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PREDICTION OF ELECTRONIC WASTE DISPOSALS FROM RESIDENTIAL AREAS IN MALAYSIA

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Abstract

The most fundamental element in planning electronic waste management is to acquire reliable data on the total volume of electronic waste generated from various sources such as residential premises, commercial buildings and industrial areas. Hence, a crucial aspect of electronic waste management is to predict the accumulation of electronic wastes in the future. This study aims to predict electronic waste to be disposed of for the next 15 years, focusing only on electronic waste from residential areas. A few rural and urban areas of residential premises were randomly selected as a case study. The result for this study was deduced from the survey and interviews conducted in the vicinity of the study area. Thirty sets of questionnaire were distributed randomly at each selected area. The residential area was divided into three categories i.e. residents with low income (LI), residents with medium income (MI) and residents with high income (HI). The survey was done by distributing the questionnaire to investigate electronic equipment usage and its lifespan by users as well as the waste management option preferred by the residents. The findings of the study showed that approximately 51% of the generated electronic waste will go through four stages of waste management options i.e. reuse, repair, remanufacturing and recycling, while approximately 49% of the generated electronic waste will go through the disposal option i.e. landfill sites. The result of the study showed that the predicted lifespan for the electronic equipment used by residents in Malaysia is between the ranges of 0-15 years. On average, as much as 5% of used home electronic equipment will be disposed of after 6 years of usage, 41% after 9 years and 3% after 12 years. From the study, the information regarding the percentage of electronic waste that will be reused, repaired, remanufactured, recycled and disposed of for the next 15 years can be gained and is presented via scientific analysis.

Keywords: Reuse, repair, remanufacture, recycle, dispose

Abstrak

Elemen yang paling asas dalam perancangan pengurusan sisa elektronik adalah untuk mendapatkan data yang boleh dipercayai terhadap jumlah keseluruhan sisa elektronik yang dihasilkan dari pelbagai sumber seperti premis kediaman, bangunan komersial dan kawasan perindustrian. Kajian ini bertujuan untuk meramalkan penjanaan sisa elektronik yang akan dilupuskan untuk 15 tahun akan datang dengan memberi tumpuan hanya kepada bahan buangan elektronik dari kawasan kediaman sahaja. Tiga puluh set borang soal selidik telah diedarkan secara rawak di kawasan kediaman yang telah dipilih. Kawasan kediaman dibahagikan kepada tiga kategori iaitu kediaman penduduk premis berpendapatan rendah (LI), kediaman penduduk berpendapatan sederhana (MI) dan kediaman penduduk berpendapatan tinggi (HI). Dapatan kajian ini menunjukkan bahawa kira-kira 51% daripada sisa elektronik yang dihasilkan akan melalui empat peringkat pilihan pengurusan sisa iaitu penggunaan semula, pembaikan, pengilangan semula dan kitar semula manakala kira-kira 49% daripada bahan buangan elektronik yang dihasilkan akan melalui pilihan pelupusan iaitu tapak pelupusan. Hasil kajian menunjukkan bahawa jangka hayat yang diramalkan untuk penggunaan peralatan elektronik oleh penduduk di Malaysia adalah di antara julat 0-15 tahun. Secara purata, sebanyak 5% daripada penggunaan peralatan elektronik rumah akan dilupuskan selepas penggunaan 6 tahun, 41% selepas penggunaan 9 tahun dan 3% selepas penggunaan 12 tahun. Dari kajian ini, maklumat mengenai peratusan sisa elektronik yang akan digunakan semula, dibaiki, dikilang semula, dikitar semula dan dilupuskan untuk 15 tahun akan datang boleh diperolehi dan dibentangkan dalam analisis saintifik.

