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E-Waste Management Techniques and Overview

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ABSTRACT

Development of technology helps people in their day to day lives making their life much easier. There are numerous inventions of electronic gadgets like smartphones, laptops, electronic home appliances etc. which tends to make our life stress-free and helps to do our work comfortably. Hence exponential growth in production of electronic devices is becoming a huge problem of accumulation of large amount of Electronic waste (e-waste) all over the world. Analysis from research illustrates that the majority of e-waste comes from developed countries to less developed countries since the difference in development and the production of e-waste is relatively lesser. Currently e-waste handling have been driven by profit and market supply which is not with recycling and e-waste collection thereby causing serious threat to environment as some electronic components contains some harmful components and are mostly non-biodegradable which upon dumping can remove lead and other various substances in groundwater and soil making them unfit for usage. This paper describes about various strategies to be implemented in India to have better e-waste management thereby reducing serious threats to the environment.

Index Terms – Green Computing, E-waste Management, Recycle, Reuse.

1. INTRODUCTION

The term e-waste refers to discarded electronic or electrical waste which is of no use to the person and is destined for recycle, refurbishment or disposal. This may include working and broken items which are dumped in garbage by the owner or donated to others in charity. Often the item unsold in big electronic stores is generally thrown away which is also referred as e-waste.

The term e-waste is very much vast and there are many types of it, some of which are-

Household Equipment- These appliances include all the equipment which are used in our house on our day to day basis, they include toasters, water gadgets, vacuum cleaners, tickers, electric drills, hair dryers, sewing machines, fridges, water coolers, microwave ovens, heater, cooler etc.

Office Equipment-They include all the appliances used in office work ,they include appliances like mobile phones, PC, laptops, landline phones scanners, printers, photocopy machines, typewriters, cameras etc.

Medical Equipment- They include all the appliances used in medicine practices and surgery which includes stethoscopes, ventilators, electronic hospital beds, oximeters, thermometers, respirometer, electric wheelchairs, glucometers etc.

Recreational/Games Hardware- These types of equipment include all the waste devices used for recreational activities like PlayStation, Xbox, Nintendo Wii, electronic trains, PCs for biking, paddling, running and other handheld computer games.

Industrial Equipment- It includes all the appliances used in big industries like big gears for turning, processing, pounding, shearing, cutting of big woods, metals and other things, equipment for nailing, riveting, screwing bolts, nails, screws etc. Instruments for welding, patching etc. all these comes under industrial equipment.

As discussed above the various types of equipment used in various sectors they can be turned into e-waste and can have deteriorating effects on the environment components like water, soil, air etc. and can have damaging health hazards as well ,for example the printed circuit boards used in industries have lead as its constituent ,improper handling and dumping of it can damage central and peripheral nervous system, chip resistors and semiconductors used have cadmium elements as its constituents which can cause neural damage to human beings if handled carelessly, computer and cabling equipment is made up of plastic containing PVC which upon burning produces toxin which causes reproductive and developmental problems, damages the immune system and can also cause hormonal disbalance in the body, motherboards used in PC's and laptops contains beryllium which can lead to lung cancer if not dumped properly. As these were some examples of how e-waste can have various health hazards there are various methods of handling e-waste, some of them used in practice are-

Reuse-It is practice of making equipment to use either for its original function or for different function. Person who are currently not using any electronic devices like cell phones, laptops, televisions etc can sell or give in charity to another person so that it can be reused by him instead of buying a new product thereby reducing electronic device manufacturing and thus contributing a lot towards e-waste management as lesser the e-waste better it can be managed properly.

Recycle-It is the method of collecting and processing materials that would otherwise be thrown away in trash and can be used in making new products. Cell phones, personal computers, screens etc. can be taken into consideration of it as it includes detachment of its parts and then using it elsewhere thus decreasing manufacturing of certain parts of equipment thereby contributing to managing e-waste.

