

A STUDY OF E-WASTE PROCESSES AND FACILITIES: CASE STUDY OF NCR

**A dissertation submitted to the Panjab University,
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By

Dr. Rajat Bhargava, IAS

Roll No. 4402

Under the Guidance of

Dr. Kusum Lata



**INDIAN INSTITUTE OF PUBLIC ADMINISTRATION
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PUBLIC ADMINISTRATION**

2018-19

CERTIFICATE

I have the pleasure to certify that **Dr. Rajat Bhargava** has pursued his research work and prepared the present dissertation titled "**A study of E-waste processes and facilities: Case study of NCR**" under my guidance and supervision. The dissertation is the result of his own research and to the best of my knowledge, no part of it has earlier comprised any other monograph, dissertation or book.

The dissertation is being submitted to the Panjab University, Chandigarh for the degree of Master of Philosophy in Social Sciences in partial fulfilment of the requirement for the Advanced Professional Programme in Public Administration (APPPA) of the Indian Institute of Public Administration (IIPA), New Delhi.

I recommend that the dissertation of **Dr. Rajat Bhargava** is worthy of consideration for the award of M. Phil degree of the Panjab University, Chandigarh.

(Dr. Kusum Lata)
Indian Institute of Public
Administration
IP Estate, Ring Road
New Delhi-110 002

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Dr. Rajat Bhargava

EXECUTIVE SUMMARY

Electrical and electronic waste known as e-waste is currently one of the largest growing waste streams in the world. It is hazardous and complex in nature. At the same time it is expensive to treat it in an environmentally sound manner. E-waste contains many hazardous substances such as lead, arsenic, mercury, hexavalent chromium, cadmium, barium and phosphorous which not only affect environment but also the health of people if, these substances are not properly treated at the end of life (EoL) of the equipment. Furthermore, developing countries globally are additionally bearing a disproportionate burden of handling e-waste without having the technology to deal with it. This is because of the illegal shipment of e-waste generated in developed countries to developing countries such as China, India, Ghana and Nigeria etc. While on one hand the developing countries themselves are increasingly generating significant quantities of e-waste, further adds to the adverse environmental and health implications in these countries.

India is a developing and one of the fastest growing economies in the world. In the recent years the growth of information and communication technology (ICT) sector has fuelled the consumption of electrical and electronic equipment (EEE) both

from the institutional users and households. With the advent of this higher rate of consumption, and the shortened product lifecycles due to rapid advancement of technology, e-waste such as discarded mobile phones, computer and related equipment etc., has emerged as a fastest growing waste stream. In India, e-waste is mainly handled by people in informal sector. Within the informal economy, it is recycled for its many valuable materials by recyclers using rudimentary techniques such as burning of cables and acid bath to recover precious metals. Effluents from these techniques pollute environment and cause harm to the health of the people. The resource efficiency of these processes is also poor.

This study explores the volumes, sources and flows of e-waste, the risks it poses to e-waste workers and the environment, occupational safety and health issues of the labour and regulatory frameworks in context of India.

India has initiated policy initiatives on this front, the most important are the E-waste Rules, 2011 **(amended in 2016, 2018)** putting the onus of handling of e-waste on producers in the form of Extended Producer Responsibility (EPR) besides the guidelines for Environmentally Sound Management of E-Waste, 2011. The dismantling/recycling facilities are required to be licensed under these rules. The paper has explored that the EPR

policies should be designed according to the socio-economic and cultural context of the country by choosing appropriate policy instruments rather than taking just one model of responsibilities allocated to producers as in the EU model. Policy lessons from other countries that have implemented the principle need to be learnt.

This will not only help in assessing the suitability of the principle in the Indian context and also help in sustainable management of e-waste in India. It is important to recognize that implementing a high-tech, capital-intensive recycling process will not be appropriate in every country. Effective regulation must be combined with incentives for recyclers in the informal sector to deliver recovered parts to central collection sites rather than process them themselves. Multidisciplinary solutions are vital in addition to technical solutions, as is addressing the underlying social inequities inherent in the e-waste business. It should not be forgotten that recycling operations in the informal sector of the economy enable employment for hundreds of thousands of people in poverty. More generally, solutions to the e-waste problem involve awareness raising among both consumers and e-waste recyclers in the informal economy, inclusion of the informal sector with the formal, creating jobs, enforcing legislation and labour standards, and eliminating practices which are harmful to

human health and the environment. It is also imperative to strictly implement electrical and electronics manufacturers by introducing Extended Producer Responsibility (EPR) legislation.

In considering solutions to the e-waste problem, this study focuses on need for appropriate implementation of legislation, addressing the concerns of informal recycling sector and the opportunities generated by the cooperative organization of e-waste workers. Appropriate questionnaire was addressed to the five set of participants i.e. the recyclers, dismantlers, producers, bulk consumers & consumers. The data was analysed through statistical tools and 9 different set of hypothesis were tested to arrive at the conclusion. It is clear that the future of e-waste management depends not only on the effectiveness of local government authorities working with the operators of recycling services but also on informal community participation, along with the increase in awareness and strict implementation of regulations.

CONTENTS

CERTIFICATE.....	ii
ACKNOWLEDGEMENT	iii
EXECUTIVE SUMMARY	iv
CONTENTS.....	viii
LIST OF TABLES	xiii
LIST OF FIGURES	xvii
LIST OF ANNEXURES.....	xx
LIST OF ABBREVIATION	xxi
Chapter I	1
Introduction	1
1.1 Background	1
1.2 What is E-Waste?	5
1.3 Quantum of e-waste	8
1.4 E-waste: A concern for developing countries	12
1.5 Sustainable management of e-waste	13
1.6 Circular Economy and E-waste	14
1.7 An estimation of e-waste:.....	17
1.8 Effects of e-waste on human health and environment	19
1.9 Statement of the Problem.....	21
1.10 Objectives of the study	21
1.11 Research Design	22

1.12	Research Method & Data Sources.....	22
1.13	Research Questions.....	22
1.14	Research Limitations	23
1.15	Sampling	23
1.16	Testing of Hypothesis	24
Chapter 2	.....	27
	Literature Review	27
2.1	Management of e-waste guidelines	37
2.2	Law and Policy	48
2.3	Management of E-Waste.....	50
2.4	International Policies and Regulations	57
2.5	Research Gaps in Literature	68
Chapter 3	.....	70
	Impact of E-waste on Health and Environment	70
3.1	Potential contaminants associated with E-waste	71
3.2	Pollutants in e-waste.....	72
3.3	Disposal of e-waste	74
3.4	Effect on health and environment	77
3.5	Hazards of e-waste due to informal sector in India	82
Chapter 4	.....	86
	Economic Benefits of e-waste Recycling.....	86
4.1	Source of Employment	86
4.2	Cost Minimization	87
4.3	Monetary Incentives	87
4.4	Resource Conservation.....	88

4.5	Energy Efficiency	88
4.6	Provides Good Business Opportunities	88
4.7	Scope of Research	89
4.8	Koh, Cucchiella, D'Adamo, and Paolo.....	89
4.9	Rare Earth Elements in e-waste	90
4.10	Economy in Recycling.....	92
4.11	The objectives of e-waste recycling.....	94
4.12	Recycling Chain	95
4.13	Benefits of recycling in reduction of GHG	97
4.14	Recycling in Developed versus Developing countries ...	99
4.15	Economics of E-waste in India.....	103
4.16	Challenges in recycling of e-waste	106
Chapter 5	.....	109
E-waste IN India	.....	109
5.1	Background and Regulatory Framework for e-waste in India 111	
5.2	What is EPR?	114
5.3	Agencies for implementation of e-waste management..	118
5.4	Non Government Organisations working in e-waste	119
5.5	Status of e-waste in India.....	122
5.6	Sources of e-waste	122
5.7	India and e-waste in cities	128
Chapter 6	.....	135
CASE STUDY OF NCR ON E-WASTE PROCESSES AND THEIR HANDLING: AN ANALYSIS	.....	135
6.1	Introduction.....	135

6.2	Factors that contribute to the thriving e-waste recycling business in Delhi and NCR.....	138
6.3	Good Practices in Delhi and NCR areas	138
6.4	A Survey for Consumers of Electronic Products.....	141
6.5	Testing of Hypothesis for Consumer Data through SPSS	156
6.6	A Survey for Dismantlers of E-waste	161
6.7	Testing of Hypothesis for Data on Dismantlers through SPSS	189
6.8	A Survey for Recyclers of E-waste	193
6.9	Testing of Hypothesis for Data on Recyclers through SPSS	216
6.10	A Survey for Bulk Consumers of Electronic Equipments	219
6.11	Testing of Hypothesis for Data on Bulk Consumers through SPSS	231
6.12	A Survey for Producers of Electronic Equipments	233
6.13	Testing of Hypothesis for Data on Producers through SPSS	255
Chapter 7	.....	257
Findings and Analysis	.....	257
7.1	Basis of Findings	257
7.2	Findings based on literature survey & secondary data ..	257
7.3	Implementation of e-waste Rules	262
7.4	An analysis of survey data	262
7.5	Analysis of survey done for dismantlers.....	264
7.6	Analysis of survey done for Recyclers.....	267
7.7	Analysis of survey of Bulk Consumers	268
7.8	Analysis for survey of producers.....	269

7.9	Analysis of Hypothesis Tested	271
7.10	Challenges faced in e-waste implementation	278
7.11	Issues arising in e -waste management	282
Chapter 8	.....	288
	Recommendations and Conclusion	288
8.1	Recommendations	288
	LIST OF References.....	297
	List of Bibliography	307
	LIST OF ANNEXURES.....	313

LIST OF TABLES

Table 1.1: Summary of selected e-waste definitions	5
Table 1.2: Classification of E-waste	6
Table 1.3: Hazardous E-wastes	20
 Table 3.1 Pollutants and their occurrence in e-waste	 73
 Table 6.1: Informal Recycling Locations in Delhi.....	 135
Table 6.2: Number of electronic products used by male and female consumer	143
Table 6.3: Consumer response when products are not working. .	144
Table 6.4: Consumer awareness about e-Waste	145
Table 6.5: Consumer awareness about e-Waste policy	146
Table 6.6: How consumer discard the electric products.	146
Table 6.7: Consumer awareness about harmful effects on Environment on e-waste	147
Table 6.8: Consumer knowledge about take back programme on electronic products	148
Table 6.9: Consumer knowledge about buyback scheme by seller of electronic products	149
Table 6.10: Whether consumers have availed of any buy back scheme.....	150
Table 6.11: Need for more awareness about e-waste.....	151
Table 6.12: Consumers as part of RWA.....	152
Table 6.13: Consumers desire for Government intervention.....	153
Table 6.14: Consumer survey on Health.....	154
Table 6.15: Consumer awareness about electronics products containing hazardous substances	155
Table 6.16: Consumers need for more awareness about health problems created by e-waste.....	156
Table 6.17: Awareness about e-waste.....	157
Table 6.18: Result of chi-square test performed on awareness of e-waste for Hypothesis 1.....	157
Table 6.19: Consumer awareness about harmful effects of e-waste on environment	158
Table 6.20: Result of chi-square test performed on awareness of harmful effects on e-waste for Hypothesis 2	159
Table 6.21: Consumer response for availing any buy back scheme.	160
Table 6.22: Result of chi-square test performed on response of consumers for availing any buy back scheme for Hypothesis 3...	160
Table 6.23: Number of days for which dismantler work in a year	170

Table 6.24: qualification of dismantlers and number of days for which they work in a year	170
Table 6.25: Whether dismantler use gloves	171
Table 6.26: Qualification wise dismantler using the gloves	171
Table 6.27: Dismantler using shoes while working.....	173
Table 6.28: Qualification wise dismantlers using shoes while working	173
Table 6.29: Dismantlers using mask while working.....	174
Table 6.30: Qualification wise dismantlers using mask while working	174
Table 6.31: Dismantlers status on periodic health check up	175
Table 6.32: Qualification wise dismantlers status on periodic health check up	175
Table 6.33: Status of dismantlers family working in the unit.....	176
Table 6.34: Status of qualification wise dismantlers family working in the unit	177
Table 6.35: Health diseases status of dismantlers	178
Table 6.36: Qualification wise health diseases status of dismantlers	178
Table 6.37: Status of dismantlers admitted to hospital.....	179
Table 6.38: Qualification wise status of dismantlers admitted to hospital.....	179
Table 6.39: Number of boards dismantled per day by the dismantler	180
Table 6.40: Qualification wise number of boards dismantled per day by the dismantler	180
Table 6.41: Number of dismantler using acids for dispensing off the e-waste	181
Table 6.42: Qualification wise number of dismantler using acids for disposing off the e-waste	182
Table 6.43: Waste disposal by dismantler.....	182
Table 6.44: Qualification wise waste disposal by dismantler.....	183
Table 6.45: Number of dismantler who get hurt while disposing the e-waste	185
Table 6.46: Qualification wise number of dismantler who get hurt while disposing the e-waste.....	185
Table 6.47: Number of children of dismantler working in the unit.....	186
Table 6.48: Qualification wise number of children of dismantler working in the unit	186
Table 6.49: Disposal of scrap by dismantler to others	187
Table 6.50: Qualification wise disposal of scrap by dismantler to others.....	187
Table 6.51: Whether dismantler felt safe while working	188
Table 6.52: Qualification wise safety felt by dismantler while working	188
Table 6.53: Whether dismantler felt safe while working	189

