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Occurrence and distribution of organochlorine pesticides and polycyclic aromatic hydrocarbons in surface sediments from Qinghai Lake, northeast Qinghai–Tibet plateau, China

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ABSTRACT

Organochlorine pesticides (OCPs) and polycyclic aromiatic hydrocarbons (PAHs) were analyzed in surface sediment samples collected from Qinghai Lake, the largest lake in China, which is situated in the northeast Qinghai–Tibet plateau at an altitude of 3200 m. The concentrations of these pollutants ranged from 0.02 to 1.00 ng/g for hexachlorocyclohexanes (HCHs), from not detected to 0.86 ng/g for dichlorodiphenyltrichloroethanes (DDTs), from 0.26 to 1.73 ng/g for OCPs, and from 366 to 966 ng/g for PAHs. The predominance of α-HCH suggests that long-range atmospheric transport is an important source for HCHs. A low α- to γ-HCH ratio (3.87 on average) indicates the possible usage of lindane in the drainage basin. The high percentage of p,p′-DDE and p,p′-DDD and the low percentage of o,p′-DDT indicated significant degradation from previous inputs, and no recent inputs of dicofol derived DDT. Based on the analysis of the component ratios, PAHs were found to be primarily from the combustion of biomass and coal-based fossil fuels. Using the Canadian sediment guidelines, PAHs are of greater ecological concern than OCPs in Qinghai Lake.

Introduction

Qinghai Lake (36°32′–37°15′N and 99°36′–100°47′E) is a closed semi-saline lake located in the northeast Qinghai–Tibet plateau at an altitude of about 3200 m. It is the largest lake in China, with a surface area of about 4500 km^2 and a catchment area of over 30,000 km^2. The lake's watershed is dominated by grassland, but includes swampland and tundra (Li et al., 2009). Forty rivers flow into the lake, most of which are seasonal, and the largest seven account for 95% of the total discharge into the lake (Colman et al., 2007). The total population of the lake region is approximately 85,600, with nearly 70,000 people living on pasture, and 6000 engaged in agriculture. Industry, primarily resource exploitation, is very limited within the lake catchment. National highway 109 is to the south of the lake, and national highway 315 and Qinghai–Tibet railway are to the north, with the two national highways being connected by the East and West Qinghai Lake Roads.

Qinghai Lake is located at the crossroads of the migration routes of many bird species in Asia, several of which are endangered and use the lake as an intermediate stop during their migration. Due to its importance for biodiversity conservation, the Qinghai Lake wetland is listed in the List of Wetlands of International Importance (The Ramsar List, 2012). In recent decades, the rapid development of the local economy, as well as climate change, has greatly altered the local environment. For example, overgrazing has caused the degradation of the surrounding grassland (Zhang et al., 2006). The tourism industry has increased rapidly, and over one million people visited Qinghai Lake in 2012. These activities might be causing great pressure on the lakes water quality and the local ecosystem. In addition to the local impacts, pollutants can be transported to the Qinghai Lake area through atmospheric deposition. The area is within the transitional zones affected by East Asian monsoon, Indian monsoon, winter monsoon, and westerly atmospheric flow; and, as a result, the lake can be vulnerable to airborne pollutants.

Semi-volatile persistent organic pollutants (POPs), such as organochlorine pesticides (OCPs) and polycyclic aromatic hydrocarbons (PAHs), have been found to be ubiquitous in the global environment as both OCPs and PAHs can be transported from source areas to remote areas through atmospheric circulation (Scheringer et al., 2004). As a result of the long range atmospheric transport and 'cold trapping' effects, semi-volatile organic pollutants can migrate to polar and high altitude regions (Gong et al., 2010; Grimalt et al., 2004; Wania, 2003). Qinghai Lake is situated in the Qinghai–Tibet plateau, often known as the "third pole" of the world due to the high altitude and cold climate. As a result it may be highly susceptible to contamination from long-range atmospheric input.

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Both OCPs and PAHs are lipophilic and can bioaccumulate in biological tissue (Baumard et al., 1999; Nakata et al., 2003; Zhao et al., 2009). OCPs can biomagnify in food chains, while trophic dilution has been observed for PAHs, which is likely due to the efficient metabolic transformation in organisms at higher trophic levels (Foster et al., 2011; Wan et al., 2007; Takeuchi et al., 2009). Qinghai Lake is an important habitat for many migratory and resident bird species. This includes several endangered species, such as black stork (*Ciconia nigra*) and black-necked crane (*Grus nigricollis*). Contamination of the lake by POPs could pose potential health risks to the birds (Fisk et al., 2001; Lam et al., 2008; Zhang et al., 2011). Few studies have been performed to investigate POPs in the Qinghai Lake area. Wang et al. (2010) studied the sedimentary record of PAHs in a sediment core from the lake, and results indicated a rapid increase of PAHs concentrations starting in 1970s. Yang et al. (2010) investigated the OCPs and polychlorinated biphenyls (PCBs) in fish from lakes in the Tibetan Plateau, including Qinghai Lake, and found OCP concentrations to be comparable to, or lower than those found in remote mountains of Europe and North American. However, the pollution level and potential sources of POPs in Lake Qinghai is still unclear. The purpose of this study was to determine the residual concentrations and spatial distribution of OCPs and PAHs in Qinghai Lake surface sediments, and evaluate their potential sources and biological risks.