Kata kunci: Diguna semula, dibaiki, dikilang semula, dikitar semula, dilupuskan

1.0 INTRODUCTION

Electronic wastes (E-wastes) are known as unusable or unwanted electric and electronic appliances that need to be disposed after becoming obsolete, either as a whole or by parts. The Basel Action Network has stated that electronic waste encompasses a large range of household electronic inventions such as refrigerators, air-conditioners, telephones, personal stereos and computers that had been discarded by consumers [1]. Nowadays, electronic equipment production is one of the fastest growing industries. However, electronic equipment has a relatively short lifespan before becoming obsolete with the rapid development of technology [2]. This development has led to the increase of E-wastes. The world generates about 40 million tons of computers, cathode-ray tube screens, fax machines, game consoles, mobile phones and other E-waste every year [3]. The growing desire of the consumers to possess symbols of prosperity and an improved quality of life are several reasons that explain the trend of increasing E-wastes. Besides that, it is also cheaper to buy a new product rather than repairing the old one.

In general, electronic wastes comprise of more than 1000 various components in which most of the components contain high toxic compounds that are able to pollute the environment [4]. The toxic constituents in electronic waste are heavy metal (cadmium, lead, chromium, mercury, plumbum, arsenic, selenium, etc.); precious metals like silver, gold, copper and platinum [5]; organic chemical compounds i.e. Poly Chloro Biphenyls and flame retardant materials including plastic resins Polyvinyl Chlorine [2]. Flame retardant consists of constituents like chlorine, phosphorus, nitrogen and bromine that contribute to environmental problems due to its toxic characteristics and ability to produce bio-particles [6]. A scientific study also showed that this compound may increase the risks for cancer and is the cause of toxic neutron effects [7]. Electronic and electrical waste contains toxic materials that cause pollution towards the environment if an improper disposal method is implemented. Therefore, it is important to have good E-waste management in order to ensure that it will not give harm to humans and the environment. Basically, an industry's management of E-waste should begin at the generation point. This can be done by waste minimization techniques and sustainable product design. Waste minimization in industries involves inventory management, production-process modification, volume reduction and the preferable method, which is recovery, reuse and recycle [8]. Reduction of hazardous materials in the design phase and improvement of recycling ratio is important to ensure sustainable management of e-waste [9].

In view of the environmental problems involved in the management of E-waste, many countries and organizations have drafted national legislation to improve on reusing, recycling and other forms of recovery of such wastes to reduce disposals [10], [11], [12]. E-waste management is an important subject, not only from the perspective of waste treatment but also from the aspect of recovery of valuable materials [12]. Basically, the practiced methods in managing electronic wastes are reuse, recycle and disposing. The reuse method incorporates the concept of contribution or donation whereby users give away unwanted electronic products to others, manufacturers reclaim electronic apparatuses for further processing and users restore the electronic waste components. As for the recycling method, materials from electronic wastes like plastics, metals and other valuable components will be accumulated at recycling centres. These materials will be processed into secondary raw materials and then sold to local or international manufacturers for the production of other products. The disposal method that practices landfill technology will dispose the electronic wastes that have lost their values in an absolute manner [13]. From the point of view of the thermal treatment concept, studies found that electronic plastic wastes have the potential to become resources for energy generation [14]. This is because these wastes have a very high calorific value summing up to 7,375 kcal/kg in comparison with only 3,450 kcal/kg that of Municipal Solid Wastes [15].

Residential areas, Commercial areas and Industrial areas are the three main sources that produce E-wastes. Combination of these three areas will generate a huge number of E-wastes. Basically, the end-of-life of an E-waste refers to electric and electronic products that no longer satisfy the initial purchaser. In general, there are five end-of-life scenarios of a particular product, namely, Reuse, Repair, Remanufacture, Recycle and disposal. The last end-of-life scenario is disposal. At present, the method for dealing with end-of-life is by disposing the waste to landfills or through incineration, with or without energy recovery [16]. In order to manage a huge number of E-waste, a model to calculate the generated rate of E-waste needs to be constructed. For that reason, the objective of this study is to predict E-waste generation with focus on residential areas. In this paper, the residential premises with low income, middle income and high income residents have been selected as a case study in order to develop the model for the prediction of E-waste in the future.