Table 6.54: Qualification wise safety felt by dismantler while working	189
Table 6.55: Result of chi-square test performed on response of dismantlers as to the safety factor while their working for Hypothesis 4	190
Table 6.56: Periodical health checkups done by dismantlers	191
Table 6.57: Qualification wise periodical health checkups done by dismantlers	191
Table 6.58: Result of chi-square test performed on response of dismantlers to the health checkups while working Hypothesis 5 .	192
Table 6.59: Recyclers obtaining environmental clearances from agencies	202
Table 6.60: Recyclers List of equipment, technologies and facilities at the plant	203
Table 6.61: Recycler's collection centres	204
Table 6.62: Minimum wages, etc. given by recyclers	205
Table 6.63: Good manufacturing practices done by recyclers	206
Table 6.64: Whether recycler have layout plan of good manufacturing practices	207
Table 6.65: Qualification of recycler employees.....	207
Table 6.66: Awareness programme for environment safe recycling of e-waste	208
Table 6.67: Whether noble metals are recycled or not.	209
Table 6.68: How the recycler manage the residues (Solid and Liquid) of your plant?.....	210
Table 6.69: Whether recycler have a DG Set	212
Table 6.70: Hhow recyclers do transportation	212
Table 6.71: Comfort level of recyclers in filling up a form which are to be filled periodically with the CPCB/SPCBs. Would you suggest any changes in the same? Please provide details.....	213
Table 6.72: Whether recycler has undergone R-2 certification....	214
Table 6.73: Whether recycler has any tie-up with producers as part of the EPR.	215
Table 6.74: Llinkage with whether recycler has any tie-up with producers as part of the EPR	215
Table 6.75: Recycler is comfortable with filling up a form	216
Table 6.76: Result of chi-square test performed on recyclers and their following regulatory norms for Hypothesis 6.....	216
Table 6.77: Recycler linkage with transportation of e-waste	218
Table 6.78: Result of chi-square test performed on recyclers and the transportation of e-waste for Hypothesis 7.....	218
Table 6.79: Registration of Bulk consumer with SPCB	221
Table 6.80: Range of Products used Bulk Consumers	222
Table 6.81: E-waste in opinion of Bulk Consumer	223
Table 6.82: E-waste in opinion of Bulk Consumers	224
Table 6.83: Opinion on e-waste Policy of Bulk Consumers	225

Table 6.84: How Bulk Consumers deal with discarded products..	226
Table 6.85: How Bulk consumers deal with discarded products ..	227
Table 6.86: Bulk consumers and take back program.....	228
Table 6.87: Take Back scheme availed.....	229
Table 6.88: Technical and Financial Evaluation carried out by Bulk consumers	230
Table 6.89: Broad criterion for choosing specific recycler.....	231
Table 6.90: Bulk consumers regulated with SPCB.....	232
Table 6.91: Chi Square test of hypothesis	232
Table 6.92: Showing registration of producers with SPCB.	236
Table 6.93: Producers having EPR Policy	237
Table 6.94: producers registered with SPCB having EPR Policy...	237
Table 6.95: Producer Policy for end of life products and policy on take back	238
Table 6.96: How producers deal with defective products	239
Table 6.97: Do producers have policy for end of life products. ...	240
Table 6.98: Producers using service of recyclers	241
Table 6.99: E-waste given to collection centres.....	243
Table 6.100: Documentary evidence of dismantled products.....	244
Table 6.101: Have producers established collection centres.....	245
Table 6.102: How producers motivate individual users.....	246
Table 6.103: How producers train & develop capacity building ...	248
Table 6.104: Do producers make a distinction between recyclers and dismantlers	249
Table 6.105: Do producers have a policy of RoHS	249
Table 6.106: Kind of GMP's followed by producers.....	250
Table 6.107: Impediments to implementation of EPR.....	251
Table 6.108: Feedback on E-waste Management Rules	252
Table 6.109: Kind of linkages you have with recyclers	254
Table 6.110: Kind of linkages with dealers and recyclers	255
Table 6.111: Chi Square test of Hypothesis 9	255

LIST OF FIGURES

Fig.2.1: E-waste Volume-I (Inventory Assessment Manual)	29
Fig.2.2: Different stakeholders involved in the E-waste flow	30
Fig.2.3: E-waste generated by Country (2016, total in Million Tons).....	57
Fig.3.1: Disposal of E-waste: Routes and Destinations	74
Fig.3.2: Informal Recycling hub in Moradabad	84
Fig.4.1: Recycling Chain	95
Fig.4.2: Comparative analysis of selected developing countries regarding the dimension of the formal and informal e-waste recycling sector.....	102
Fig.5.1: Implementation of EPR	113
Fig.5.2: Source of e-waste in India.....	122
Fig.5.3: Source of e-waste	123
Fig.5.4: City wise E-waste generation in India (% of total e-waste)	124
Fig.5.5: E-waste flow within India.....	126
Fig.5.6: State-wise E-waste Generation in India	129
Fig.6.1: Photos of informal recycling unit in Shastri Nagar, New Delhi during the visit to dismantling Areas.....	137
Fig.6.2: Photos of stacking done by informal recycling unit in Turkmaan Gate, New Delhi during the visit to recycling Areas....	139
Fig.6.3: Photos of stacking done by informal recycling unit in Mundka, New Delhi during the visit to recycling Areas.....	140
Fig.6.4: Chart showing gender segregation of consumer survey .	142
Fig.6.5: Graph showing number of electronics products used by the consumer	142
Fig.6.6: Showing details when products are not working	143
Fig.6.7: Awareness about e-waste.....	144
Fig.6.8: Percentage of people aware of e-policy.	145
Fig.6.9: How electrical products are disposed	146
Fig.6.10: Harmful effects of e-waste	147
Fig.6.11: Take back scheme of Electronic products	148
Fig.6.12: Buy back program of seller	149
Fig.6.13: Availment of buyback scheme	150
Fig.6.14: Need for awareness about e-waste	151
Fig.6.15: Consumer as part of RWA	152
Fig.6.16: Government need for more awareness	153
Fig.6.17: Electronic Products affecting health.....	154

Fig.6.18: Electronic products containing hazardous substances ..	155
Fig.6.19: Awareness about health problems	156
Fig.6.20: Dismantler at work, Seelampur, Delhi	162
Fig.6.21: Floppy Drive at dismantling site in Turkman Gate, Delhi	166
Fig.6.22: Loosely stacked e-waste at a dismantling site at Shastri Park, New Delhi.	167
Fig.6.23: Pie chart showing qualification	169
Fig.6.24: Number of days of employment for dismantlers.....	170
Fig.6.25: Use of safety products - gloves	171
Fig.6.26: Author with the dismantlers at dismantling site, Shastri Park, New Delhi	172
Fig.6.27: use of safety products-shoes.....	173
Fig.6.28: Use of safety products-masks	174
Fig.6.29: Periodical Health checkups.....	175
Fig.6.30: Family members working in a unit	176
Fig.6.31: Health Diseases status for Dismantlers.....	177
Fig.6.32: Admission to hospitals.....	179
Fig.6.33: Number of boards dismantled per day	180
Fig.6.34: Use of Acids for dismantling	181
Fig.6.35: Disposal of waste	182
Fig.6.36: E-waste stacks loosely kept at a dismantling site, Mundaka, Delhi	183
Fig.6.37: E-waste scrap at a dismantling site Turkeman Gate, Delhi	184
Fig.6.38: Number of Dismantlers who get hurt.....	185
Fig.6.39: Children of Dismantlers working	186
Fig.6.40: Selling waste scrap	187
Fig.6.41: Dismantlers feeling safe	188
Fig.6.42: E-waste (ATM's) arriving in a van at a Recycler site, Delhi	200
Fig.6.43: Qualification of Recyclers.....	201
Fig.6.44: Recyclers obtaining environmental clearance	202
Fig.6.45: Recyclers with S.S.I registration	203
Fig.6.46: List of equipment at a plant	203
Fig.6.47: Recyclers having collection centres	204
Fig.6.48: Minimum wages of Recyclers.....	205
Fig.6.49: Recyclers using GMP's	206
Fig.6.50: Layout plan supporting GMP's	207
Fig.6.51: Qualification of Recycler employees	207
Fig.6.52: Awareness program for safe Recycling	208
Fig.6.53: Recycling of Noble metals	209
Fig.6.54: Management of Residues	210
Fig.6.55: Waste thrown on open Municipal ground by a recycler, Delhi	211
Fig.6.56: Recyclers having D.G.sets	212

Fig.6.57: Transportation of e-wastes	212
Fig.6.58: Recyclers comfort with filling of forms	213
Fig.6.59: Recyclers undergone R-2 Certification	214
Fig.6.60: Recyclers tie up with producers for EPR	214
Fig.6.61: Linkages with recognized refurbishers	215
Fig.6.62: Qualifications of Bulk Consumers	220
Fig.6.63: Gender of Bulk Consumers.....	221
Fig.6.64: Bulk Consumers registered with SPCB	221
Fig.6.65: Products used by Bulk Consumers	222
Fig.6.66: Number of companies whose products are used	223
Fig.6.67: Categorisation of e-waste	224
Fig.6.68: Idea about EPR Policy	225
Fig.6.69: Deal with discarded products at the end of life stage...	226
Fig.6.70: Disposal of discarded products	227
Fig.6.71: Knowledge about take back program	228
Fig.6.72: Take back scheme of seller	229
Fig.6.73: Technical & Financial evaluation	230
Fig.6.74: Criterion for choosing specific recycler.....	231
Fig.6.75: Authorisation from SPCB	235
Fig.6.76: Problem faced while taking authorization	236
Fig.6.77: Do producer have an EPR policy	237
Fig.6.78: Do producer have any policy to back their end-of-life/discarded waster electroic products.....	238
Fig.6.79: Policy of defective products.....	239
Fig.6.80: Policy on Tack Back	240
Fig.6.81: using service of Recyclers / Dismantlers	241
Fig.6.82: E-waste given to collection centres-verification	242
Fig.6.83: Documentary evidence of products dismantled	244
Fig.6.84: Collection Centres established by producers.....	245
Fig.6.85: How do producers motivate users.....	246
Fig.6.86: Photo of e-waste with recyclers	247
Fig.6.87: How do producers do training.....	247
Fig.6.88: Distinction between producers and recyclers	248
Fig.6.89: Policy of RoHS.....	249
Fig.6.90: GMP's followed by producers	250
Fig.6.91: Impediments for implementation of EPR	251
Fig.6.92: Feedback on e-waste rules.....	252
Fig.6.93: Linkages with Recyclers.....	254

LIST OF ANNEXURES

Annexure – 1	News Item on use of e-waste for making medals	313
Annexure – 2	Categorization of e-waste	314
Annexure – 3	Quantity of metals present in mobile phones	316
Annexure – 4	Metal composition of e-waste	317
Annexure – 5	Hazardous Substances in e-Waste	318
Annexure – 6	E-Waste Generation per Year	320
Annexure – 7	E-Waste Generation	320
Annexure – 8	State wise quantity of e-waste	321
Annexure – 9	The State/UT wise details of authorized dismantlers/recyclers	322
Annexure – 10	A Survey for Consumers of Electronic Products	323
Annexure – 11	A Survey for Recyclers of e-waste	375
Annexure –12	A Survey for Dismantlers of e-waste	393
Annexure –13	A Survey for Bulk Consumers of Electronic Equipment;	415
Annexure –14	A Survey for Producers of Electronic Equipments;	428
Annexure – 15	Statistical Analysis of Consumers	449
Annexure – 16	Statistical Analysis of Recyclers	455
Annexure – 17	Statistical Analysis of Dismantlers	459
Annexure – 18	Statistical Analysis of Bulk Consumers	463
Annexure – 19	Statistical Analysis of Producers	465

