International Journal of Engineering Research and General Science Volume 2, Issue 6, October-November, 2014
ISSN 2091-2730

Forecasting e-waste amounts in India

Sirajuddin Ahmed[1] ,Rashmi Makkar Panwar[2],Anubhav Sharma[3]
[1] Department of Civil Engineering, Jamia Millia Islamia, Delhi, India
[2]Research Scholar, Department of Civil Engineering, Jamia Millia Islamia, Delhi, India
[3]G.B.Pant Polytechnic, DTTE, New Delhi, India

E-mail: rashmimakkarpanwar@gmail.com , Contact No.- 09811512801

Abstract: The increase in sales of electronic goods and their rapid obsolescence has resulted in generation of electronic waste, which is popularly known as e-waste. Changing trends and exponential growth of electronics industry, increase of electrical and electronic products, consumption rates and higher obsolescence rate leads to higher generation of e-waste. This paper presents a study of the amount of e-waste generated by different sectors and devices during the last few years and the trend it follows. It includes the prediction of amount of E-waste trend. The amount of E-waste generated is increasing at higher rate annually and if not treated properly it will not only have adverse impact on environment but also on human lives. The purpose of this study is to establish a set of baseline data for management of e-waste by reviewing the e-waste problem in terms of quantity and hazardous constituents present in it.

Keywords: e-waste, forecasting, sales, components, lifespan, desktops, laptops, mobile phones, televisions

1. Introduction

In this paper, the amount of e-waste created in India every year is analyzed based on the data provided by various agencies and based on that the e-waste from various appliances is estimated and predicted for the years to follow. Although no definite official data exist on how much waste is generated in India or how much is disposed off, there are estimations based on independent studies conducted by the NGOs or government agencies. It is necessary for effective e-waste management to quantify and characterize electronic waste stream, identify the major generators and assess the risk involved. It is also pertinent for government to keep the inventory [1]. Reliable figures on quantity are crucial in order to evaluate compliance with regulations set by authorities. Reliable figures are also important for monitoring and further improvement of return schemes [2]. The difficulty in Inventorization is one of the important barriers to safe e-waste management [3].

The main sources of electronic waste in India are the government, public and private (industrial) sectors, which account for almost 70 per cent of total waste generation. The contribution of individual households is relatively small at about 15 per cent; the rest being contributed by manufacturers. Though individual households are not large contributors to waste generated by computers, they consume large quantities of consumer durables and are, therefore, potential creators of waste.[4]. India generated around 4 lakh tonnes of electronic waste in 2010, up from 1.47 lakh tonnes in 2005.[5]

India's E-Waste market has been divided into various segments including IT and Telecom, Large Household Appliances and Consumer Electronics. Some of the key products generating most of the E-Waste in the country include PCs, mobile phones, laptops, televisions, refrigerators, washing machines etc. The following three categories of WEEE account for almost 90% of the generation [6] :

- Large household appliances: 42%,
- Information and communications technology equipment: 33.9% and
- Consumer electronics: 13.7%.

Because electrical and electronic products come in such a wide range of varieties, such as household appliances, telecommunication and information technology equipment, toys, lighting equipment, and medical equipment, it would be far too complicated to address the problems arising from all electrical and electronic products here. Thus, this paper chiefly is concerned with four appliances/devices which can be simultaneously categorized as IT, telecom and consumer electronic devices i.e., PCs(Desktops and laptops), Mobile phones and Televisions (CRT, Plasma, LCD & LED).

1.1 Composition of E-waste

The composition of e-waste is diverse and falls under 'hazardous' and 'non-hazardous' categories. Broadly, it consists of ferrous and non-ferrous metals, plastics, glass, wood and plywood, printed circuit boards, concrete, ceramics, rubber and other items. Iron and steel constitute about 50% of the waste, followed by plastics (21%), non-ferrous metals (13%) and other constituents. Non-ferrous metals consist of metals like copper, aluminium and precious metals like silver, gold, platinum, palladium and so on [7]. The presence of elements like lead, mercury, arsenic, cadmium, selenium, hexavalent chromium, and flame retardants beyond threshold quantities make e-waste hazardous in nature. It contains over 1000 different substances, many of which are toxic, and creates serious pollution upon disposal [8].

1.2 Method used for Forecasting

The tool used for future prediction of sale values of electronic equipment for the upcoming years is Microsoft Excel. By using regression analysis [9], trendline is extended in a chart beyond the actual data to predict future values. This method is defined to calculate, or predict, a future value [10]of e-waste by using existing values.

