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Occurrence and distribution of sediment-associated insecticides in urban waterways in the Pearl River Delta, China

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ABSTRACT

Sediment-associated pesticides, including organochlorine (OCP), organophosphate (OP), and pyrethroid insecticides, were analyzed in urban waterways in three cities (Guangzhou, Dongguan, and Shenzhen) in the Pearl River Delta (PRD), China. The OCPs represented 27.2% of the detectable insecticides in sediment, and chlordanes, DDTs, and endosulfans were the most frequently detected OCPs. The currently used insecticide chlorpyrifos was the only OP detected above the reporting limit (RL), with concentrations ranging from <RL to 100 ng g^{-1} dry weight (dw). Additionally, pyrethroids were detected in all sediments with the sum pyrethroid concentrations ranging from 4.26 to 384 ng g^{-1} dw and this represented 64.9% of the sum insecticide concentration. Despite their widespread use, no studies have been conducted investigating the occurrence and distribution of pyrethroids in China. As the first report of pyrethroids in urban waterways in China, the current study found cypermethrin was the most abundant insecticide detected in the PRD at concentrations ranging from 1.44 to 219 ng g^{-1} dw. Spatially, sediment from more populous and urbanized areas (Shenzhen and Tianhe district in Guangzhou) had higher insecticide residues than less populous agricultural areas. In the more modernized city of Shenzhen, the OCPs were seldom detected, whereas more diverse patterns of pyrethroids were observed. Potential sources of these insecticides, especially the frequently detected pyrethroids, were most likely from pest control during urban landscaping maintenance and from abatement programs targeting mosquitoes and ants. Results suggested that a shift in application pattern and elevated urbanization increased accumulation of currently used insecticides like pyrethroids in sediment, and made them the predominate insecticides in the PRD urban waterways.

1. Introduction

The Pearl River is the third largest river in China, with the watershed draining approximately 453 690 km^2 of Southern China (mostly within Guangdong province) and portions of Vietnam (Chen et al., 2004), and the Pearl River Delta (PRD) is one of China's most populous and economically developed regions. In 2008, the PRD area had a population of over 47 million and a high degree of urbanization (80%), with a regional GDP of 4977 billion RMB (≈730 billion US dollars) (http://www.gdstats.gov.cn/tjnj/table/20/c20_3.htm). The rapid urbanization and economic boom have led to the degradation of aquatic systems in the PRD. Of special concern are aquatic systems that are local or pass through the city and hence are directly affected by the urbanization. These waterways have been termed as the "transfluxing city waters" or "urban waterways". Zhu et al. (2002) found severe deterioration of urban waterways in the PRD, and suggested that industrial waste, domestic sewage and pesticide runoff were all contributing to the degradation of urban waterways in the PRD.

Recent studies (Weston et al., 2005; Amweg et al., 2006; Holmes et al., 2008; Wong et al., 2009) have raised concerns about the impact pesticides have on sediments in urban areas. A study by the US Geological Survey suggested at least one pesticide was detected in 97% of urban streams in the US (Gilliom, 2007). Similarly, China has also had extensive pesticide applications, and the Chinese Ministry of Agriculture predicted that the pesticide demand in China in 2010 would be 302 700 tons including 129 500 tons of insecticides, among which 72%, 5.5%, and 2.8% were organophosphate (OPs), carbamate, and pyrethroid insecticides, respectively (http://www.chinapesticide.gov.cn/doc09/09112306.html). Geographically, the PRD is located in the subtropical zone, and has mild temperatures, heavy rainfall, and humid weather conditions all year long. This type of weather promotes insect propagation,

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thus insecticides are widely used for pest control throughout the PRD. As a result, the estimated pesticide usage in farmland in Guangdong province (2.7 g m^{-2}) is quite high (http://www.gd.xinhuanet.com/newscenter/2010-01/07/content_18704269.htm). Previous studies examining occurrence and distribution of pesticides in the PRD all focused on organochlorine pesticides (OCPs), and showed that OCPs were ubiquitous in waters, sediment, and biota sampled in the PRD (Zhang et al., 2007; Guo et al., 2009).

The banning of OCPs in the 1980s and the recent restrictions on the toxic OPs in China required a shift in insecticide usage to new generations of insecticides, such as the OP chlorpyrifos and pyrethroids. Although transition from the legacy OCPs to the currently used insecticides has occurred in recent years, studies focusing on their occurrence and distribution in the PRD are scarce. To our knowledge, there are no studies that have addressed sediment-associated pyrethroids in Southern China.

The main objective of the current study was to assess the occurrence of legacy and current-use insecticides in sediment in urban waterways in the PRD. Additionally, spatial distribution and composition of the insecticides were evaluated by comparing insecticides detected in sediments sampled in the three largest cities in the PRD. The influence of urbanization on the insecticidal occurrence and distribution was addressed as well.

