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Model for developing efficient E-waste recycling system in India

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Abstract— Electrical and Electronics industry is one of the fastest growing industry at the present time. Where large scale industrialization and development is not possible without the availability of these electrical and electronics equipments (EEE) ,they serve a lot in daily life. This ever increasing demand for electronic equipments with the presence of hazardous materials in them makes it an issue of concern and look for e-waste recycling after their end of life. The paper underlines the presence of formal and informal sectors of e-waste recycling in India. The paper highlights the existence of inefficiency in the present formal and informal recycling systems. Formal sector is facing challenges in collection of E-waste and high cost of transportation of waste to processing units. An entry survey results conducted to seek solutions and enhance collection are also presented in the paper. System modeling based on k-means clustering algorithm comprising of collection ,processing and financial models as a great tool is emphasized for the development of an efficient e-waste recycling system in India.

Index Terms— EEE, EPR ,E-Waste, K-Means, Management, Recycling, WEEE.

1 INTRODUCTION

Electronic waste or e-scrap may be defined as discarded computers, office electronic equipment, entertainment devices, mobile phones ,television sets and refrigerators. Large scale consumption of these devices and changing technology brings end to their life and makes them obsolete ,thus increasing waste stream. As per the Moore's law after every 2 years transistor count per unit chip space doubles of itself which cuts short the probability of repair and recycling [1]. Furthermore, the post consumptive remains of these electronic and electrical products contain toxic elements like mercury, cadmium, lead ,nickel, polyvinyl chloride , BFRs which leads to various diseases of the skin and decrease nerve conduction velocity, lung cancer, kidney damage, pulmonary emphysema and bone diseases and many more [2]. E-waste is not hazardous if it is stocked in safe storage or recycled by scientific methods and transported from one place to the other in an organized and environment friendly manner. On the other hand, e-waste can prove to be hazardous if recycled in informal manner using primitive methods [3]. Thus ,it becomes necessary to look for solutions that provide proper end of life management to these obsolete turned devices. Table 1 depicts the various kinds of materials found in e-waste along with their percentage.

Table 1. Materials found in waste electronic equipments [4]

Materials found in WEEE	Percentage (%)
Ferrous metals	38
Plastics	19
Non-ferrous metals	28
Glass	4
Other	11

2 GROWTH IN E-WASTE –AN ISSUE OF CONCERN

E-waste stream is growing at an exponential rate because of increase in spending and utilization of electronic products everywhere in the world. Electronic products turn obsolete at a very young age with the rapid advancement in the market. Today's best product cannot regain its best title after some period of time leading to e-waste growth. E-Waste in India is growing at over 500% every year and less than 5% of it is being recycled properly [5]. MAIT studies reveal that India is expected to generate about 1.5 lakh tonne of wastage from the use of electronics every year by 2020 [6].Presently, e-waste is growing at the fastest rate in solid waste as compared with other types of waste. About 3 to 5 percent of the solid waste is comprised of e-waste and this share is growing at a rate of 3 times every year [7].Thus , e-waste is turning menace to biotic life. The toxic elements like mercury, cadmium, lead ,nickel, polyvinyl chloride , BFRs present in the e-waste are creeping slowly and steadily inside the environment and making it sick. Entering the soil and leading to soil degradation by eating all the soil nutrients, these hazardous elements are making soil infertile and anemic. Suspending themselves in the air, their toxicity is making breathing for the biotic life a cause of various health issues. Flowing with the groundwater and subsequently mixing with rivers and seas, marine life is being damaged . Directly or indirectly, the biotic life comprising of bio diverse natural vegetation, human population and animal husbandry is suffering the hazardous influences. A study reveals that high concentration and profiles of polychlorinated dioxins and furans are present in e-waste open burning and treatment sites which pose a great threat to the environment [8].

3 E-WASTE RECYCLING

E-waste recycling aims at making reuse and recovery of components and precious elements with the help of series of processes and machinery in recycling plants. Recycling Solutions provide huge monetary returns if seen as a business model. E-

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waste Recycling can be categorized into two categories depending upon the level of formalization.

