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Ecological and health risk assessment of PAHs, OCPs, and PCBs in Taihu Lake basin

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A R T I C L E I N F O

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A B S T R A C T

With rapid economic, agricultural, and industrial development in the Taihu Lake basin, persistent organic pollutants (POPs) have become a major concern in recent years and hence a focus of research. Our study performed characteristic analysis, source analysis, and ecological and health risk assessment for three kinds of Persistent Organic Pollutants (POPs) − polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs) in the Taihu Lake basin. Using measured data from the centralized source of drinking water in the basin as well as historical data, we analyzed the characteristics and sources of the three POPs. Then the ecological risks of PAHs, OCPs, and PCBs were assessed according to the environmental quality standards in sediment of USEPA, and the health risks were assessed with the exposure assessment method. The results show that for centralized drinking water source of Taihu Lake basin: the sampled products were detected in 11 kinds of PAHs, which ranged from nd to 280 ng/g and are at low ecological and health risks level. OCPs in surface sediments are mainly from soil and may have new benzex sources and have low ecological and health risks. PCBs are mainly from pollution from factories and are at low ecological and health risks level. Results of this study can provide a reference for drinking water management of the lake.

1. Introduction

Persistent organic pollutants (POPs), such as Polycyclic Aromatic Hydrocarbons (PAHs), Organochlorine pesticides (OCPs), and Polychlorinated biphenyls (PCBs), which cause environmental and human damage, are of widespread concern because of their toxicity, persistence, easy to accumulate and less than easy degradation (Raeisi et al., 2016; Dobaradaran et al., 2010; Jones and De Voogt, 1999; Gao et al., 2000; Mondal et al., 2005; Thakur et al., 2012; Zhang et al., 2012). Riding et al. (2013) investigated the bioavailability of PAHs in soil. Lee et al. (2005) studied the sources of PAHs and PCBs of coal and wood burning in Britain. Eljarrat et al. (2001) examined the pollution of OCPs in the Spanish soil. Baumard et al. (1998) studied the origin and bioavailability of mussels and sediment PAHs in the Mediterranean region. Yunker et al. (2002) examined the origin and composition of PAHs in Fraser River.

As China's the third largest freshwater lake, Taihu Lake, where the industry and agriculture have been developing at a rapid pace, the deterioration of water and environmental pollution is receiving much attention. Therefore, it is important to investigate persistent organic pollutants in the Taihu Lake basin. Some studies have been done on POPs in the lake. For example, Shu and Li (2008) studied the distribution of PAHs pollution in surface sediments in Meiliang Bay and carried out source analysis and ecological risk assessment, and showed that PAHs were mostly from combustion and had low ecological risk. Yuan et al. (2003) studied PCBs in the sediment in the basin, and indicated that the main source was surface runoff entering into the lake, atmospheric deposition and industrial discharge and had low ecological risk. Qi et al. (2015) examined the source and destination of PCBs in the sediments in Taihu Lake by an impedance theoretical model and showed that hexachlorobenzene (HCB) had the highest sediment content, hexachlorocyclohexanes (HCHs) was the main source of water for the release of sediment, and dichlorodiphenyltrichloroethane (DDT) may have a new source channel.

Chemical carcinogen-induced health risks fluctuated, while non-chemical carcinogen-induced health hazards of individual risk

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remained stable. Ji et al. (2009) assessed ecological risk of PCBs in sediments in northern Taihu, indicating that the level was not high, but the potential hazard should not be overlooked. For centralized drinking water sources, Fan et al. (2009) performed health risk assessment of the Taihu source of drinking water and concluded that from 2005 to 2009, chemical carcinogens had much higher risk than non-chemical carcinogens. Chen (2014) carried out the risk assessment of the Suzhou Taihu source of drinking water and concluded that health risk of chemical carcinogen hexavalent chromium and arsenic were several times more than the recommended values, which should be the priority to carcinogenic pollutant monitoring and control. However, comprehensive understanding of ecological and health risk level of typical POPs in Taihu Lake basin, especially in centralized drinking waters, is required for water environment protection.

Most of the persistent organic pollutants are non-chemical carcinogenic and the health risks are currently at a low level.

This paper therefore performed characteristic analysis, source analysis, and ecological and health risk assessment for PAHs, OCPs and PCBs in the Taihu Lake basin. Using measured data from the centralized source of drinking water in the basin and historical data from other regions, this paper analyzed the characteristics and sources of the three POPs. The ecological risk of PAHs, OCPs, and PCBs in the basin were assessed, according to the environmental quality standards in sediment of USEPA, and health risks were assessed with the exposure assessment method.

