## Contamination Associated with E-waste Recycling in India

Annamalai Subramanian[1], Shin Takahashi[1], Peethambaram Parthasarathy[2], Kesav A. Bulbule[3], Shinsuke Tanabe[1]
[1]Center for Marine Environmental Studies, Ehime University, Matsuyama, Japan
[2]E-Parisara Pvt. Ltd., Karnataka Industrial Area Development Board, Bangalore, India
[3]Nijalingappa College, Rajaji Nagar, Bangalore, India

### Introduction

Activities related to electric and electronic waste (e-waste) is one of the emerging problems of the 21st century world (Schmidt 2002). Global dumping of e-waste comprising televisions, computers, mobile phones accounts to nearly 20-50 million tons/year which could bring serious risks to human health and environment. While the European Union, Japan, South Korea, Taiwan and several states in the USA have introduced legislative measures to control this menace, the e-waste recycling sector in many parts of Asia remains largely unregulated. It is also poorly studied with regard to its impacts and on the ambient environment and around as well as the health of recycling workers and surrounding communities (Greenpeace International 2005). Results of many recent studies confirm that all stages in the processing of electrical and electronic wastes have the potential to release several organic compounds like brominated flame retardants (BFRs) such as polybrominated diphenyl ethers (PBDEs), hexachlorocyclododecanes (HBCDs), polychlorinated dibenzo dioxins (PCDDs) and related chemicals, polychlorinated biphenyls (PCBs) and also heavy metals to the workplace environment and surrounding soils and water courses (Ramu et al. 2007, Sudaryanto et al. 2008). In its recent report Greenpeace International (2005) has shown and predicted several other contamination by the recycling of electronic wastes in China and India where more than 80% of the world's e-wastes end up for processing. In spite of this, not much has been done to monitor and control the contamination by e-waste recycling industry in India.

India is now confronting the huge problem of e-waste both locally generated and internationally imported which feeds to a lucrative industry but posing a serious threat to human health and the environment. According to Toxics Link, a non-governmental organization (NGO) in New Delhi, India says that the country annually generates $1.5 billion worth of e-waste domestically, with the booming IT sector being the largest contributor. Large e-waste centers exist in Delhi, Meerut, Ferozabad, Chennai, Bangalore and Mumbai. Bangalore, the city which is called as the Silicon Valley of India alone generates 8,000 tons of e-waste a year. Apart from the licensed e-waste processing industries in the outskirts of this city most of the recycling processes are held using very crude methods in the alleys and by-lanes in the

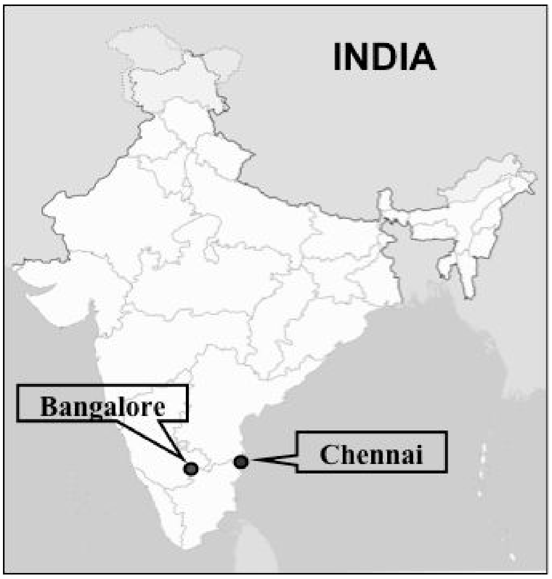

Fig. 1. Sampling locations

suburban locations of the city, at many instances in the open. Even small children are involved in processes using crude methods and handle dangerous chemicals without any known precautionary measures for extracting the valuable material like gold from the e-waste like obsolete computers. Workers in these industries are poorly protected in an environment where e-waste is burned in the open, releasing toxic chemicals into the air. It is a means of livelihood for thousands of unorganized recyclers. Due to lack of awareness, they are risking their health and the environment as well.

