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Polycyclic aromatic hydrocarbon concentrations, compositions, sources, and associated carcinogenic risks to humans in farmland soils and riverine sediments from Guiyu, China

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ABSTRACT

The concentrations of 16 priority polycyclic aromatic hydrocarbons (PAHs) were measured in 23 farmland soil samples and 10 riverine sediment samples from Guiyu, China, and the carcinogenic risks associated with PAHs in the samples were evaluated. Guiyu is the largest electronic waste (EW) dismantling area globally, and has been well known for the primitive and crude manner in which EWs are disposed, such as by open burning and roasting. The total PAH concentrations were 56–567 ng/g in the soils and 181–3034 ng/g in the sediments. The Shanglian and Huamei districts were found to be more contaminated with PAHs than the north of Guiyu. The soils were relatively weakly contaminated but the sediments were more contaminated, and sediments in some river sections might cause carcinogenic risks to the groundwater system. The PAHs in the soils were derived from combustion sources, but the PAHs in the sediments were derived from both combustion and petroleum sources.

Introduction

Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous environmental pollutants that can bring adverse health effects to humans, including carcinogenicity, teratogenicity and mutagenicity. The United States Environmental Protection Agency (USEPA) has identified 16 PAHs as "priority PAHs", seven of which are potential carcinogens. PAHs are derived from natural and anthropogenic processes. Natural sources include diagenesis, volcanic eruptions, and some biological processes; anthropogenic sources include the combustion of biomass (e.g., wood and grass) and fossil fuels (e.g., petroleum and coal), crude oil and refined oil product spillages, and vehicle exhaust emissions. Natural sources predominantly produce naphthalene, phenanthrene and perylene, whereas combustion contributes high molecular weight (HMW, 4–6 ring) PAHs, and petroleum product spillages contain low molecular weight (LMW, 2–3 ring) PAHs (Soclo et al., 2000). Most HMW PAHs are carcinogens.

Guiyu, a small town in South China, is the largest and best-known electronic waste (EW) dismantling area in the world. More than 1×10^6 t of EWs are disposed of in Guiyu annually, accounting for 70% of the EWs produced globally

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(UNEP, 2005). However, the disposal methods for EWs are primitive and crude, and include roasting of circuit boards over grills, open burning of EW scrap, and melting of plastics (BAN and SVTC, 2002). These thermal disposal processes are usually performed on farmland, particularly near rivers, and the disposed residues are often dumped into the river. Because of this, the Guiyu area has become severely contaminated with polychlorinated and polybrominated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs, PBDD/Fs) (Li et al., 2007), polychlorinated biphenyls (PCBs) (Xing et al., 2009), polybrominated diphenyl ethers (PBDEs) (Zhang et al., 2014), and other pollutants. We have previously studied the concentrations and sources of PCDD/Fs in farmland soils of Guiyu (Xu et al., 2013). In the study presented here, we focus on PAHs, which are also produced by thermal processes. We determined the concentrations, compositions, and sources of PAHs in farmland soils and riverine sediments, and evaluated the carcinogenic risks to humans associated with them.

1. Experimental

1.1. Study area and sampling

Guiyu town is located in the west of Shantou City, Guangdong Province, China. It has an area of 52 km^2 and a population of 150,000. Guiyu is divided into three geographical districts, Nanyang (NY), Shanglian (SL) and Huamei (HM) districts, which are located in the north, southeast and southwest of Guiyu, respectively. The disposal of EWs is the dominant industry in these three districts and in Yaocuowei (YCW) and Longmen (LM) villages, which border on the northwestern edge of Guiyu. A total of 18 farmland soil sites in the EW disposal area above-mentioned were selected. Two background sites in Fushan (FS) and YCW villages are located in the north of Guiyu, on the windward side of the EW disposal area, where disposal of EWs is not performed. Three sites from neighboring towns were chosen, namely eastern Gurao town (GR), southern Chendian

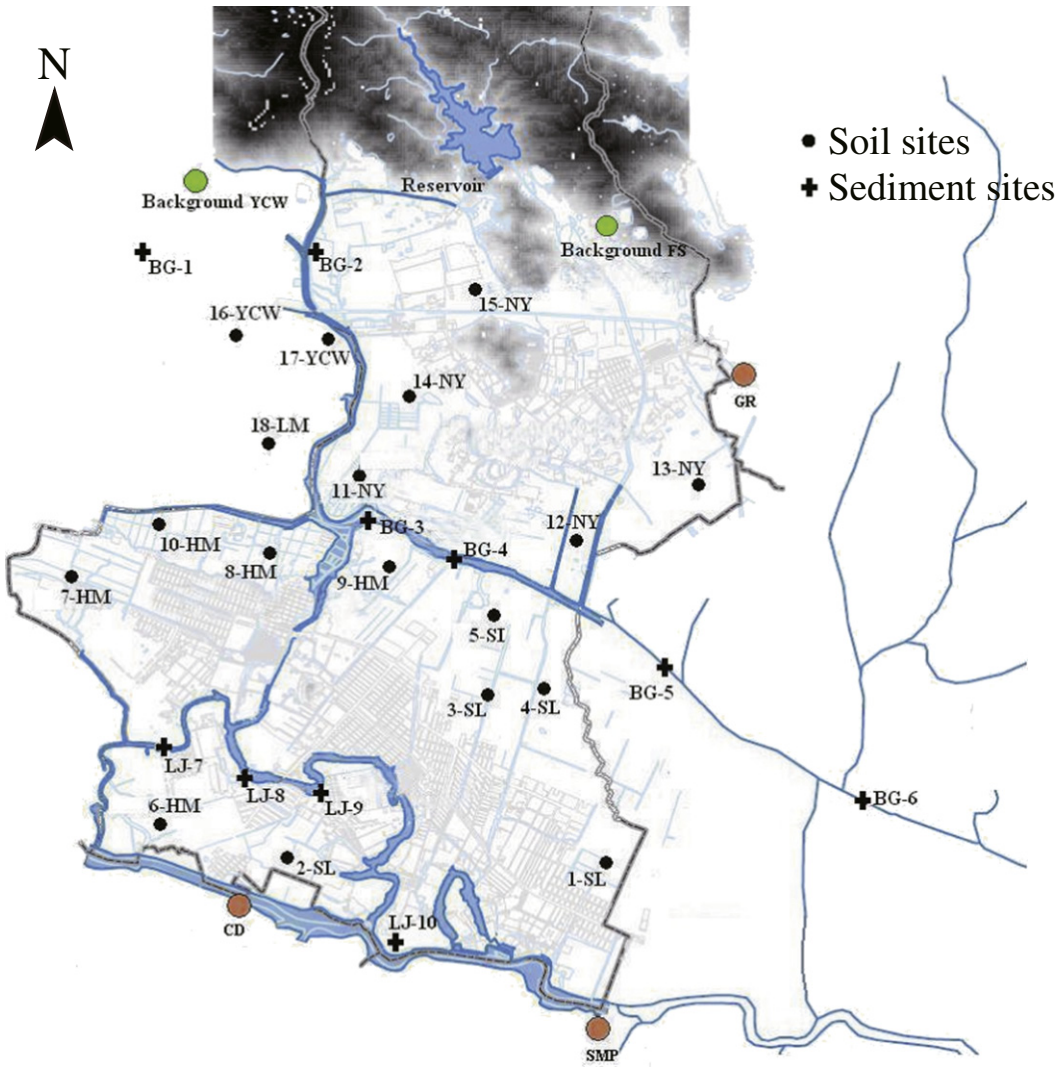

Fig. 1 – Soil and sediment sampling sites in Guiyu and adjacent towns.