LIST OF ABBREVIATION

ABLOS	Advisory Board on Laws of the Sea
ADB	Asian Development Bank
ADCP	Acoustic Doppler Current Profiler
ADLS	Automated Data Logging System
AIS	Automatic Identification System
ALH	Advanced Light Helicopter
AMHS	Admiralty Manual of Hydrographic Surveying
APEC	Asia-Pacific Economic Cooperation
ASV	Autonomous Surface Vehicles
ATG	Automatic Tide Gauge
AUV	Autonomous and Unmanned Vehicles
BIWTA	Bangladesh Inland Water Transport Authority
BNHD	Bangladesh Navy Hydrographic Department
BNHOC	Bangladesh Navy Hydrographic and Oceanographic Center
BNHS	Bangladesh Navy Hydrographic School
CATZOC	Category Zone of Confidence
CHS	Canadian Hydrographic Service
CHSVs	Catamaran Hull Survey Vessels
CLCS	Commission on the Limits of the Continental Shelf
CRZ	Coastal Regulatory Zone
CSB	Crowd Sourced Bathymetry
CSBWG	Crowd Sourced Bathymetry Working Group
CTD	Conductivity, Temperature, Depth sensor
CZM	Coastal Zone Management
DVL	Doppler Velocity Log
DGPS	Differential Global Positioning System
DCDB	Data Centre for Digital Bathymetry
DP	Dynamic Positioning

ECDIS	Electronic Chart Display and Information System
ENC	Electronic Navigation Chart
EEZ	Economic Exclusive Zone
GCC	Gulf Cooperation Council
GEBCO	General Bathymetric Chart of the Oceans
GIHS	General instructions for hydrographic surveyors of Admiralty
GMDSS	Global Maritime Distress and Safety Services
GoI	Government of India
GoM	Government of Mauritius
GPS	Global Positioning System
HADR	Humanitarian Aid and Disaster Relief
HDRTN	Hydrographic Department, Royal Thai Navy
HPD	Hydrography Product Database
HQAIs	Hydrographic Quality Assurance Instructions for Admiralty Surveys
HQIDS	Headquarters, Integrated Defence Staff
ICG	Indian Coast Guard
IDSA	Institute of Defence Studies and Analyses
IFMS	Interferometric sonar
IHB	International Hydrographic Bureau
IHO	International Hydrographic Organisation
IHPT	Portuguese Hydrographic Institute
I-MaGIC	Indonesian Marine Geospatial Information Center
IMO	International Maritime Organization
IN	Indian Navy
INAHINA	Mozambique National Institute of Hydrography and Navigation
INHC	Iranian National Hydrographic Committee
INHD	Indian Naval Hydrographic Department
INHO	Indian Naval Hydrographic Office

INHTT	Indian Naval Hydrographic Training Team
INS	Indian Naval Ship / Inertial Navigation Sysytem
INSPIRE	Innovation in Science Pursuit for Inspired Research
INT Charts	International Series Charts
IOC	Intergovernmental Oceanographic Commission
IONS	Indian Ocean Symposium
IOR	Indian Ocean Region
IRCC	Inter-Regional Coordinating Committee
ISV	Inshore Survey Vessel
ITEC	Indian Technical and Economic Cooperation
KHS	Kenya Hydrographic Service
KPA	Kenya Ports Authority
KPMG	Klynveld Peat Marwick Goerdeler
LABS	Laser Airborne Bathymetry
LADS	Laser Airborne Depth System (SBL) LBL
LBL	Long Base Line
LIDAR	Light Detection and Ranging
MBES	Multibeam echo sounders
MCPI	Ministry of Construction and Public Infrastructure
MCPPI	Maritime Capability Perspective Plan
MEA	Ministry of External Affairs.
MHS	Mauritius Hydrographic Service
MLHSSD	Ministry of Lands, Housing and Human Settlements Development
MN	Myanmar Navy
MNDF	Maldives National Defence Force
MNHC	Myanmar Naval Hydrographic Centre
MSD	Military Survey Department of UAE Armed Forces
MSDI	Marine Spatial Data Infrastruture
MSIS	Maritime Safety Information Services
MSP	Maritime Security Policy

NARA	National Aquatic Resources and Research Agency
NCWG	Nautical Cartography Working Group
NFT	National Flag Tonnage
NIH	National Institute of Hydrography
NIOHC	North Indian Ocean Hydrographic Commission
NIPWG	Nautical Information Provision Working Group
NOAA	National Oceanic and Atmospheric Administration
OJT	On job training
OSD	Overseas Deployment
PCA	Primary Charting Authority
PWC	Price Water House Cooper pvt Ltd
PWGCA	Permanent Working Group on Cooperation in Antarctica
QA/QC	Quality Assurance and Quality Check
RAN	Royal Australian Navy
RENC	Regional ENC Coordinating Centre
RHCs	Regional Hydrographic Commissions
RNO	Royal Navy of Oman
ROVs	Remotely operated Vehicles
SAIHC	Southern Africa and Island Hydrographic Commission
SANHO	South Africa National Hydrographic Office
SAR	Synthetic Aperture Sonar
SBES	Single Beam Echo Sounder
SBL	Short Base Line
SBS	Swath Bathymetric Systems
SCG	Seychelles Coast Guard
SDB	Satellite Derived Bathymetry
SHOALS	Scanning Hydrographic Operation Airborne
SLN	Sri Lanka Navy
SMEs	Subject Matter Experts

SMSA	Seychelles Maritime Safety Administration
SoK	Survey of Kenya
SOLAS	Safety of Life At Sea Convention
SONAR	sound navigation ranging
SPWG	Strategic Planning Working Group
SSS	Side Scan Sonar
SUMATRA	Surface and Marine Transport Regulatory Authority
SVP	Sound Velocity Profiler
THU	Total Horizontal Uncertainty
TMS	Tether management system
TPA	Tanzania Ports Authority
TQM	Total Quality Management'
TSS	Traffic Separation Scheme
TVU	Total Vertical Uncertainty
TWLCWG	Tides, Water Level and Currents Working Group
UKHO	United Kingdom Hydrographic Office
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USBL	Ultra Short Baseline
USI	United Services Institute
USV	Unmanned Surface Vehicles
WEND	World Electronic Chart Data Base



"A technological society has two choices. First, it can wait until catastrophic failures expose systemic deficiencies, distortions, and self-deceptions. Secondly, a culture can provide social checks and balances to correct for systemic distortion prior to catastrophic failures"

- Mahatma Gandhi

44th APPPA Training Program
A STUDY OF E-WASTE PROCESSES AND FACILITIES:
CASE STUDY OF NCR

- By Rajat Bhargava

Chapter **I**

INTRODUCTION

1.1 Background

Waste Electrical and Electronic Equipment or e-waste has attracted global attention since late 20th century. The electronics industry has also emerged as the fastest growing segment¹ of the Indian industry both in terms of production and exports. Liberalization and the opening up of Indian markets facilitated the growth of IT industry. According to the recent estimates made by the ***Manufacturers' Association of Information Technology (MAIT)***² the Indian PC industry is growing at a 25% compounded annual growth rate and India has emerged as the 5th largest electronic waste producer in the world.

¹ December, 2018. Growth Revenue from digital segment is expected to comprise 38 per cent of the forecasted. References: Media Reports, Press Information Bureau (PIB), Department of Industrial Ministry of Electronics and Information Technology, www.ibef.org

² MAIT, Set up in 1982, MAIT is the apex body representing India's ICT sector. MAIT is recognized by both the Government, as well as the industry, for its role in the growth and development of the IT Hardware industry. www.mait.com

The high rate of obsolescence of the electronic products is a major factor leading to increased generation of e-waste. E-waste comprises of all end-of-use electrical and electronic products such as computers, handheld cellular phones, personal stereos, including large household appliances such as refrigerators, air conditioners etc., which are not fit for their original intended use and are destined for recovery, recycling or disposal.

Currently, most of the electronic and electrical products at the end-of-use, are dealt with as electronics scrap/e-waste, find their way to scrap dealers from where they reach the dismantlers and recyclers in the informal sector. The informal recyclers are mushrooming in the peri-urban areas. The processes used in such operations are hazardous leading to major ***Environmental and Health problems***³.

These have been exponential changes as the electronic revolution has fast tracked e-governance bringing in a new era. The electronic age has made unprecedented impact on human society and spectacularly enhanced the connectivity across the globe. The Employment, Opportunities, Communication strategies and business environment has also benefitted from this e-revolution⁴. However, along with the benefits, it has created numerous challenges especially the disposal of e-waste. A number of studies have highlighted the environmental impacts of the fast growth which are having a detrimental effect on the society at large.

3 Environmental Health by David J. Robbins et al 2019, <https://ehjournal.biomedcentral.com/Articles>

4 ELECTRONIC WASTE MANAGEMENT IN INDIA-ISSUES AND STRATEGIES, January 2007, Kurian Joseph, Anna University, Chennai, www.researchgate.net

With increasing prosperity the depletion of resources is happening at an exponential rate, which has resulted in high consumption of resources. While the economic growth of a country is frequently linked with consumption and more consumption of materials, there is no talk of consumptive use. This has resulted in toxic pollution of resources and degradation of lands. There is a need to have sustainable development using more efficient method and effective utilisation of resources. This brings us to a bigger question of handling the e-waste in a scientific manner. There is a dire need to have consumptive use of our resource keeping in mind the future of our generation.

An area where international forums have gained momentum is disposal of **Electrical and Electronic Equipment (EEE)**⁵ the change of consumer face in usage of electronic items is posing significant challenges. The amount of this equipment reaching end-of-life called waste electrical and electronic equipment (WEEE) or e-waste poses a gigantic task as use frequently upgrade the electronic gadgets like computers, mobile phones, Television, Audio equipment, electrical gadgets, photocopiers, printers etc. There is a huge policy disconnect in disposal of the old gadgets. The electrical and electronics equipment having shorter lifecycle are part of rapidly developing newer technology the setting in discarding of obsolete technology and redundant manufacturing processes, increasing use of hazardous material resulted in higher production of e-waste.

5 Electrical and electronic equipment' or 'EEE' means equipment which is dependent on electric currents or electromagnetic fields to fulfill its basic function and to work properly.(www.eur-lex.europa.eu/legal-content/EN/TXT?uri=CELEX:32012L0019#ntr4-L_2012197EN.01003801-E0004)

The process of dismantling is an important stage in e-waste processing. It involves breaking of end-of-use equipment into its components and segregating them for the convenience of recycling. However, it does not end there, as some of the dismantlers also recycle the e-waste to recover the valuable materials like precious metals etc., which is creating a piquant situation. There is need for a comprehensive study into processes for recycling of e waste by studying disposal practices in a city and working out a suitable model for E-waste.



Fig.1.1: Cartoon on increasing pace of e-waste

Source: Donation of Electronic waste/Old Electronic items for Reuse or Recycling, www.greenciti.org

However it is seen that In India recycling of e-waste is not undertaken to an adequate degree because of:

- Poor existing management practices
- Policy initiatives not being implemented in an appropriate way.
- Processes of e-waste handling, dismantling etc are unsafe/complicated and expensive.
- The acute problem of e-waste along with its policy level implications needs examination.

1.2 What is E-Waste?

E-waste is synonymously used with the term **Waste Electrical and Electronic Equipment (WEEE)**⁶ In the international literature (Gaidais, Angelakoglou and Aktsoylou, 2010). There are many definitions of WEEE / E-waste used in international forums. Some of the selected definitions are summarized in table below.

Table 1.1: Summary of selected e-waste definitions

Reference	Term-Definition
European Directive 2012/19/EU (www.eur-lex.europa.eu)	Waste electrical and electronic equipment (WEEE), including all components, subassemblies and consumables which are part of the product at the time of discarding". The Directive 75/442/EEC, Article I (a), defines as "waste" "any substance or object which the holder discards or is required to discard in compliance with the national legislative provisions.
Basel Action Network (www.ban.org)	E-waste includes a wide and developing range of electronic appliances ranging from large household appliances, such as refrigerators, air-conditioners, cell phones, stereo Systems and consumable electronic items to computers discarded by their users.
GEeD (www.oecd.org)	Any household appliance consuming electricity and reaching its life cycle end.
Solving the E-waste Problem (StEP) (www.step-initiative.org)	"E-Waste is a term used to cover items of all types of electrical and electronic equipment (EEE) and its parts that have been discarded by the owner as waste without the intention of re-use."

⁶ **Electrical and electronic equipment (EEE)** is regulated to reduce the amount of **waste electrical and electronic equipment (WEEE)** incinerated or sent to landfill sites. The Waste Electrical and Electronic Equipment Regulations 2013 (as amended) is the underpinning UK legislation. Jan 8, 2018

E-waste (Management and Handling) Rules, 2011, India (E-waste rules, 2011)

E-waste means waste electrical and electronic equipment, whole or in part or rejects from their manufacturing and repair process, which are intended to be discarded."

Based on the types of EEE (electrical and electronic equipment), the WEEE can be classified broadly into the 10 different categories as defined in EU directives **(Directive 2012/19/EU)** (see **Table 1.2**).