2.0 METHODOLOGY

In brief, the research methodology is divided into three parts i.e. observation, survey and interviews, and also data analysis. Data on the amount of E-waste generated and also the management practices of the residential area was obtained through surveys and interviews that were conducted on the residents. The residential area was divided into three categories i.e. premises of residents with low income (LI), middle income (MI) and high income (HI). The survey was done by distributing 30 sets of questionnaire to each type of resident premises in order to know the usage of electronic equipment by the residents in Lower

Income, Middle Income and High Income premises. For each type of resident premise, the houses were selected randomly in the study area. The information about the total usage of electronic equipment, lifespan of electronic equipment and the management option of the electronic equipment from each category can be gained from the survey. From the data collection, the projection of the E-waste generated for every 3 years will be calculated based on the end-of-life concept as stated in equation (1). The projection data can help in forecasting the amount of electronic waste to be dumped in the future.

$$D = E - \left(R_1 + R_2 + R_3 + R_4\right) \quad (1)$$

Where:

D = Disposal of E-waste (%)

E = E-Waste generated (%)

R_1 = Reuse of E-waste (%)

R_2 = Repair of E-waste (%)

R_3 = Remanufacturing of E-waste (%)

R_4 = Recycling of E-waste (%)

3.0 RESULTS AND DISCUSSION

Table 1, Table 2 and Table 3 show the prediction for the percentage of E-waste generated by the residents with lower income (LI), middle income (MI) and high income (HI) for the next 15 years. The result in Table 1 predicts that approximately 86% of the E-waste generated by LI residents will go through the four stages of waste management option i.e. reuse, repair, remanufacturing and recycling, while approximately 14% of the E-waste generated by LI residents will go through the disposal option i.e. landfill sites. From the result analysis, it is predicted that the lifespan of electronic equipment by LI residents is in the range of 0-12 years. From observation, LI residents tend to buy electronic items that are not branded. Normally, non-branded electronic items are cheaper and low quality compared to branded electronic items. This scenario contributes to the shorter lifespan of the electronic items. However, LI residents mostly practice reuse, repair, remanufacture and recycle for their e-wastes. Hence, by practicing waste management options, residents have reduced the amount of e-waste generated for disposal at landfill sites.

Table 1 Prediction of the percentage of E-waste generated for disposal by LI residents

Projection (Years)	Generated E-waste (%)	Reuse, Repair, Remanufacturing and Recycling (%)	E-waste Disposal (%)
0-3	5.2	3.3	1.9
3-6	65.0	58.1	6.9
6-9	27.6	22.2	5.4
9-12	2.2	2.2	0
12-15	0	0	0
Total	100%	86%	14%

The result in Table 2 predicts that approximately 33% of the E-waste generated by MI residents will go through the four stages of waste management options i.e. reuse, repair, remanufacturing and recycling while approximately 67% of the E-waste will go through the disposal option i.e. landfill site. From the result analysis, it is predicted that the lifespan of electronic equipment used by MI residents range from 0-15 years. From observation, MI residents tend to buy electronic items that are branded. Normally, branded electronic item is of higher quality compared to the non-branded electronic items. This scenario contributes to the longer lifespan of the electronic items. However, most MI residents do not practice reuse, repair, remanufacture and recycle for their e-wastes. This might be due to their higher paying salary that entices them to buy new electronic items. From the survey and observation, it shows that most MI residents have decent employments. For that reason, they do not have enough time to practice reuse, repair, remanufacture and recycle for their e-waste. Hence, waste management options practiced by MI residents increase the e-waste generated for disposals.

The result in Table 3 predicts that approximately 35% of the E-waste generated by HI residents will go through the four stages of waste management i.e. reuse, repair, remanufacturing and recycling while the remaining 65% of the E-waste will be disposed of in landfill sites. From the result analysis, it is predicted that the lifespan of electronic equipment by HI residents is in the range of 0-12 years. From observation, HI residents tend to buy the latest electronic items. Based on the interviews with the HI residents, they have a tendency to replace an electronic item with the latest item even though the former is still functioning. This scenario contributes to shorter lifespan usage for the electronic items. In addition, most HI residents do not practice reuse, repair, remanufacture and recycle for their e-waste. Similar to MI residents, HI residents also have excess riches that also entice them to buy new electronic items. From the survey and observation, it shows that most of the HI residents also have stable careers. For that reason, they do not have time to practice reuse, repair, remanufacture and recycle of their e-waste. Hence, their waste management practices increase the amount of e-wastes generated for disposal at landfill sites.

