Environmental Impact Evaluation of Mobile Phone via Life Cycle Assessment

Witthawin Sangprasert, Chanathip Pharino

Abstract-- This research evaluated levels of environmental impacts of mobile phones throughout its life cycle from cradle to gate using LCA software SimaPro Version7.3.3 and expressed with the eco-indicator'99 life cycle impact assessment method, ecoinvent 2.1 database. By disassembling mobile phone, there are main components 4 parts (mobile phone casing, charger casing, charger, battery). By comparing the impacts of each individual part, charger has higher environment impacts than other parts. The result from the method in mid-point categories by normalization found that environmental impact from mineral extraction has highest impact. The result of Ecoindicator’99 points (Pt) from the method in end-point categories found that resources (minerals and fossil fuel) depletion is the highest environment impacts. The composition of mobile phone is metal, plastic, rubber and paper. The main composition is metal (50%) and plastic (46%). High percentage of metal and plastic in mobile phone present high potential to be recycle but product re-design and waste collection system are needed to reduce or minimize the impacts from mobile phone.

Key words— Mobile phone wastes, LCA, Environmental Impact

I. Introduction

Mobile phone wastes have the potential to generate the environment impact because mobile phones contain toxic and rare substances. The toxicity potentials are evaluated by using heavy metal content, respective characterization factor, a pathway and impact model for heavy metals that considers end of life disposal in landfills or incineration. A recent study found that cancer potentials are from Pb and As which are contained in the mobile phone, present in the new model of mobile phone can’t reduce in the hazardous elements because they are mainly component of print wiring board (PWB) [1]. The toxic substance of mobile phones can pollute into the air, soil or water. Many of toxic substance can persist in the environment by bio-accumulating through the food chain.

LCA is environmental assessment tool standardized by International Standard Organization (ISO) that provides quantitative environmental impact.

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LCA concerns about inventory of relevant energy and material inputs and environmental releases, evaluating the potential impacts associated with identified inputs and releases [2]. LCA study of a Chinese desktop personal computer by Simapro software version7.0, expressed with the Eco-indicator’99, Ecoinvent 1.3 database shows the result of Ecoindicator’99 points (EIP) from single score, found that the manufacture and use phase generate with about 41 EIP and 43 EIP respectively. The manufacturing and the use of such devices are of the highest environmental importance because the manufacturing and the use are dominated by the fossil resource consumption. In the manufacturing of such devices, the Liquid Crystal Display (LCD) is part contributing most to the impact, while keyboard and mouse are of minor impact. LCD module has Ecoindicator’99 points (EIP) from score about 8.5 EIP [3].

LCA study of Television in China using Simapro software version 7.2 expressed with the Eco-indicator’99, Ecoinvent 2.2 database [4]. The result shows that the use stage of such devices has the highest environment impact, has Ecoindicator’99 points from single score about 63.43 Pt more than 99% is attributable to electricity consumption, followed by the manufacturing stage has about 30.68 Pt, about 42% due to the consumption of fossil resources and minerals.

The major challenges in the mobile phone wastes management are: (1) redesign of mobile phones and their accessories to facilitate reuse, recycling and reduce the chemical contained in these products [5]. The electro-electronics industry has already used tools such as life cycle assessment (LCA), eco-design and end of life (EOL) [6] to improve its environmental performance [7]. (2) Development of programs that keep used mobile phones out of the waste stream by collecting and recycling [2], the disposal of mobile phones needs to be managed to minimize impact to environment and human health, if their disposal is not properly managed, it could lead to the released of toxic substances [8]. This work has scope of LCA analysis from cradle to gate in order to estimate the environment impacts from the mobile phone. The objective of the research is to analyze which compartment in the phone that cause the highest impact and has a potential to recover or recycle to minimize environmental impact.

II. MATERIALS AND METHODOLOGY

A. Select the model of mobile phone representatives in case study

Model A is chosen to representative in this study because it is a basic cell phone model capable of making call and sending SMS or text messages. Unlike today's common are smartphones. Model A has no camera, no expandable memory storage and no operating system

Fig. 1 Model A

B. Disassembly the model of mobile phone & weight the component

To collect the data in the part of component and weight from mobile phone components to use as data to be analyzed by LCA software SimaPro Version7.3.3.

