LIFE CYCLE ASSESSMENTS ON RECYCLING OF TV CABINET BACK COVERS CONTAINING BROMINATED FLAME RETARDANTS

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Abstract

Lifecycle assessment on the recycling and waste treatment of plastic back covers of television sets was performed. The impact categories (inventory items) were climate change (CO_2 emission), landfill consumption, and toxicity to humans (PBDE emission). Two weighting methods (prevention cost method and damage cost method) were applied. Feedstock recycling in coke ovens had the lowest environmental impact among the five scenarios. However, because of the Br content in the plastic, the capacity of the feedstock recycling is limited. The second best scenario was material recycling (video cassette cases). This scenario had the highest PBDE exposure. To improve the reliability of this result, enhancement of the target compounds such as PBDD/DFs is important.

Introduction

Recycling facilities of home electronics appliances generate waste plastic containing brominated flame retardants. This waste plastic is recycled and treated using a variety of methods, but there is little knowledge about the environmental emissions of those brominated flame retardants in the recycling process. Environmental emissions of flame retardants and other substances must be considered when comparing treatment methods to see which are better. This paper therefore performed life cycle assessments on the methods of treating TV cabinet back covers, with the focus on waste plastic containing brominated flame retardants.

Method

Our functional unit was “a 25-inch television used for 10 years,” and the assumed number of units recycled was set at 3.8 million.[1] The number of units is only the number of TVs taken to recycling facilities for treatment and this TV flow does not take into consideration factors such as the export of used TVs.

The life cycle assessed extends from the manufacture of plastic (polystyrene, PS) to the final disposal of waste plastic from back covers (Figure 1). The assessment covers only system operation, not facility construction. We defined the system boundary as whether there was a possibility of release of Polybrominated diphenyl ether (PBDE) to the atmosphere. In each scenario we assumed that appliance recycling plants used the same processes up to shredding and separation (α), and that 9500 t of shredded plastic and 855 t of Decabromo diphenyl ether (D10BDE) were generated. We assumed that after this, the waste would be treated in one of five ways: material recycling (video cassettes, scenario 1), thermal recovery (waste to power, scenario 2), chemical recycling (coke oven reduction, scenario 3), landfilling (scenario 4), and landfilling followed by open-air incineration (scenario 4′).

The impact categories for the LCA impact assessment we chose were global warming, human health impacts due to PBDE exposure, and landfill consumption. Inventory analysis items were CO_2 emissions, PBDE emissions, and amount landfilled. For PBDE emissions a distinction was made between ambient air and indoor air. The characterization factor used for both was the intake fraction, which is used to find exposure. The prevention cost method and damage cost method were used for weighting between impact categories.

Results and Discussion

Inventory analysis results are in Table 1, while weighting results appear in Figures 2 and 3.

Weighting assessment results indicated that scenario 3 (coke oven reduction) was the best. The reasons are the big CO_2 reduction owing to the large amount of power generated from byproduct gas and the comparatively small amount of PBDE exposure. At present the steel industry can accept 80,000 t of waste plastic annually,[2] and if the Br content is 0.5%, or the same as Cl content, that is 400 t Br. Because there is 705 t of Br in the PBDEs of the back covers, it would be hard for the steel industry to take all the waste plastic from TV cabinet back covers, thereby making it necessary to think of the next best thing.

Our assessment found that the second-best was scenario 1 (material recycling). Because Scenario 1 includes exposure in the process of using PBDE-containing recycled products (video cassettes), its PBDE exposure is the next-largest after scenario 4′ (landfilling with some open-air burning). We considered only D10BDE for the damage factor of brominated flame retardant exposure, and did not count exposure to other PBDE homologues, or to thermal breakdown products such as PBDD/DFs. It is therefore possible that monetary damage was underestimated. It will be important to refine these and to see whether material recycling or thermal recovery is better.