2. Study sites

Taihu Lake, the third largest freshwater lake in China, is located in the south portion of the Yangtze River delta (Fig. 1). The total water area is about 2, 338 km^2; the mean water volume is around 44.297×10^8 m^3 and. The Taihu Lake is the primary source of drinking for nearby inhabitants, and supplies the water for agricultural irrigation in Jiangsu and Zhejiang provinces (Wang et al., 2011). Intense human development in the Taihu Lake Basin has also had negative consequences on the aquatic environment. In recent years, Taihu Lake has been plagued by pollution as the surrounding region experienced rapid industrial development.

3. Materials and methods

3.1. Sampling and chemical analysis

Total five sediment samples were collected by use of bottom sampler as shown in Fig. 1. All sampling sites were in the centralized drinking water resources of eastern Taihu Lake. At each sampling site, 1 kg sediment was collected for persistent organic pollutants analysis and refrigerated at < 4 °C. All analytical laboratory methods adopted here were from USEPA 8310–1986, USEPA 8081B–2007, and USEPA 8082A–2007.

3.2. Ecological risk assessment

Long et al. (1994) presented the Environmental Quality Standard for sediments, which has been designated as the national standard by USEPA. The standard proposed that organic matter in sediments can be divided into two boundaries, which is low toxic effects (Effects Range Low, ERL) and toxic effects in value (Effects Range Median, ERM). When the target pollutant concentration is less than ERL, the probability of biological effects is less than 10 percent. When the target contaminant concentration is greater than ERM, the probability of biological effects is greater than 50% (Long et al., 1998).

3.3. Health risk assessment

For POPs in the water, we used the USEPA exposure calculation method to conduct the human health risk assessment.

3.3.1. Health risk assessment model

The health risk assessment model includes health risk calculation caused by carcinogens and non-carcinogens.

(1) Carcinogen-induced health risk was calculated as follows:

$$R_i^c = [1 - \exp(-D_i q_i)]/Y \quad (1)$$

where R_i^c is the average annual individual carcinogenic risk of carcinogen i produced by drinking water, a^{-1}; q_i is the carcinogenic strength coefficient by way of drinking watermg/(kg·d), Y is the average life expectancy;D_i is the daily average exposure dose per body weight of chemical carcinogens by way of drinking water, mg/(kg·d), which was calculated as follows:

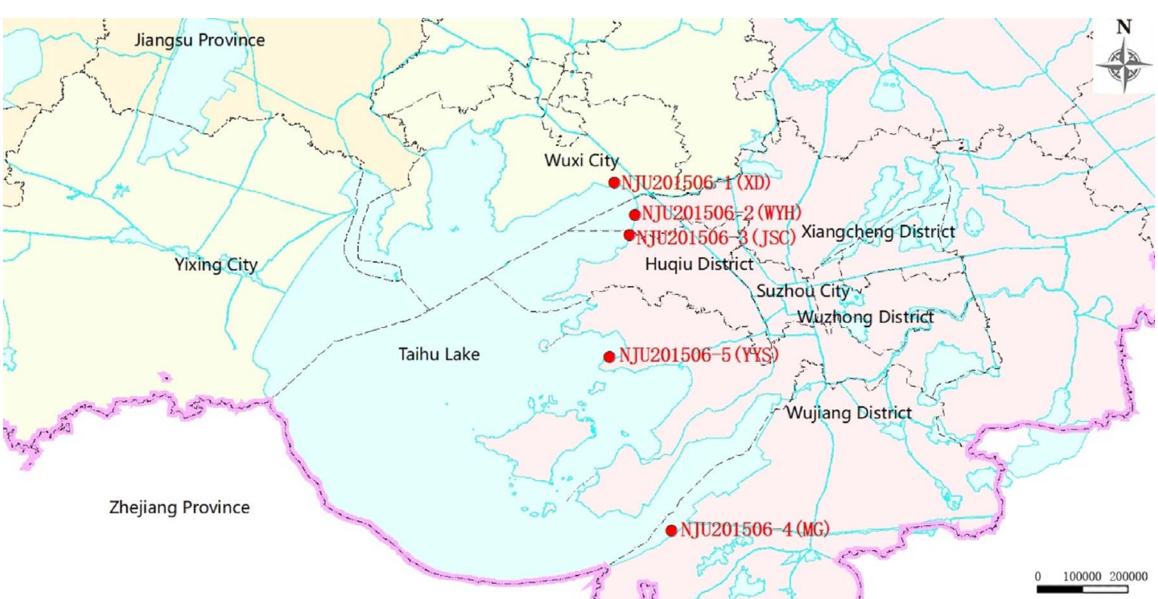

Fig. 1. Schematic illustration of sampling site distribution in the Taihu drinking water source.