Table 1.2: Classification of E-waste

No	Category	Label
1	Large household appliances	Large HA
2	Small household appliances	Small HA
3	IT and telecommunication equipment	ICT
4	Consumer Equipment	CE
5	Lighting equipment	Lighting
6	Electrical and electronic tools (with the exception of large-scale stationary industrial tools)	E&E tools
7	Toys, leisure and sports equipment	Toys
8	Medical devices	Medical devices
9	Monitoring & control instruments	M&c
10	Automatic dispensers	Dispensers

Source: EU Directive 2012/19/EC, www.eur-lex.europa.eu/legal



Fig.1.2: Source: Electronic Waste Disposal: An Environmental concern in India, 2016 (www.thepontychadhaoundation.org/environment/electricwaste)

For each category, its function, weight, size, material composition differ. These end of- life attributes determine different waste quantities, economic values, as well as potential environmental and health impacts due to inappropriate cycling **(Robinson, 2009)**. Robinson has also mentioned that "The contribution of an item to the annual E-waste production, E (kg/year) depends on the mass of the item, M (Kg), the number of units in service, N , and its average lifespan, L (years), $E=MN/L$

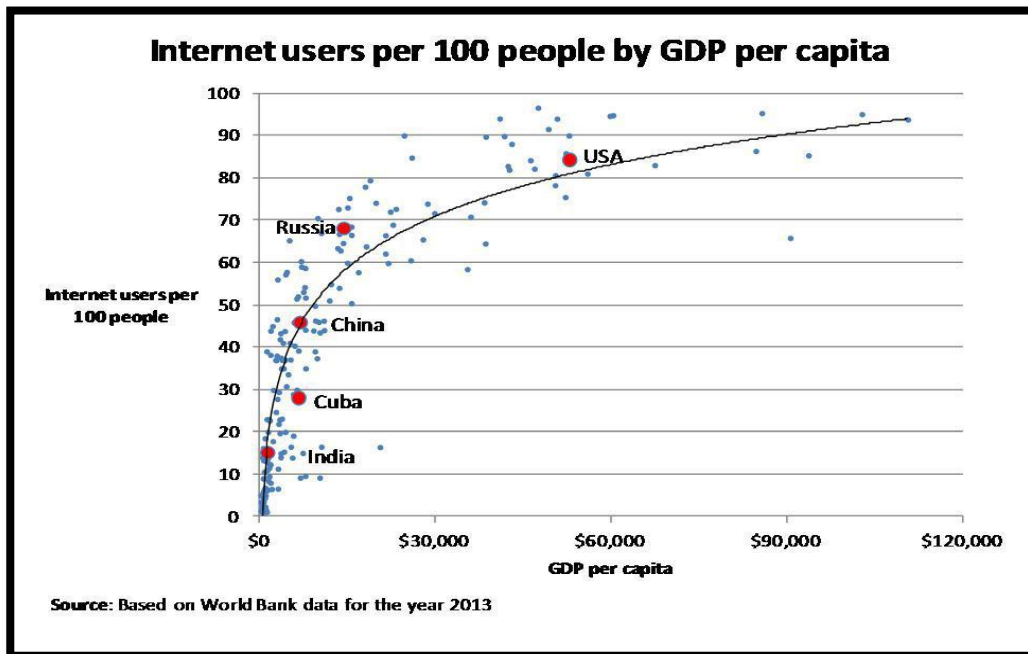


Fig.1.3: Sources: World Bank, 2013.

E-waste differs chemically and physically from urban or industrial waste. E-waste toxic constituents such as lead, cadmium, mercury, polychlorinated bi-phenyls, asbestos, nickel etc. and also recoverable metals like gold, silver, platinum, copper, aluminium, iron, plastics and glass etc. Thus e-waste contains both dangerous and valuable materials requiring special treatment and recycling practices to avoid, adverse environmental impact and harmful impact on human health. E-waste in its non-dispersed form is not a threat to environment but any attempt to recover useful material from dismantled/dispersed e-waste. Without having environmentally sound recycling/processing facilities processing of e-waste adversely affects human health and environment both.

1.3 Quantum of e-waste

E-waste is growing exponentially because global consumer demand continues to increase for newer technologies. The scale of problem is increasing as the quantities of e-waste produced

worldwide are very large and constantly growing. As many parts of expanding world cross over to the other side of the “digital divide” the contemporary consumer demands the means to enjoy more comfortable and high consumption lifestyle in the ***Digital Democracy***⁷.

But it is difficult to quantify e-waste amounts as much of the planet's e-waste is unaccounted for. Moreover, the types of e-waste included in government initiated policies and collection programmes vary from country to country. Under the current version of the WEEE Directive, the EU has 10 distinct product categories, whereas in North America it is typically limited to Information and Communications Technology (ICT) products and televisions and in Japan to 'four product categories including TVs, air conditioners, refrigerators and washing machines ***(Robinson, 2009); Balde, Wang, Kuehr, Huisman, 2015*** in the report titled ***'The Global e-waste monitor-2014'*** have explained how the estimation of e-waste data is done by using empirical data relating to sales, lifetime span etc. by applying the "Sales - Lifespan Distribution" method.

The global production of e-waste changes as economies grow and new technologies are developed. For any given country, the total number of computers and other potential e-waste items is strongly correlated with the country's GDP, because electrical and electronic items are essential for the functioning of all economies. The supposition that economic growth results in more e-waste production is supported by Figure showing the total number of

7 With a whopping 3 million tons of e-waste production to be generated by the end 2018, Cerebra Green launches the 'India Clean Up Week' across 7 cities in India from the 13th to the 19th October, 2018, www.businessworld.in

computers per country as a function of that country's GDP
(Robinson, 2009).

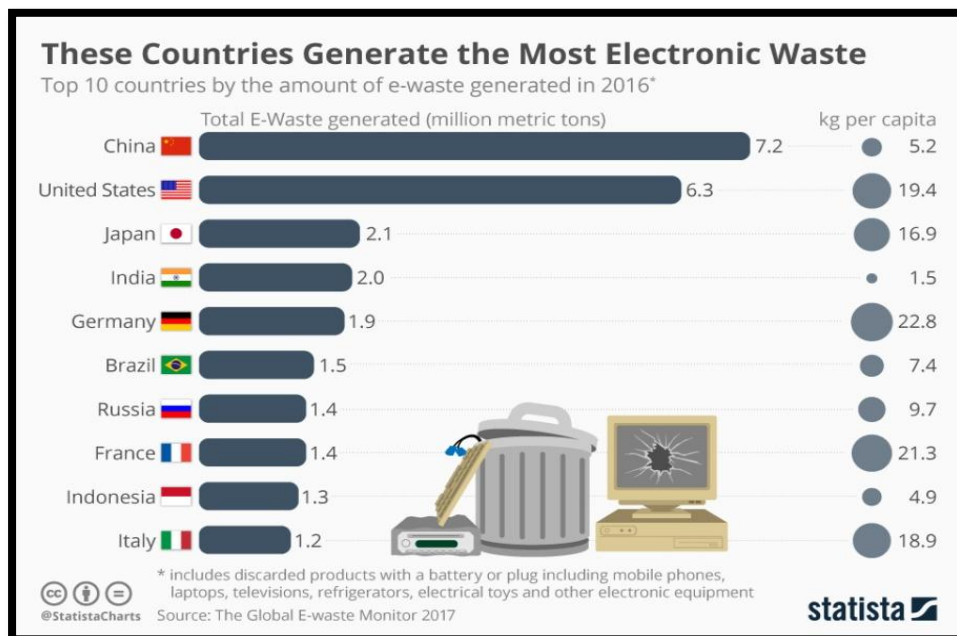


Fig.1.4: Countries generating electronic waste.
 Source: The Global E-waste Monitor, 2017.

Changes in technology greatly affect the global mass of e-waste produced. Short innovation cycles of hardware lead to a high turnover of devices and hence e-waste.

Blade et al (2015) in 'The Global e-waste monitor-2014' estimated the total amount e-waste generated in 2014 as 41.5 million metric tonnes (Mt) and it has been forecasted that this amount will increase to 50 Mt of e-waste in 2018. According to UNEP (2009) report titled 'Recycling from E-waste to resources', e-waste is one of the world's fastest-growing waste streams. The United Nations Environment Programme (UNEP)⁸ describes mobile phone circuit boards an 'unprecedented tsunami of electronic

8 **UNEP**, International Program, Organization Established in 1972 written by Karen Mingst, www.britannica.com

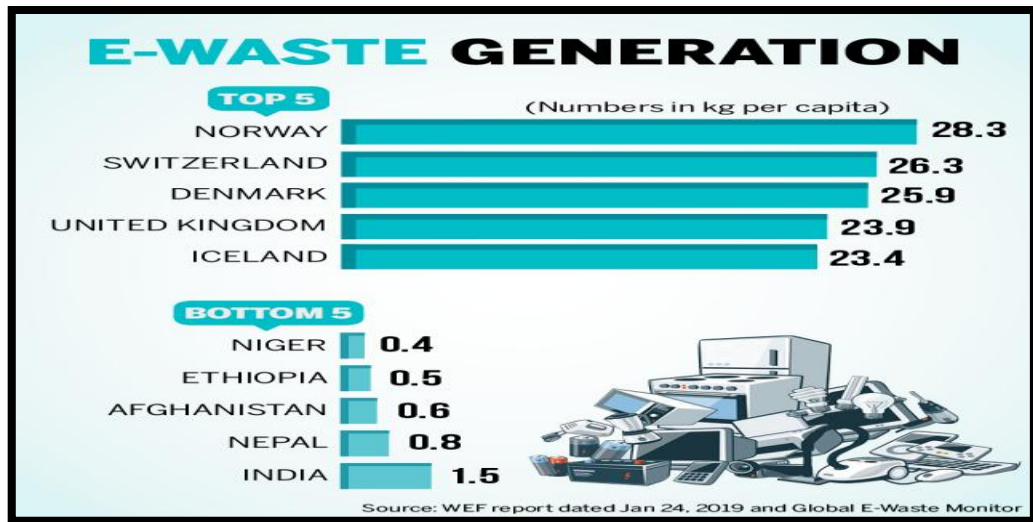
waste'. The US-EPA (United States Environmental Protection Agency⁹) has estimated a 5% to 10% global increase in the generation of e-waste each year. ([www.step-initiative.org/initiative/what is E-waste.html](http://www.step-initiative.org/initiative/what%20is%20E-waste.html)).

As per the **WEF report dated 24th January 2019** E-waste has touched 48.5m tonnes in 2018 with Norway and Switzerland as top producers. E-waste is worth \$62.5bn annually, which is more than the GDP of most nations.



Fig.1.5: E-waste Generation

9 **The Environmental Protection Agency (EPA)** is an independent agency of the United States federal government for environmental protection. It has the responsibility of maintaining and enforcing national standards under a variety of environmental laws, in consultation with state, tribal, and local governments.
www.epa.gov



Source: WEF report dated 24th January, 2019 and Global Economic Monitor.

Another factor which make the accounting of e-waste difficult globally is illegal shipment to developing countries, like China and India; Domestic 'informal' processing centres which do not maintain record of e-waste handled; as well as the e-waste that remains in the sheds, attics and storage rooms of the owners is a crucial factor which makes accounting very difficult.

1.4 E-waste: A concern for developing countries

One of a big global concern at present is appropriate handling of e-waste because of the nature of production and disposal of e-waste in a globalized world. The large volumes of such waste end up in places where processing occurs at a very rudimentary level like developing countries where these wastes are dumped in abundance. The developing countries like China, India have two sources of e-waste; one that is internally generated and the other that is internationally dumped (***The end of life product by the developed countries dumped in developing***

***countries*¹⁰**). This raises concerns about resource efficiency as also the immediate concerns of the dangers to human's beings and the environment in these countries.

Thus developing countries are known to bear the largest e-waste burden. Often ill equipped to treat e-waste efficiently, these countries face grove consequences as a result of adverse effects of e-waste. The environment and the health of citizens suffer. An analysis of the environmental implications of e-waste and its effects on human health identifies the factors to be considered when designing policy and regulation in the Government. The Management of e-waste, by ensuring sustainable consumption, and a healthy environment are urgent challenges for the developing countries. The general principles of e-waste management, including relevant processes and technologies as well an overview of policies, strategies and regulatory frameworks should be effective by done to in promote environmentally sustainable management of e-waste in the developing countries .

1.5 Sustainable management of e-waste

Waste management is vital to the healthy functioning of a society and so is the e-waste .management. Improper waste management has negative effects on individual health, and similarly it also negatively impacts environmental health. Positive waste management systems, however, can prevent the negative impacts that a waste has on the environment. Recycling, or reusing materials that have already been used once, is an environmentally friendly way of utilizing waste. Thus 3Rs i.e.

10 Toxic 'e-waste' dumped in poor nations, says United Nations by The Guardian Global Development/The observer Recycling/waste/news, www.theguardian.com

Reduce (to the extent Possible), Reuse and Recycle are the key words in the management of waste.