Incineration-In this technique of waste management the electronic as well as electrical items which are now waste are completely burned down at high temperatures in special incineration chambers. By this technique large volumes of e-waste are reduced to very great extent and liveliness got is also used separately.

Land-Filling- This is the most popular method for dumping e-waste. In this technique earth is removed and pits are made for covering the waste under the soil, but this technique can be proved as harmful to environment as many toxic materials like cadmium from e-waste can come in contact with ground water thereby polluting it and make unfit for human consumption.

Acid Bath-It includes the corrosive shower which douse the electronic devices as well as electrical circuits in concentrated sulphuric and nitric acids that can remove the metals from their electronic connections. The metal extracted from this procedure is used as a part of combining of different things while the dangerous corrosive waste enters the sources of water in the neighbourhood.

2. LITERATURE SURVEY

Waste from electrical and electronic equipment (WEEE) come which arises due to increasing usage of electronic devices in our day to day lives, comes under different category of waste management. Reena Gupta et al [1] have discussed about increasing number of the e-waste produced in India and globally which is causing a serious environmental hazard. From the research work and analysis it is found that only 3 percentage of e-waste generated in India does recycling in the correct manner while the others is done by the workers, working with hands without any protection and with no proper equipment for 12 to 14 hours a day in a very much toxic environment. Keeping in view of situation many acts have been brought to legislation like Basal convention which abides on the minimization of movement of hazardous wastes and the removal across borders, which says that electronic and

electrical equipment assembly not valid for direct use but can be recycled. Apart from this authors have found that problem with e-waste management is that no such technology has been deployed in India to have check on e-waste disposal and they also found that main problems factories have to manage is detachment of e-waste in separate components [1].

Vinay Kumar Pant et al have discussed global and Indian perspectives to e-waste management [2]. Three countries are taken for research- Delhi-India, Beijing-China, and Johannesburg-South Africa and from research work analysis it has been found that recycling e-waste has been developed as market-based activities. In global perspective the research data proposed that Europe continent has been the highest producer of e-waste in recent years contributing to almost 52 percentage of total e-waste produced globally, followed, followed by Asia with 19 percentage , America with 17 percentage ,Africa with 12 percentage and Australia with 1 percentage of total e-waste generated globally. Data analysis has been done on Indian states as well and found out that Maharashtra is the largest producer of e-waste in India contributing to 20.1 percent of total e-waste produced in India. Due to alarming increase of e-waste it has various environmental effects as well thereby degrading the quality soil ,air, water and other natural elements. To control the waste there are three methods to curb e-waste which are- recycling of e-waste, increasing active donation of old equipments and involving public and private industries. India needs to improve participation of private and public sectors or organizations in managing e-waste. [2].

WEEE refers to the electronic materials that are discarded. Without proper regulation to supervise the control on disposing and discarded materials will at last end up in the junkyard or disposal area. Recycling is a procedure of reusing the waste or used electronic substance into new by-product, which prevents the materials that go in waste. The PC that weighs 60lbs is made up of more than 33 forms of materials such as plastic, Pb, Sn, Au, Al, Ag and etc., these useful materials can be reclaimed[3]. The life span of any electronic materials can be increased by recycling and reusing these materials. Based upon the research by Japan Electronic and Information Technology Association (JEITA), the lifespan of a Personal Computer is 6.7 years, At the same time the Economic and Social Research Institute of Japan detailed that the avg. lifespan is 4.3 years[4].

E- waste is the unused, abandoned household and the business products with the set of electronics devices and electrical circuit constituents which are made up of power adaptors and batteries. The strategy to remove this e-waste by not impairing nature is e-waste handling which is added to a difficult situation every year [5]. To understand the impact of this as a glimpse at the data which was declared in 2016, the nation's widespread around the globe give rise to million metric(mt) tons of e-waste. There is an estimation that post the year 2021, the quantity of the above mentioned would expand to 52.3 mt. India is one of the fastest-expanding countries and industries concerned with the electronic materials, which churn out much of e-waste and give out to the complete e-waste that is generated in the world[6].

