MATERIAL FLOW OF INFORMAL ELECTRONIC WASTE DISMANTLING IN RURAL AREA OF NORTHEASTERN THAILAND

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Abstract- There is a huge amount of electronic waste (e-waste) worldwide. In Thailand, there is a rapid growth in the number of informal e-waste separators who dismantle and recover electronic waste mostly comes from households. This study illustrates the material flow of e-waste dismantling in rural area of northeastern Thailand by informal separators. The dismantling process uses primitive methods to separate materials from the equipment, such as physical dismantling by hammer, chisel, and screw driver, and open burning some components. The result showed the amount and types of e-waste. It was found that there were 12 types of e-wastes that the informal separators buy from households or recycled junk shop. Valuable materials were steel, copper, aluminium, stainless, plastic, and wires. When the 12 e-wastes were dismantled, the amount of the sorted materials was found to be in the percentage of 69.48-96.59%. This was considered a high portion compared to the percentage of non-valuable materials. This is why people are becoming more interested in this activity, without considering the impact on the environment and health caused by improper handling.

Keywords- Electronic waste, Informal separators, Material flow

I. INTRODUCTION

Electronic waste (e-waste) is a major problem in many countries as the amount of e-waste has been increasing every year. This is due to advanced technology and production, leading to the consumers' increasing demand of electric and electronic appliances. And when these appliances are expired, degenerated, damaged, or out of date, they become e-waste pending for management or disposal. In 2014, the amount of e-waste around the world was 41.8 million tons and this was increasing at the rate of 4% per year, and in 2018, the amount of e-waste is foreseen to increase to 50 million tons [1]. In regard to this, 80% of the e-waste from the developed countries will be sent to the developing countries in Asia [2]. Large e-waste dismantling sites are dispersed in many countries in Asia and Africa, such as China, India, Pakistan, Nigeria, Ghana, and Vietnam [3]. The dismantling process in the developing countries is not conducted in recycling plants, but by informal separators or in the households where primitive dismantling methods such as cut, break, smash, and open burning are used to separate the valuable parts for sale. And the workers do not use any safety equipment [2]. Previous studies found that such dismantling process that did not follow the standard caused a huge amount of heavy metals and organic substances to accumulate in the environment. This affected the dismantling workers as they are directly exposed to the electronic waste through inhalation, dermal contact, and ingestion. Moreover, the pollution accumulated in the environment will enter the food chain which may also harm humans indirectly. Pollution Control Department of Thailand (2014) reported that the amount of e-waste in the year 2014 was 376,801 tons. And it is increasing at the rate of 12% per year. Eight types of e-waste which were mostly found included: televisions, refrigerators, air conditioners, washing machines, computers, VCD/DVD players, mobile phones, and digital cameras. The large informal dismantling sites in Thailand are found at Kalasin and Buriram in northeastern Thailand [7]. The dismantling process is done manually in the residence by the dismantlers who use almost all types of e-waste, both small and large household appliances from neighboring provinces. After sorting, valuable materials such as copper, steel, aluminium, and plastic are sold, while the residue waste such as debris, chips, foam, and other materials are disposed to the dump site in the area. Because the e-waste in the area is handled improperly, it causes human health and environmental problems. In Thailand, there is no complete system for recycling e-waste that has economic value. Another major problem is the collection of the e-waste to be sent to factories whose recycling process was granted license from the government, as there are a few of such factories [8]. Most of the e-waste is disposed together with municipal waste or sold to recycled junk shop. Therefore, informal separators play an important role in the management of these e-wastes.

To react to the problems, the Pollution Control Department (PCD), under the Thai government suggested that the local governments should buy back the waste electrical and electronic equipment (WEEE) from households, as the informal separators take up a large part in the market and this can worsen the impact on communities and environment. To

make it possible for the government to receive fees from the sales of some products for supporting the buy-back and subsidizing the recycling, a law was drafted under the National Integrated Strategy for the Management of Waste Electrical and Electronic Equipment (henceforth The Thai WEEE Strategy) [7]. The principle of this draft is to involve all sectors and increase the Extended Producer Responsibility (EPR), in which the producers are responsible for the expenses occurred from the disposal of the product remains. This will encourage them to redesign the products to be easier for recycling and to be more environmental friendly by reducing hazardous substances, thus, promoting sustainable production and consumption. Although strategies are established to manage the remains of these electric and electronic products, there is still a lack of the data on the amount of the e-waste and the flow of materials where informal separators are involved. This research aims to study the material flow, amount and types of e-waste, sorted valuable materials, and the debris left from dismantling by informal separators. These data enable us to gain insight on particular dismantling method and the tendency of the amount of the materials occurred in the area.