## Materials and Methods

The investigation and sampling for this work were conducted in Bangalore and Chennai, India in the years 2003-2006. The air and soil samples were collected from the storage and outside the main building of an e-waste recycling facility and the backyard recycling sites in the slum areas of Bangalore. The hair samples were collected from the workers in the e-waste recycling industry after obtaining informed consent. All the samples were transported in dry ice and kept at -25 ºC in the Environmental specimen Bank (es-BANK) of Ehime University, Japan until chemical analysis. The samples collected from non e-waste areas at Chennai and other locations in India were used as Reference (Fig. 1). The air samples were estimated for PBDEs and PCBs and the soil samples for PBDEs, HBCDs and DRCs including brominated dioxins whereas the hair samples were evaluated for their heavy metal contents. The analysis of the brominated flame retardants (PBDEs and HBCDs), dioxins and related chemicals (PCDDs, PCDFs, PBDDs, co-planar PCBs) and heavy metals were carried out as described in our previous reports (Tanabe et al. 2004, Ramu et al. 2007, Ha et al. 2009).

## Results and Discussion

All the samples in this study contained all the chemicals analyzed. It has been noticed that the recycling activities, both in the recycle facility as well as in the backyard recycle areas had elevated levels of PBDEs in their ambient air with the backyard recycling area containing the highest level (54 ng/m$^3$) whereas the control sites samples collected from different locations in India had values ranging from none to 0.16 ng/m$^3$. A same type of distribution of PCBs was also observed in the air samples collected from different locations (Fig. 2).

The higher levels of PBDEs observed in the ambient air of the e-waste processing areas of Bangalore seemed to reflect in the soil samples collected from the same locations with considerably higher levels in them than in the reference samples collected from Chennai (Fig. 3). The PBDEs levels in the soils from e-waste areas of the present study were lower than in Guiyu,

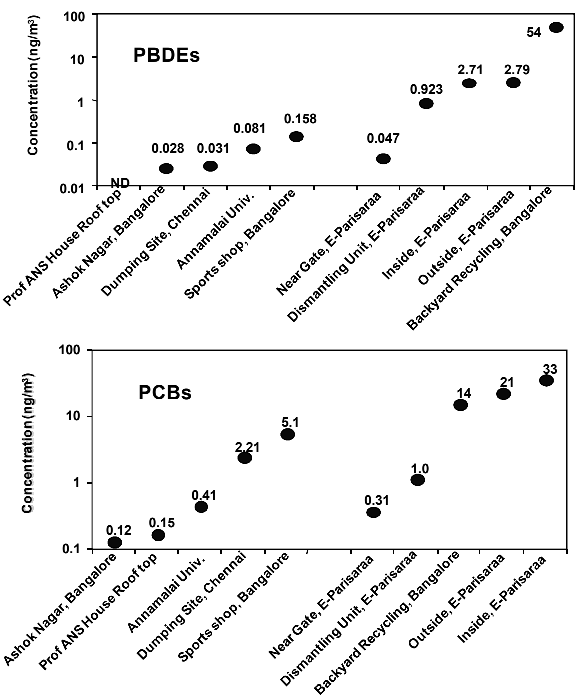


Fig. 2. Levels of PBDEs and PCBs in the air samples from e-waste recycling locations and reference sites in India

China (popular e-waste processing area) but comparable or even higher than in industrial areas in developed countries. Apart from this we observed higher levels of the other brominated flame retardant chemical, HBCDs in the e-waste recycling areas than in no e-waste soils.