The technique to better the situation of e-waste based on self-executing contracts, developed using block chain technology. Block-chain enables proper bookkeeping of the Electrical and Electronic Equipment in markets by independent retailers and producers. This will permit the self-executing contracts to identify the collection target and discipline the party when it is essential. It provides incentives to customers when the e-waste is directed into the official sector. Smart contracts helped to balance the origin and quantity of e-waste composed, carried and recycled all over the procedure. A system representation, the product is manufactured and it particulars have been added by the manufacturer towards the block-chain grid. The trader acquires the merchandise in possession. From merchants, different sellers to the selling to the users. The customers may merchandise the goods as a second-hand trade market. Everything is brought into the blockchain network for a nicely assembled trail [7].

M. Khurrum S. Bhutta et al.[8] provides a few e-waste estimation techniques by using linear regression using which we can estimate the amount of e-waste to be generated in the coming years. Some of the techniques are: predicting the quantity of End of Life(EOL) materials that went to recycling vs that are disposed of, predicting the portion of EOL electronics recycled, and predicting the part of EOL Electronics Disposed. E-waste management in Industries are also proposed using the techniques mentioned. In summary, less than 19% of the EOL electronics goods produced in the year 2007 was used for recycling, and with more than 81% going to landfills according to the waste management of the EOL[8].

Since technology is evolving rapidly and more people have access to it now, disposal of old electronic and electrical items are increasing. There is a need for e-waste management for a sustainable technological future. Major e-waste comes from mobile devices. These are the most often disposed devices. A modular device can be developed so that a piece can be replaced in place of the entire cell phone when people need to update their cell phones[9].

Shagun et. al [10] identifies the following issues in the Indian scenario: There are schools across India which are built on toxic waste which puts at risk thousands of students in developing cancer, learning disorders, asthma and other diseases related to environmental Pollutants. According to preliminary estimates, India generates around 1,46,000 tonnes of WEEE every year. With over 200 million current mobile users , 25 million household electronic appliances and 75 million phones every year reaching EOL, it is no surprise that in India ,around 70% of the heavy metals and 40% lead in landfills come from e-waste. Indians also

upgrade their phones every 18 months and electronics manufacture take more than 22% of the yearly world consumption of mercury and more of acid content flow into the land contaminating the soil and land value[10].

Atul et al[11] have suggested that, out of all electronics imported to Ghana 30% were new whereas 70% were used goods and out of the used products 15% of the products were not reused but instead were scrapped or discarded. The USA discards 30 million computers each year and 100 in Europe ,100 million tonnes of mobile phones are disposed of. It also gives some solutions for e-waste handling like the entire ban on the importing of e- waste, starting legal domestic structure to manage holes in importing of e-waste, mixing recycling with products, obsolete and burnt, insisting on domestic processing, provide training to generators on e-waste handling, introducing tax incentives for scrap dealers, rewarding/reprimanding schemes for performance of e-waste management, adding disposal fee from manufacturers and consumers and subsidizing recycling and disposal industry with schemes for garbage collectors for general public. Since electronic goods are becoming obsolete at a very fast rate, e-waste management is very necessary. Since Bengaluru is an IT hub, proper e-waste management is important. Some of the e-waste like PC's, televisions, etc. contain very harmful chemicals and are non-biodegradable. If not managed properly, harmful chemicals like lead can filter into the earth and ground-water. A lot of e-waste in Bengaluru is thrown in land-fills or is incinerated which leads to generation of harmful chemicals into air [11].

