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PERFLUORINATED COMPOUNDS IN SURFACE WATERS AND TAP WATER OF EASTERN CHINA

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Introduction

The eastern China is the most industrialized and populated part of the country. Past studies have shown that concentrations of PFOS and PFOA in surface waters of the Yangtze River Delta, the most urbanized region in China, were significantly higher than other regions of China (1-2). Though PFCs in waters of several individual rivers and lakes in eastern China have been reported, at present there is lack of information about how PFC contamination levels and compositions in surface waters are changed from south to north in the eastern China. This information may reveal the PFC sources in different areas in the eastern China with different levels of urbanization, industrialization, and economic development. Different from natural rivers in which the PFCs may be carried by water flow from the upstream so that the information on a local PFC pollution may be lost, the flow of canals and lakes, on the other hand, are much weaker than natural rivers, therefore both the PFC levels and compositions in water may more truly reflect the local sources of PFCs. Based on the fact that the source of tap waters in many parts of China is mainly from surface waters, the relations between the tap waters and surface waters in local areas of the eastern China were investigated.

Materials and methods

A total of 41 river water, 24 lake water, and 43tap water samples were collected in eastern China in June 2014(Fig. 1). Water samples were collected with a stainless steel bucket. Water samples were analyzed for 17 PFCs, including PFOS, PFHxS, PFBS, PFDS, PFOcDA, PFHxA, PFTeDA, PFDoDA, PFUnDA, PFDA, PFOA, PFNA, PFBA, PFHpA, PFPeA, PFHxDA, and PFTrDA. The water samples were extracted using solid phase extraction (SPE) with WAX cartridges following the published method (2-3).

Results and discussion:

1. The Grand Canal

The total concentrations of perfluorinated compounds (ΣPFCs) in the Grand Canal water were in the range from 8.4 to 130.9 ng/L. Based on the changes in the concentration and composition of PFCs in water, the Grand Canal can be divided into five sections, i.e. the Hangzhou, Yangtze River Delta, North Jiangsu, Shandong, and Tianjin sections. The highest values occurred in the Hangzhou section rather than the Yangtze River Delta section (Fig. 2). The paper industries in the upper-stream of the Qiantang River are believed to be the major source of PFCs. The concentrations of PFC have a general decreasing trend from south to north. Significantly higher total PFCs concentrations (∑PFCs) occurred in the southern part of the Grand Canal located in the region where the levels of urbanization and economic development are high (Fig.3). The dominancy of PFOA reduced in the northern part of the Canal.

2. Lakes

The total concentrations of perfluorinated compounds in 24 lake surface water samples from 8 lakes ranged from 9.8 to 179.3 ng/L.The maximum value appeared in West Lake of Hangzhou, followed by Taihu Lake(90.7 ng/L). The lowest value appeared in Hongze Lake. The concentration of PFCAs in all water samples was higher than that of PFSAs. Compared with the river water, long-chain PFCs in lake water samples had a higher detection rate. PFOA was the dominant compound in West Lake water, while the compositions of PFCs in the lakes north of the Yangtze River in eastern China were quite different from those in the south, characterized by high proportions of PFOS, PFBA, PFBS, PFTrDA(Fig. 4).

3. Tap water

The total concentrations of perfluorinated compounds in 49tap water samples from 16 cities ranged from 1.4 to 175.3 ng/L. The highest value occurred at Changshu where fluorochemical plants are located.

In comparison, Mak et al. (2009) (4) reported that the mean of ΣPFCs was 130 ng/Lin Shanghai tap waters. The compositions of PFCs in the tap waters in Hangzhou, Hai'ning, Suzhou, and Wuxu were more close to those of the adjacent surface waters (Fig.5).The ΣPFCs in the tap waters were at a moderate contamination level that may not pose health risk to the local residents. Good correlations between PFC concentrations in surface waters and tap waters from the studied areas were observed (r#0.73 for Suzhou; r#0.86 for Wuxi; r#0.99 for Hangzhou, $p<0.05$). Some PFC compounds in the local tap water plants may not be removed effectively. Based on the fact that the source of tap waters in Hangzhou is mainly the Qiangtang River water, the removal efficiency of PFCs was estimated to be 65% in the local tap water plants.