The total lifespan of electronic products is equal to the amount of time they are in use. First, we searched for new and updated information on product lifespan. As a result, we developed separate commercial-sector lifespan assumptions for these devices. Though, comprehensively nationally-representative data on the life spans of electronic products, the patterns of use across residential and commercial institutions, and the quantity of electronic products collected for recycling do not yet exist. Then we applied data on the lifespan of electronic products to the sales data to estimate the number and weight of products in use and end-of-life management for each year.

The present work considers the approximation of e-waste generation based on variance in the distribution of
product life span, in the absence of reliable information on actual WEEE arising. After a certain time span (average life time) the end-of-life goods are passed on for collection. It is assumed that in the consumption period no losses occur and no conversion of material takes place. By making prediction, this helps to make informed decisions to plan and develop strategies for collection, storage, treatment, disposal and recycling services in order to channel computer waste through environmentally sound waste management system to prevent environmental and public health impacts.

1.3 Lifespan of Electronic equipments

The useful life of consumer electronic products is relatively short, and decreasing as a result of rapid changes in equipment features and capabilities [11]. The lifespan of central processing units in computers dropped from 4 to 6 years in 1997 to 2 years in 2005 [12]. The average life of electronic equipment mentioned above for which the device will operate without getting obsolete is normally different for every equipment [13].

Device	**Avg Lifespan in Years**
Desktop	5
Laptop	4
Television	10
Mobile phones	6
Printer	4

Table 1. Devices and their average life span

But in Indian scenario, the reality is different. The life time of an equipment will depend on the distribution around the equipment average lifetime because equipment are often reused or restored [14].

Equipment		**Years till the device operate**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**

Desktop			25%	50%	25%							
Laptop		10%	50%	20%	20%							
Mobile phone	25%		25%			50 %						
Television										60%		40%

Table 2 Distribution around equipment average lifetime [15] and [16]

2. Sales and E-waste prediction of Equipments

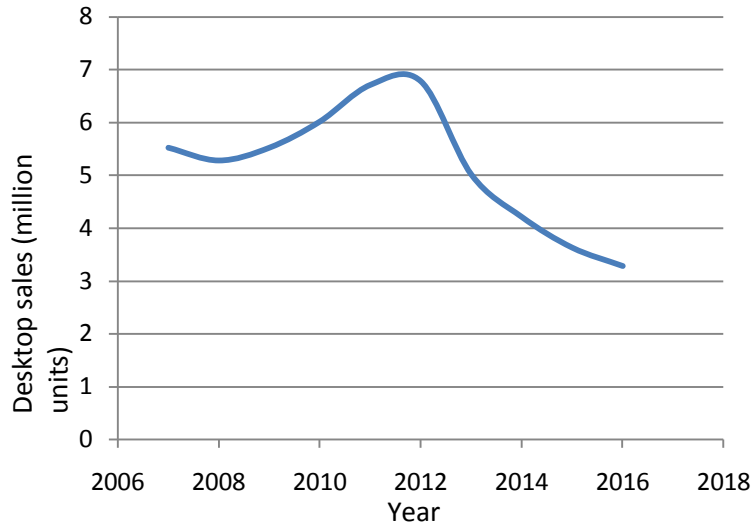
2.1. Desktop Computers

The electronics industry is driven mainly by the computer and computer component sectors with as much as a fifth of its revenues coming from sales of Personal Computers. The huge scale of demand in the market can be observed from the sale of the desktop PCs during the period 2007-2013 as shown in the table below. A shift in the governance systems with e-governance initiatives adopted by the Central and the State Governments, the telecom, banking and education sectors, Small and Medium Enterprises (SMEs) and IT enabled services have been a major factor leading to the vibrancy of consumption in the information technology market

2.1.1. Sales (2007-13) and forecast (till 2016-17)

Year	Million units
2007	5.522
2008	5.28
2009	5.522
2010	6.016
2011	6.71
2012	6.778
2013	5.015
2014	4.212
2015	3.631
2016	3.284

Table 3. Sales and forecast for desktops [17]



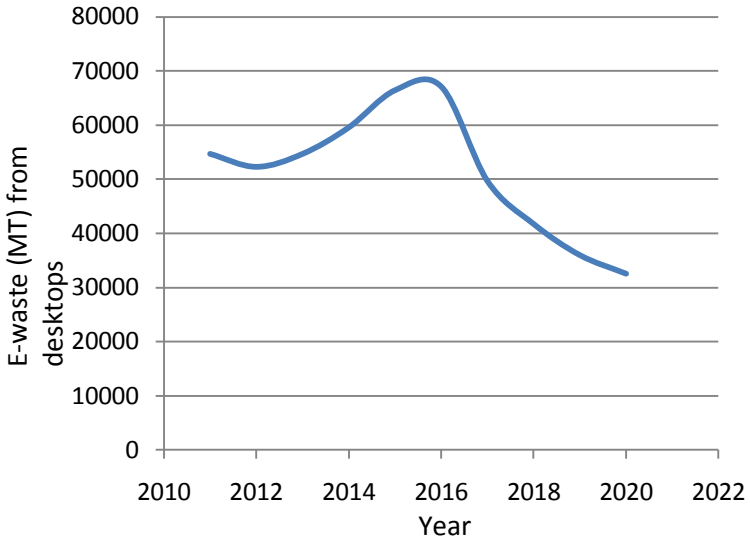
Graph 1.