3.1 FORMAL RECYCLING

The formal recycling needs the joint efforts of all the stakeholders covering producers ,consumers, bulk consumers so that an environment friendly recycling be carried out [9] .Such a kind of recycling involves use of proper tools, equipments ,machinery which without damaging health of labor results in efficient end of life management. Life cycle of the electronic and electrical equipments starting from the birth at manufacturing sector reaches the consumers and after their consumption at user end ,these equipments enter the chain of recycling at the collection centers designated by companies and thus reaching authorized recyclers and dismantlers. A number of companies have already taken initiative in this regard and have developed channels for taking back their products. Some such companies include Apple, Dell, Epson, Gateway, HP, IBM, Lexmark, Sony &Toshiba.

3.2 INFORMAL RECYCLING

Recycling of E- waste is presently more concentrated in the informal (unauthorized) sector which has no organized collection system and their operations are mostly dangerous to human life and environment. In India about 95 percent of the e-waste is entering the informal sector via kabaadiwalas and reaching the poor houses where families are engaged in extraction of components and material recovery manually using rudimentary and risky processes like the boards are initially heated on gas stove or through blowtorch to loosen the lead soldering [10],[11],[12]. Such activities results in fugitive emissions and slag containing heavy metals which makes it an issue of health concern.

4 INEFFICIENCY IN EXISTING SYSTEM

In order to check inefficiency in the existing E-waste recycling system in India, various recycling units were visited and interaction was the tool used to find loopholes leading to inefficiency.

4.1 Issues with Formal Sector

Formal Sector had the problem of less availability of E-waste. There is lack in infrastructure meant for collection of E-waste. Collection centers authorized by state pollution control boards are very few in number in every state and are not able to cater entirely. Stringent formalities for seeking authorization for collection center results in less number of entrepreneurs in this area. People wish to get returns for their E-waste prefer selling to kabaadiwalas. Even companies on which Extended producer responsibility (EPR) puts onus lack in collection facilities. Unsystematic locations of processing units without caring for collection centers locations contributes to high cost of transportation of E-waste from collection centers to processing units. Thus, major challenges faced by formal recycling system in India are collection and high cost of transportation.

4.2 Issues with Informal Sector

In informal sector, for extraction of precious metals ,manual and unscientific methods are prevalent. This not only leads to environmental and health hazards of the workers but also leads to inefficiency . In the dust, soil around the informal processing units, heavy metals like lead, cadmium, nickel and iron are found which are finally lost in the dumps and leads to inefficiency.

5 ENTRY SURVEY AND RESULTS

An entry survey in the form of questionnaire to seek responses from the public and help in finding solutions was conducted both online using Google Form and offline. The key objective of the survey was to get an idea about awareness of public of E-waste, movement of E-waste and solution to enhance collection of E-waste as desired by the public. The survey covered strata of age groups important for the finding of solutions. Various categories of professionals participated in the survey.

Key Findings-

i. 39 percent of participants were aware of E-waste whereas 26 percent were completely unaware of it and 22 percent had heard of it but do not have clear understanding about it. Figure 1 shows the awareness of public towards E-waste.

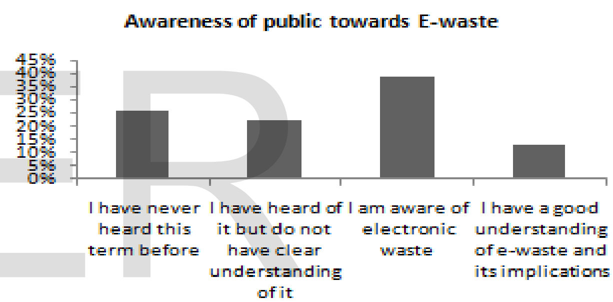

Fig 1. Shows awareness of public towards E-waste.

ii. 75 percent of participants were completely unaware of E-waste management and handling rules,2011 by Govt. of India.

iii. 74 percent of participants were completely unaware of Extended producer responsibility (EPR). Figure 2 gives the awareness of public towards EPR.

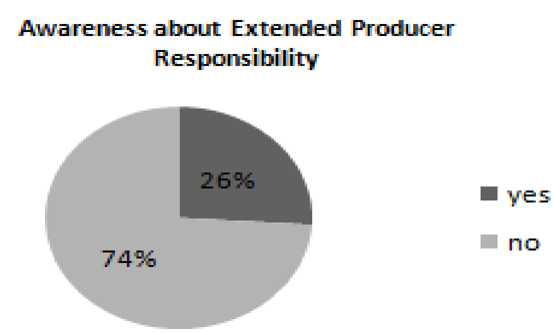

Fig 2. Shows awareness of public towards EPR.

iv. 65 percent of participants said that discarded electronic products resulted in negative impacts to environment and still 17 percent changed electronic products for the sake of fashion.

v. Only 6 percent give E-waste to authorized recycler, 19 percent to seller on a buy back arrangement whereas rest either give to family or friends ,disassemble to reuse some parts , store on premises with maximum 35 percent preferred selling it as second hand or to kabaadiwalas.

vi. For collection of E-waste 78 percent of participants wanted that more number of collection centers should be there and close to their place whereas only 21 percent wanted E-waste to be collected from their place by regular pick up drives. Figure 3 depicts response of public towards collection method to be employed as desired by them.