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Fig. 1 Map of the sampling sites and sections

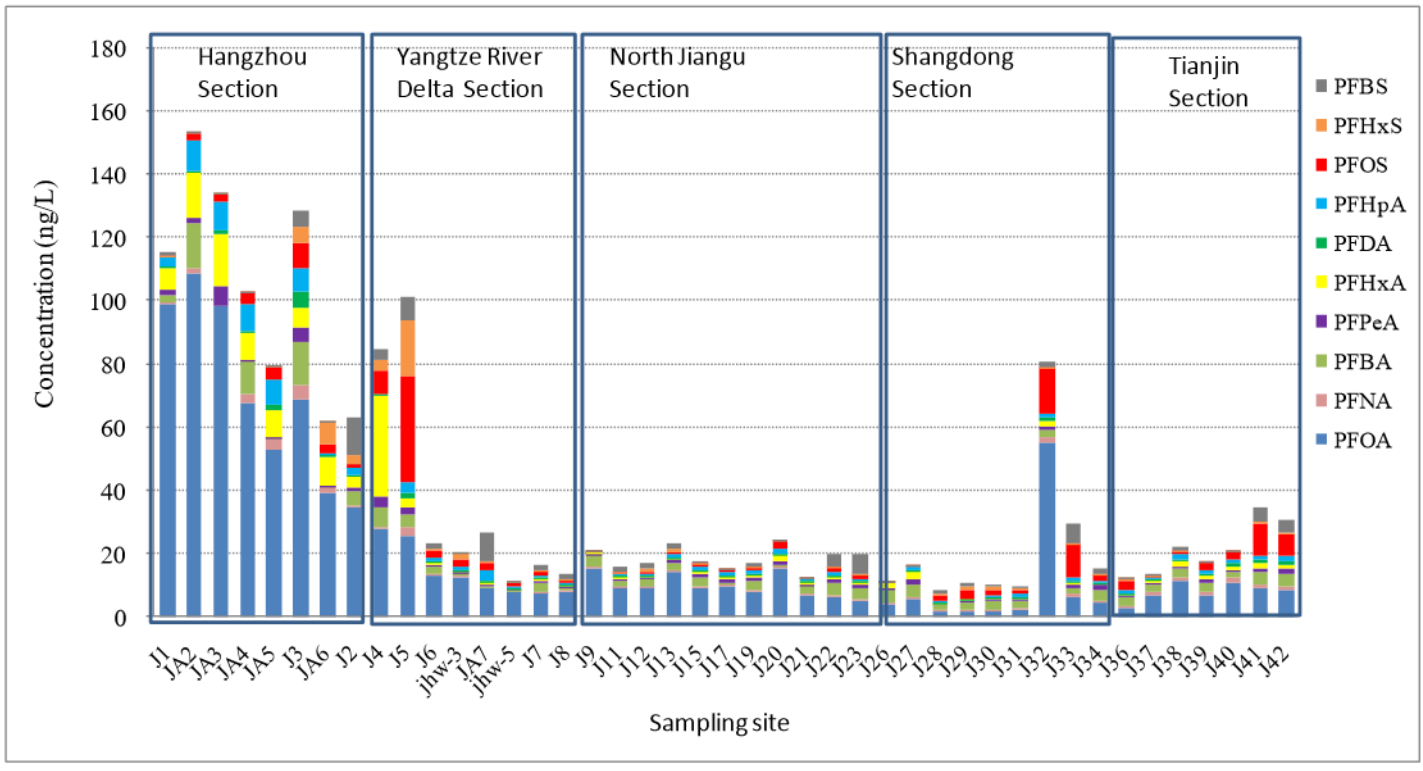

Fig. 2 Concentration profile of PFCs in waters along the Grand Canal

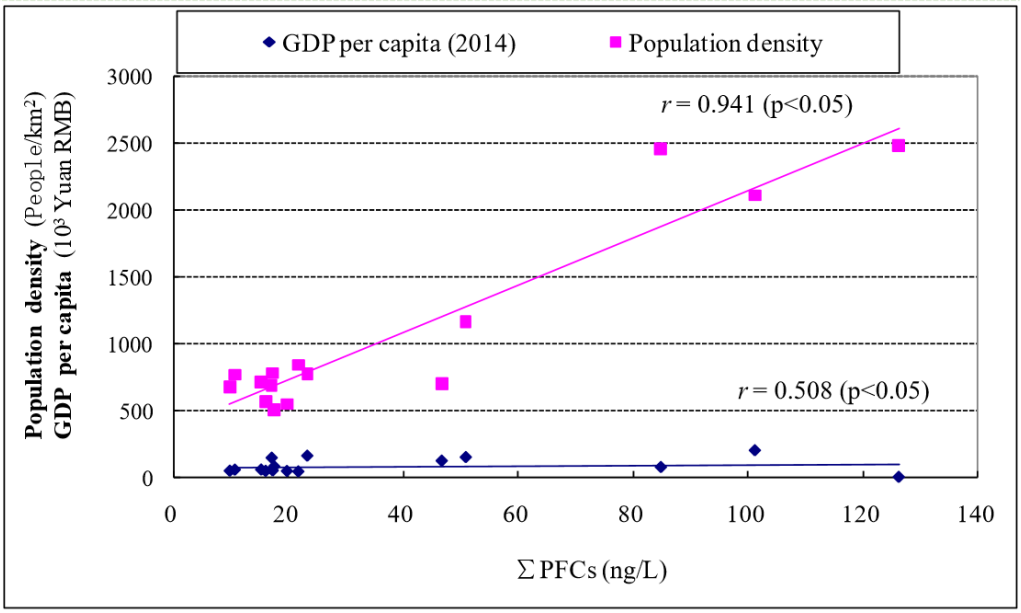