A core principal of sustainable development is the production of goods and services in ways that mimic natural processes, where energy is derived from renewable sources and 'waste' is simply raw material for another product or service. The concept of 'cradle-to-cradle' production, a phrase invented by **walter R. Stahel in the 1970s** and popularized by **William McDonough and Michael Braungart in 2002**, seeks to create a holistic economic, industrial and social framework that is not only efficient but also essentially waste free. It implies that anything at the end of its useful life is remade into the same thing, or something similar (**www.sustainabilitydictionary.com/cradle-to-cradle**). As the concept is applied to information and communication technologies, it is found that many products/equipments can be recycled for basic components, particularly metals like ferrous, copper and aluminium or precious metals with positive benefits on raw materials extractions and energy demand.

1.6 Circular Economy and E-waste

Circular economy is a economy in which the resources are kept in use for as long as possible, extract the maximum value from them whilst in use, then recover and regenerate products and materials at the end of each service life. A circular economy is an alternative to a traditional linear economy which emphasises on make, use and dispose. A circular economy aims at reducing waste and driving greater resources productivity.

Balde et al (2015) has reported in the **'The Global e-waste monitor-2014'** that the intrinsic materials value of global e-

waste is estimated to be 48 billion euro in 2014 dominated by the values of gold, copper and plastic contents.

While a circular economy in management of e-waste may reduce waste and help in driving the resource productivity besides reducing the environmental impacts, it may also lead to creation of new opportunities for growth and thus leading to sustainable development in the economy as a whole

(www.wrap.org.uk/content/wrap-and-circular-economy)

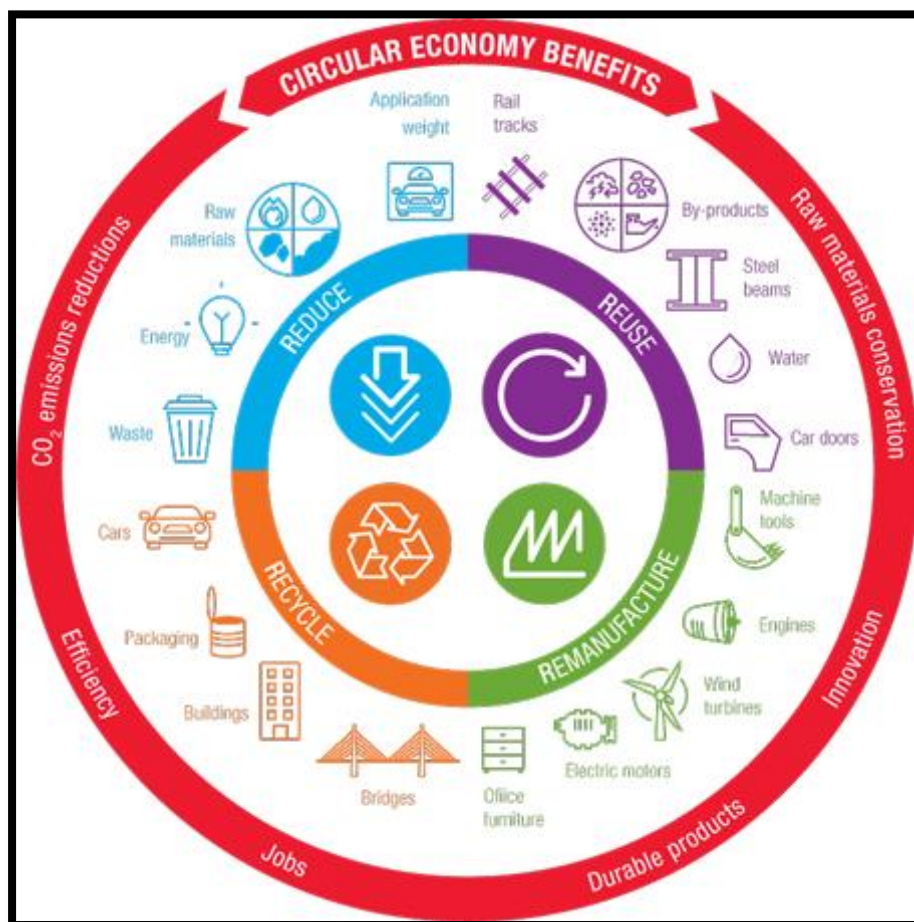


Fig.1.6: Circular Economy
Source: Business World, 4th March 2019

As per **Business World 2019**, globally systems for the management of E-Waste are addressed on the concept of the circular economy. According to the **Ellen Macarthur Foundation** the circular economy is restorative and regenerative by design. It

involves a lifecycle and closed loop approach and encourages innovation at the design stage of products to minimise waste and the negative impacts of material used. A circular economy approach relies on policy instruments that incentivise the manufacturers (producers) of electronics to take a life cycle approach to products past the factory gate, beyond the point of purchase and post the warranty period. The **Ellen Macarthur Foundation** further says that underpinned by a transition to renewable energy sources, the circular model builds economic, natural, and social capital. It is based on three principles:

- a) Design out waste and pollution
- b) Keep products and materials in use
- c) Regenerate natural systems

A common policy instrument applied is Extended Producer Responsibility (EPR) where producers pay for the costs associated with collecting, recycling and responsibly disposing products at the end of their life. EPR encourages design innovation to make it easier to recycle and dispose of products while minimizing social and financial costs to society as producers are able to integrate the costs associated with recycling without incurring any loss.

Producers will often rely on a **Producer Responsibility Organisation (PRO)**¹¹ to collect and dispose of waste on their behalf.

¹¹ Review of extended producer responsibility: A case study approach, Waste Management & Research written by Yamini Gupta et al, University of Delhi, July 2015, www.researchgate.net

1.7 An estimation of e-waste:

The exponential growth of internet users from 501 million in 2006 to over 1.3 billion at in 2011 in developing countries (**Krishna and Saha 2014**) indicates that the sale of computers and other terminals has grown at an exponential rate. It is seen that while in 2006, 44% internet users were in developing countries it increased to 62% in 2011. It is also to be noted that global Personal computer sales significantly increased from 170 million in 2000 to 370 million in 2010. The sales in 2014 reached 470 million units which are more than double in the last 10 years. Taking a case of India, it is estimated that approximately 1.42 million PCs get obsolete every year. ITU data release of June 2012 indicates that total number of mobile cellular subscriptions reached almost 6 billion by the end of 2011.



Fig.1.7: Export of E-waste
Source: Greenpeace, Basel Action Network

The report "**Recycling - from E-Waste to Resources**" issued at a meeting of the **Basel Convention** estimated that, by 2020 in China and South Africa, the e-waste from computers would

increase between 200% and 400% over 2007 figures and 500% in India. It was also estimated that by 2020 in India the amount of e-waste from mobile phones would be 18 times higher than the 2007 figures and 7 times higher in China. Basel Action Network stated that 50-80% of e-waste generated in USA is exported to India, China, Pakistan, Taiwan and African countries. **UNEP** estimates that e-waste is increasing by 40% per year worldwide and e-waste is the fastest-growing type of waste. Between 20 to 50 million metric tons of e-waste are generated worldwide every year, representing more than 5% of urban solid waste, particularly in some developing countries where the volume is expected to grow up to 500 percent over the next decade.



Fig.1.8: World Worst Electronic Waste Offenders
Source: Forbes Statistics



Fig.1.9: International Dumping of E-waste
Source: E-waste Dumping, 2015

In India, volume of e-waste is estimated to be 0.8 million tons in 2012. According to the **Controller and Auditor General's (CAG) report**, over 7.2 MT of industrial hazardous waste, 4 lakh tonnes of electronic waste, 1.5 MT of plastic waste, 1.7 MT of medical waste, 48 MT of municipal waste are generated in the country annually.

1.8 Effects of e-waste on human health and environment

E-waste is highly complex to handle because of its composition. It is made up of multiple components some of which contain toxic substances that have an adverse impact on human health and environment if not handled properly that is if improper recycling and disposal methods are deployed. So there is a need for appropriate technology for handling and disposal of these chemicals. **Basel Convention** characterizes e-waste as hazardous when they contain and are contaminated with mercury, lead, cadmium, polychlorinated biphenyl etc. Wastes containing insulation or metal cables coated with plastics contaminated with or containing

lead, coal tar, cadmium, **Poly chlorinated Biphenyl (PCB)** etc are also characterized as hazardous wastes. Also precious metal ash from printed circuit boards, glass waste from cathode-ray tubes, LCD screens and other activated glasses are classified as hazardous wastes. Effects of some of the prime hazardous components in of e-waste are mentioned below: **(See Table 1.3)**

Table 1.3: Hazardous E-wastes

S. No.	Hazardous Components	Effect of Hazardous components of e-waste
1	Arsenic	Can affect skin and can decrease nerve conduction velocity. Chronic exposure to arsenic may cause lung cancer and sometimes be fatal.
2	Lead	May affect kidneys, reproductive systems, and nervous connections. May cause blood and brain disorders, sometimes may be fatal.
3	Barium	Can affect heart muscle.
4	Chromium	Can damage liver, kidneys and may cause asthmatic bronchitis and lung cancer.
5	Beryllium	May cause lung diseases.
6	Mercury	Affects the central nervous system, kidneys and immune system, it impairs foetus growth. May cause brain or liver damage.
7	Cadmium	May cause severe pain in the joints and spine. It affects the kidneys and softens bones.
8	BFR (Brominated flame retardants)	Can harm reproductive and immune systems, may cause Hormonal disorder.
9	Chlorofluorocarbon (CFC)	May affect the ozone layer. It may cause skin cancer in human and genetic damage in organisms.
10	Polychlorinated Biphenyl (PCB)	May cause cancer in animals, can affect the immune system, reproductive system, nervous system, endocrine system. PCBs persistently contaminate in the environment and cause severe damage.
11	Polyvinyl Chloride (PVC)	PVC contains upto 56% chlorine and when burnt, produces Hydrogen chloride gas which in turn produces hydrochloric acid that is dangerous to respiratory system.
12	Dioxin	These are highly toxic to animals and can lead to malfunction of foetus, decreased reproduction and growth rates, affect immune system.

Source: Ramkrishna and Saha (2014)

1.9 Statement of the Problem

The study would project an overview of state-of-the-art e-waste practice through literature review and study of best practices, examine existing guidelines and work done and do a critical analysis of e-waste Management of a city.

The following problem statement needs to be addressed:

- Typical constraints of e-waste projects
- e-waste classification difficult to understand for general public/lay man
- The current industry practice as well as research advancement in e-waste is limited
- e-waste practices of Delhi-NCR region poorly highlighted

1.10 Objectives of the study

The broad objective of the study is to develop a framework of formalized e-waste Management system. It aims at providing a comprehensive review of relevant literatures and industry practices in relation to constraint analysis and outlines an operative framework for effective e-waste Management. The specific objectives of the study are as under:

- a) To provide a comprehensive review of sources and characteristics of e-waste;
- b) To develop a classification for easier identification and modeling;
- c) To study current industry practices;
- d) To study researches with special reference to e-waste and its impact on health & environment, and;
- e) To outline a scholastic framework for total e-waste Management of a city.

1.11 Research Design

Descriptive and causal, as the intention is to explain the current status of risk assessment within the existing e-waste management guidelines along with selected parameters, analyze the indicators based findings and validate them within the framework of the existing Act.

1.12 Research Method & Data Sources

Study based on both Primary and Secondary sources.

Primary source based on:

Survey: Questionnaire to be administered on the Select producers recyclers; Consumers and dismantlers

Interviews with some producers both State as well as Central level; industry representatives and researchers.

Secondary source based on:

Case Studies of few countries

literature survey of relevant Books; academic papers; reports; newspaper & magazine articles; and different government documents on the subject

1.13 Research Questions

Q1. What is e-waste and what are its impact on the health and environment?

Q2. What is the way through which India is currently managing its e-waste?

Q3. Are the steps sufficient for the management of the e-waste?

Q4. What are the possible gaps that are required to be filled up for efficient and sustainable management of e-waste?

1.14 Research Limitations

Several limitations of the research process are anticipated. These limitations are as follows:

- a) Information and data on e-waste is very limited in Public domain.
- b) Availability of policy makers and key stake holders for interview is limited.
- c) Limited availability of cross country data.
- d) E-waste is a relatively new phenomenon.

1.15 Sampling

Following have been kept in mind while ensuring a good representative sample:

- (a) That the sample data should be Truly representative
 - (b) That the sample data should be Avoid system bias
 - (c) That the sample data has a small sampling error
- For the producers and recyclers – the number being small entire universe is kept as the sample i.e. 10 producers and 25 recyclers.
 - For Bulk consumers, data from 25 bulk consumers was collected.
 - To select dismantlers it is proposed to have the entire universe of recyclers from which **Purposive sampling** technique to select 05 recyclers who are dismantling entire range of e-waste.

