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Gradient distribution of persistent organic contaminants along northern slope of central-Himalayas, China

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Abstract

High mountains may serve as condenser for persistent organic pollutants (POPs) and the vegetation in remote areas has been used as a means to characterized atmospheric concentrations of air pollutants. In this study, organochlorine pesticides (OCPs) and polycyclic aromatic hydrocarbons (PAHs) in Himalayan spruce needle samples from Zhangmu–Nyalam region (central-Himalayas) were analyzed and the altitudinal gradient of these pollutants was investigated. Total HCHs and DDTs concentration in needles were in the range of 1.3–2.9 ng g^{-1} dry weight and 1.7–11 ng g^{-1} dry weight, which were lower than concentrations reported in spruce needles from Alps, however higher than concentrations in conifer needles from mountain areas of Alberta. Total Himalayan spruce needle PAHs was below 600 ng g^{-1} and fluorene, phenanthrene and acenaphthene were abundant individual compounds measured. The ratios of α-HCH/γ-HCH in pine needles were similar with the usual values for technical HCH, implying technical HCHs might be used in this region. The high ratios of *o-p′*-DDT/*p-p′*-DDT and no *p-p′*-DDE measured in this study led to the suspicion that a new source of *o-p′*-DDT and/or *p-p′*-DDT existed in this region. In addition, higher ratios of low molecular weight-/high molecular weight-PAHs in this region indicated that petroleum combustion, vehicle emission and low-temperature combustion might be the major contributions of PAH source. To examine the POPs distillation, the analyte concentrations were correlated with altitude. The more volatile OCPs, α-HCH, γ-HCH, aldrin and α-endosulfan positively correlated with altitude, however, less volatile OCPs (DDT and DDD) inversely related with elevation. Almost all PAHs detected in this area showed positive correlations with altitude. It is worthy to note that heavy PAHs (Benzo[k] fluoranthene and Benzo[a] anthracene) displayed positive correlation, which implied the sources of PAHs were near the sampling sites. The distillation of POPs was strongly affected by the proximity between sampling sites and contaminant sources. If the contaminant sources are close to the mountains, it may be the dominant factor that controls the concentration gradient.
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Keywords: Persistent organic pollutants; Central-Himalayas; Gradient distribution

1. Introduction

Plant biomass plays a significant role in the global environmental partitioning and plants are good indicators of tropospheric contamination levels. Plant biomass is believed to accumulate and circulate the residues of

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pollutant (Calamari et al., 1991). Therefore that should offer indirect evidence for the long-range atmospheric transport of persistent organic contaminants (POPs) in remote areas (Aston and Seiber, 1997; Migaszewski, 1999; Notarianni et al., 1998; Weiss et al., 1998). Remote and regions with cold climates are prone to enrich POPs through global fractionation (Wania and Mackay, 1993) and particular attention has been performed in Antarctica (Tanabe et al., 1983), Sweden (Bidleman et al., 1987), and Arctic (Hisato et al., 1994). Recently, there has been increased interest in quantifying POPs levels in mountain regions (Daly and Wania, 2005). Contaminant transport and distribution in mountain may assist in understanding the mechanisms operating on a larger scale and the influence of various environmental parameters (climate, altitude, etc.). In addition, mountain regions have traditionally been considered as pristine environments and thus are suitable to study effects of remote pollution sources. The altitude distribution of POPs in mountains has been widely investigated. Weiss et al. (2000) extensively investigated the distribution of semi-volatile organic contaminants (SOCs) in needles and humus layers of the Austrian and Slovenian Alps. PCBs, PCDD/Fs, and several organochlorine pesticides (OCPs) showed the highest concentrations in needles from high sampling site (Weiss et al., 2000). Aston's result demonstrated that concentrations of organophosphate pesticides (OPPs) in Himalayan spruce needles decreased with the increasing elevation in the Sierra Nevada (Aston and Seiber, 1997). The field data on POPs contamination patterns with altitude can be bewildering in complexity. Some studies show clear concentration gradients whereas others do not. Sometimes, a certain altitudinal pattern is observed for one group of compounds, but not another. Although many researches have paid their attention to the role of mountains in POPs distribution and transportation, major mountain regions such as the Himalayas has received little attention, and, so far, no work on contaminants in this mountain region has been reported.

The Himalaya is wedged in between India and China, the two most populous countries in the world. Mountain Qomolangma (8844.43 m above sea level (masl)) represents the highest peak in the Himalayan Mountains and in the world. In the past, the India subcontinent and China have experienced heavy use of organochlorine pesticides (OCPs), such as hexachlorocyclohexanes (HCHs) and DDT. In addition, many human activities in India and China led to the formation of polycyclic aromatic hydrocarbons (PAHs), such as vehicle emissions, use of fuel, industrial processes, electric production, and waste incineration. Hence, region of Himalaya might be exposed to the danger of these contaminations.

The aims of this paper are to determine the levels of OCPs and PAHs in Himalayan spruce needles from Zhangmu–Nyalam region, discuss POPs concentration differences along altitudinal gradients, and evaluate the sources and transport pathways of these contaminants.

2. Experimental

2.1. Regional background and sample collection

Central-Himalaya is a geographical division zone of two large population countries, China and India. Zhangmu (2300 m masl.) is located at the border between China and Nepal, the southern of the central-Himalaya, in Tibetan Plateau of China (Fig. 1). In addition, Zhangmu is the biggest trade-port between Nepal and China, and is about 90 km apart from Katmandu (Capital of Nepal), 30 km from Nyalam

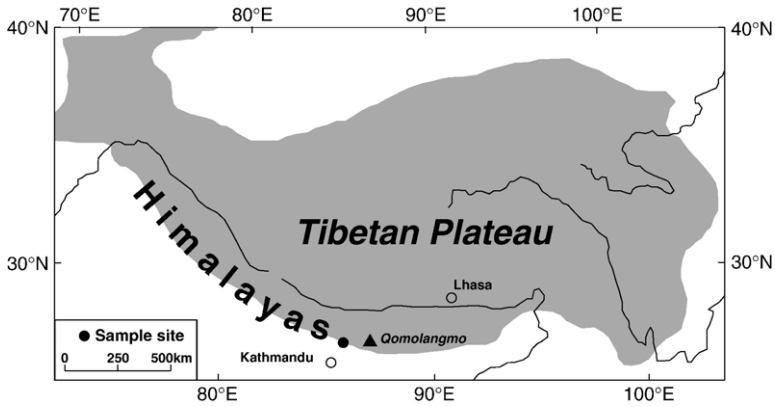

Fig. 1. Schematic map showing the sampling sites.

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