20 – 65 ng/l
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Sediments

Marine sediments	45 – 147 ng/g
River sediments	75 ng/g

Mussels

	57- 167 ng/gr ww
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Kouimtzis et al., 2002 / Kamarianos et al., 2002

Suggestions...

- Inventory of materials / equipment containing PCBs that are currently in use
- Inventory of suspected contaminated sites
- Inventory of possible PCBs-sources (industry, traffic etc)
- Data base concerning the background levels of PCBs in air, soil, water in urban, industrial and rural areas