Amit Kumar et. al makes an attempt to study the awareness and knowledge about E-Waste management in college students [12]. 60 students each from professional courses and non-professional courses were chosen randomly and a questionnaire was given to them. The questionnaire had questions regarding Existence, Risk and Management of e-Waste. After the evaluation of the students' answers it was concluded that students from both professional and non-professional courses were well aware about the existence of e-waste. But students from professional courses are more aware about the risks of e-Waste than the students from non-professional courses. It was also found that both of them were unaware about the e-Waste management and its techniques. So, awareness about the risks and management of E-Waste is very less in students and measures to be taken to educate them in this regard. As the world is moving towards the technological revolution-Waste will become a huge problem. So, we need to educate the students regardless of their courses and make them aware of the risks and management techniques related to e-Waste [12].

Lim Fung Chen [13] commented on the awareness of the younger peer group towards e-waste management. The study shows that only 10.96% of the students have clear understanding on e-waste management, 27.74% of them have the basic knowledge on e-waste management, 28.74% are aware but not sure and the rest 32.85% don't have any idea, which shows the awareness among students is very less. It also shows that 33.58% of students are vending, 35.07% are keeping it in the store room and the rest are disposing it as household waste. The study also shows that 40.16% of the students did not inquire about Green IT in their program. Haw Wai Yee believed that due to not offering Green IT as a subject in College's program, the knowledge about e-waste management is affected among many [13].

3. PROPOSED METHODS

A. Suggested Methods for E-Waste Management

1) Minimize the complexity of chemicals to be treated: The full disassembly of the devices is the best way. But due it's complex nature it is very difficult to automate this step. It is still carried out manually in India. So, it is very difficult to segregate to its elementary level since it is not cost effective. The most common approach is grinding at the scale of the device before any chemical treatment. After that particles should be separated by physical methods using the magnetic properties or difference in its densities. After checking the purity of those, thermal or chemical treatments can be used. In case of chemical treatment, the most used method is liquid-liquid extraction. In this method first metals are dissolved in an acid, then they prepare an emulsion. It is repeated several times to get the pure metal.

2) Recovery of Rare Earth Metals: These precious metals are mainly found in mobile phones. At present these are rarely recycled. But the production of these materials are very expensive. Results show that combination of two specific molecules for extraction gives efficiency almost 100 times more than the one, when used separately.

3) Microfluidic Approach: In this approach each of the modules can find use in other cases. For example, liquid-liquid extraction is useful in the study of extraction of organic molecules. Similarly Infrared spectroscopy module is useful in monitoring the agri-food processes.

B. Collection of Electric & E-Waste

The collection of all the possible e-waste routes and flows does have a huge environmental impact on society. Chemical composition of the e-wastes that are collected will depend on the type and the materials of the electronic matter that has been collected and discarded. It is mainly the metal alloys, like Al, Fe, Ni and Cu are mixed with several ceramics and plastic and other materials so can be made using recycled items. Some of these are heavy-metals that are mainly used in the generation of different

and standard electrical and electronic items, such as Poly-cyclic Aromatic Hydro-carbons (PAHs); they are generated by burning the e-waste collected at reasonably flat temperatures. Incineration of residue of the plastic protection that is collected from cables in an open furnace produces hundred times more dioxins and oxides than the regular waste burning and causes various hazards to the living beings and nature [14]. Nearly 80% of total number gathered for re-cycling is transported to foreign countries like Philippines, India, Ghana, Vietnam, Malaysia, Africa, Pakistan etc.[15].These problems grow bigger and bigger by taking into consideration of the fact that the majority of these wastage are not getting recycled, because of various electrical and electronic items that are produced along with regular daily waste are not subject to any additional treatment[16]. The general management of practice towards compression of e waste before and during the process of discarding in landfills will drastically increase the volume due to the disturbance and the composition of several electronic circuit parts and other plastic components present, for that reason, it is highly proposed and justified to perform cement solidification one waste that increases pH which makes it basic in nature and decreases the aqueous solutions' flow in the waste discarded which helps to save the nature [17]. This results in the treatment of environmental frameworks that have incredible increase in the impact on the nature and the people who are assigned in these specific operations. It is stressed out that all environmental benefit by reusing does vanishes a larger content of the waste that has to be recycled and shipped to a very great distance due to the adhesive and extreme impact that has on the nature which also cause a high consumption of resources to transport these materials for a long distance.

