

OCCURRENCE AND BEHAVIOUR OF PERSISTENT LIPOPHILIC CONTAMINANTS IN THE SOUTHERN HEMISPHERE

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Introduction

Lipophilic substances, having environmental persistence and occurring widely in ecosystems, have been generally described as persistent lipophilic contaminants (PLCs) or persistent organic pollutants (POPs). These include the semivolatile and persistent chlorohydrocarbon pesticides, such as DDT, HCH's, dieldrin and chlordane, and industrial chlorohydrocarbons such as the PCBs and HCB, which were detected throughout environmental compartments and were found to be bioaccumulative in lipid-containing tissues (Woodwell *et al.*, 1971). In addition, there have been combustion product residues detected consisting principally of the polychlorodibenzodioxins (PCDDs) and the polychlorodibenzofurans (PCDFs) which share the persistent, lipophilic and bioaccumulative properties of the chlorohydrocarbons (Rappe *et al.*, 1978). Thus, currently the following substances are usually considered to be globally important PLCs: chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene (HCB), hexachlorocyclohexane (HCH including lindane), mirex, polychlorobiphenyls (PCBs), PCDDs, PCDFs and toxaphene. In recent years, residues of such substances as the polycyclic aromatic hydrocarbons (PAHs), endosulfan, atrazine and many other substances have been detected in many sectors of the environment and share many of the attributes of PLCs (for example Yang *et al.*, 1991)

Investigations and studies in the 1980s and 90s have identified long-range transport through the atmosphere, primarily in the Northern Hemisphere, as a mechanism which is important in the distribution of these substances. Recent studies have focused on the global distribution of PLCs and hypotheses such as the "grasshopper effect" have been proposed to explain the nature of the distribution of some PLCs from lower to higher latitudes (eg. equatorial to polar regions) particularly in the Northern Hemisphere (Mackay and Wania, 1995). The significance of the usage patterns and distributions of PLCs and other related compounds within countries and geographical regions of the Southern Hemisphere remains much less clear.

The objectives of this investigation were to evaluate the data available on PLCs and other compounds producing residues in the Southern Hemisphere and to evaluate temporal changes and assess the processes of global distribution.

Methodology

The scope of the literature review conducted for this review was confined to Southern Hemisphere sources or references on environmental levels of POPs. Primary sources for published international studies on POPs were computerised databases. Two major CD-Rom databases were searched, Polltox 1 (Pollution and Toxicology) and Environment Abstracts. Polltox was searched

from 1990-1995 (June). Periodicals covered by this CD-Rom database included Environmental Science and Technology, Science of the Total Environment, Marine Pollution Bulletin, Chemosphere, Bulletin of Environmental Contamination and Toxicology, Water, Air and Soil Pollution, Water- South Africa, and the Australian Journal of Marine and Freshwater Research. Keywords used were individual pesticides (eg DDT) in combination with countries of the Southern Hemisphere. General terms used included "organochlorine insecticide", "polyaromatic hydrocarbon", "pesticide", "organochlorine insecticide", "PCB" and all countries (by name) in Africa, South America, and Australasia-Oceania. Time constraints have prevented direct follow-up with research groups in major countries within the Southern Hemisphere and International or Government Agencies concerned with monitoring for local, regional or global levels of various POPS.

Significant data on PLCs in the Southern Hemisphere appear limited to aldrin, chlordane, DDT, dieldrin, heptachlor (heptachlor epoxide), HCB, HCH, ($\alpha,\beta,\delta,\gamma$), and PCBs. Some limited to very limited data are available on dioxins and furans, PAHs, endosulfan, and atrazine.

Comparative levels of persistent chlorohydrocarbons in air, seawaters, sediments and biota from the northern and southern hemispheres are available from several international studies (eg. Iwata et al., 1993; 1994; Simonich and Hites, 1995).

Results and Discussion

Levels of PLCs in the Environment and Biota

Concentrations of chlorohydrocarbons (DDT, HCH, PCBs, HCB, heptachlor & heptachlorepoide and chlordane) in the atmosphere in oceanic environments concentrations are generally less than 1 ng/m^3 (1000 pg/m^3) and frequently below 0.1 ng/m^3 (100 pg/m^3). However some elevated levels are associated with Ross Island in Antarctica where a base is established. River and estuarine air levels reported by Iwata *et al* (1994) in the Australasian region are higher and range up to 8.0 ng/m^3 , which is probably to be expected since these zones are closer to potential sources compared with oceanic environments. The concentrations of DDTs and PCBs are generally higher than the other compounds detected with the PCBs in oceanic environments exhibiting a maximum of 12.3 ng/m^3 and the DDTs a comparable maximum of 0.240 ng/m^3 (Connell et al, 1999).