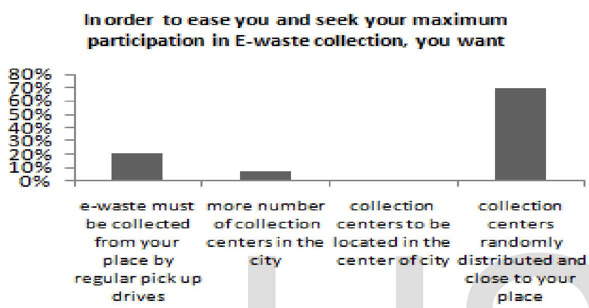

Fig 3. Shows response of public towards collection method to be employed as desired by them.

Thus, as a solution to enhance collection of E-waste, people wished that there must be more number of collection centers and close to their place. More awareness needs to be generated amongst people about Extended producer responsibility (EPR), E-waste management and handling rules and concern to E-waste.

6 E-WASTE SYSTEM MODELLING TO DEVELOP EFFICIENT RECYCLING SYSTEM

A modeling framework comprising of sub models to develop an efficient recycling system can be used. This modeling comprises of tools to check two basic functions of e-waste recycling system which are collection and processing [13].

6.1 COLLECTION MODEL

Collection model projects the mass of e-waste collected ,cost of operating collection sites and the costs and environmental impacts of transporting e-waste .Collection model is the most important model which actually enhances collection and develops efficient recycling system. In order to have large collection of e-waste, it is important to have proper location of collection center [14]. It has been found in a survey that participation of owner in collection process varies with the distance of collection center from individual ,weight of e-waste and transportation cost incurred.

E-waste Collected = E-waste per participant *Participation Factor (Q)

Where Q depends upon -

i. Distance of collection center
ii. Weight of e-waste
iii. Transportation cost

Thus, it is important to have such location of e-waste collection center where maximum participation can be obtained and Participation factor(Q) can have maximum value [15],[16].

Algorithm using K-MEANS Function to locate collection center: Algorithm using K-MEANS Clustering function can be used to locate collection center position where maximum participation factor value can be achieved. K-Means clustering function is a systematic way of grouping data into a desired number of clusters such that the mean value of each cluster is minimized. Using this function, collection centers can be located at such places in the city so that each participant has to travel least possible distance to reach collection point and therefore it increases collection .Figure 4 gives the algorithm using K-Means function to locate collection center.

K-Means clustering function in Matlab:
IDX = kmeans(X,k)

K-Means clustering algorithm in Matlab:

```
rng('default') % For reproducibility
X = [randn(100,2)+ones(100,2);...
    randn(100,2)-ones(100,2)];

opts = statset('Display','final');
[idx,ctrs] = kmeans(X,2,'Distance','city',...
          'Replicates',5,'Options',opts);

plot(X(idx==1,1),X(idx==1,2),'r.','MarkerSize',12)
hold on
plot(X(idx==2,1),X(idx==2,2),'b.','MarkerSize',12)
plot(ctrs(:,1),ctrs(:,2),'kx',...
    'MarkerSize',12,'LineWidth',2)
plot(ctrs(:,1),ctrs(:,2),'ko',...
    'MarkerSize',12,'LineWidth',2)
legend('Cluster 1','Cluster 2','Centroids',...
     'Location','NW')
hold off
```

Fig 4. Shows algorithm using K-Means function to locate collection center.

6.2 PROCESSING MODEL

In order to cut cost of transportation of e-waste collected from various collection centers, it is essential to have proper location of processing unit. So that the waste collected can reach the processing plant with reduced cost and time of transportation. This can be achieved with K-Means clustering algorithm as done to locate collection center. Here the model takes different picture with collection centers as sample number and cluster mean as location of processing unit.

