USAGES AND RESIDUES OF ENDOSULFAN IN CHINESE AGRICULTURE SOIL

Jia HL[1], Li YF[2,1], Liu Y[1], Yang M[1], Zhou L[1], Wu HL[1], Ma J[2], Sverko E[2]

[1] International Joint Research Center for Persistent Toxic Substances, Dalian Maritime University, Dalian, China

[2] Science and Technology Branch, Environment Canada, Toronto/Burlington, Canada

Abstract

The annual application loadings of endosulfan during a period from 1994 to 2004 in China were estimated, and around 25,700 t of endosulfan were used in China between 1994 and 2004. Gridded usage, emission, and residue inventories of endosulfan with 1/4° longitude by 1/6° latitude resolution have been created. Total emissions of α- and β-endosulfan from 1994 to 2004 were estimated to be 10,700 t, and residues for these 2 compounds in Chinese agricultural soil were 127 t for 2005. Concentrations of α- and β-endosulfan in soil were also calculated for each cell, and the modelling data were compared to the monitoring data from the Chinese POPs Air and Soil Monitoring (PASM) Program run by the International Joint Research Center for Persistent Toxic Substances (IJRC-PTS), China and the Science and Technology Branch, Environment Canada. The results show that α- and β-endosulfan concentrations in surface soil measured from the 52 sampling sites and estimated for those grid cells for the corresponding sites are consistent in general. This work is the first comprehensive and systematic study of its kind for pesticides in Chinese surface soil conducted on a national scale.

Introduction

The organochlorine pesticide (OCP) endosulfan is a non-systemic and ingested insecticide and acaricide for use on a wide variety of agricultural crops. The commercial technical endosulfan mixture consists of 70% α-endosulfan and 30% β-endosulfan[1,2], which exhibit similar insecticidal properties but different physicochemical properties[3,4]. In the environment, the cyclic sulfite group of endosulfan can be hydrolyzed to form endosulfan diol[3,5] or oxidized to the corresponding endosulfan sulfate[6,7]. Endosulfan is classified by the World Health Organization and U.S. Environmental Protection Agency as priority pollutants[8], and a nominator for inclusion in a future iteration of the POPs treaty.

Widespread use and atmospheric transport of endosulfan account for its ubiquitous global distribution. It is the highest measured OCP in air globally, in the range of tens to hundreds of pg/m^3. Endosulfan has also been found in the Arctic. A time trend of α-endosulfan air concentration at Alert between 1987 and 1997 shows this to be one of the few OCPs that is still increasing in arctic air, and consistent with the emission data, suggesting the atmosphere to be the important transporting medium[9].

The goal of this paper is to study the use of endosulfan in China and the residues of this chemical in Chinese surface soil due to the use of the pesticide.

Usage

Annual endosulfan usage from 1994 to 2004 in China is shown in Figure 1. From 1994 to 1997, endosulfan was employed on cotton land only, and the usage decreased with average annual use of 1,400 t. The annual use of endosulfan has increased to almost 3,000 t annually since 1998 when endosulfan started to be used on other crops, such as wheat, tea trees, apple trees, and tobacco. The total endosulfan usage in this period was estimated to be 25,700 t. Using Simplified Gridded Pesticide Emission and Residue Model (SGPERM)[10], gridded usage inventories with a 1/4° longitude by 1/6° latitude resolution were created, and the results are given in Figure 2. It indicates that endosulfan usage is most intensive in the south of Hebei Province, west of Shangdong Province, east of Henan Province, north of Anhui Province, east of Jiangsu Province, and some areas in Yunan Province and Xinjiang Autonomous Region.

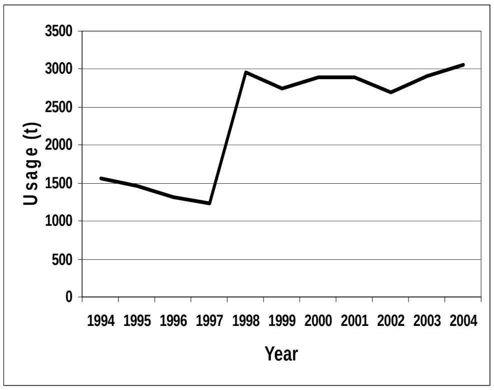

Figure 1. Annual endosulfan usage from 1994 to 2004.

