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# Polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) in water and suspended particulate matter from the Xijiang River, China

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**Abstract**

Concentrations of polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) in water and suspended particulate matter (SPM) collected from the Xijiang River, China, were measured by the quarter from September 2005 to June 2006. Total PCDD/F concentration ranged from 2.659 to 4.596 pg/L for water and from 562.4 to 3259.5 pg/g for SPM. Concentrations were high in summer and low in winter. I-TEQ values in water and SPM were low, ranging from 0.012 to 0.075 pg/L, with a mean value of 0.039 pg/L. Calculated annual loadings of total PCDD/Fs and I-TEQ were 8.55 kg and 0.026 kg, respectively. Composition and homologue distribution of PCDD/Fs were varied because of large seasonal differences in discharge from the Xijiang River into the South China Sea. Comparison of the PCDD/Fs homologue and congener profiles of atmospheric deposition, soil, and water revealed that soil was the dominant source of PCDD/Fs in the Xijiang River. Industrial effluents were also possible sources of PCDD/Fs. A good correlation between $\log K_{oc}$ and $\log K_{ow}$ was observed for 2,3,7,8-substituted PCDDs and PCDFs and correlation coefficients were 0.71 and 0.84, indicating organic matter in SPM played a dominant role in PCDD/Fs partition between SPM and water.


*Keywords:* PCDD/Fs; SPM; $K_{oc}$; PCDD/Fs loading; Xijiang River

## 1. Introduction

Polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) are the most persistent and toxic pollutants in the natural environment, and they may cause serious human health and ecosystem problems. These compounds are unintentionally produced during solid waste incineration, chemical manufacturing, disposal of sewage sludge, vehicle exhaust, and domestic fires [1] and occur ubiquitously in many environmental compartments. Due to their low water solubility and semi-volatility, PCDD/Fs can be transported over long distance via various routes such as atmosphere and water, and thus affect regional environmental quality [2]. In the past few decades, researchers have conducted many studies on PCDD/Fs in ambient air, sediments, and soils [3–8].

However, PCDD/Fs in aquatic systems have received much less attention. Water, which acts as an intermediate for transfer PCDD/Fs from air to sediment, plays a very important role in the environmental behaviors of these compounds. Suspended particulate matter (SPM) in water is the predecessor of sediment. The PCDD/Fs in SPM, therefore, undergo less transformation than in sediments and may contain a strong signal indicative of their source. Studies focused on PCDD/Fs in SPM and partition between SPM and water will help elucidate the sources, transformation, and final fate of PCDD/Fs in the water and sediments.

The Xijiang River is the major tributary of the Pearl River that is the third largest river in China. It originates in Yunnan Province; flows through Guizhou, Guangxi, and Guangdong; and finally enters into the South China Sea (Fig. 1). The Xijiang River is 2214 km long and has a catchment area of $3.53 \times 10^5$ km$^2$. The catchment is located in a tropical and semitropical area, and the river discharges $2.38 \times 10^{11}$ m$^3$ of fresh water to the sea annually, which accounts for 70.8% of total runoff of the Pearl River. The Xijiang River is an important source of water for agricultural and industry activities and also

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serves as a major supplier of drinking water for 86 counties with a total population of 28.7 million. However, data that describe the concentration and distribution of PCDD/Fs in the Xijiang River do not exist.

This study focuses on water quality in Guangdong province, China. Our primary aim was to estimate the concentration and total loading of PCDD/Fs in the Xijiang River due to the increase of anthropogenic activities and fast economic development in China, especially in the Pearl River Delta. The results provide the basic information needed to assess the risk of exposure to PCDD/Fs in the Xijiang River. They also may be helpful in forming water protection strategies in this river.