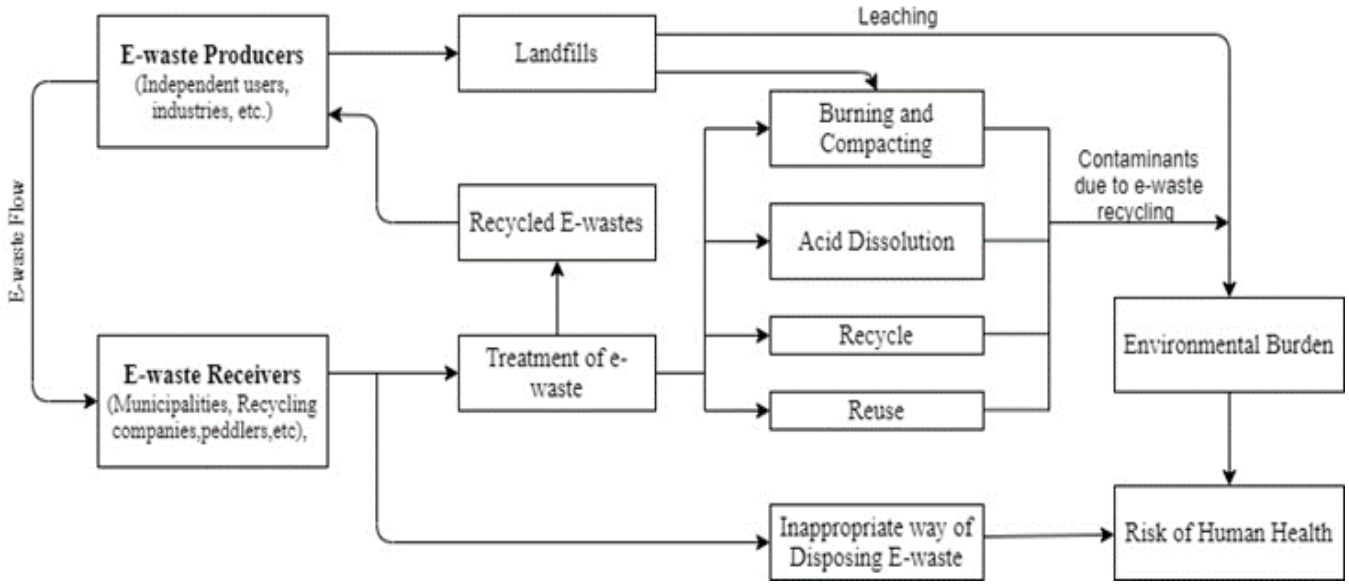

Figure 1 Routes of Electronic-Waste

C. Approximation Techniques for E-Waste

To approximate the amount of wastes and the weight of e-waste in tons for the mentioned years, linear regression technique is applied using Microsoft Excel. Figure 2 shows the structure for modelling the product life cycle. In Phase 1, product sales data are congregated with the facts on the yearly mean mass of products. The sales of products needing EOL management for the years 1980-2007 was taken by the model and the yearly quantity was predicted till 2007[18].

1) Approximating the amount of EOL Products produced which are Disposed versus Recycled: The approximation of the amount of wastes that are produced every year for the handling of EOL was generated by the model. Recycling and disposal are the two ways shown in phase 3 of figure 2. Disposal was the difference between management of EOL generation and recycled products.

2) Approximating the part of EOL Electronics Recycled: Municipal and other collection programs play an important role in recycling of consumer electronics for substance detachment and recovering and reuse in foreign and domestic markets. Businessmen and institutions may also directly contract with recyclers of electronics for recycling assistance of their EOL apparatus. EOL electronic equipment are also collected by donation organizations for reuse or recycling. Prior to EOL management, the reuse of consumer electronics is assumed to occur before they get into the management system.