C. Evaluate the environment impact of mobile phones by SimaPro Version7.3.3

Key data component and weighting from mobile phone, the data will be analyzed in LCA software SimaPro Version7.3.3 and expressed with the Eco-indicator'99 life cycle impact assessment method, ecoinvent 2.1 database. The scope of LCA analysis from this proceeding is from cradle to gate, not including the phone assembly due to limitation of information access.

III. RESULTS AND DISCUSSION

The table 1 shows the result of weighs of each compartment from disassembly of mobile phone. Model A has 4 main components (mobile phone casing, charger casing, charger, battery). The main material used for mobile phone casing is plastic [9]. The main material in charger casing, charger and battery is metal [6]. Fig. 2 shows the percentage of each material used to produce mobile phone. The resource composition of smartphone is metal, plastic, rubber and paper. The main composition is metal (50%) and plastic (46%). High proportion of metal and plastic from the mobile phone wastes has a potential to be recycled instead of left in the landfill, if appropriately collected.

TABLE I
RESULTS FROM DISASSEMBLY OF MOBILE PHONE [MODEL A]

Component	Weight (g)
1. Mobile phone Casing	
1.1 Plastic	33.2546
1.2 Rubber	1.9288
1.3 Screws	0.8
1.4 Metal (Fe)	0.4
2.Charger Casing	
2.1 plastic housing	5.6549
2.2 Metal (Gold plating)	0.003
2.3 Metal (Stainless)	2.0908
2.4 Paper (Carbon)	0.4053
2.5 Rubber	0.5619
2.6 Metal (Cu)	0.0236
2.7 Metal (Fe)	0.9919
3. Charger	
3.1 LCD	4.2253
3.2 Metal (Al)	5.8752
3.3 Intergrated Circuit (IC)	1.4148
3.4 Inductor	1.7756
3.5 Print wiring board (PWB)	13.4512
3.6 Plastic	4.9701
3.7 Metal (Fe)	0.4893
4. Battery	
4.1 Plastic	3.4683
4.2 Metal (Tin)	0.37
4.3 Print wiring board (PWB)	0.41
4.4 Battery Pack	19.6087
4.5 Rubber	0.0388

Fig. 3 is show the result from the method approach mid-point categories: Carcinogens, Respiratory inorganic, Climate change, Acidification/Eutrophication and Minerals. Results based on damage assessment, most of the impacts mainly caused by charger. The final normalization is then performed at this damage level in fig. 4 found that minerals has higher impacts than other damage categories, followed by respiratory inorganic, climate change, carcinogen and acidification respectively. The impact of minerals if compared with the other is almost 100%, respiratory inorganic (13.3%), climate change (6.6%), carcinogens (3.3%) and Acidification has almost 0%.

