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Heavy metal contamination in soils and vegetables near an e-waste processing site, south China

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ABSTRACT

Environmental pollution due to uncontrolled e-waste recycling activities has been reported in a number of locations of China. In the present study, metal pollution to the surrounding environment from a primitive e-waste processing facility was investigated. Soils at sites where e-waste is burned in the open air, those of surrounding paddy fields and vegetable gardens, as well as common vegetable samples were collected and analyzed for heavy metals. The results showed that the soils of former incineration sites had the highest concentrations of Cd, Cu, Pb, and Zn with mean values of 17.1, 11,140, 4500, and 3690 mg kg^{-1}, respectively. The soils of nearby paddy fields and vegetable gardens also had relatively high concentrations of Cd and Cu. In the edible tissues of vegetables, the concentrations of Cd and Pb in most samples exceeded the maximum level permitted for food in China. Sequential leaching tests revealed that the Cu, Pb, and Zn were predominantly associated with the residual fraction, followed by the carbonate/specifically adsorbed phases with the exception of Cd, which was mainly in the extractable form in paddy fields and vegetable soils. The data showed that uncontrolled e-waste processing operations caused serious pollution to local soils and vegetables. The cleaning up of former incineration sites should be a priority in any future remediation program.

1. Introduction

Driven by profits, the recycling of e-waste using primitive processes is being carried out extremely actively in a few locations in south China. It is becoming an important new source of environmental pollution in these regions [1–3]. The operations commonly used in processing e-waste in order to extract precious metals, such as strong acid leaching and the open burning of dismantled components, has led to the release of large quantities of toxic metals and organic pollutants into the surrounding environment. The air, surface water, ground water, soil, and river sediment of e-waste processing sites have been severely contaminated by heavy metals, such as Cd, Cu, and Pb, as well as organic contaminants, such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and polybrominated diphenyls ethers (PBDEs) [3–8]. The laborers dismantling discarded electronic items and local residents may be seriously affected through direct inhalation and dermal contact with these contaminants. Strikingly high concentrations of 100 μg l^{-1} lead [9,10], and 3100 ng g^{-1} lipid BDE-209 [1] have been found in the blood of workers engaged in this work, and in that of the children living nearby. As well, a very high occurrence of various diseases has been reported in primitive e-waste processing areas [11]. An increasing amount of attention is being paid to this emerging environmental issue in China and other developing countries [12–16].

E-waste processing sites are usually located in fields adjacent to land used for agricultural purposes. Heavy metals released from salvaging useful materials and from the uncontrolled open burning of electronic waste could penetrate the soils where vegetables and crops are grown by contaminating irrigation water and through direct deposition by air. Plants can take up these metals from soil by their roots, transport them upwards to their shoots, and finally accumulate them inside their tissues, although there are large variations among different plant species in terms of metal accumulation ability [17,18]. In addition, direct foliar uptake of heavy metals from the atmosphere can also occur during plant growth [19]. Oral ingestion of contaminated food has been proved to be an important pathway for the transfer of heavy metals from the environment to human bodies. Investigations on the accumulation of heavy metals from rice, and organic pollutants from vegetables grown around uncontrolled e-waste recycling sites have revealed high levels of Pb, Cd, polybrominated biphenyls (PBBs), PBDEs, and PCBs in these local food samples [20,21]. In this context, the risks associated with the consumption of contaminated