3) Approximating the Portion of Discarded EOL Electronics

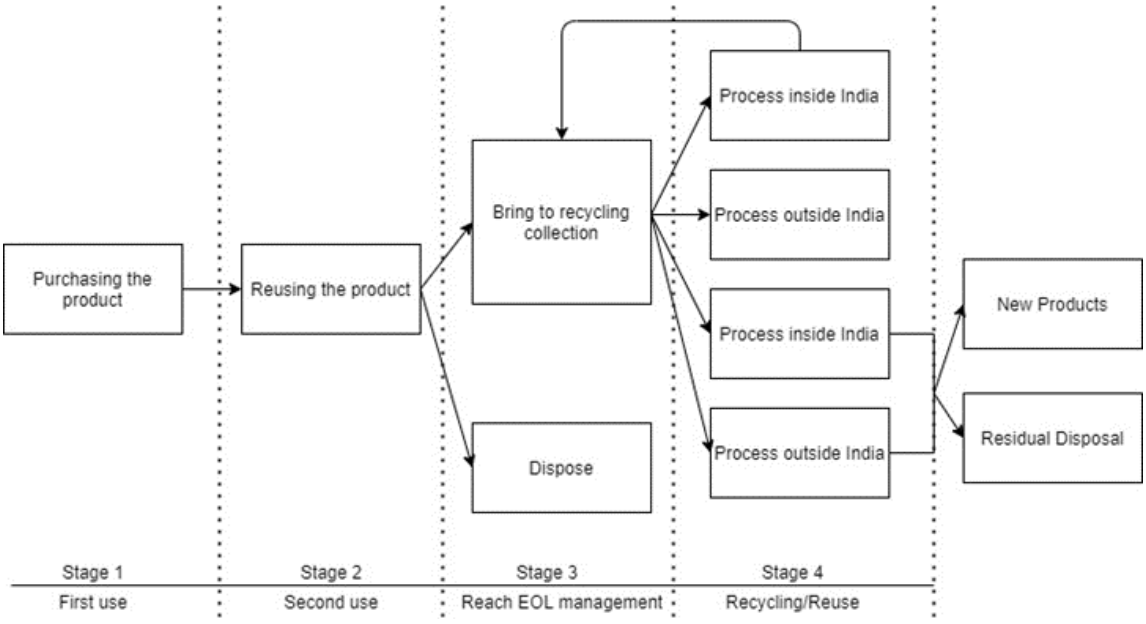

Figure 2 Framework for Modelling the Product Life-Cycle

D. Adding Green Computing in College Program

The quantity approximated to be recycled is subtracted from the quantity of approximate generation for EOL management, to estimate the fraction of the estimated EOL electronics accomplished every year which is disposed of. Table 1 shows the disposal estimates for 1997 to 2007. 18.41% of the EOL electronics produced by weight in 2007 were gathered for recycling. Even though the quantity of materials being recycled increased from 1999 to 2005, the quantity of EOL wastes produced also increased thus the percentage of materials being recycled remained comparatively sustained. There was estimated to be larger earnings in the price of recycling for 2006-2007.There has been an increase in the recycling in the electronics industry due to the implementation of state electronics recovery and disposal regulations. Table 2 shows the estimation of EOL till 2015.