2.1.2 E-waste generated from Desktop computers

Based on the distribution of Lifespan [Table 2], sales data [Table 3] and taking the average weight of desktop computers as 9.9kg [18], E-waste generated in Metric Tonne due to desktop computers is estimated till the year 2020.

Year	**Metric Tonne**
2011	54667.8
2012	52272
2013	54667.8
2014	59558.4
2015	66429
2016	67102.2
2017	49648.5
2018	41698.8
2019	35946.9
2020	**32511.6**

Table 4. E-waste generated from Desktops



Graph 2.

2.1.3. Hazardous substances in components of desktop computers waste

Description	Weight of material	Gross material by 2020 (MT)
Plastic	2.635 kg	8653
Lead	0.72 kg	2364
Mercury	0.252 gm	0.827
Arsenic	0.149 gm	0.489
Cadmium	1.077 gm	3.536
Chromium	0.72 gm	2.364
Barium	3.61 gm	11.855
Beryllium	1.79 gm	5.878
Copper	0.683 kg	2243

Table 5. [19]

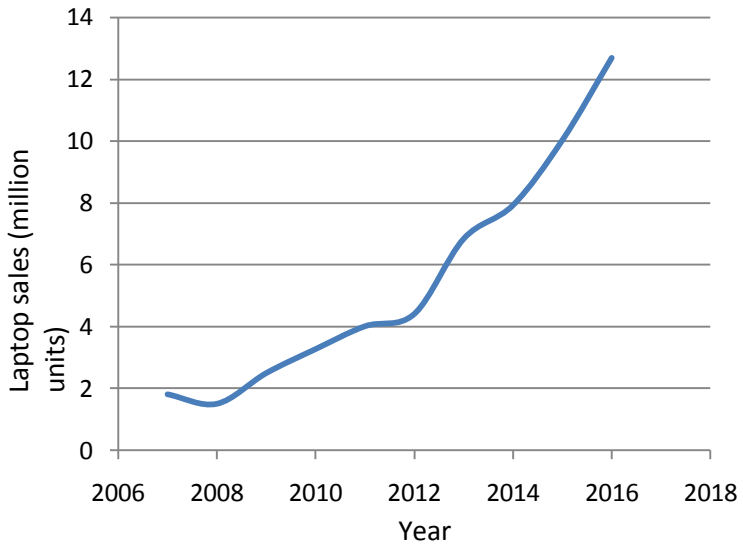
2.2 Laptops

2.2.1. Laptop sales (2007-2016) and forecast (till 2018)

Year	Million units
2007	1.822
2008	1.516
2009	2.508
2010	3.284
2011	4.022
2012	4.421
2013	6.849

2014	7.936
2015	10.038
2016	12.698
2017	15.899
2018	20.09

Table 6. Laptop sales [17]



Graph 3.

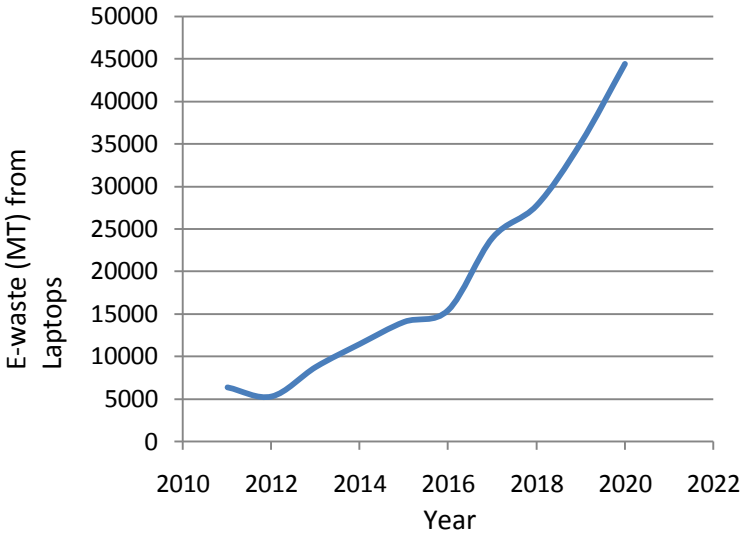
The Laptop market grew by 55 percent in 2013-14 and the overall sales in the PC market was up by six percent owing to the negative growth of the Desktops [see table 3 & 6] [17]

2.2.2 E-waste generated from Laptops

Based on the average lifespan distribution[Table 2], sales data [Table 6] and taking the average weight of Laptop PCs as 3.5kg [20], the E-waste generated in Metric tone is estimated till the year 2020.