- These 5 recyclers together have a universe of 512 dismantlers working as follows:-

Industry wise population as per record is given below:-

S.No.	Industry	Population of workers	Sample size selected
1	Recycler 01	115	22
2	Recycler 02	102	21
3	Recycler 03	89	17
4	Recycler 04	121	22
5	Recycler 05	85	17
Total		512	94

Thus above mentioned population has been considered for the study to get the effective feedback of respondents in determining the size of the sample. Following has therefore been considered:

1. At what level of confidence the results have to be tested.
2. Degree of accuracy of the estimation of parameters using statistical tool; ensuring confidence level of 90%, with less than 10% margin of error, a sample size of 94 for the study has been arrived at.
3. It is proposed to do sampling from existing consumer of electronic users since the universe is very large; a stratified random sample of 500 numbers is proposed from amongst consumers.

1.16 Testing of Hypothesis

Null Hypothesis 1

H₀ Consumers are not aware about E-waste.

H₁ Consumers are aware about E-waste.

Null Hypothesis 2

Ho Consumers are not aware about harmful effects of E-waste.

H1 Consumers are aware about harmful effects of E-waste.

Null Hypothesis 3

Ho Consumers are not aware of buy back scheme under EPA.

H1 Consumers are aware of buy back scheme under EPA.

Null Hypothesis 4

Ho Dismantlers do not face any safety issues.

H1 Dismantlers have safety issues.

Null Hypothesis 5

Ho Dismantlers do not have periodicals health checks-ups.

H1 Dismantlers have periodicals health check-ups.

Null Hypothesis 6

Ho Recyclers do not comply with statutory regulation of E-waste Management Rule, 2011.

H1 Recyclers comply with statutory regulation of E-waste Management Rule, 2011.

Null Hypothesis 7

Ho Recyclers do not do safe transportation of E-waste.

H1 Recyclers do safe transportation of E-waste.

Null Hypothesis 8

H₀ Bulk consumers are not registered with pollution/environmental regulatory Agency.

H₁ Bulk consumers are registered with pollution/environmental regulatory Agency.

Null Hypothesis 9

H₀ Producers do not have direct access to recyclers and dismantlers for implementation of EPR.

H₁ Producers have direct access to recyclers and dismantlers for implementation of EPR.

Chapter 2

LITERATURE REVIEW

Literature on e-waste has been limited and has been largely driven by consideration of environmental sustenance and recycling. Not many national level surveys have happened in either developed and developing economies.

However, recent studies of e-waste in India have been correlated by **Harshini Vakkalanka 2018 (*The Hindu*, 18th June, 2018)** in an article on "A-2 of e-waste Management in India"

The ***Business world*, 4th March 2019** carried a lead story on "E-waste in India highlighting that India will consume \$ 400b worth of Electronic goods by 2020, generating a huge growth in end of life products while the e-waste can setup huge environmental and health hazards.

2019 has surprisingly been a year of literacy articles on e-waste. At the India international e-waste exposition, 2019 at Bangalore between 28th February to 1st March 2019, a number of companies showed their interest in e-waste recycling in India (***[www.recycling_magazine.com/India institutional e-waste](http://www.recycling_magazine.com/India_institutional_e-waste) 2019***). There have been both a mix of positive and negative impacts of recycling within India.

A social story in Think ***Change India dated 26th February 2019*** writes about a 60 year old differently abled man from Gujarat

recycle e-waste to build bikes **([yourstory.com/social story/2019/02 "60 Years old builds e-bike from e-waste](https://yourstory.com/social-story/2019/02/60-Years-old-builds-e-bike-from-e-waste))**.

Miles Parl (February 2019) has extensively worked on the condition of recycling workers in India and their appalling state (**([the conversation.com/electronic waste-is-recycle in appalling conditions in India – 110063](https://theconversation.com/electronic-waste-is-recycle-in-appalling-conditions-in-india-110063))**). He mentions about the need for change and imbibing newer and safer technologies.

Dinesh Raj Bandela (2018) in a blog on Down to Earth magazine mentions that 82% of India's e-waste comes from personal devices.

Snehal Famandris (2018) writing in Hindustan times speaks about e-waste releasing toxic chemicals into soil in India's metro's.

Sapna Mishra, et al, 2017 have covered wide areas in exposing the awareness regarding E-waste.

The Basel Convention on the control of Transboundary Movements of Hazardous Waste and their disposal (UNEP, Geneva, Switzerland) defines wastes as substances or objects which are disposed of as per National laws.

The report of CAG¹² (2008) on performance Audit of **"Management of wastes in India" Report no PA 14 of 2008,** **www.cag.gov.in** further dwelt on category of wastes including categorizing them into sources of waste like end of vehicles, packing waste, agricultural waste etc.

¹² Controller and Audit General of India (CAG) of Management of Waste in India, 2008 www.cag.gov.in

It is seen that the distinction between e-waste and WEEE has become less sharp due to the advent of pervasive computing (**Kohler and Erdmann, 2004**) as programmable microprocessors were incorporated into latest electrical equipments such as refrigerators, etc. (**Hilty, 2005**).

The rapid growth and short life cycle of computing devices drew attention of (**Ladou and Lovegrove, 2008**).

UNEP (2007) in its report on "E-waste Volume-I (Inventory Assessment Manual) has applied the 'Four – Phase – Model' approach in "Life cycle" of electrical and electronic equipment (**see figure 2.1**) where each phase describes respective unit operations and different stakeholders.

Phase I	Production / Sales
Phase II	Consumption
Phase III	Generation / Collection
Phase IV	Treatment / Disposal

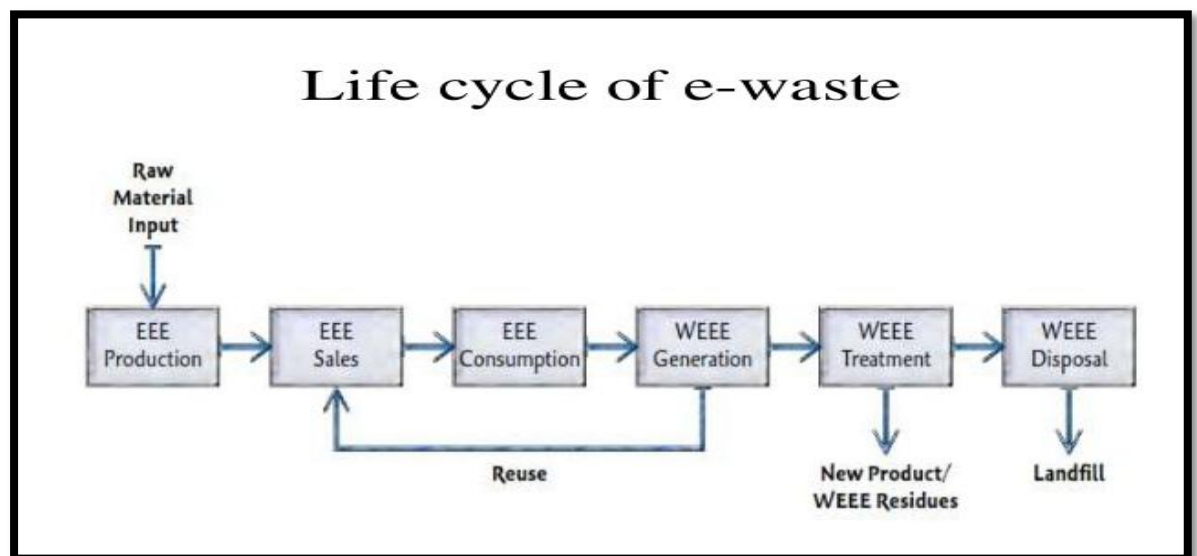


Fig.2.1: E-waste Volume-I (Inventory Assessment Manual)
Source: UNEP, 2007)

UNEP (2007) report has also examined some of the key stakeholders involved in each phase of the life cycle of e-waste, (Figure 2.2). It is noticed that flow, e-waste gets generated in at each and every level.

Phase I	Manufactures/ Importers/retailers
Phase II	Consumers, Households, Commercial places, Business houses, Industry
Phase III	Importers, Traders like Collectors, Scrap dealers
Phase IV	Dismantlers, Smelters, Recyclers

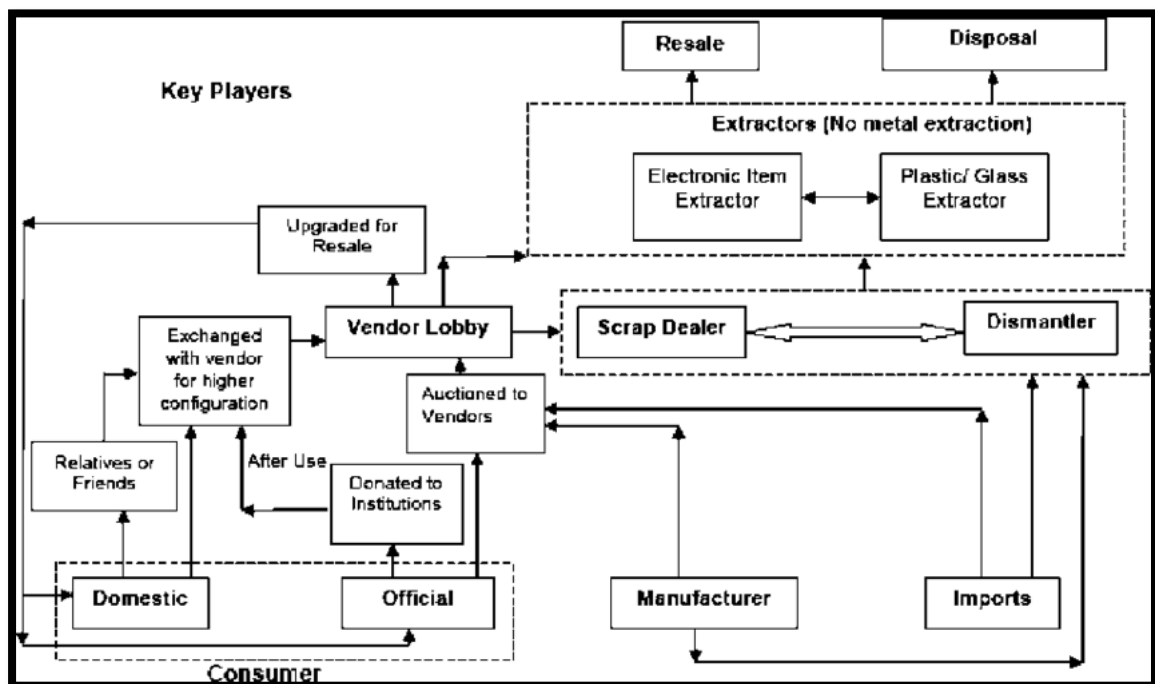


Fig.2.2: Different stakeholders involved in the E-waste flow
(Source: Borthakur et al, 2012)

UNEP (2007) drew attention to the average life cycle / obsolescence rate of electronic goods which has been defined as the time span after which the electrical and electronic item comes to its "end of life". It can be clearly seen that, it has been depicted as:

Average life cycle/Obsolescence rate = Active Life + Passive Life + Storage

Whereas,

- Active life is the number of years, a machine can be effectively used,
- Passive life is the time period for which it can be refurbished or reused, and
- Storage includes storage time before disposal and storage at repair shops before dismantling.

The UNEP (2007) report further adds that in developed countries, average life cycle of electrical and electronic equipment is generally equivalent to "Active Life", while in developing countries, it is a sum of active life, passive life and storage. Therefore, in developing countries like India, a second hand market exists for e-waste after its active life. However all the three parameters vary differently in different geographical regions which lead to different WEEE / E-waste inventory?

Sunil Kumar, Stephen R Smith et al (2018) in an auto clean Royal Society wrote about waste management in India and its impact on health and environment.

Abhishek Kumar Awasthi, Mengweng Weng and others (2018) have attempted a review of e-waste management in Indian context. They have stressed on need for more focus on e-waste and environmentally sound management.

The countries of the **European Union (EU)** and other developed countries to an extent have addressed the issue of e-waste by taking policy initiatives and by adopting scientific methods of recycling and disposal of such waste. The **EU** defines this new waste stream as **'Waste Electrical and Electronic Equipment' (WEEE)**. As per its directive, the main features of the WEEE include definition of 'EEE', its classification into 10 categories and its extent as per voltage rating of 1000 volts for alternating current and 1500

volts for direct current. The EEE has been further classified into 'components', 'sub-assemblies' and 'consumables'. Since there is no definition of the WEEE in the environmental regulations in India, it is simply called 'e-waste'. E-waste or electronic waste, therefore, broadly describes loosely discarded, surplus, obsolete, broken, electrical or electronic devices.