Acknowledgements

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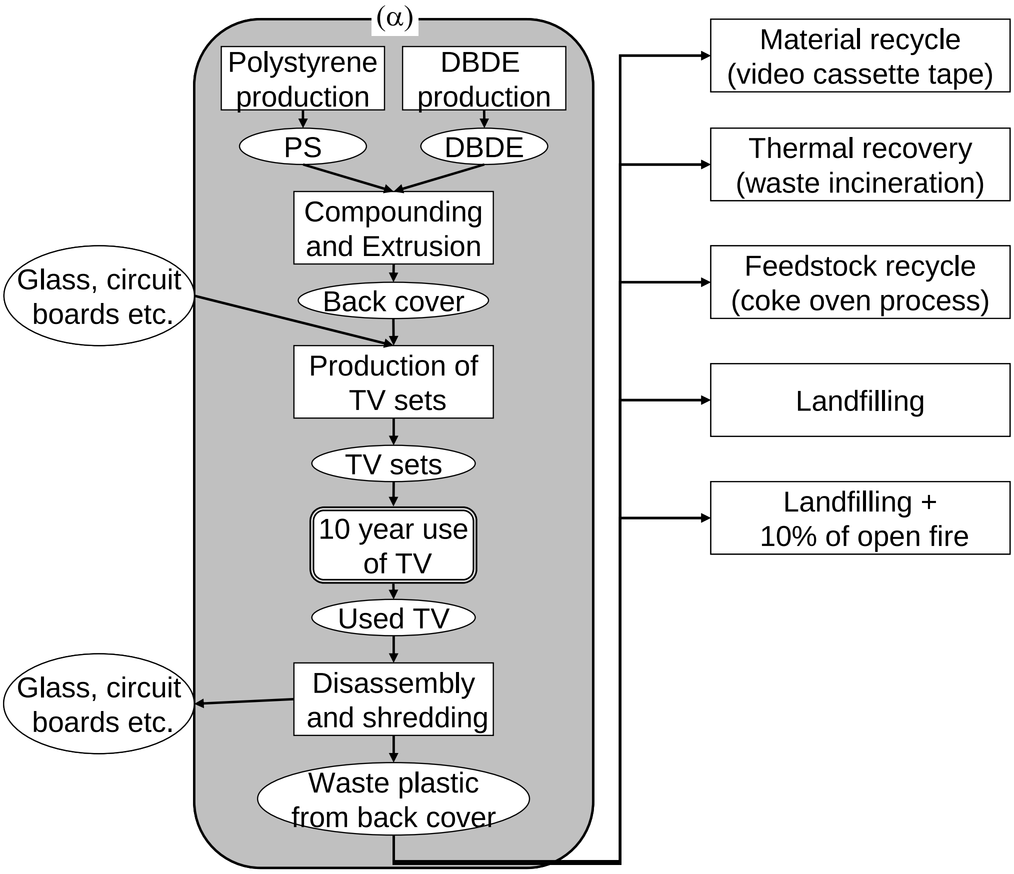

Figure 1 System Boundary of the Waste Plastic Recycling.

Table 1 Inventory Results

Scenario	CO_2 emissions ($ton\text{-}CO_2$)	Landfill consumption (m^3)	PBDE exposure (g-PBDE)
Material recycling (scenario 1)	-15,600	0	54
Thermal recovery (scenario 2)	26,500	295	0.33
Feedstock recycling (scenario 3)*	-42,300	0	0.011
Landfilling (scenario 4)	240	9,050	0
Landfilling with some open fire (scenario 4′)**	3,200	8,170	9.8

* The waste plastic replaces coal in cokes oven.
** An assumption was made that 10% of waste plastic was burned.