Year	**Metric tonne**
2012	7875
2013	9971
2014	12640
2015	15248
2016	20673
2017	25290
2018	32360
2019	40367
2020	**50769**

Table 7. E-waste from Laptops



Graph 4.

By the end of the year 2020-21, there will be around 15 million computers (Desktops+Laptops) in India and it will take nearly three decades at the current rate of penetration before there is one computer per capita across the nation [21]. It is clear from the research that by 2020, India's e-waste from old computers (desktop + laptop) will increase by 36% from the 2012 levels with discarded Laptops occupying the major chunk.

2.2.3 Hazardous substances in components of laptop waste

Description	Weight of material	Gross material by 2020 (MT)
Glass	.382 kg	5541
PCB	.450kg	6527
Battery/ Transformer/ Capacitors	.273kg	3960
Plastic parts	.760kg	11024

Table 8. [22]

2.3 Mobile Phones

The mobile phone phenomenon is unique in the histories of both the telecommunication and consumer electronics markets. In less than a decade, people have adopted mobile phones on a massive scale. This is about three times the size of the television or PC markets. Growth has been fuelled by the spectacular evolution of mobile phone technologies, both in terms of performance and miniaturization. As a result, unlike many other appliances, users change their mobile phones on average every two years. Consequently, replacement handsets today represent about 80% of all mobile phone purchase [23].

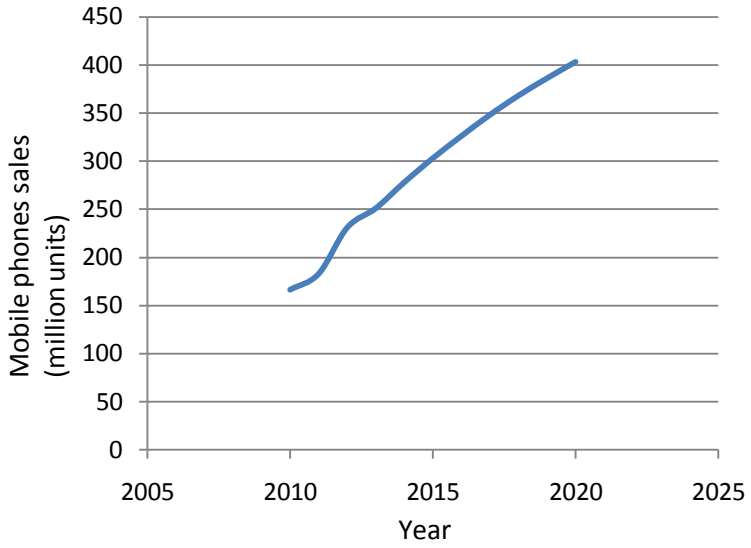
This rapid growth has been possible due to various proactive and positive decisions of the Government and contribution of both by the public and the private sector. The rapid strides in the telecom sector have been facilitated by liberal policies of the Government that provide easy market access for telecom equipment and a fair regulatory framework for offering telecom services to the Indian consumers at affordable prices.

2.3.1 SALES (2010-2013) AND FORECAST (TILL 2020)

The consistent growth in the smartphone market is driven by enhanced consumer preference for smart devices and narrowing price differences. The smartphone penetration in India in quarter 1 of 2014 hovered at 10 per cent [24] and it is expected to grow due to a variety of factors including greater availability of low-cost devices and additional sales emphasis by top-flight vendors on less populous parts of the country. This rapid pace of growth in smartphones is expected to continue in India and is estimated below in table 9.

Year	**Million units**
2008	94.6
2009	100.9
2010	166.5
2011	213
2012	231
2013	251
2014	278
2015	303
2016	326
2017	348
2018	368
2019	386
2020	**403**

TABLE 9. SALES FORECAST FOR MOBILE PHONES IN INDIA 1.[24] 2.[25]



Graph 5

2.3.2 E-waste generated from Mobile phones

Components of a mobile phone	Constituents
Circuit Boards	Copper, Gold, Lead, Nickel, Zinc, Beryllium, Tantalum and other metals
LCD	Mercury, plastic and glass
Rechargeable battery	Ni-MH and Ni-Cd batteries contain Nickel, cobalt, zinc, cadmium and copper. Li-ion batteries use Lithium metallic oxide and carbon based materials.