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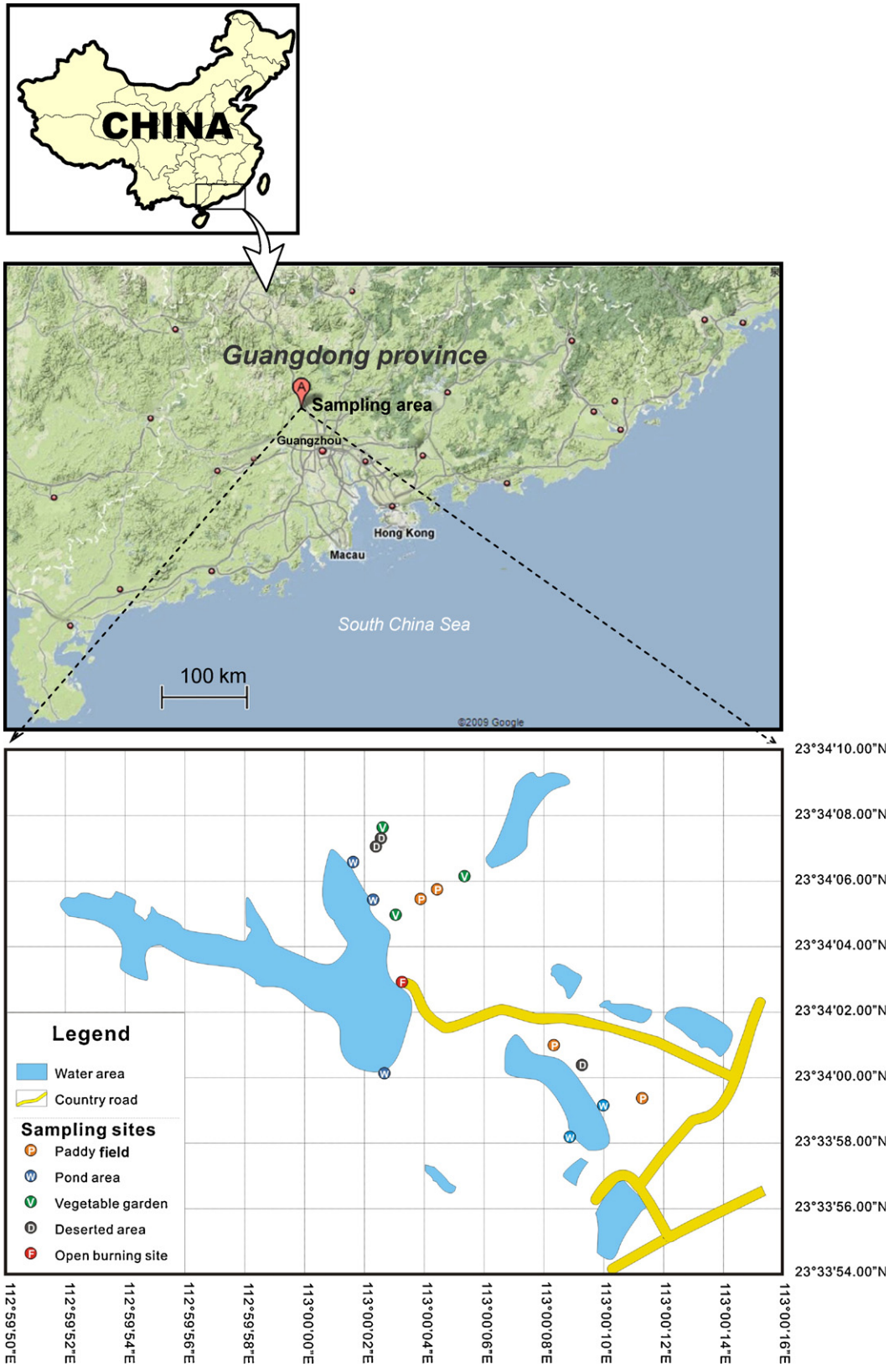

Fig. 1. Map of the sampling location. P, paddy field; W, pond area; V, vegetable garden; D, deserted area; and F, open burning sites.

food grown in e-waste processing regions may be a potential health concern.

The present study was carried out in a small town of Longtang in northern Guangdong province with 100 thousand residents, and the local economy is mainly dependent on the manufacturing industry, agriculture and metal recycling from obsolete electronic products. This site was one of the e-waste processing villages in south China, where e-waste recycling can be traced back to the