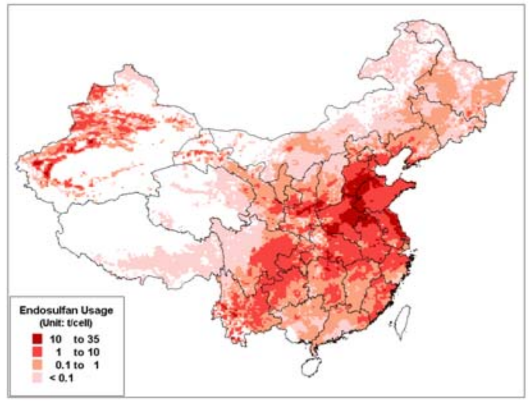

Figure 2. Distribution of endosulfan usage in China from 1994 to 2004 with 1/4° longitude by 1/6° latitude resolution.

Emissions and residues

Emission and residue inventories were created using SGPERM[10], and shown in Figures 3 and 4, respectively. Total emissions of α- and β-endosulfan from 1994 to 2004 were estimated to be 10,700 t, and residues for these 2 compounds in Chinese agricultural soil were 127 t for 2005.

Soil concentrations

By assuming that endosulfan was contained in the top 20 cm layer of cropland soil and the density of the soil is 2.65 (g cm^{-3})[11], the average soil concentrations were calculated for each grid cell, and the results are given in Figure 5. According to modelling results, concentrations of α- and β-endosulfan in most Chinese agricultural soils were less than 1 ng/g dw.

Very few data have been published for endosulfan in Chinese soil. The International Joint Research Center for Persistent Toxic Substances (IJRC-PTS), China and the Science and Technology Branch, Environment Canada started a Chinese POPs Air and Soil Monitoring (PASM) Program[12] in 2004 to monitor concurrently the concentration level of POPs in both Chinese air and soil. This is the first comprehensive and systematic study of its kind for pesticides in Chinese surface soil on a national scale. The mean concentration level for all sites is 0.021 ng/g dry weight, ranged from below detection limit to 0.9 ng/g dry weight.

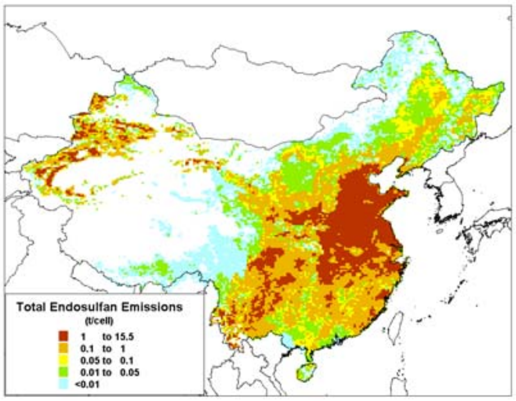

Figure 3: Distribution of α- and β-endosulfan emissions in China from 1994 to 2004 with 1/4° x 1/6° longitude and latitude resolution.

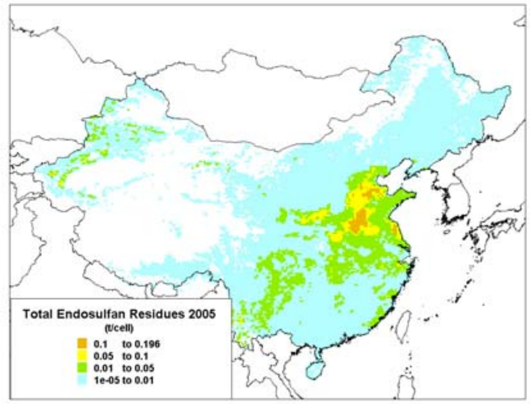

Figure 4: Distribution of α- and β-endosulfan residues in China in 2005 with 1/4° x 1/6° longitude and latitude resolution.

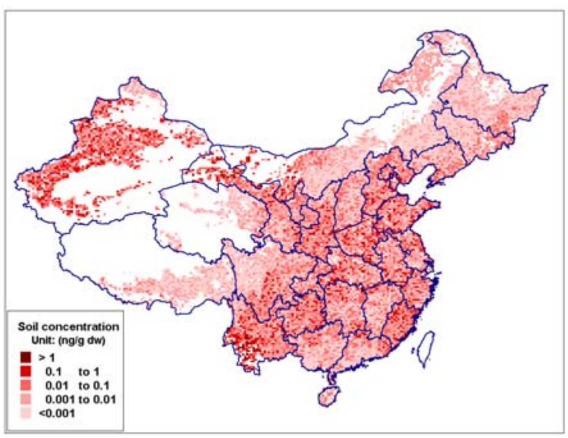

Figure 5: Distribution of total endosulfan (α- and β-endosulfan) soil concentration (ng/g dw) in China in 2005 with 1/4° x 1/6° longitude and latitude resolution.