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7 RESULTS AND CONCLUSION

Using K-Means clustering algorithm ,an example consisting of 100 households was divided into 2 clusters ,each having mean point where distance of each household is minimized to the collection center and maximum participation is achieved as shown in Figure 5.

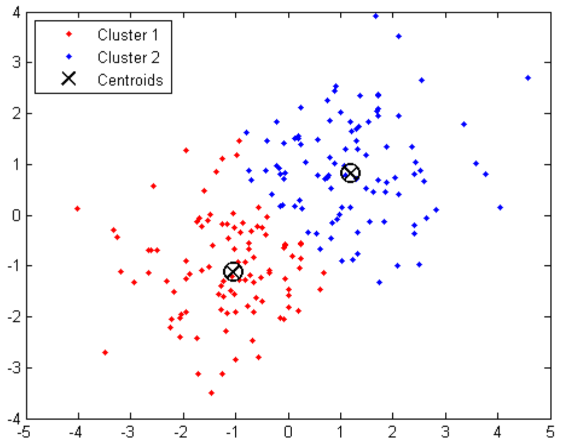

Fig 5. Shows 100 households divided into 2 clusters with collection centers locations.

Similarly ,K-Means algorithm can be used for any number of households in a city for finding desired locations of collection centers .This algorithm can be further used to find position of processing unit where distance from collection centers can be minimized and transportation cost can be reduced. This model can be used to develop an efficient recycling system in India.

REFERENCES

[1] ″Moore's law″ [online]. Available: http://en.wikipedia.org/wiki/Moore-s_law.

[2] S. Devika, "Environmental Impact of Improper Disposal of Electronic Waste", IEEE, ISSN 978-1-4244-9184-1, 2010.

[3] Gulshan Siekeck, Gaurav Gupta, "Managing E-waste in India ",International journal of scientific and engineering research, vol 3,issue 7,ISSN 2229-5518,2012.

[4] N.I. Onwughara, I.C.Nnorom,O.C.Kanno,R.C.Chukwuma,"Disposal methods and heavy metals released from certain electrical and electronic equipment wastes in Nigeria: Adoption of environmental sound recycling system", International Journal of Environmental Science and Development,Vol.1,No.4,ISSN:2010-0264, 2010.

[5] MAIT,"E-waste growth in India" [online]. Available: http://mait.com/ewaste.

[6] ToI (Times of India)," India to generate 1.5 lakh tonne e-waste a year by 2020 - MAIT"[online].Available:http://timesofindia.indiatimes.com/tech/tech-news/hardware/India-to-generate-1-5-lakh-tonne-e-waste-a-year-by-2020-MAIT.

[7] Hobi, Report "E-waste recycling and reuse services world-wide"[Online].Available : http://hobi.com.

[8] Mingzhong Ren, Sukun Zhang, "Concentrations and Profiles of Polychlorinated Dioxins and Furans in a Discarded Electronic Waste Open Burning Site" ,IEEE, ISSN 2151-7614, 2010.

[9] S. Chatterjee and Krishna Kumar, "Effective electronic waste management and recycling process involving formal and non-formal sectors" International Journal of Physical Sciences Vol. 4 No.13 ,2009.

[10] Anil Kumar Saini and Abhishek Taneja, "Managing E-Waste in India - A Review" International Journal of Applied Engineering Research, ISSN 0973-4562 Vol.7 No.11, 2012.

[11] Toxic Links, "E-waste recycling rules notified on may 1 ,no infrastructure in place even now" Media coverage report, 2012.

[12] Sharma Pramila, Fulekar M.H. and Pathal Bhawana, "E-Waste- A challenge for Tomorrow", Research Journal of Recent Sciences, Vol.1(3),86-93, ISSN: 2277-2502,2012.

[13] Susan Fredholm, "Evaluating Electronic waste Recycling Systems: The influence of Physical Architecture on system performance", Masters Thesis, MIT, 2008.

[14] Egwali Annie O and Imouokhome F A, "Managing th challenges of E-waste recycling in Nigeria", Science and Information Conference, 2013.

[15] S.Lozano, J.Esparza, B.Adenso-Diaz, J.M.Garcia, "Clustering Spanish Households E-waste disposal behaviour using self organizing feature maps", IEEE, ISSN: 978-4244-8503-1/10, 2010.

[16] S.P.Victor and S.Suresh Kumar,"Roadway for sustainable diaposal of scrap computers in India", IEEE, ISSN:978-1-4673-0671-3/11, 2011.

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