DISTRIBUTION PATTERNS OF ORGANOCHLORINE PESTICIDES AND POLYCHLORINATED BIPHENYLS IN RUOERGAI HIGH PLATEAU AND HIGH MOUNTAINS IN CHINA

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Introduction

Evidence that POPs levels in soils increase with altitude in some high mountain areas with wet precipitation as the main controlling factor has been proved by field observation in high mountains[1,2]. Differences in POPs composition change in soil with altitude of the Peruvian Andes and the Italian Alps were noted[2]. Wania and Westgate[2] proposed the "Mountain-POP" model[1], POPs carried by air mass, moving towards higher altitude along with decreasing temperature, can be fractionated with some enriched at higher altitude due to their different chemico-physical properties. High plateaus are different in both climate and topography from high mountains. The air masses in high plateau areas are often from high altitude atmosphere in nature. The altitude gradients in terrains of high plateau regions are more flat. For example, the transition zone of between the low altitude areas and the Qinghai-Tibetan Plateau can cross a distance of hundred or even thousand kilometers. The altitudes of high plateau regions are often greater than 3500 m, subject to special climate's influence, and with longer snow precipitation period. The behaviors of POPs in these regions could be expected to be different from ordinary mountains, therefore are ideal places for study of POPs' long-range transport via atmosphere and its relation with seasonal change. In the present study, concentrations of OCPs and PCBs in high mountains (Changbai Mt., Northeast China, Nanling and Luofu Mt., South China, and Wolong Natural Reserve, the southwestern China) and Ruoergai high Plateau are discussed (Fig. 1).

Materials and methods

A high volume air sampler (constant flow rate of 1.04 m^3 min^{-1}) was used to collect air samples in the particulate and gas phases separately at Ruoergai County (33.62 °N, 102.94 °E, 3500 m a.s.l.) located in the eastern edge of the Qinghai-Tibetan Plateau in different seasons of 2011. Rain and snow sample were collected in a container (20 L). Surface soil samples (n=36) were collected in April, November 2011 and June 2012, wrapped in aluminum foil (pretreated by baking at 500 °C for 12 h) and stored frozen until analysis. The extraction and cleanup procedure and HRGC–HRMS analysis for OCPs and PCBs were similar to Ref. 3.

Results and discussions

1. OCPs and PCBs in Ruoergai high plateau

(1) Air All of DDT isomers, six indicator congeners of PCBs and α-endosulfan were detected in vapor form in Ruoergai during winter, in contrast to the results for aerosols in winter, suggesting that more compounds with low volatility are able to transport via vapor form to Ruoergai area in winter. Only PCB28 and PCB52 were detected in aerosol in Ruoergai area, PCB101, 153, 138, 180, *p,p'*-DDT, *o,p'*-DDT, DDD, and endosulfans were not detected, suggesting that only those more volatile congeners are able to transport via atmosphere to reach Ruoergai area.

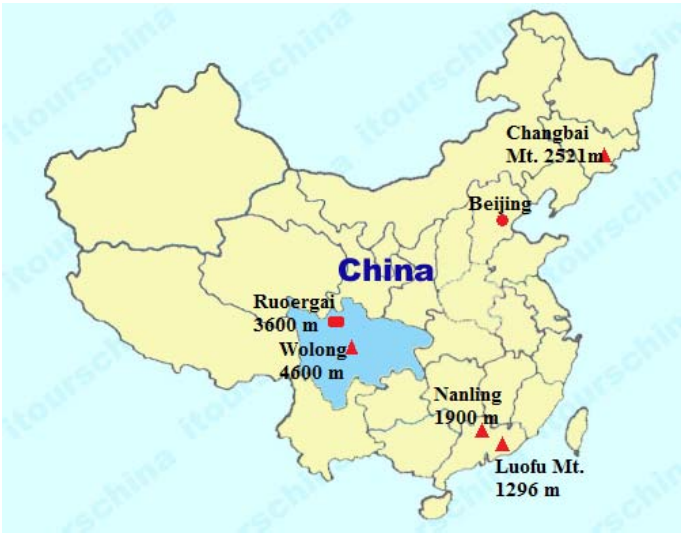

Fig. 1 Mountains and high plateau studied and their altitudes

(2) Snow The concentrations of OCPs and PCBs in snow in Ruoergai area are shown in Fig. 2(a). The highest deposition fluxes for HCHs, DDTs, and PCBs were all occurred in winter, followed by spring. The deposition fluxes of OCPs and PCBs in Ruoergai area were in general lower than those in European high mountains[4]. The seasonal changes in precipitation fluxes of PCB28 and PCB52 were similar to OCPs, i.e., winter > spring > summer. PCB28 accounted for 80% of the total PCBs.