Between 2008 to 2010 a number of Indian authors have dwelt on rules of e-waste and related them to their global problem. Further **"e-waste Caring a scare"** highlighted the depth of the problem in the social realm.

Amit Jain (2008) has written extensively on composition of e-waste "Global-e-waste growth in **Rakesh Jain's** edited book-"e-waste, implications, regulations and management in India and current global practices, (TERI, 2008).

A news item in 2009 in **The Hindu Newspaper** (20th December 2009) on **"Rules in e-waste Management"** by March is forth coming on rules being enforced at an early date. This was followed by an article in times of India on 24th April 2010 by **Neha Lalchandani on "e-scare"**. This article is critical of the processes being followed in e-waste disposal and calls for distinction between "hazardous" and "non-hazardous" elements. It also dwells on the need for safe disposal guidelines. In 2006, the **International Association of Electronics Recyclers (IAER)** projected that 3 billion electronic and electrical appliances would become WEEE or e-waste by 2010. The IAER was acquired by the Institute of Scrap Recycling Industries, Inc. (ISRI) in January 2009. ISRI, based in Washington D.C., USA, which is the voice of the scrap recycling industry, an association of companies that process, broker and consume scrap commodities.

A **UNEP** press release of 27th 2006 was categorical as it addressed challenges related to e-waste.

Ravi Agarwal (2010) in an article in the Hindustan Times on 4th May 2010 has quoted CAG report on amount of e-waste produced in the country. However, no official data exists on how much e-waste is generated and disposed off. There are some studies done by NGO's which do give estimations of the amount of e-waste generated.

Sandeep Joshi in his article in the Hindu "Grooming e-waste is causing concern "(Published on 28th February 2009)" had stressed on the urgency to treat e-waste and safe recycling.

In a report by **ELCINA in 2009** (Electronics Industry Association of India, a estimate of e-waste generated in India was done. Another article during the period by **Moushari Basen (2010)** on "New-e waste Management plan lucrative for states in The Pioneer on 18th May 2010 quotes CPCB's estimates of 8 lakhs tones in 2010.

Sanjay Jog (2008) wrote on "Ten States contribute 70% of e-waste in India" in the Financial Express. There are 10 States that contribute to 70 per cent of the total e-waste generated in the country, while 65 cities generate more than 60 per cent of the total e-waste in India. Among the 10 largest e-wastes generating States, Maharashtra ranks first followed by Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab. Among the top ten cities generating e-waste, Mumbai ranks first followed by Delhi, Bengaluru, Chennai, Kolkata, Ahmedabad, Hyderabad, Pune, Surat and Nagpur.

This is substantiated by a similar article by **Satish Sinha** (2007) on downside of Digital Revolution. (www.toxcislink.org) An **Indian market Research Bureau (IMRB)** survey of 'E-waste generation at Source' in 2009 found that out of the total e-waste volume in India, televisions and desktops including servers comprised 68 per cent and 27 per cent respectively. Imports and mobile phones comprised of 2 per cent and 1 per cent respectively.

The Cobalt-60 radiation tragedy at Mayapuri in Delhi in which one person lost his life and six persons were admitted to hospital served as a wakeup call drawing attention to the mounting quantity of hazardous waste including e-waste. **(Mayapuri: Disaster protocol not clear Times of India, May 2010)**

In the meanwhile **MoEF** notified the Hazardous wastes management handling Rules, 2008.

Schwazer S, A.D Bono et al (2005) mentioned that around 50 millions MT of e-waste is generated every year. A report of the United Nations predicted that by 2020, e-waste from old computers would jump by 400 per cent on 2007 levels in China and by 500 per cent in India. Additionally, e-waste from discarded mobile phones would be about seven times higher than 2007 levels and, in India. 18 times higher by 2020. According to the **UN Under-Secretary General Achim Steiner**, China, India, Brazil, Mexico and others would face rising environmental damage and health problems if e-waste recycling is left to the vagaries of the informal sector.

Satish Sinha (2008) in his article "Dark Shadows of digitization on Indian horizon" in **Rakesh Joshi's book**, e-waste; implications regulation and management in India...." (TERI pg 27) mentions the changing face of life, rapid urbanization and purchasing capacity of middle class of explosion of e-waste. This

has been compounded by change in consumptive pattern in the society.

Quantity of WEEE (Waste Electrical and Electronic Equipment) generated in Indian States

State / UT	WEEE (tones)
Andaman and Nicobar Islands	92.2
Andhra Pradesh	12780.3
Arunachal Pradesh	131.7
Assam	2176.7
Bihar	3055.6
Chandigarh	359.7
Chhattisgarh	2149.9
Dadra and Nagar Haveli	29.4
Daman and Diu	40.8
Delhi	9729.2
Goa	427.4
Gujarat	8994.3
Haryana	4506.9
Himachal Pradesh	1595.1
Jammu and Kashmir	1521.5
Jharkhand	2021.6
Karnataka	9118.7
Kerala	6171.8
Lakshadweep	7.4
Madhya Pradesh	7800.6
Maharashtra	20270.6
Manipur	231.7
Meghalaya	211.6
Mizoram	79.3
Nagaland	145.1
Orissa	2937.8
Puducherry	284.2
Punjab	6958.5
Rajasthan	6326.9
Sikkim	78.1
Tamil Nadu	13486.2
Tripura	378.3
Uttar Pradesh	10381.1
Uttarakhand	1641.1
West Bengal	10059.4
Total	146180.7

Source: Sanjay Jag (2008) Financial Express

Supreme Court (2003) in WP No. 657 of 1995 between Research Foundations for Science Technology and National Resources policy v/s UoI directed that the State Government build systems for disposal of hazardous waste. However, the **CAG report in 2009** quoted by **Sandeep Joslin** in "Growing e-waste concerns published in the Hindu 28th February 2009 says that 75% of state bodies were not complying with the instructions.

Since, e-waste has significant health and environment hazardous need for proper recycling and disposal is a must.

P.Srisudha 2009 identified resources for reasons for improper recycling and disposal of e-waste (P.Srisudha, tackling e-waste, The Hindu 28th June 2009)

Alexander Jaz and Bernard Bilitewski, 2008 gave a simple classification for pollutants occurring in e-waste in their article "Hazardous substances in WEEE"

Pollutants and their occurrence in waste electrical and electronic equipment;

Pollutant	Occurrence
Arsenic	Semiconductors, diodes, microwaves, LEDs (Light-emitting diodes), solar cells
Barium	Electron tubes, filler for plastic and rubber, lubricant additives
Brominated flame-proofing agent	Casing, circuit boards (plastic), cables and PVC cables
Cadmium	Batteries, pigments, solder, alloys, circuit boards, computer batteries, monitor cathode ray tubes (CRTs)
Chrome	Dyes/pigments, switches, solar
Cobalt	Insulators
Copper	Conducted in cables, copper ribbons, coils, circuitry, pigments
Lead	Lead rechargeable batteries, solar, transistors, lithium batteries, PVC, (polyvinyl chloride)

	stabilizers, lasers, LEDs, thermoelectric elements, circuit boards
Liquid crystal	Displays
Lithium	Mobile telephones, photographic equipment, video equipment (batteries)
Mercury	Components in copper machines and steam irons; batteries in clocks and pocket calculators, switches, LCDs
Nickel	Alloys, batteries, relays, semiconductors, pigments
PCBs (polychlorinated biphenyls)	Transformers, capacitors, softening agents for paint, glue, plastic
Selenium	Photoelectric cells, pigments, photocopiers, fax machines
Silver	Capacitors, switches (contacts), batteries, resistors
Zinc	Steel, brass, alloys, disposable and rechargeable batteries, luminous substances

Source: (Alexander Jaz and Bernard Bilitewski, 2008 in an article Hazardous waste in WEEE)

2.1 Management of e-waste guidelines

The **Constitution of India** mentions about solid waste disposal in the 12th schedule relating to minefields: In India, the Constitution assigns solid waste management as a primary responsibility to the Municipalities under the **Twelfth Schedule**. **Article 243W** empowers the State legislatures to frame legislations in respect of waste management. The Municipal Solid **Wastes (Management & Handling) Rules, 2000** were enacted by the Central Government which came into force from 25 September 2000.

Also it may be mentioned that **CPCB was delegated for issuing Notices** under section 3 of the Environment Protection Act 1986. It may be mentioned that after the enactment of the Environment Protection Act, 1986, the Central Pollution Control Board (CPCB) was delegated the functions to implement rules on

hazardous wastes, bio-medical wastes, municipal solid wastes and plastic wastes. Under the purview of the CPCB, the Division of Hazardous Waste Management has been overseeing the management of e-waste.

In 2005 a private member bill on **"The Electronic waste (Handling & dispatch) Bill, 2005"** was introduced in Parliament. However, the bill did not get approval of the Parliament. In 1986, India enacted its first comprehensive environmental law, namely, the Environmental (Protection) Act, 1986 (EPA) after the Bhopal Gas tragedy and as a commitment under the Stockholm Conference¹¹⁰ in 1972.

Hazardous waste **(Management and Handling Rules were enacted in 1989)** and awarded in 2003. A study sponsored by **Maharashtra Pollution** Control Board to Aditye Environmental series titled "Impact of Hazardous waste in Maharashtra listed Hazardous waste and number of waste streams.

Guidelines for **Environmentally sound Management of e-waste (2008)** were issued by **CPCB**. These were followed by Hazardous works (Management and Tran boundary Management Rules, 2008.

M.P.Ram Mohan, Iti Garg and Gayatri Kumar is their article "Regulating e-waste review of the International and National legal framework on e-waste, 2008 (TERI) have gone into executive details of these rules.

Down to Earth Magazine in an article in 2010 in the article "It's underbelly" alter "fled a classified of wastes & dangers as thereof:

Listed in the table below are the harmful elements in the compositions of electrical and electronic appliances that can be hazardous to health and environment:

Metal	Danger
Lead	A neurotoxin that affects the kidneys and the reproductive system. High quantities can be fatal. It affects mental development in children. Mechanical breaking of CRTs (cathode ray tubes) and removing solder from microchips release lead as powder and fumes.
Plastics	Found in circuit boards, cabinets and cables, they contain carcinogens. BFRs or brominated flame retardants give out carcinogenic brominated dioxins and furans. Dioxins can harm reproductive and immune systems. Burning PVC, a component of plastics, also produces dioxins. BFR can leach into landfills. Even the dust on computer cabinets contains BFR.
Chromium	Used to protect metal housings and plates in a computer from Corrosion. Inhaling hexavalent chromium or chromium 6 can damage liver and kidneys and cause bronchial maladies including asthmatic bronchitis and lung cancer.
Mercury	Affects the central nervous system, kidneys and immune system. It impairs foetus growth and harms infants through mother's milk. It is released while breaking and burning of circuit boards and switches. Mercury in water bodies can form methylated mercury through microbial activity. Methylated mercury is toxic and can enter the human food chain through aquatic.
Beryllium	Found in switch boards and printed circuit boards. It is carcinogenic and causes lung diseases.
Cadmium	A carcinogen. Long-term exposure causes <i>Itai-itai</i> disease, which causes severe pain in the joints and spine. It affects the kidneys and softens bones. Cadmium is released into the environment as powder while crushing and milling of plastics, CRTs and circuit boards. Cadmium may be released with dust, entering surface water and groundwater.
Acid	Sulphuric and hydrochloric acids are used to separate metals from circuit boards. Fumes contain chlorine and sulphur dioxide, which cause respiratory problems.

They are corrosive to the eye and skin.

Source: Down to earth, magazine 2010 in an article "classification of waste & dangers thereof.

Most electronic goods contain significant quantities of toxic metals and chemicals like mercury, which is currently being phased out in the developed countries. Mercury is mobile and poisonous in any form - inorganic, organic or elemental. Its organic compound methyl mercury has been scientifically proved to be a neuron-toxicant that damages the brain. It is gene-toxic too as it passes through the placental and the blood brain barrier, putting the foetus at risk. Mercury is known to cause severe and permanent damage to the central nervous system, lungs and kidneys. It can trigger depression and suicidal tendencies and cause paralysis, Alzheimer's disease, speech and vision impairment, allergies, hypospermia and impotence. Mercury bio-accumulates (builds up in organisms) and biomagnifies (moves up the food chain). According to the **United Nations Environment Programme's (UNEP)** Global Mercury Assessment Report, even minuscule increases in methyl mercury exposures can affect the cardiovascular system.

E-waste typically contains complex combinations of materials and components down to microscopic levels. The wastes are broken down in not just for recycling but for the recoverable materials such as plastic, iron, aluminium, copper and gold. However, since e-waste also contains significant concentration of substances that are hazardous to human health and the environment, even a small amount of e-waste entering the residual waste will introduce relatively high amount of heavy metals and halogenated substances. Such harmful substances leach into the surrounding soil, water and air during waste treatment or when they are

dumped in landfills or left to lie around near it. Sooner or later they would adversely affect human health and ecology.