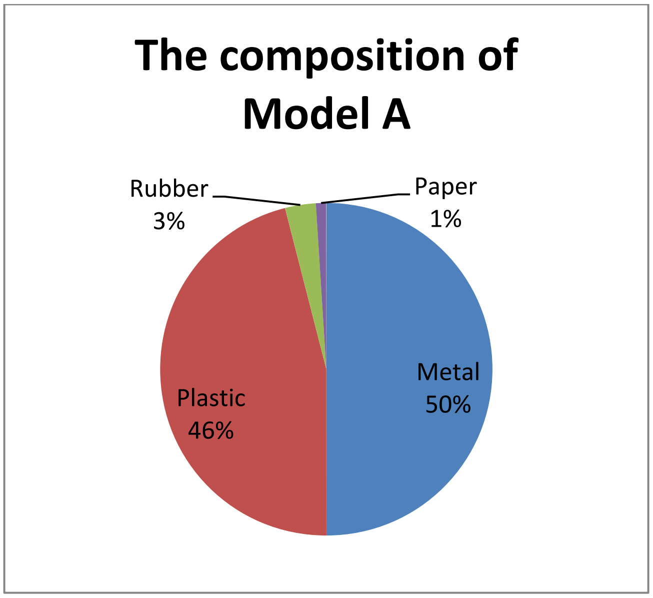

Fig. 2 The Composition of Model A

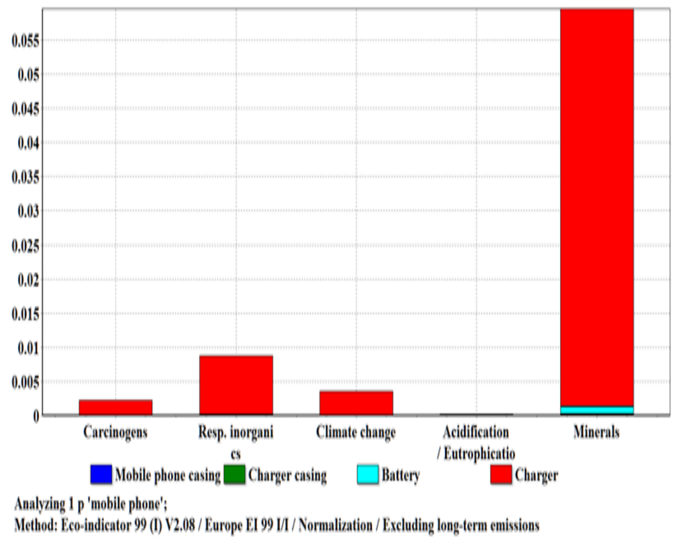

Fig. 4 The normalization of the damage assessment of model A

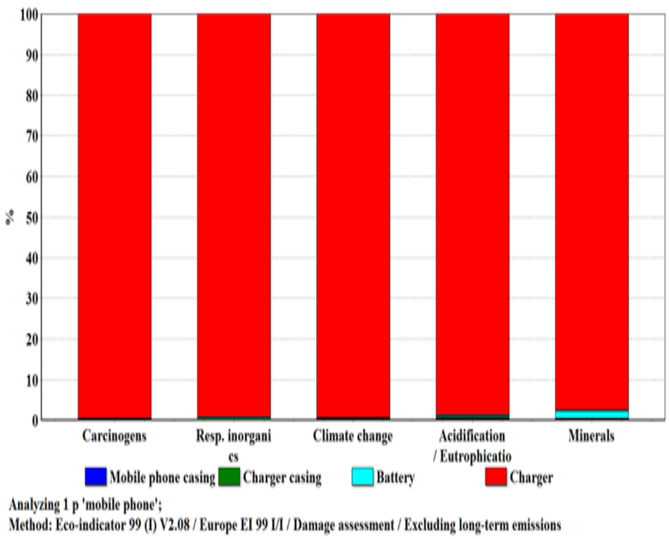

Fig. 3 The damage assessment of model A

The various environmental impacts are examined with the end-point approach which is summed up in three damage categories: human health, ecosystem quality and resources. The final weighting and single score steps are then performed at this damage level as shown in figure 5 & 6 respectively.

Fig. 5 shows the result of Ecoindicator'99 points (Pt) from weighting found that impact on resources has about 12 Pt, human health has 8 Pt and ecosystem quality has almost 0 Pt. So Impact to resource depletion has higher environmental impact when compared to the other damage categories, consequent in fig. 4 minerals has higher impacts that others, minerals are grouped of end points in damage categories of resources [8]. The second highest score is human health due to carcinogens, respiratory inorganic and climate change are grouped of end points in this damage category [10]. The least ecoindicator point is ecosystem quality due to acidification is grouped of end points in this damage category, which the normalization in fig. 4 found that acidification has almost 0%. In the use stage from LCA study of a Chinese desktop personal computer by Simapro software version7.0, expressed with the Eco-indicator'99, Ecoinvent 1.3 database shows the result of Ecoindicator'99 points (EIP) found human health has 27 Pt ,resources has about 12 Pt, and ecosystem quality has 4 Pt [3].So human health has higher environment impacts than others. It is different from the result this study. Due to the scope of LCA analysis in this research is from cradle to gate, not include the manufacture or smartphone assembly but the scope LCA study of a Chinese desktop personal computer is in the use stage.