II. MATERIALS AND PROCEDURES

This study was conducted during July, 2016 and June, 2017. The e-waste dismantling site is located at Buriram province in northeastern Thailand. The total number of informal separators was 130 households. The amount and types of e-waste were collected from the monthly record of e-waste purchase and material sale, and the record of elements and weight of the sorted e-waste both recyclable and non-recyclable materials. For the procedure of e-waste dismantling, 30 of e-waste samples in each type of e-waste product were studied. The procedure, and measure the weight of the e-waste before dismantling and the sorted materials after dismantling from the beginning until the end of the process were observed and recorded using a record of elements and weight of the sorted e-waste.

III. RESULTS AND DISCUSSION

3.1 The flow of e-waste dismantling process

The flow of e-waste dismantling in Thailand by informal separators is explained in Fig 1.The route of electric and electronic appliances which later become the source of e-waste starts from when the consumers buy the products. When they are out of order or damaged, they are sent to repair or sold to recycled junk shop or to informal separators who provide the pick-up service.

Then, the dismantlers buy the e-waste from recycled junk shop or pick up from households to dismantle before separating valuable materials for sale. For the parts that cannot be sold, they will illegally burn or dump them in other areas, while the e-waste disposed together with municipal waste will be collected and landfilled by the municipality or local sectors.

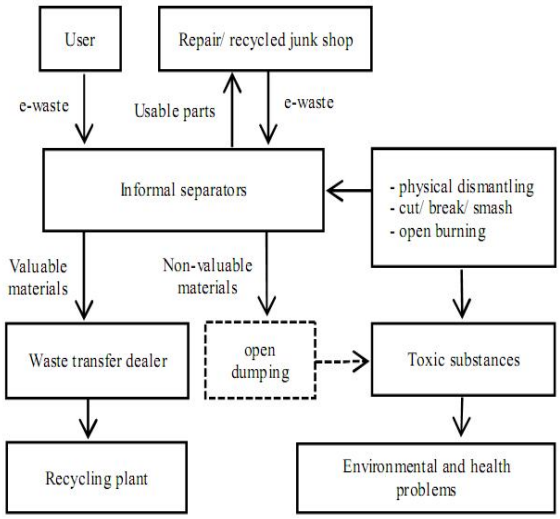

Fig.1. The simple diagram of the flow of e-waste dismantling by informal separators

The procedure of e-waste dismantling by informal separators begins with buying e-waste from households or junk shops, piling them up in their residence, then starting the dismantling from the large products such as washing machines, refrigerators, and air conditioners first, by removing the external structure made of steel, aluminium, or plastic. Then, the internal elements are separated, such as electric motors, printed circuits boards, and wires. These elements are smashed and separated again to retrieve valuable materials inside, which are copper and steel. For televisions and computer screens, the dismantling is different. That is, when the external parts are removed, the glass element which is the screens of the cathode ray tube (CRT) are beaten to get to the steel and aluminium structure, while the glass pieces and electron gun assembly are thrown away. All the wires from every electric appliance are burned for copper. This is a popular method as it can extract a large amount of copper within a shorter time than peeling the wires with a knife. For small wires, the informal separators usually burn them up in an open field.

3.2 The amount and types of e-waste

From the survey on the amount and types of the e-waste that the informal separators buy from households or recycled junk shop, it was found that there were 12 types of e-wastes, as shown in Table 1. According to The Waste Electrical and Electronic Equipment Directive (WEEE Directive), the electronic waste could be categorized into 4 groups out of 10 as follows; (1) large household appliances; (2) small household appliances; (3) IT and telecommunications equipment; and (4) consumer equipment [8].