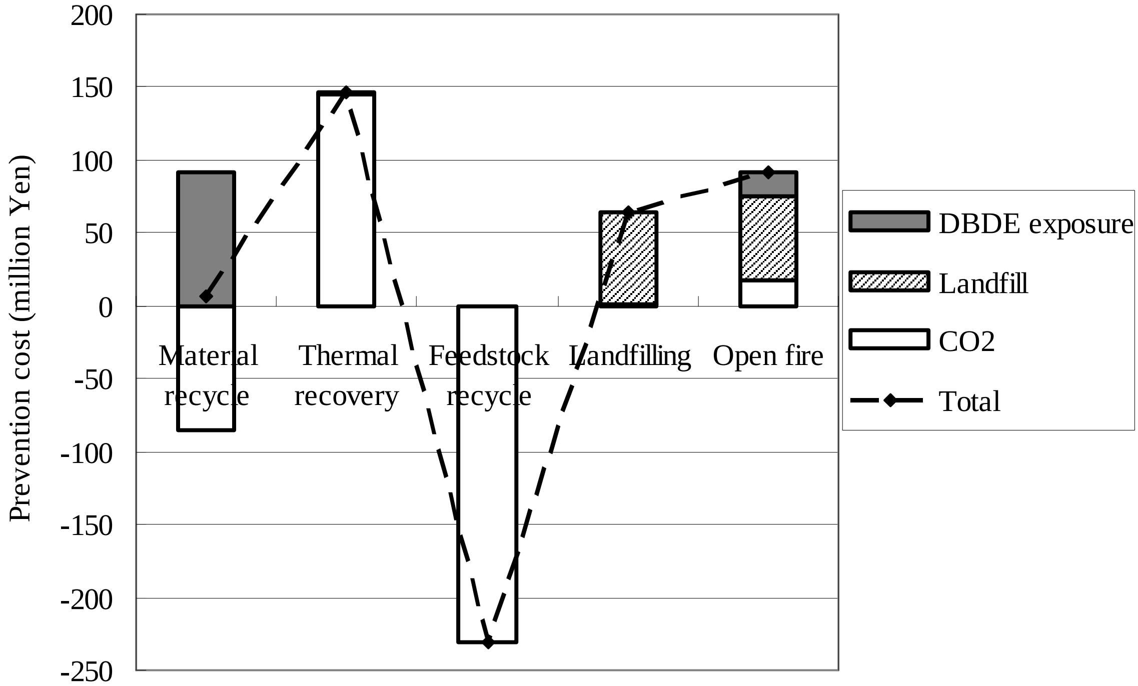

Figure 2 Weighting Result According to Prevention Cost Method

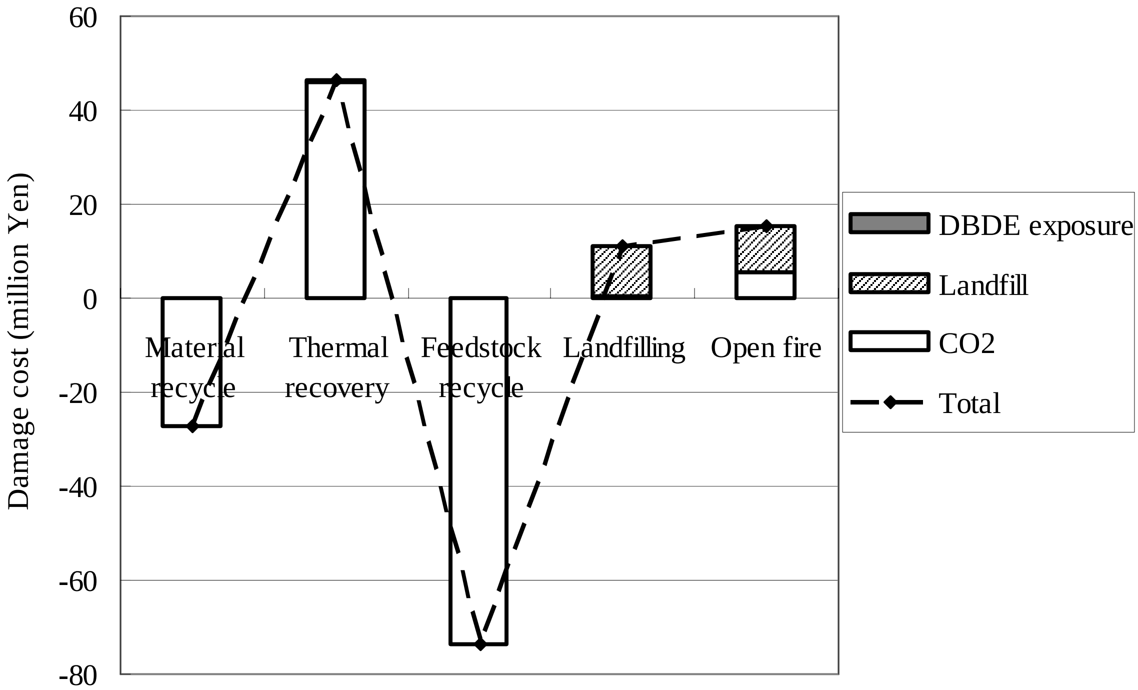

Figure 3 Weighting Result According to Damage Assessment Method