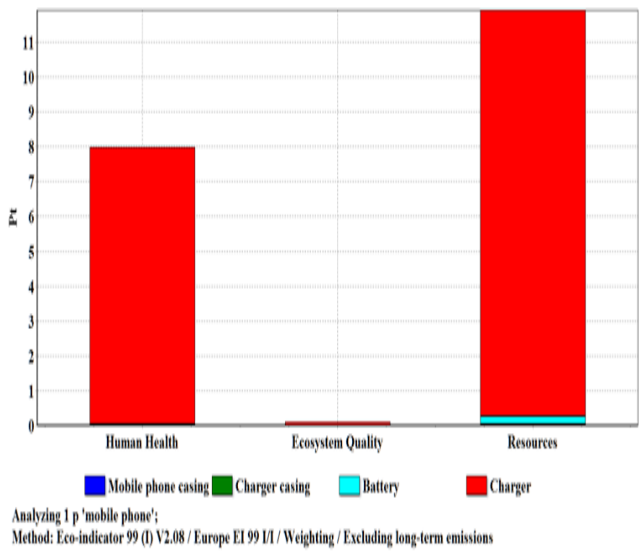

Fig. 5 The result of Ecoindicator'99 points (Pt) from weighting of model A

In addition when compared the impacts of each individual parts of model S. Fig. 6 show the result of Ecoindicator'99 points (Pt) from single score, found that the charger has about 20 Pt, Battery has about 0.4 Pt, mobile phone casing and charger casing has almost negligible impact. So charger has higher environment impacts than other parts, this is supported by data in table 1 found that the mainly components of charger is print wiring board (PWB) which are composed of hazardous substances such as As, Pb, Hg etc. It is the mainly cause of toxicity if contaminate into the environment [1]. This is consistent with the results from LCA study on TV in China by Simapro software version7.2, expressed with the Eco-indicator'99, Ecoinvent 2.2 database shows that in manufacturing stage the CRT and the Printed Circuit Board (PCB) are those components contributing the most environmental impacts. The CRT has about 15 Pt and the PCB has about 11.5 Pt [4]. In the part of mobile phone casing and charger casing, they hardly have the impact on the environment.

As seen from the above that mobile phone wastes needs to be managed to minimize releases of toxic substance into the environment and to lower amount of material and energy used for production and usage. If their disposal is not properly managed, it could lead to the released of toxic substances. Electronics industry has redesigned of mobile phones to facilitate recycling because smartphones have high proportion of metal and plastic which has a potential to be collected and recycle instead of left in the landfill. So development of recycling programs that keep used mobile phone out of the waste stream by collecting and recycling, are necessary to solve the mobile phone wastes problem in the future.

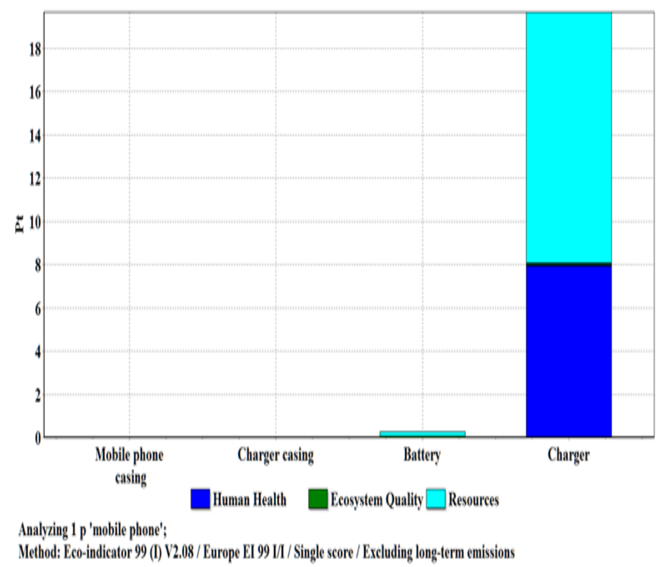

Fig. 6 The result of Ecoindicator'99 points (Pt) from Single score of model A

IV. Conclusion

Result from LCA software found that charger has the highest impacting score in the damage assessment when compared with other parts of the phone in this case study. This is also due to the main component of charger is print wiring board (PWB) which are composed of hazardous substances such as As, Pb. It is the mainly cause of toxicity if contaminate into the environment. The normalization at this damage level (mid-point) found that minerals have higher impacts than other damage categories, followed by respiratory inorganic, climate change, carcinogen and acidification respectively. The result of weighting at this damage level (end-point) found that impact to resource depletion has higher environmental impact when compared to the other damage categories followed by human health and ecosystem quality respectively. Main composition of mobile phone is metal and plastic. High percentage of metal and plastic in mobile phone presents high potential to be recycled. Therefore, development of efficient waste collection and recycling system can reduce or minimize the impacts from life cycle of a mobile phone.