## 2. Materials and methods

### 2.1. Sample collection and preparation

We collected the samples at Gaoyao Hydrological Station, which is located at the most downstream section of the Xijiang River (Fig. 1). It is far removed from the South China Sea, so this area is not influenced by tides. The discharge of the Xijiang River changes between the dry season (October–March) and the wet period (June, July, and August). We collected the water samples in the different seasons, from September 2005 to June 2006, from the upper, middle, and lower layer of the water column. To obtain sufficient SPM for analysis of PCDD/Fs, we collected about 1000 L of water for each sample. Water depth, temperature, pH, and turbidity were measured and recorded in the Gaoyao Hydrological Station (Table 1). Water was pumped into 10 L pre-cleaned brown glass containers with a stainless-steel submersible pump that contained $NaN_3$ (100 mg/L) (Damao Chemicals Co., Tianjin, China) to inhibit bacteria growth. We transported the water samples into the laboratory and filtered them as quickly as possible to avoid precipitation of SPM in containers. We used glass fiber filters (GF/F, 0.7 μm pore size, 142 mm diameter; Whatman International Ltd., Maidstone, England) to collect SPM; they were pre-combusted at 450 °C for 5 h and weighed before use. After filtering, the glass fibers with SPM were wrapped with aluminum foil and stored in sealed bags at −20 °C until analysis. After filtration of a sample, the organic pollutants dissolved in the water phase were extracted by polyurethane foam (PUF). Prior to be used to extract, the PUF was purified with toluene, methanol, and dichloromethane for 24 h, respectively and was kept at sealed

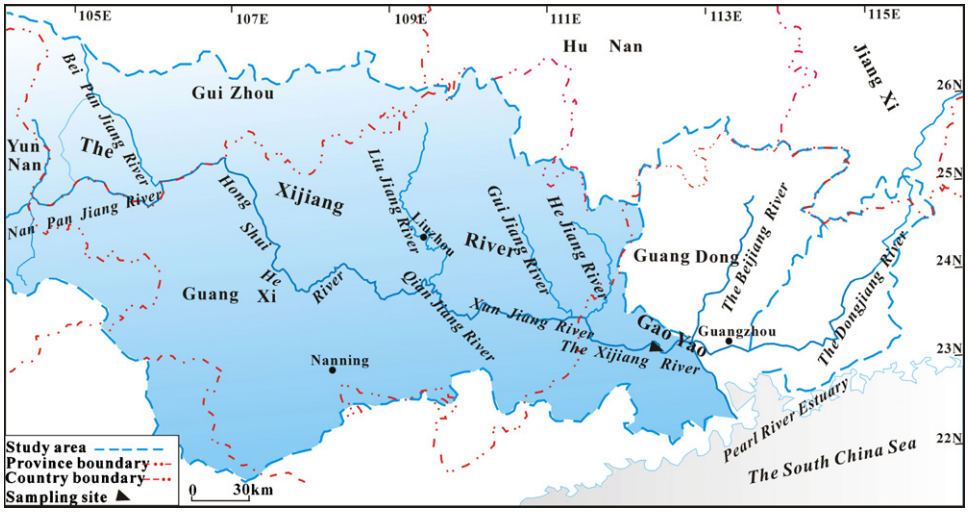


Fig. 1. Sampling site and study area. The catchment area is shadowed in black.

Table 1
Basic sampling data

| Sampling date | 09/2005 | | | 12/2005 | | | 04/2006 | | | 06/2006 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Discharge ($m^3$/s) | | 4400 | | | 1800 | | | 4300 | | | 15300 | |
| Layer | A[a] | B[b] | C[c] | A | B | C | A | B | C | A | B | C |
| Depth (m) | 0.5 | 5.2 | 9.5 | 0.5 | 5.3 | 9 | 0.55 | 5 | 9 | 0.5 | 8.2 | 16 |
| $T$ (°C) | 28 | 28 | 28 | 16 | 16 | 16 | 16 | 16 | 16 | 25 | 25 | 25 |
| pH | 8.10 | 8.08 | 8.05 | 7.93 | 7.94 | 7.93 | 7.93 | 7.90 | 7.90 | 7.88 | 7.89 | 7.90 |
| Turbidity | 12 | 22 | 23 | 30 | 25 | 25 | 17 | 18 | 19 | 233 | 236 | 238 |
| Salinity (mg/L) | 6.1 | 6.6 | 10.9 | 6.5 | 5.7 | 5.7 | 7.7 | 7.2 | 8.1 | 6.1 | 5.9 | 6.1 |
| SPM (mg/L) | 5 | 6 | 9 | 12 | 11 | 9 | 11 | 13 | 14 | 25 | 27 | 19 |
| DOC (mg/L) | 1.09 | 1.15 | 1.16 | 1.54 | 1.41 | 1.39 | 1.58 | 1.53 | 1.64 | 1.11 | 1.16 | 1.16 |
| POC (%) | 5.46 | 3.25 | 3.84 | 4.39 | 4.20 | 4.57 | 6.48 | 4.77 | 4.70 | 2.07 | 2.56 | 2.37 |

[a] The upper layer of the water column.
[b] The middle layer of the water column.
[c] The bottom layer of the water column.