Table 10 Constituents of different components of a mobile phone [26]

Based on the sales data [Table 9], average lifespan [table 2] and taking the average weight as 130 gm [27], E-waste from Mobile phones in India is estimated for the year 2020.

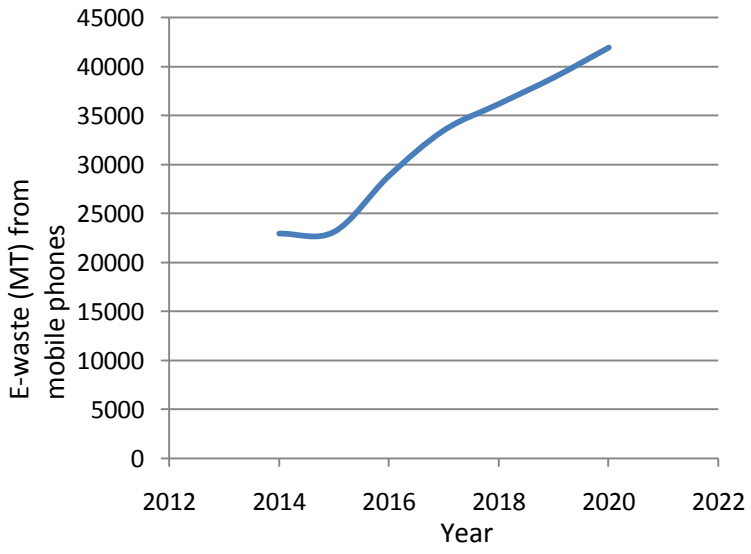
Year	Metric Tonne
2014	22919
2015	23101
2016	28827.5
2017	33475
2018	36172.5
2019	38870
2020	**41925**

Table11 E-waste from Mobile phones in India

2.3.3 Hazardous substances in components of mobile phone waste

Description	weight of material	Gross weight by 2020 (Metric Tonne)
Acrylonitrile butadiene Styrene/Polycarbonate (ABS-PC)	37.7gm	12158
Cu and compounds	19.50gm	6289
Epoxy Plastics	11.70gm	3773
Flame retardant	1.25gm	403
Nickel	1.35gm	435
Zinc	1.3gm	419
Pb, Cd, Hg,	1.3gm	420

Table 12 Hazardous waste components in Mobile phone [28]



Graph 6

2.4 Television

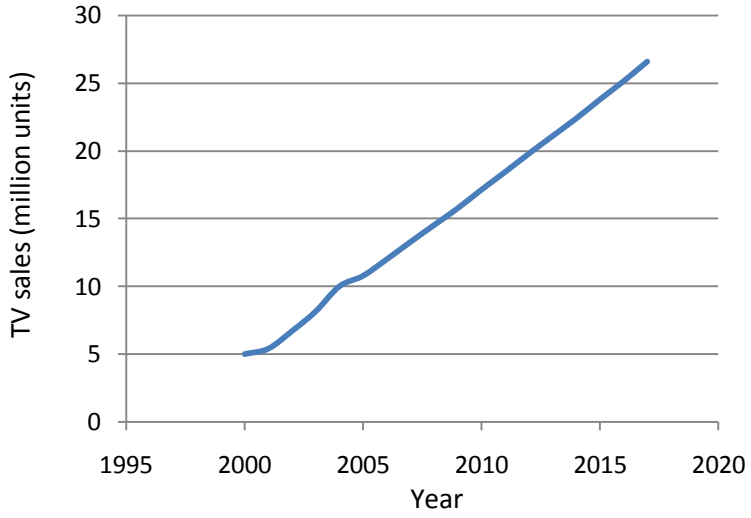
In the television segment, the advent of Liquid Crystal Display (LCD) and plasma screens have altered the concept of the television for viewers. Better technology has meant improved picture quality and a diminishing price difference between the traditional CRT (Cathode Ray Tube) television and the new flat screen LCD television. It has resulted in the popularity of the latter. Moreover, increasing disposable income and the price decline influenced by robust demand has been factoring the growth in this segment.

2.4.1 Sales (2000-13) and forecast (2014-2017)

TVs are the largest contributors to the Consumer durables segment. Introduction of HDTVs is set to drive demand growth from affluent consumers Liquid crystal displays (LCDs). The price decline due to relatively low import duty on LCD panels, higher penetration levels, and the introduction of small entry-size models are key growth drivers. [29].