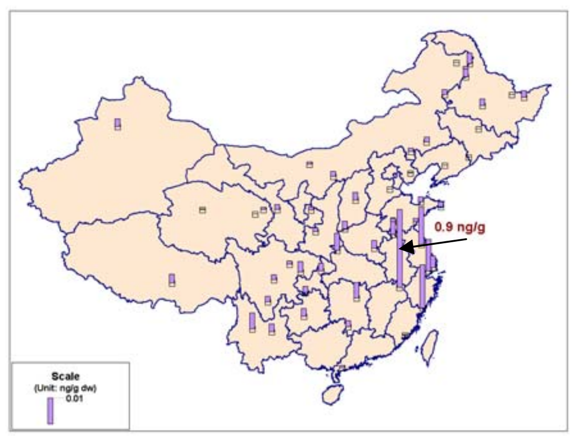

Figure 6. Distribution of α- and + β-endosulfan in Chinese surface soil in 2005. Note that the bar with 0.9 ng/g dw is not on scale.

Figure 7 presents α- and β-endosulfan concentrations in surface soil measured from the 52 sampling sites and estimated for those grid cells where the 52 sites are located. The average concentrations for the sampling sites and the corresponding grid cells are 0.021 ng/g dw and 0.016 ng/g dw, respectively, indicating good agreement between the measured data and the modelling results.

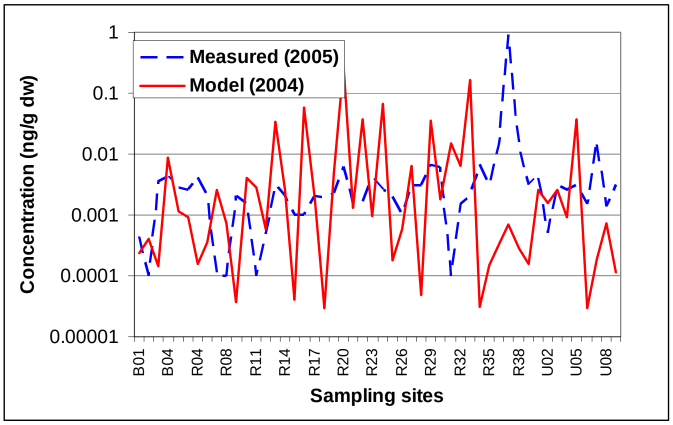

Figure 7. Soil concentrations of α- and β-endosulfan measured from the sampling sites and estimated for those grid cells where the sites are located.

References

1. Maier-Bode H. *Residue Rev* 1968; 22:1.
2. Rice CP, Chernyak SM, McConnell LL. *J Agric Food Chem* 1997; 45:2291.
3. Peterson SM, Batley GE. *Environ Pollut* 1993; 82:143.
4. Schmidt WF, Hapeman CJ, Fettinger JC, Rice CP, Bilboulian S. *J Agric Food Chem* 1997; 45: 1023.
5. Gupta PK, Gupta RC. *Toxicology* 1979; 13:115.
6. Chandler GT, Scott GI. *Environ Toxicol Chem* 1991; 10:375.
7. Miles CJ, Pfeuffer RJ. *Arch. Environ Contam Toxicol* 1997; 32:337.
8. McLachlan MS, Czub G., Wania F. *Environ Sci Technol* 2002; 36: 4860.
9. Li YF, MacDonald R. 2005. *Sci Total Environ* 342, 87-106.
10. Li YF, S. Venkatesh S Li DC, *Environ Model Assess*, 2005; 9:237.
11. Cuenca RH, *Irrigation System Design: An Engineering Approach* (Prentice-Hall, Old Tappan, NJ, 1989).
12. Ren N Q, Que M X, Li Y F, Liu Y, Wan X N, Xu D D, Ed Sverko, And Ma J M. *Environ. Sci. Technol. 2007;* Accepted.