Table 1. Types and categorization of e-waste

Product type	Category	Accumulated amount (ton/ year/ household)	
		Small	Large
1. Fan	2	5.37	11.24
2. Television (CRT)	4	12.33	15.67
3. Washing machine	1	10.06	13.34
4. Refrigerator	1	8.26	17.25
5. Rice cooker	2	0.26	0.71
6. Desktop computer	3	1.88	5.42
7. CD/ VCD player	4	0.085	0.526
8. Microwave	2	0.200	0.847
9. Printer	3	0.008	0.211
10. Iron	2	0.028	0.037
11. Electric jar pot	2	0.047	0.059
12. Air conditioner	1	0.297	1.267

(1) Large household appliances; (2) Small household appliances;
(3)IT and telecommunications equipment; (4) consumer equipment

Informal separators are divided into 2 groups; (1) small households that have 3-4 workers and (2) large households that have 5-6 workers. Five e-wastes which were found most were fans, televisions, washing machines, refrigerators, and desktop computers. The types of the e-waste bought for dismantling depended on the occasion and the time of purchasing. Most of the e-waste was found to be electric appliances used in households. Beside the e-waste mentioned above, other electric appliances were also found, such as mechanical tools, electric toys, but in a small amount, as the informal separators selected bigger e-waste which contained more valuable materials first. Previous researches in China, India, and Vietnam also pointed out that most of the e-waste which was bought for dismantle were electric home appliances [9] – [14].

The procedure of e-waste dismantling in each category from 30 products was studied. The procedure and the weight of the e-waste before dismantling and the sorted materials after dismantling from the beginning until the end of the process were observed and recorded using a record of elements and weight of the sorted e-waste. The result of the sorted materials weight is shown in Table 2

Table 2. The contribution of valuable materials and non-valuable materials after e-waste dismantling process

Unit: Percentage (%)

Product type	Weight (kg)	Valuable materials	Non-valuable materials
1. Fan	4.49	92.45	7.55
2. Television (CRT)	22.97	69.48	30.52
3. Washing machine	33.10	96.59	3.41
4. Refrigerator	40.87	92.23	7.77
5. Rice cooker	2.48	84.78	15.22
6. Desktop computer	25.80	75.35	24.65
7. CD/ VCD player	2.12	76.92	23.08
8. Microwave	15.40	94.55	5.45
9. Printer	4.06	88.38	11.62
10. Iron	1.42	84.31	15.69
11. Electric jar pot	2.46	74.19	25.81
12. Air conditioner	59.42	88.34	11.66

Valuable materials separated from each e-waste were found to be the same, which were steel, copper, aluminium, stainless, plastic, and wires, but the weights were different. The remains with no economic value were also different according to the type of each e-waste. Also, loss of materials could occur during the dismantling procedure. According to Table 2 showing the percentage of sorted materials, it was found that fans, washing machines, and refrigerators had a higher percentage of valuable materials. The results corresponded with the data on the amount of e-waste purchase in Table 1, these 3 e-wastes were also found most. For televisions (CRT), there was a large amount of purchasing as the consumers preferred LCD screen to CRT, causing more TVs to be disposed. But as most of the weight of a TV is from the glass screen, the percentage of non-valuable materials was more than other types of e-waste. For example, in a dismantling of a fan, the total average weight of the fan was 4.49 kilograms. When dismantled, the percentage of valuable materials and non-valuable materials were found to be 92.45 and 7.55, respectively. The percentage of each material found in the fan was plastic (45.63%), steel (38.97%), copper (5.39%), wires (1.39%), printed circuit board (1.07%), and the remains to be disposed was cardboard paper and residue (7.55%). E-wastes with higher than 90% of valuable materials were fans, washing machines, refrigerator, and microwaves (92.23-96.59%). The data regarding the weight of each material suggested that the e-waste had value, and could generate income from dismantling. It also led us to know the amount of the remains to be disposed. From the amount of valuable materials retrieved, it obviously had economic value. That's why people are interested in this activity, causing the number of informal separators to increase in the past few years.

CONCLUSION

This research presented the flow of e-waste dismantling from the beginning of the procedure until the end. The data found were the types and amount of the electronic waste and valuable and non-valuable materials retrieved from the dismantling. Informal separators play a major role in the electronic waste management, as they generate values from electronic waste, though the methods were primitive and without other advanced technology in the process.

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