Materials and methods

Sample collection

Surface sediment (0–10 cm) samples were collected in June 2012 from fifteen locations in Qinghai Lake using a Peterson grab sampler (Fig. 1). From each location, two grabs were taken, thoroughly mixed, and approximately 1 kg of sub-sample was placed into polyethylene bags. The collected samples were transported back to the laboratory in a cooler, freeze-dried, and kept frozen (−20 °C) until analysis.

OCPs and PAHs analysis

OCPs monitored in this study include HCHs (α-HCH, β-HCH, γ-HCH, δ-HCH), DDTs (p, p′-DDT; o, p′-DDT; p, p′-DDD and p, p′-DDE), chlordanes (trans-chlordane and cis-chlordane), hexachlorobenzene (HCB),

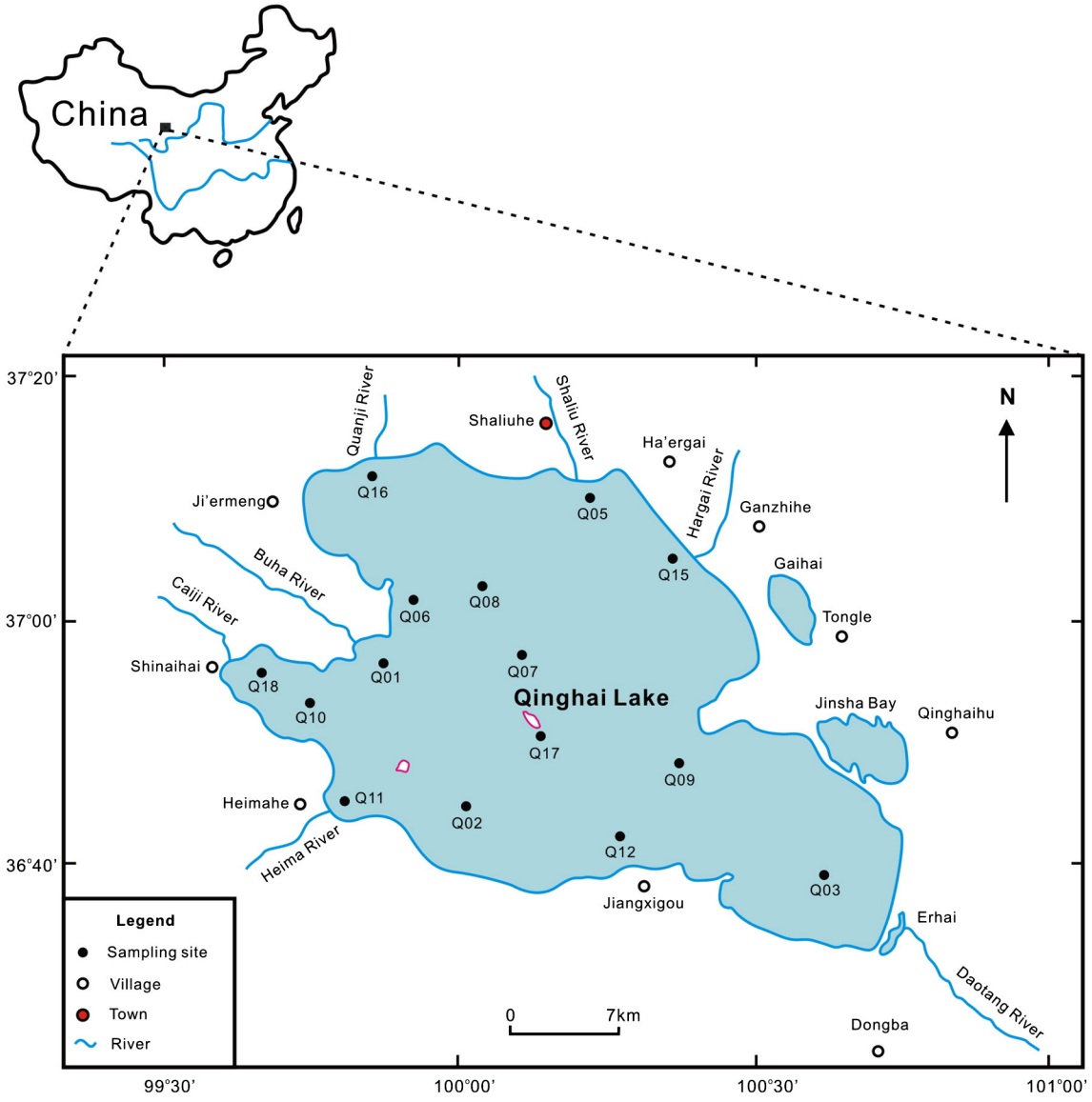

Fig. 1. The study area and sampling locations in Qinghai Lake.

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