Year	**Million units**
2000	5
2001	5.4
2002	6.7
2003	8.15
2004	10
2005	10.781
2006	12
2007	13.28
2008	14.53
2009	15.77
2010	17.14
2011	18.45
2012	19.8
2013	21.1
2014	22.4
2015	23.8
2016	25.15
2017	26.6

Table 13. Year wise TV sales in India [29]



Graph 7

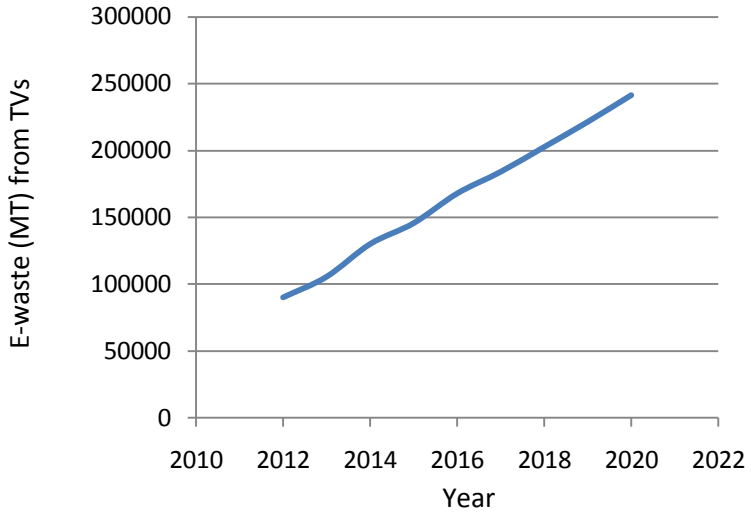
2.4.2 E-waste generated from TVs in India

Televisions are more likely disposed off by the people in case of technological failures as they prefer to exchange with a new one rather than repairing non-functional equipment. The other driving forces for television replacement are to match with latest trends and technology, upgraded features and peer pressure [30]. In case of televisions; a lot of relocation happens to the nearby villages, towns and cities, resulting into repeated cycles of reuse. [30]. As a result, there is a huge gap between the potential e-waste generated and the e-waste actually recycled.

Based on the sales data (see table13), average lifespan distribution (see table 2) and assuming the average weight of television as 15kg [15], the total e-waste generated from televisions in India is estimated till the year 2020-21.

Year	**Metric tone**
2012	90300
2013	105750
2014	130200
2015	145800
2016	168000
2017	184200
2018	202770
2019	221550
2020	**241500**

Table 14. E-waste generated in India from TVs



Graph 8

2.4.3 Hazardous substances in components of television waste [31] [32]

Description	Weight of material	Gross material by 2020 (MT)
Lead	1.095kg	17629.5
Copper	0.375kg	6037.5
Zinc	4.5gm	72.45
Cadmium	0.15gm	2.415
Plastics	4.56 kg	73416

Table 15. Hazardous materials in television

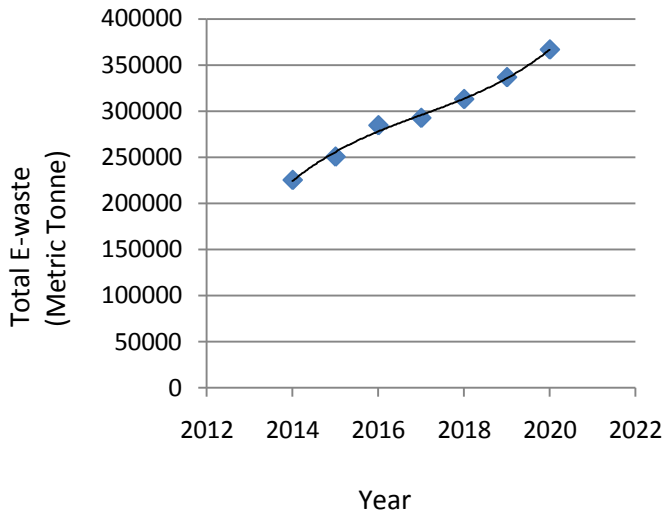
3. Results

3.1 Forecast for total E-waste generated annually

Forecast (2014-2020) for the total E-waste and the gross annual E-waste generated from the four electronic devices can be summarized as below:-

E-waste generated annually (Metric Tonne)							
Device	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Desktop PCs	59558	66429	67102	49648.5	41699	35947	32511
Laptops	12640	15248	20673	25290	32360	40367	50769
Mobile phones	22919	23101	28827.5	33475	36172.5	38870	41925
Televisions	130200	145800	168000	184200	202770	221550	241500
Total E-waste generated annually	**225317**	**250578**	**284602.5**	**292613.5**	**313001.5**	**336734**	**366705**