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Role of Bacteria and Mold as Agent Plant Litter Composting

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Abstract— Utilization of leaf litter are still rare. Leaf litter only accumulate or even burned. Burning waste can pollute the environment. Use cellulolytic microorganisms, leaf litter can be processed into compost that has economic value. The objective of the research are to obtain suitable microorganism use for composting, particularly for leaf litters composting. The method used in this study is the selective isolation of cellulolytic bacteria and fungi litter at both locations were grown on selective medium CMC, avicel, xylan, and tannin, then the best selected isolates were inoculated in leaf litter composting experiment. A total of 72 isolates microorganism were isolated, 28 belong to bacterial and 44 belong to fungal. Leaf itter with the addition of inoculum of bacteria and molds showed a faster process than the litter without inoculums, with the final C / N ratio of 19.56 accordance with the standars of the compos Asia trade.

Keywords—Cellulolytic microorganism, Leaf litter, Composting.

I. Introduction

UTILIZATION accumulated leaf litters, such as in the yard, sidewalks, and lawn are still rare, moreover adds to the overall problem of municipial waste [1]. Leaf litters are often accumulated piled up, discarded indiscriminately, or set on fire [2]. Burning leaf litters can pollute the environment.

Leaf litters could be turned from liabilities into compos. Leaf litters accumulated are potential substrate for compos that has economic value. Composting of leaf litter need specific microorganism because of leaf litter complex composition. Leaf litter consisted of cellulosic material including cellulose, hemicelluloses, and lignin that not easily degrade [3]. Only a few microorgnisms are able to degrade. Cellulolytic bacteria and cellulolytic mold which utilize cellulosic materials for their energy source could be exploited for the conversion of leaf litters into compos.

The availability of big amount of leaf litters as cellulosic materials in Indonesia underlines the need to explore the potentials of the cellulolytic bacteria and cellulolytic mold for the transformation of these wastes into useful products like compos.

The objective of the research are to obtain suitable microorganism use for composting, particularly for leaf litters composting. The research was command by collecting and composting leaf litters from Biological Forest and Biology Field Station Gadjah Mada University, Indonesia. Selection isolate that had been isolation from leaf litters compos based on they capability on degrading of cellulose (CMC and Avicel), Hemicelluloses (Xylan), and Lignin (Tanin). The highest cellulose activity on cellulose agar substrate were selected for further composting experiment.

The study comprise of two phase. First phase, leaf litter were collected then composting, , strains from compos sample were isolated onto selective medium. Second phase is composting experiment, the best selected isolates were inoculated in leaf litter composting experiment. Compost quality was defined by decrease C : N ratio [4].

First phase, leaf litters were collected from Biological Forest and Biology Field Station Gadjah Mada University, Indonesia. Leaf litter colllected from ten different plot, use Random Sampling method. For each plot, collected ± 500 g leaf litter, then accumulated in the holes in the ground, with the length, width, and depth, 0.75 m x 0.50 m x 0.30 m (Figure. 1). Composting leaf litter naturally left for 20 days to allow for natural decomposition process. Ten gram of the leaf litter compos was asceptically introduced into 90 ml of sterile distilled water and shaken vigorously. Subsequently serial dillution suspension was plated onto selective medium.

Fig.1. Composting Hole

Isolation of cellulolytic bacteria from the leaf litter using a modification selective medium described by [5]. The medium contained the following per litre composition :0,8g K_2HPO_4, 0,2g KH_2PO_4 ; 0,2g $MgSO_4.7H_20$; 0.2g NaCl ; 1 g NaNO3 ; 0,01g $CaCO_3$; 0,5g yeast extract ; 20g agar and 10g cellulosic materials (CMC, Avicel) for isolation cellulolytic bacteria or Hemicellulosic material (Xylan) for isolation hemicellulolytic bacteria. Isolation of cellulolytic fungi from

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