Organochlorine Pesticide Emission Inventory Review

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Organochlorine pesticides are pesticides in which carbon and chlorine are combined. Most organochlorine pesticides are Persistent Organic Pollutants (POPs). The 1998 Aarhus Protocol on Persistent Organic Pollutants listed 16 POPs substances, 11 of which are pesticides – aldrine, dieldrine, endrine, chlordane, DDT, heptachlore, hexachlorobenzene, mirex, chlordecone, lindane, and toxaphene.

There is considerable evidence that persistent organochlorine pesticides circulate globally and accumulate in remote areas like the Arctic (Macdonald et al. 2000). Establishing the sources of pollutants and their emissions and residues are first steps towards reducing their levels in the environment. The analysis of usage and emission trends is also important in developing ways to determine the sources and pathways of the pollutants (Li et al. 1998; 2001b; 2002a).

Regional Scale versus Global Scale

Perhaps the most important characteristics of any inventory are its geographical area and spatial scale. The standard spatial scale adopted by GEIA is 1° longitude by 1° latitude resolution. This standard spatial scale has been used for our global pesticide usage/emission inventories (Li et al. 1996; 2000; Li, 1999). A more fine scale with 1/4° longitude by 1/6° latitude resolution has also been adopted for our regional pesticide usage, emission and residue inventories for China, Canada and the United States (Li et al. 1999; 2001a,b; Li, 2001). The quality of inventories on a global scale depends on the quality of those on a regional scale.

Emissions versus Residues

Organochlorine pesticides are an important part of persistent organic pollutants, and are chemically stable in nature. They break down only very slowly and can remain in the environment for a long time. Half-lives of organochlorine pesticides are diverse, from 1 year for g-HCH (Wauchope et al., 1992) to 10 years for toxaphene (Mackay et al., 1997). Organochlorine pesticide residues have been detected in air, water, soil, sediment, fish, and birds worldwide even more than one decade after the use of these pesticides was banned. Therefore, emissions of organochlorine pesticides must take into account not only current pesticide use, but also the residues due to use in the past.

The global gridded emission inventories of a-HCH (Li et al. 2000) are not only the first gridded emission inventories of pesticides on a global scale, but also the first emission inventories that consider the residues due to application of pesticides in previous years.

Gridded toxaphene residue inventories in agricultural soil in the United States at the beginning of 2000, with 1/4° longitude by 1/6° latitude resolution were presented by Li et al. (2001b) This is the first gridded residue inventories for pesticides. The results indicate that, almost 20 years after the ban of toxaphene use in the USA in 1982, the total toxaphene residues left in agricultural soil in the United States were around 29 kt at the beginning of 2000; 0.4 kt of that was emitted into the atmosphere in 2000, although there

was no current usage of that pesticide in the USA.

Uncertainties

It is difficult, if not impossible, to give a quantitative estimate for the uncertainty of pesticide usage/emission data. A qualitative uncertainty estimate will thus be given for each pesticide emission inventory. The major uncertainty comes from the country-based usage data that were reported or estimated. The reported information on present and historical use of pesticides is difficult to obtain and is highly uncertain. Many countries do not keep records on this pesticide, while in other countries such information is confidential. In order to fill spatial and temporal gaps of the usage data, a linear interpolation has to be used. Another source of uncertainty is due to the gridding process. Although the cropland data set that is used as the surrogate in this work is of high accuracy, some pesticides may not be used in cropland. The emission factors and half-lives that are used to calculate the emissions and residues also introduce uncertainty. A qualitative uncertainty estimate (low, medium, and high) is thus assigned by region according to the level of regional detail of the usage data (Li 1999, Li et al. 2000).

Generally speaking, the accuracy of the gridded pesticide data presented in our inventory study is quite high.

The high quality of our global HCH usage and emission inventories is supported by the fact that the ratios of air concentrations of a-HCH in the Arctic to those in the Antarctic are very close to the ratios between the total technical HCH usage in the Northern Hemisphere and in the Southern Hemisphere for 1980, 1987, and 1990, and also by local contamination levels in various countries (Li 1999).

From our gridded technical HCH usage inventories, the total accumulated application rate was obtained for each grid cell. Our estimated application rate of this pesticide between 1953 and 1983 in the Taihu Lake Basin of China is 360 kg/ha, which is very close to the rate of 375 kg/ha found in the survey conducted by the Chinese government in the same area for the same period of time (Li et al. 2001a).

Our gridded usage, emission and residue inventories of toxaphene for the USA have a high quality as well. Figure 1 gives average toxaphene soil concentrations by state in the USA in 1971. It shows that the data calculated from our residue inventories match very well with those obtained by the USA National Monitoring Program (Li et al. 2001b).

Table 1 gives a list of emission inventories for some organochlorine pesticides produced or to be produced soon.

Table 1. Global and regional organochlorine pesticides emission inventories.

Pesticides	Spatial Scale	Resolution	Period	Temporal Scale	Referer
a-HCH	Global	1x1 lat/long	1948-2000	Annual	Li et al. 20

b-HCH	Global	1x1 lat/long	1948-2000	Annual	Li et al. 20
g--HCH	Global	1x1 lat/long	1948-2000	Annual	Li et al. 20
toxaphene	Global	1x1 lat/long	1945-2000	Annual	Li 2002a
DDT	Global	1x1 lat/long	1945-2000	Annual	Li 2002b
toxaphene	USA	1/4x1/6 lat/long	1947-2000	Annual	Li et al. 20
DDT	USA	1/4x1/6 lat/long	1945-2000	Annual	Li 2002c

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