Table 16. Forecast for Total E-waste generated annually from 2014 to 2020

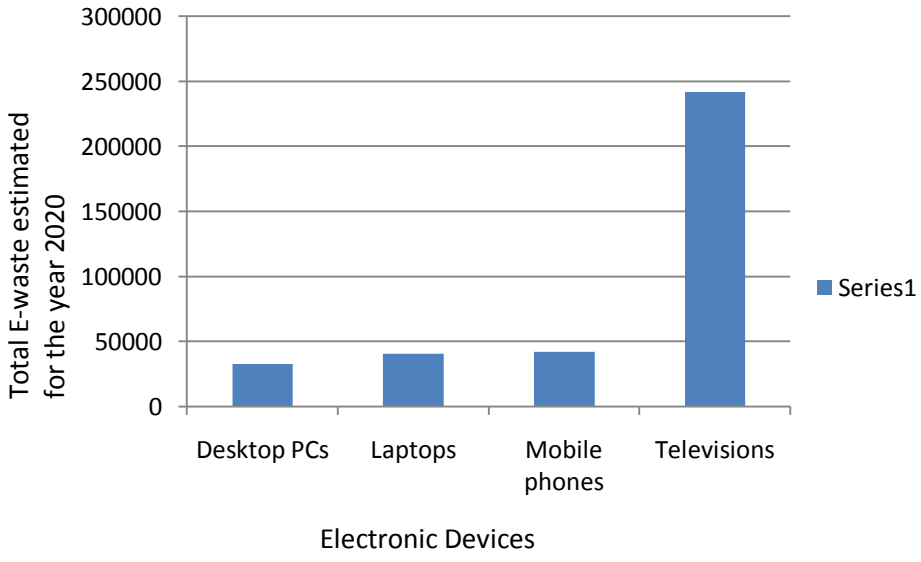


Graph 9

As per the above research, the total E-waste generated [Table 4,7,11,14] from the four electronic devices under study in 2020 is estimated as below:-

Equipment	Metric Tonne
Desktop PCs	32511.6
Laptops	40367
Mobile phones	41925
Televisions	241500

Table 16. Total E-waste generated in 2020



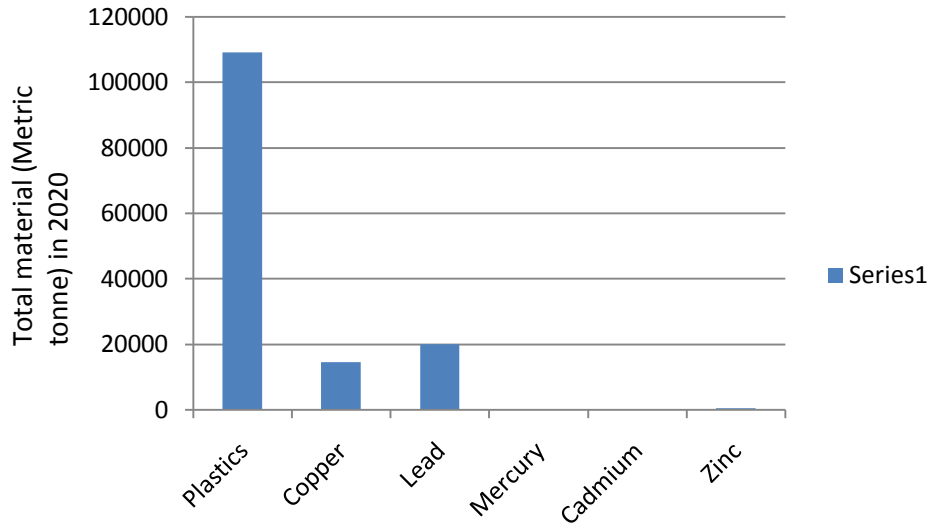
Graph 10

3.2 Forecast for the total amount of hazardous material from E-waste in 2020

Total amount of Hazardous material to be accumulated in 2020 [Table 5,8,12,15] due to the obsolete Desktops, Laptops, Mobile phones and Televisions is estimated as below:-

Material	Metric Tonne
Plastics	109024
Copper	14569.5
Lead	20133.5
Mercury	140.5
Cadmium	146
Zinc	491

Table17. Total hazardous material (estimated) to be accumulated in 2020



Graph 11

4. Discussions

As its quite conspicuous from the above study, India is at a crossroads with tremendous growth in the electronics industry but it also faces the exponential growth of electronic waste. The reasons as have been discussed above for prompt generation and obsolesces of E-waste include rapid economic growth, urbanization, industrialization, increased consumerism etc.

The above stated materials [Table 17] are toxic substances that have adverse impacts on human health and the environment if not handled properly. Mercury leaches when certain electronic devices, such as circuit breakers are destroyed. And when Cadmium containing plastics are landfilled, cadmium may leach into the soil and groundwater. Also, significant amounts of lead ion are dissolved from broken lead containing glass, such as the cone glass of cathode ray tubes, gets mixed with acid waters and are a common occurrence in landfills. The most dangerous form of burning E-waste is the open-air burning of plastics in order to recover copper and other metals [33].