(3) Soils The average concentrations of OCPs and PCBs from 36 surface soils in Ruoergai high plateau during summer and winter of 2011 are shown in Fig. 2(b). The detection rates for α-HCHs, β-HCH, γ-HCH, HCB, *p,p'*-DDE were 100%, followed by *p,p'*-DDD (92.6%), *p,p'*-DDT (92.6%), *p,p'*-DDT (70.4%), α-endosulfan (14.8%), and β–endosulfan (66.7%). ∑HCHs were higher in summer than in winter, while ∑DDTs in summer were about the same level as in winter. PCB28 and 52 were detected in all surface soils in Ruoergai area. The detection rates for PCB101 were 44.3% in summer and 33.3% in winter. PCB153 was not detected in winter but with the detection rate 11.1% in summer. PCB153, 138, and 180 were not detected. $\sum_6$PCBs were in the range of 0.22~1.96 μg kg^{-1} dw in summer, and in the range of 0.34~2.31 ng g^{-1} dw in winter.

2. The difference between high mountains and high plateau

Lei and Wania[5] proposed that the washout ratio of organic compounds for snow is higher than for rainfall, and the partition coefficients between air and solid phase have strong temperature dependency. The model predicts that PCB180 and PCB153 can be relatively enriched in the high altitude of the mountain while lighter PCBs and HCB can not. This has been consistent to the observations in Changbai Mt., Nanling Mountain Range, and Luofu Mt. (Fig. 3. Fig. 4. and Fig. 5). The compounds with higher washout ratios observed in Ruoergai high plateau were DDTs, followed by β-HCH due to its higher water solubility, and γ-HCH, α-HCH, PCB52, and PCB28 (Fig. 6 left). In contrast, PCB153, PCB138, and PCB180 were not detected in snow precipitations in Ruoergai area.

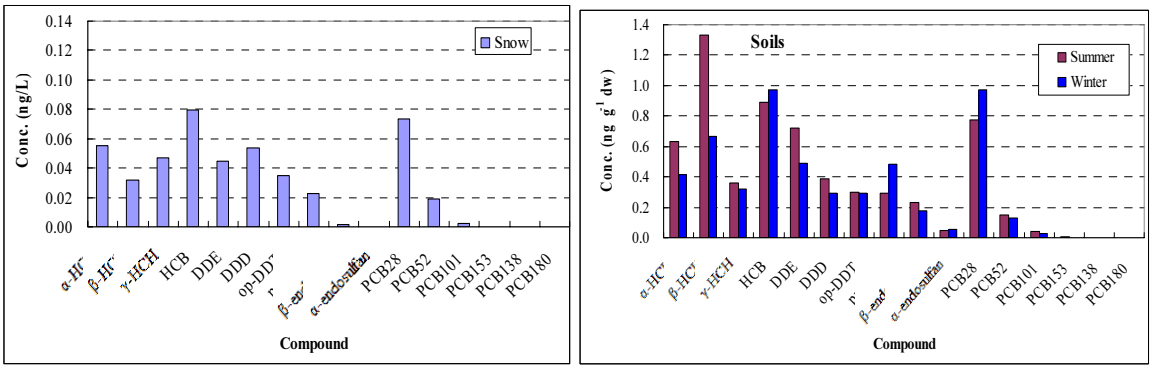

Fig. 2 Average ∑OCPs and ∑PCBs concentrations in (a) snow and (b) top-soils samples from Ruoergai

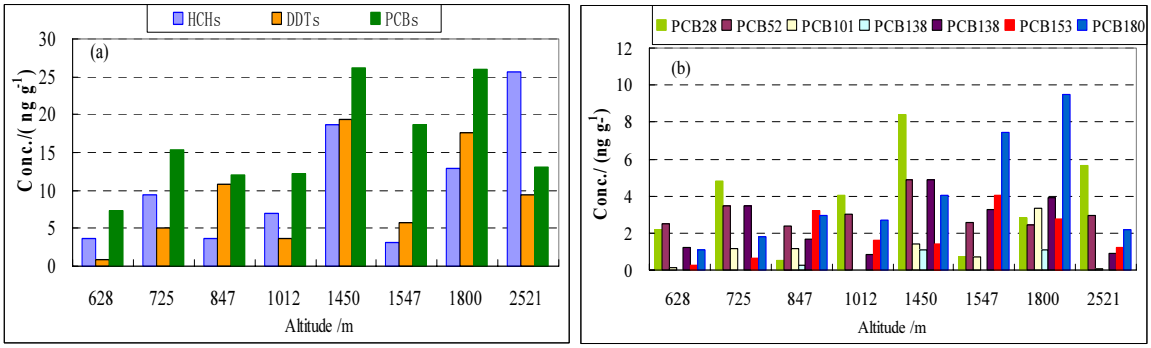

Fig. 3 Concentrations of OCPs and PCBs in topsoils along the altitude gradient in Changbai Mountain, Jilin Province, the northeastern China