2. Materials and methods

2.1. Sampling areas

Sediment samples were collected from creeks located in the three most urbanized and populated cities in the PRD, Guangzhou (GZ), Shenzhen (SZ), and Dongguan (DG) (Fig. 1), and general information on the sampling sites, such as coordinates and total organic carbon contents of the sediments, are presented in Table 1. The top 5 cm of sediment was collected using a spade shovel by wading into the creeks, and then sieved through a 2-mm sieve to remove rocks or organic debris. The sediments were immediately transported back to the laboratory, homogenized and stored at 4 °C until use.

Nine sediments were sampled in two areas in Guangzhou, the capital of Guangdong province. Five sediments (GZ1-5) were collected in the College City, which was formerly agricultural lands, but became home for 10 universities in 2003. Meanwhile, four sediments (GZ6-9) were collected in creeks in Tianhe District which is the economic center of Guangzhou and more crowded than the College City.

Shenzhen is located next to Hongkong, and is one of the first Open Economic Zones in China. Of the six sediments collected in

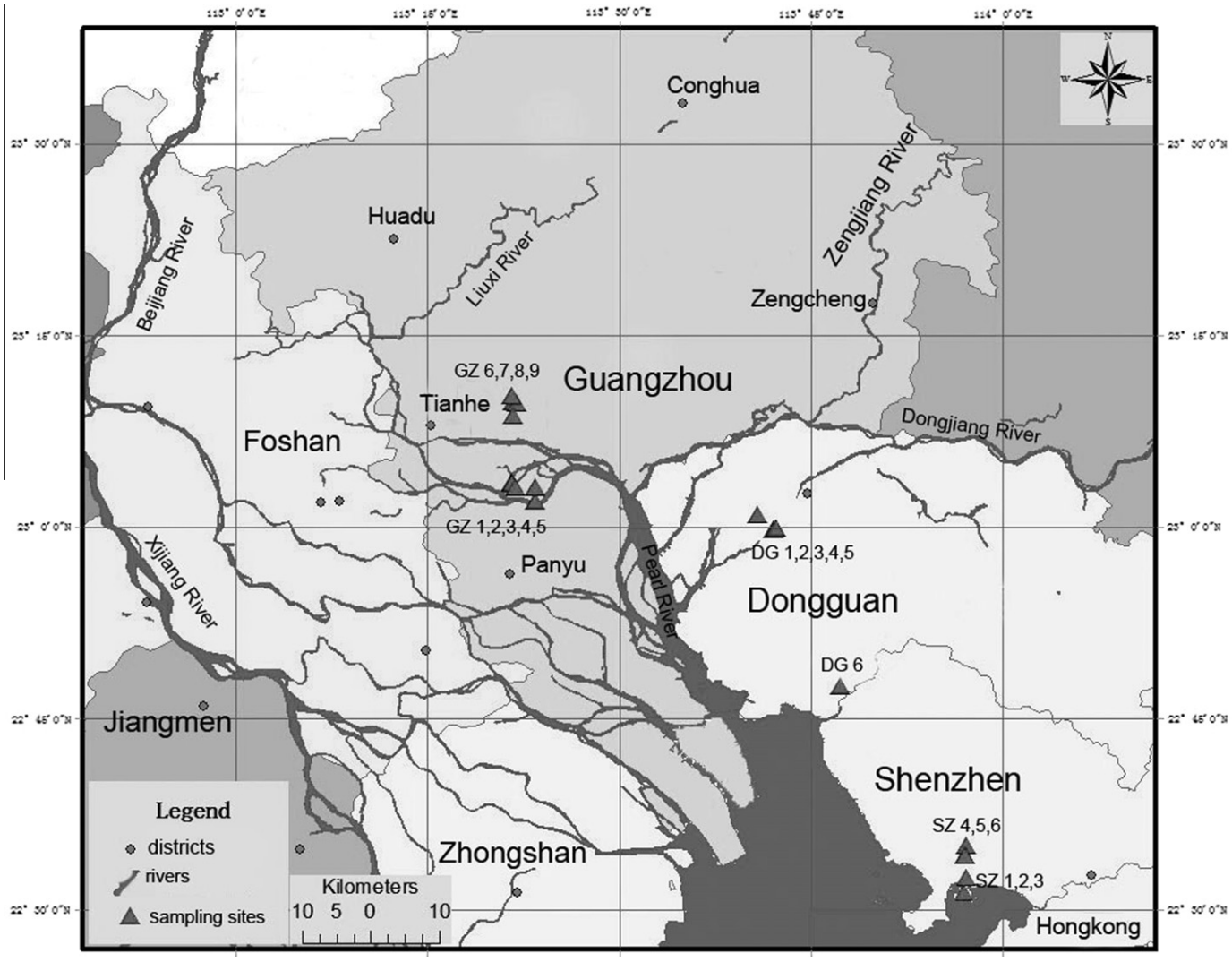

Fig. 1. Map of the sampling sites in the Pearl River Delta, China. The triangles represent the sampling sites in Guangzhou (GZ), Shenzhen (SZ), and Dongguan (DG).