High obsolescence of electronic products and the necessity for supporting upgrades compound the problem. Often, these hazards arise due to the improper recycling and disposal processes that are in practice in India. Such offensive practices can have serious aftermath for those staying in proximity to the places where E-waste is recycled or burnt. The real cause of the problem is that the Indian people are still to realize the associations between the cause of generation of E-waste and its effects including detrimental health and environmental effects. The government must also essentially and effectively implement the “e-waste management and handling rules”,2011 to address and counter the ever existing pile of e-waste in India.

REFERENCES:

[1] Research Unit(LARRDIS), '*E-Waste in India',* New Delhi: Rajya Sabha Secretariat, 2011

[2] www.norden.org , '*Methods to measure the amount of WEEE generated', T*temanord, 2009

[3] www.itu.int/08e-waste , '*Discussion paper, International Telecommunication Union,* GSR 2011

[4]Satish Sinha, 'Downside of the Digital Revolution', Toxics Link, 28 December2007

[5]. CAG report, 'E Waste in India', Rajya Sabha, New Delhi, 2011

[6] Santhanam Needhidasan, Melvin Samuel and Ramalingam Chidambaram**,** Journal of Environmental Health Science & Engineering 2014, 12:36

[8]. Basel Action Network (BAN) and Silicon Valley Toxics Coalition (SVTC), 'Exporting Harm: The High-Tech Thrashing of Asia', February 25, 2002

[9]. Dr. C. Lightner, Fayetteville State University, 'Forecasting Techniques, Chapter 16', Oct 2009

[10]. Cuddington J.T. and Khindanova I., 'Integrating Financial Statement Modeling and Sales Forecasting Using EViews', Journal of Applied Business and Economics, 2011.

[11] Hai-Yong Kang and Julie M. Schoenung, 'Electronic waste recycling: A review of U.S. infrastructure and technology options', 2005

[12]. Babu R, Parande AK, Basha AC, 'Electrical and electronic waste: a global environmental problem', 2007

[13]. International Journal of Engineering Research and General Science Volume 2, Issue 4, June-July, 2014 ISSN 2091-2730

[14]. Dimitrakakis E et al, 'Creation of Optimum Knowledge Bank on E-Waste Management in India', EuropeAid Asia Pro Eco programme, 2005

[15]. IRGSSA, 'Management, handling and practices of E-waste recycling in Delhi', India, 2004

[16].Neelu Jain and Pamela Chawla, Int. J. of Emerging Technology and Advanced Engineering, Vol.2, Issue 3, March 2012

[17].MAIT, 'IT industry performance annual reports' 2007-2013, India.

[18]. Eugster, Hischier et al. 'Key Environmental Impacts of the Chinese EEE-Industry: A Life Cycle Assessment Study' 2007.
[19] Silicon Valley Toxics Coalition, 'Toxic TVs and Poison PCs', June 1999

[20] SWICO Recycling Guarantee 2006 / ecoinvent vol 2.0

[21] Neelu Jain and Pamela Chawla, Int. J. of Environmental Technology and Management, Vol.17, No.2/3/4, pp.237 – 251, 2014

[22]. AEA Technology, 'WEEE & Hazardous waste Part 2' June 2006

[23]. Alcatel Telecommunications Review, 'Understanding the Mobile Phone Market Drivers', 2003-04

[24]. IDC Worldwide Quarterly Mobile Phone Tracker report, March, 2013

[25]. Indian Mobile Market Dynamics and Forecast (2008-2013), August 2009

[26] USEPA, 'The Life Cycle of a Cell Phone', 2003 www.ewasteguide.info

[27] MPPI (Mobile Phone Partnership Initiative), 'Conference of the Parties to the Basel Convention', 2002

[28]. Basel Action Network, 'Mobile Toxic Waste: Recent Findings on the Toxicity of End-of-Life Cell Phones', April 2004

[29]. Consumer Durables Report, August 2013, India

[30]. BIRD and gtz, 'e waste assessment in India: special focus on Delhi', Nov 2007.

[31] RIS International Ltd., '*Baseline Study of End-of-Life Electrical and Electronic Equipment in Canada'*, June 2003

[32] Matsuto T et al., 'Material and heavy metal balance in a recycling facility for home electrical appliances', Waste Management 24 (2004), 434

[33]. Anwesha Borthakur and Pardeep Singh, 'Electronic waste in India: Problems and policies', IJES, Vol.3, No.1, 2012