Fig. 3 Correlations between ΣPFCs and (a) the population density, (b)GDP per capita in 2014

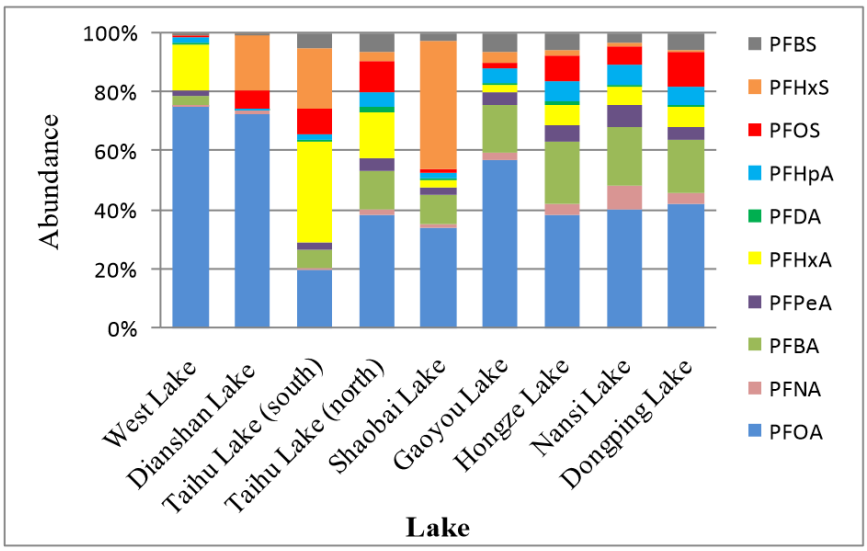

Fig. 4 Composition profiles of PFCs in lake surface waters from the eastern China

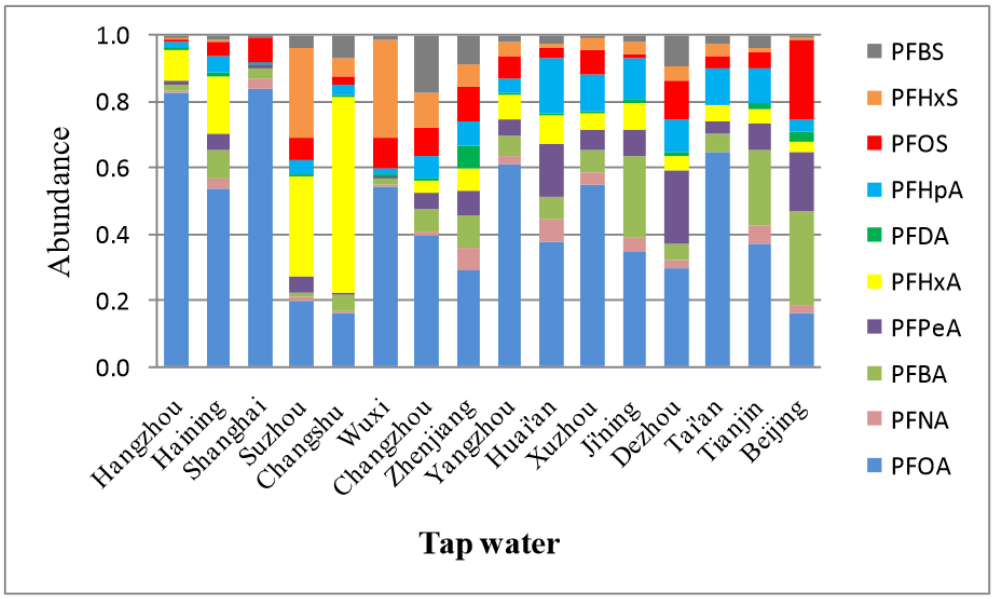

Fig. 5 Composition profiles of PFCs in tap waters from the eastern China