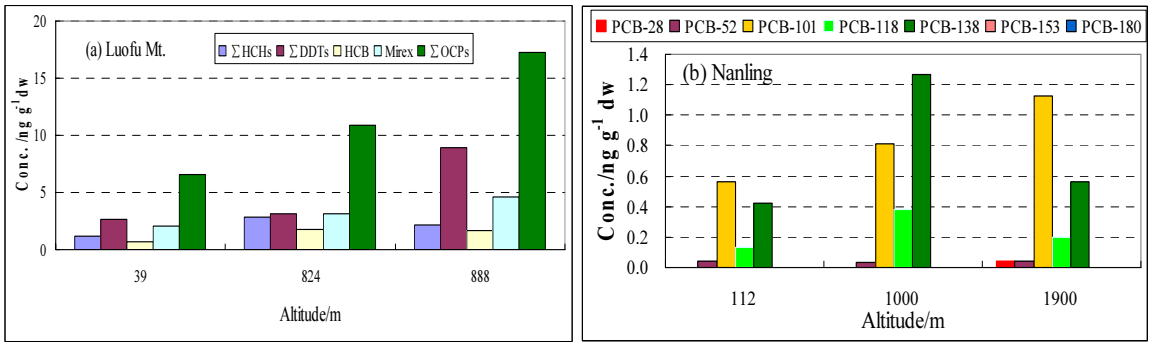

Fig. 4 Concentrations of OCPs and PCBs in topsoils along the altitude gradient in Luofu Mt. and Nanling Mountain Range, Guangdong Province, South China

It has been recognized that POPs composition along the altitude gradient showed a quite different patterns in Alps and Andes. Wania and Westgate[1] compared the differences in polar cold-trapping effect and mountain cold-trapping effect on POPs compounds. In a plot of log K_{OA} versus log K_{WA}, The POP chemicals which show polar cold-trapping and high mountain cold trapping effects lie in the central part of the area between log K_{OA} 8 ~10 and log K_{WA} 2 ~4.5. Lighter PCBs can be enriched in polar areas, but in high mountain areas, higher chlorinated PCBs can be enriched. The concepts of "Polar Contamination Potential" (ACP) [6] and "Mountain Contamination Potential" (MCP)[1] were proposed (Fig. 6 right). Our results for Ruoergai show that the high plateau is more like the polar areas, i.e. the HCB and PCB28 are relatively enriched in the precipitations (Fig. 2).

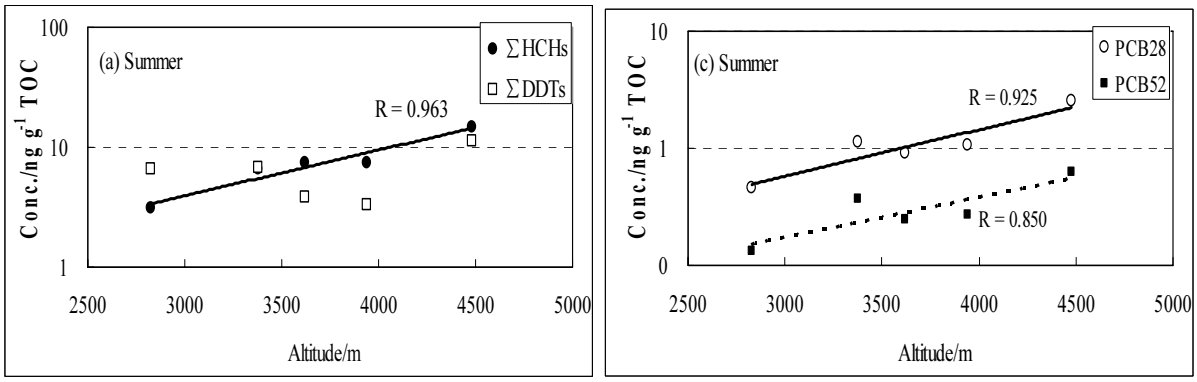

Fig. 5 Concentrations of OCPs and PCBs in topsoils in Wolong Natural Reserve, the southwestern China

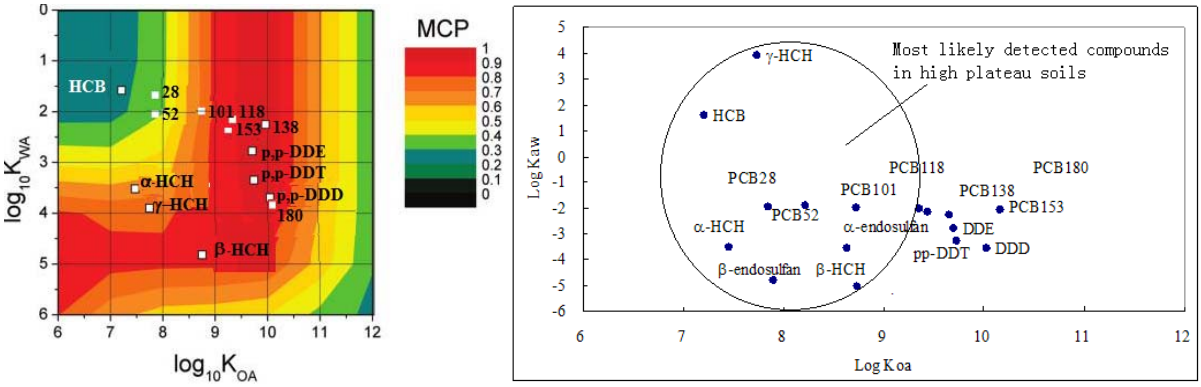

Fig. 6 Comparisons of (right) MCP[1] and (left) the most detected semi-volatile compounds in Ruoergai high plateau

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