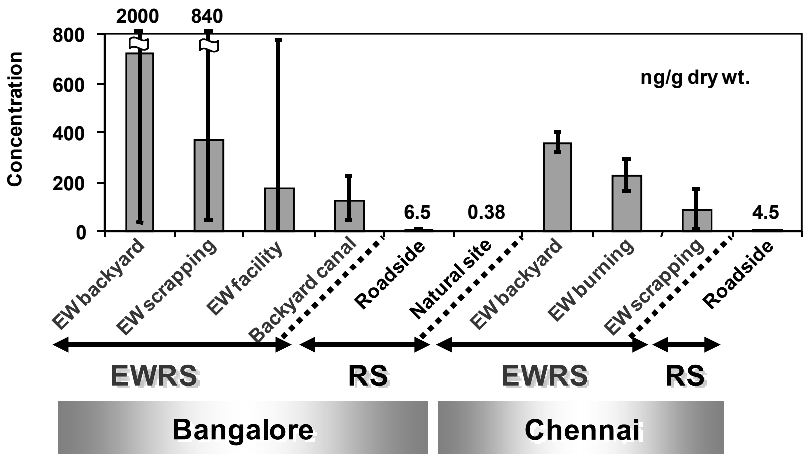


Fig. 3. Concentrations of PBDEs in the soil samples collected from e-waste recycling and reference sites in India

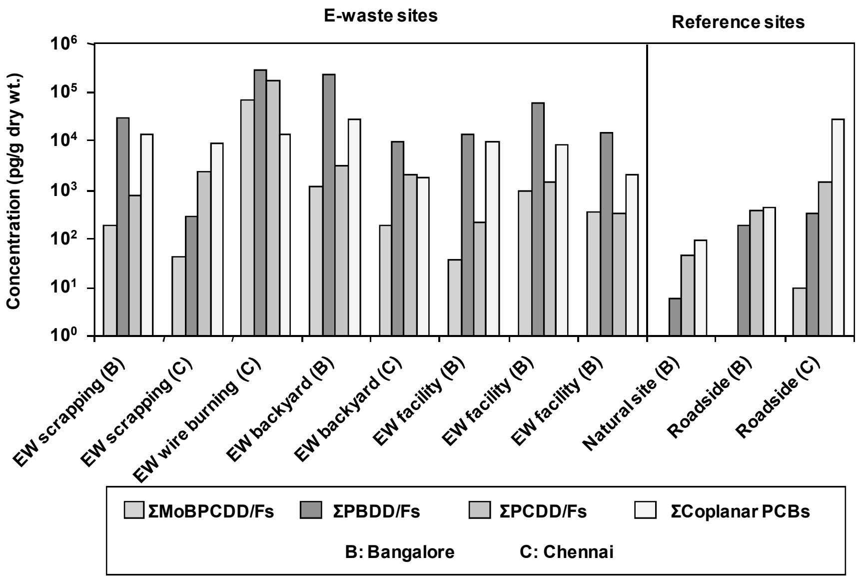


Fig. 4. Levels of dioxins and related chemicals in soils from Bangalore (e-waste) and Chennai (reference), India

Further, the concentrations of the dioxin related compounds, especially the brominated dioxins (PBDDs) were also higher in the e-waste soils than those from far away areas from e-waste recycling (Fig. 4). Comparison of the homologue profiles of PCDD/Fs of the present study with the profiles available in the literature shows a prominent release of PCDD/Fs from e-waste processing areas. It was also found that some of the DRC values observed in the present study are well above the standard values suggested by different agencies.

Heavy metal contamination was also found to be prominent with higher levels of Cu, Sb and Bi in both the recycling areas, whereas Pb, Mo, Rb and In occurred at higher levels in the hair of workers in e-waste industry and Ag, Cd and Hg being higher in the case of backyard recyclers. It has also been found that certain element levels in hair showed linear relation with the levels in air dust and some of them do occur in concentrations more than the recommended safe levels.

E-waste recycling in India seems to be mostly unregulated thus contaminating the ambient air and soil with contaminants like PCDDs/Fs, PBDEs, HBCDs, PCBs and heavy metals. Especially, the crude e-waste processing methods employed at the backyard e-waste processing in slum areas may lead to serious environmental contamination. The ambient air and soil in the e-waste processing areas were contaminated with all these chemicals with values very much higher in the backyard recycling areas showing that they are becoming hot spots of pollution. Trace element levels in the air dust samples were higher in e-waste recycling area which also reflects in the hair of the recycle workers.

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