In oceanic regions seawater concentrations for most PLCs (DDT, PCBs, HCH, chlordane and aldrin are below 0.1 ng/L . Current PCB levels (Iwata *et al*, 1993) are lower by a factor of about 7 compared to earlier values reported by Tanabe et al (1982), for samples collected in similar locations. River and estuarine waters and seawaters in the tropical archipelagos of Indo-Pacific regions tended to be in the range from about 0.1 ng/L to 10 ng/L , particularly for DDT, PCBs and HCHs. Most high values ($> 500 \text{ ng/L}$) were measured during the 1970s and early 1980s in freshwater agricultural and urban areas, but some more recent elevated levels were reported from several rivers in the range of $1\text{-}50 \text{ ng/L}$.

All of the PLCs in the chlorohydrocarbon group, except toxophene, endrin and mirex, have been detected in sediments. DDT, HCH and PCB concentrations were in the parts per billion range to part per million range, ie. $1\text{-}1000 \text{ ng/g}$. However, reported values were based on either dry or wet weight basis which makes comparisons difficult. Generally higher levels of these compounds were found in urban estuarine environments. High concentrations have also been reported for sediments in Australian agricultural freshwater areas (up to $11.3 \text{ }\mu\text{g/g}$ DDT), in an Antarctica marine area (up to $4.3\mu\text{g/g}$ PCB), Argentine lakes and rivers ($1.86\mu\text{g/g}$ HGH) and Australian river

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areas (up to 0.41 µg/g dieldrin). High levels of HCB were reported for marine sediments up to a level of 0.871 µg/g near the Sydney ocean outfall at Malabar. Exceptional levels of DDT up to 118 µg/g, dieldrin (up to 22.8 µg/g) and aldrin (up to 4.1 µg/g) were measured in Lake Kariba, Zimbabwe (Connell et al, 1999).

There was a trend for the higher concentrations to be reported during the 1970's and 1980's with lower concentrations being currently reported. An exception to this is the HCB reported from Sydney, Australia which probably originates from industrial sources.

Soil data, however, were limited to certain areas of Australia. As expected levels of contaminated soils (DDT, dieldrin, heptachlor, chlordane, HCH) ranged from about 10 ng/g to 10,000 ng/g with pasture levels under 100 ng/g. Soil levels are likely to vary with land use activities (Connell et al, 1999).

Data on PLCs in aquatic organisms seem to reflect specific studies in areas where urban and/or agricultural activities are known to result in release of such substances to the environment. Some data refer to sedentary organisms such as many invertebrates, but many species are mobile, eg. species of fish. Residue data for aquatic organisms tend to range from a part per billion (1 ng/g wet weight) to the low parts per million or more (over 1000 ng/g wet weight) for urbanised estuaries, bays and near coastal outfalls. A range of relatively high concentration is apparent with Australian invertebrates and fish exhibiting concentrations up to 40.3 µg/g DDT. However these data are generally derived from the late 1960s to early 1980s. Some high concentrations have also been reported for Antarctic invertebrates (up to 0.43 µg/g PCB), Australian invertebrates (up to 5.0 µg/g PCB), Argentinean fish and bivalves (up to 5.8 µg/g PCB), Australian fish (up to 6.0 µg/g dieldrin), Argentinean species (up to 2.0 µg/g heptachlor and heptachlor epoxide) and Australian fish species (up to 1.7 µg/g chlordane). In oceanic environments removed from known sources, there are detectable but contain low levels of many of these compounds eg. fish in the Eastern South Pacific up to 0.33 µg/g PCB and fish in the South Atlantic up to 0.02 ng/g heptachlor and heptachlor epoxide (Connell et al, 1999).

Chlorohydrocarbons PLCs have accumulated in a wide range of marine mammals (cetaceans and pinnipeds) living in waters throughout the Southern Hemisphere. Concentrations of PCBs (up to 15.5 µg/g) and DDT (up to 28.4 µg/g) have been found in the blubber of some species, eg. dolphins, off the South African and Australian coasts. Lower levels of chlorohydrocarbons, such as PCBs, are reported for Antarctica (Connell et al, 1999).

Critically, the majority of reported data on marine mammals refer to the 1980s or even earlier. Trends in levels are consequently difficult to analyse. However, de Kock *et al* (1994) found little significant change in PCB levels in dolphins from the West Coast of Africa, sampled during the 1970s to 1986-7.

Global Behaviour Patterns of PLCs

It is widely accepted that global distillation is a major process involved in the deposition of volatile PLCs such as the HCHs at the poles (Wania and Mackay, 1996). Barrie *et al* (1992) however, have concluded that both the atmosphere and ocean currents are major transport mechanisms which must operate in conjunction with global distillation for the movement of PLCs to the Poles. Important findings from the work of Levy (1990) are that little interhemispheric mixing occurs due to the presence of Hadley cells over the tropics. These conclusions are, supported, in general by the results of this work.

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