Table 2 Prediction of the percentage of E-waste generated for disposal by MI residents

Projection (Years)	Generated E-waste (%)	Reuse, Repair, Remanufacturing and Recycling (%)	E-waste Disposal (%)
0-3	0	0	0
3-6	14.3	13.0	1.3
6-9	72.4	13.8	58.6
9-12	5.7	5.7	0
12-15	7.6	0.71	6.9
Total	100%	33%	67%

Table 3 Prediction of the percentage of E-waste generated for disposal by HI residents

Projection (Years)	E-waste generating (%)	Reuse, Repair, Remanufacturing and Recycling (%)	E-waste Disposal (%)
0-3	0	0	0
3-6	8.7	2.5	6.2
6-9	85.6	27.2	58.4
9-12	5.7	5.7	0
12-15	0	0	0
Total	100%	35%	65%

As a result, the overall prediction of reuse, repair, remanufacture, recycle and disposal of e-wastes from the residents of the case study area for the next 15 years is depicted in Table 4 and Table 5. The analysis result in Table 4 and Table 5 predicts that approximately 51% of the E-waste generated by residents in the case study area will go through the four stages of waste management option i.e. reuse, repair, remanufacturing and recycling while the remaining 49% will go through the disposal option i.e. landfill site. From the result analysis, it is predicted that the lifespan of electronic equipment used by the residents of the case study area is in the range of 0-15 years.

In general, it can be argued that the total E-waste actually relies on the usage of the electronic equipment, the lifespan of the electronic equipment, waste management practices and also the living status of the country's community. E-waste is becoming a serious threat and there is a need to find new ways in managing it. While refurbishing and reusing old electronic devices seem like a viable option, in reality, it just delays the disposal problem. The key to avoid this problem is through the development of viable markets for recycling these types of waste. Manufacturers of electronic equipment should have more programs that could take back old devices with the purchase of a new one. The electronics industry should also end the use of chemicals that are dangerous to human health or to the environment (including lead, mercury, cadmium, brominates flame retardants, chlorinated solvents and other hazardous materials). They should design products that can be easily repaired and upgraded to extend their useful life, incorporate recycled content and remanufactured components into new products [17]. There is also a need to have legislation that will encourage manufacturers to improve the electronic equipment design in order to comply with the legislation that promotes sustainability. Act 627 that empowers the minister to publish matters which promote reduction, reuse and recycling of controlled solid waste should become a mandatory implementation [18].

Table 4 Prediction for the percentage of reuse, repair, remanufacture and recycling for e-waste by the residents

Projection (Years)	LI (%)	MI (%)	HI (%)	Average of Reuse, Repair, Remanufacture, Recycling (%)
0-3	3.3	0	0	1.1
3-6	58.1	13.0	2.5	24.5
6-9	22.2	13.8	27.2	21.1
9-12	2.2	5.7	5.7	4.5
12-15	0	0.7	0	0.2
TOTAL	86%	100%	35%	51%

Table 5 Prediction for the percentage of E-waste generated for disposal by the residents

Projection (Years)	LI (%)	MI (%)	HI (%)	Average of Reuse, Repair, Remanufacture, Recycling (%)
0-3	1.9	0	0	0.6
3-6	6.9	1.3	6.2	4.8
6-9	5.5	58.6	58.4	40.8
9-12	0	0	0	0
12-15	0	6.9	0	2.3
TOTAL	14%	67%	65%	49%

4.0 CONCLUSION

The quantity of electronic wastes can be controlled if there is a sustainable integrated technique in managing the electronic waste. Sustainable integrated technique should consider electronic wastes management from the production until its disposal point. Implementation of new Legislation and Act should also be considered by the authority as to develop human capital in managing electronic waste. The combination of human capital with a sustainable technique for managing electronic waste will lead to efficiency in managing electronic wastes in the future.

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