Year	Total EOL	Total recycled		Total disposed	
		Tons (000)	Ton (%)	Tons (000)	Ton (%)
1999	159	1056	157	899.2	85
2000	161.6	1282	190	1092	85
2001	193.6	1447.6	210	1237.6	85
2002	225.2	1634	250	1384	85
2003	273.8	1944.7	290	1654.7	85
2004	310.7	2043.5	320	1723.5	84
2005	342.1	2172.6	345	1827.6	84

2006	342.9	2107.8	377	1730.8	82
2007	372.7	2251.7	414	1837.7	82

Table 1 Distribution of used and EOFL Products

Year	Total EOL products		Total recycled		Total disposed	
	Units(mill)	Tons(000)	Units(mill)	Ton(%)	Units(mill)	Ton(%)
1999	159	1056	23.6	14.9	135.4	85
2000	161.6	1282	24	14.8	137.7	85
2001	193.6	1447.6	28.1	14.5	165.5	85
2002	225.2	1634	34.6	15.3	190.7	85
2003	273.8	1944.7	40.8	14.9	232.9	84
2004	310.7	2043.5	48.6	15.7	262	84
2005	342.1	2172.6	54.3	15.9	287.8	82
2006	342.9	2107.8	61.3	17.9	281.5	82
2007	372.7	2251.7	68.5	18.4	304.2	83
2008	412.6	2527.7	72.4	18	340.1	82
2009	441.5	2674.7	78.2	18.4	363.2	82
2010	470.5	2822.9	84	18.8	386.3	82
2011	499.4	2970.5	89.8	19.2	409.4	82
2012	528.4	3118.7	95.6	19.1	432.5	81
2013	557.3	3266.3	101.5	19.9	455.6	91
2014	586.3	3414.5	107.3	20.3	478.7	81

2015	615.2	3562.1	113.1	20.7	501.8	81

Table 2 Prediction of EOFL using Forecast Function

Personal computers are used extensively in educational and other industries. Every year manufacturing of computers is being increased and the awareness of green computing, sustainability and e-waste are very less among people. Increasing the awareness of environmental concerns in climate changes, has enforced a variation of industries counting the educational organization to review environmental credentials. Institutions are beginning to understand their corporate responsibility towards the environment. Universities have to be aware of Green Computing as a movement towards an environment and nature that is green which is money saving. Including Green Computing or E-waste management in the college program will educate students on e-waste management and how it can be reduced. From the collaboration in the e-waste management industry, the pupils are more constructed and evolved with the comprehension in the field of e-waste handling.

E. Organizations

Organisations and Companies have a huge role to play in controlling the amount of E-Waste as computers are an integral part of them. So, if everyone does their part to manage E waste, we can control the harm it will cause to the environment and the human body. Computers are an integral part of many industries with which the work is easy and can be done in less time. But the e-waste produced from these computer systems is more as most of them don't have much knowledge on how to reuse or/and dispose of these e-wastes By integrating a private public partnership system, bridging the private entities and the government, we may have a proper model of reinstate the currently unorganized one surrounding the unsanitary elimination procedure by junk dealers and people gathering waste [3]. Establishments responsible for higher-education can go green and save costs when they save energy using IT policy. To include information on the institutional website on efforts of green computing and to reduce carbon footprints. E-waste can be reduced by increasing the active donation of the old equipment which will be helpful for the person in need. For instance, donating it to some government school or non-profitable organizations such as training centres and foundations. Involving consumers to contact the companies to pick up and contribute the respective electronic products for recycling. Electronics companies like HCL, HP, Wipro, Xiaomi are some of the companies that are the best at minimizing e-waste using recycling [20]. These companies take initiative to make people aware of e-waste management.

4. CONCLUSION

This paper explains the negative impacts of improper disposal of E-Waste and efficient E-Waste Management techniques. It is evident that improper disposal of E-Waste can cause harm to air, water, soil and human body too. The negative health effects of these toxins in E-Waste on humans include brain, heart, liver, kidney and skeletal system damage. So, it is very crucial to practice proper disposal or management techniques in order to avoid such health effects and protect the environment. It is important to raise awareness about Existence, Risk and Management of E-Waste among the youth. Few new methods for E-Waste Estimation, Collection and Management are also proposed. It is important to teach Green Computing to every student regardless of their courses.

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