These e-wastes like mercury are neuron-toxicants that damage the brain. In fact to **quote Asha Krishnakumar, 2008** Importing danger in frontline, these metals are gene-toxic too, as they pass through the placenta and the blood-brain barrier. Mercury can also cause serious problem to CNS, Lungs, Brain and the Kidney. She cites UNEP report which says that even miniscule level increase can cause cardio-vascular risk.

The combination of materials when broken down for recycling cause air, water and soil pollution.

To quote **Tom Young (2008)**, Lianjiang River in China near a recycling village had 2400 times higher lead levels than prescribed by WHO.

Shyam Rangnathan and Raunya Kannan 2010 have documented the e-waste policy of state of T.N as also collection of e-waste by community based organisation. It also speaks about massive e-awareness programmes for the consumers.

Asha Krishnakumar (2008) and P.P.Sehgal (2010) have outlined import of hazardous e-waste in India. Data released by the Customs Department reveal imports of even prohibited wastes like clinical waste, incineration ash, municipal waste and e-waste, all of which exceed 50 lakh tonnes annually. In 2009, India generated 5.9 million tonnes of hazardous waste domestically and imported 6.4 million tonnes.⁶⁹ It generates about 3,50,000 tonnes of electronic waste every year and imports another 50,000 tonnes.

Biswajit Debnath, Reshama Roy Chowdhuri and Sadan K. Ghosh (2015) in their paper "e-waste Management A potential

route to green computing” (Published by Elsevier B.V, 2016) have written on Green computing for sustainable future. Virtualisation, cloud computing, energy minimisation and reduction in use of hazardous substances have been suggested. Thus proper use of e-waste leaves a good potential to implement green computing.

Sadia Sohail (2015) talks about EPR with take back scheme for mobile phones giving example of Nokia as also efforts to phase out hazardous wastes. She cites **Pranashu Singhal**, Head of Sustainability operations with Nokia as having taken EPR from 3 tonnes in 2009 to 65 tonnes in 2012.

Raj Kumar Joshi and Sirajuddin Ahmad (2015) in their review of challenges of MSW have also identified e-waste solutions within Indian context. A similar study was done in China by **Hongtao Wang and Yougfeng Nie (2011)**

Sunil Herat and P.Agamuthu (2012) have talked about e-waste as an opportunity and further reviewed various issues, challenges and solution within Indian economy. They have also covered transboundary movement and challenges faced by these countries. Environmentally sound management (ESM) of e-waste is thus a must.

Abhishek Kumar Awasthi and Jinhui Li (2018) have done a comparative study of e-waste of China and India. While drivelling on e-waste laws and regulation the article dwells on educating consumers. It has brought out that both countries still suffer from large informal e-waste industry.

Abhishek Kumar Awasthi, Federica Cucchiella and others (2018) have worked on modelling the correlation of e-waste quantity with economic well being. This article has attempted

to find a strong linear correlation between global e-waste generation and GDP.

It shows that an increase of 1000 GDP PPS means an additional 0.27 kg of e-waste collected and 0.22 kg of e-waste recycled. Therefore, e-waste needs to be part of circular economy for not only recovery of materials but higher economic growth.

Anwesha Bor Thakur & Madhav Govind (2018) in their article in journal of environment and planning have highlighted the issues of computer and mobile phone waste in urban India. They have attempted an analysis from the view of public perception, consumption and disposal behaviour. They have suggested establishment of appropriate and convenient e-waste facilities, implementation of laws and need for organising e-waste awareness campaigners.

Hischier R, Wagner P and Goughofer J (2005) in their article on prevention, recycle and resource of e-waste wrote about need to tackle the fast increasing e-waste stream. Their study left a gap in converging areas for directions in collection and Management of e-waste.

Kurian Joseph (2007) author of "International Work Management and Landfill identified the amount of e-waste in India and drawbacks the country suffered esp. the difficulty in interiorisation of e-wastes. The result is unhealthy conditions of informal recyclers, inadequate legislation, poor awareness and reluctance on part of corporate to address the critical uses. This has resulted in a gap in implementation.

Chhaya Changappa (2007) in an article on electrical and electronic waste in India while identifying the gap in legislation has

identified the need for regulating e-waste and role of EPR as also need for environmentally sound recycling.

UNEP report of 2010 on "Recycling from e-waste to resources" has inter-alia stated the over-whelming dependence on life cycle approach. It also talked about feasibility of implementing an E-based intelligent control system and reduce gap between end of the product and its real expected life.

Lakhani (R) 2010 in "Recycling Indian e-waste" brings jobs to poor has dwelled on e-waste collection as a new job for rag pickers. Issues in handling of e-waste and health issues are a major gap. The users are willing to pay extra for services offered writes **Swati Kwatra (2014)**. She also dwells on EPR and cost sharing between consumers and producers. The study also identified legal users related to e-waste handling and Management. There exists, however, a gap in knowledge and awareness on e-waste handling.

MoEF guidelines for 2016 were an improvement on 2011 guidelines. However issues related to disposal of heavy metals remain to be addressed.

Robinson (2009) did a comparative study of various e-waste literatures and examined challenges faced thereon.

Krishnamoorthy Y et al (2018) in their study on "Emerging Public Health Threat of e-waste Management: Global and Indian perspective" gives background of Electrical and electronic waste of e-waste emerging as a major public health threat worldwide because of rapid advances in technology leading to the generation of large amount of wastes and a lack of knowledge in handling of these wastes. According to them in 2016, 44.7 million tonnes of e-waste was generated with 2 million tonnes produced in India alone.

Out of this, only 20% of the e-waste generated globally was handled properly. The situation is worse in India where more than 90% of the e-waste was handled by informal sector workers. An important problem with the process is that they do not take necessary precautionary measures before handling e-waste.

Electrical and Electronic Waste (e-waste) is one of the fastest growing waste streams in the world. The market penetration, replacement market and high obsolescence rate make e-waste as one of the fastest growing waste streams. Many countries have / are introducing interventions. In accordance with the National Environmental Policy (NEP) and to address sustainable development concerns, there is a need to facilitate the recovery and/or reuse of useful materials from waste generated from a process and/or from the use of any material thereby, reducing the wastes destined for final disposal and to ensure the environmentally sound management of all materials.

The **NEP** also encourages giving legal recognition and strengthening the informal sectors system for collection and recycling of various materials. In particular considering the high recyclable potential of e-waste such wastes should be subject to recycling in an environmentally sound manner. E-wastes contain over 1000 different substances many of which are toxic and potentially hazardous to environment and human health if not handled in an environmentally sound manner. The growth has significant economic and social impacts. The increase in consumption and higher obsolescence adds to higher generation and more import of used electronics products. There are no large scale organized e-waste recycling facilities in India while there are small ones in big cities and most of the units are operating in un-organized sector.

Sustainable development requires a common global agenda and market concept. The challenge is to raise awareness among all actors of the different sectors in order to realize the innovation potential. Throughout the study prepared within the **"Solving the e-waste Problem (StEP) Initiative"¹³** the focus lies on a consistent set of different types of metals. Toxic and hazardous elements are present in e-waste, which are partially drivers for the implementation of sound collection and treatment processes. Therefore, in the discussion of recycling technologies, the proper handling and treatment of such harmful elements to prevent environmental or health impact is included. Furthermore, the use and generation of toxic/hazardous substances during e-waste processing is critically evaluated with respect to the sustainability of criteria for innovative technologies.

As per **Kurian Joseph (2007)** during his lecture at the Eleventh International Waste Management and Land full Symposium, Sardinia the current practices of e-waste management in India suffer from a number of drawbacks like the difficulty in inventories, unhealthy conditions of informal recycling, inadequate legislation, poor awareness and reluctance on part of the corporate to address the critical issues. The consequences are that:

Toxic materials enter the waste stream with no special precautions to avoid the known adverse effects on the environment and human health and

Resources are wasted when economically valuable materials are dumped or unhealthy conditions are developed during the informal recycling.

¹³ **Solving the E-waste Problem (StEP)** Initiative is a partnership of UN organizations, industry, governments, and non-government and science organizations. Its overall aim is to solve the e-waste problem and to facilitate approaches towards the sustainable handling of e-waste. (**www.step-initiative.org**)

E-waste is emerging as a serious environmental health issue and current management practices may result in unintended developmental neurotoxicity in vulnerable pop. It contains metals and persistent organic pollutants (PoPs). There is rampant, inappropriate & primitive e-waste recycling in several developing countries leading to release of toxicants into the environment. Particulate matters steaming from toxic waste are non-biodegradable and increase cancer, cardiovascular morbidity and mortality. E-waste unfairly and disproportionately burdens women affecting health and development of their children. Pregnant women & young children are at risk of perturbations of fetal and child neurodevelopment. There are serious health concerns but research needs are largely unaddressed.

The appropriate handling of e-waste can both prevent serious environmental damage and also recover valuable materials, especially for metals. The main objectives of e-waste recycling and basic considerations for innovation are to treat in an environmentally sound manner, recover valuable material, create eco-efficient and sustainable business and consider social impact and local context. The general criteria to specific requirements for separation and dismantling of e-waste are given and sustainability attributes used as innovation criteria and to compare current and innovative technologies are divided into economic, environmental and social aspects. In the third chapter available pre-processing technologies are described End-processing technologies are depicted for printed wiring boards and small electronic devices, metallic fractions with precious metals, other metallic fractions, and aluminum, ferrous and lead containing-glass from **cathode ray tubes (CRT).**

Swati Kwatra et al (2014) have highlighted that despite legislation there is a gap in knowledge and awareness on issues of e-waste handling and management. Significant population is unaware and the only source is Internet / print media. It is noted that 26% people replace electronic goods once in 3 years. It is also seen that the users are willing to pay extra. They also highlighted need for EPR and sharing between consumers and producers. Indian sector has a higher informal collection and therefore challenges are more. Therefore need for sharing responsibility between producers, consumers and government.

2.2 Law and Policy

Increasing volume of e-waste is being produced in India and there are major shortcomings of rules notified by **MOEF**. Health hazards during occupation exposures, and safe disposal of hazardous materials is a challenge. There is a need for context specific models for disposal, with particular reference to India. Distortions caused in the system of disposal in India due to lack of primacy of the producer and interplay between formal and informal sector exist. Both legal and illegal imports are detrimental to the Extended Producer Responsibility System. Procedural issues, lack of targets, transparency and consumer awareness adds on to implementation challenges. While the **e-waste (Management & Handling) Rules 2011** had certain shortcomings, **e-waste Management Rules 2016** aim to overcome these by Inclusion of more stakeholders and Producer Responsibility Organization (PRO) & Deposit Refund System (DRS) as two possible instruments for e-waste disposal. Despite these amendments, the Draft Rules still leave certain issues unattended. **The e-waste Management (Amendment) Rules, 2018 have brought radical changes as far as liability of producers is concerned:**

In the E-waste (Management) Rules, 2018 has brought the following Amendment to the rules of 2016.

The provisions of rule 5 have been applied to producers, who have placed any goods in the market in the current financial year and the targets for the extended producer responsibility plan shall be as per clause (ii) of sub-rule (1) of rule 13 and Schedule III of the E-waste Management Rules, 2016.

It is also stated that in case the producer has started sale recently i.e. number of years of sales operations is less than average life of their product, the Extended Producer Responsibility target shall be applicable as per Schedule- and these targets applicable from financial year 2018-2019 and once the product achieves its average life as fixed by the Central Pollution Control Board, the collection target shall be revised.

The e-waste already collected by producers as per Schedule in earlier years will be accounted for and the eligible set offs shall be provided for the corresponding years at the time of fixation of targets as per Schedule.

The revised Extended Producer Responsibility targets have been made applicable from the 1st October 2017.

In case of transfer or sale of assets by the producers the liability under Extended Producer Responsibility has also been agreed to be transferred to the buyer.

The **2018 amendment** has put on us on Producer Responsibility Organisation who has to apply to the Central Pollution Control Board for registration to undertake the activities prescribed for Producer Responsibility Organisations under these Rules.

(g) Further the **amended Act of 2018** also empowers CPCB (**Central Pollution Control Board**) to conduct random sampling of electrical and electronic equipment placed in the market to monitor and verify the compliance of Reduction of Hazardous Substances

provisions and the cost for sampling and testing would be borne by the Government for conducting the Reduction of Hazardous Substances test and the procedure of random sampling and permissible error value of Reduction of Hazardous Substances test shall be as per the guidelines of the Central Pollution Control Board.

(h) Further the Act states that the product does not comply with the Reduction of Hazardous Substances provisions, then the cost of the Reduction of Hazardous Substances test would be borne by the Producer and in addition, the Producer shall take corrective measures to bring the product into compliance and withdraw or recall the product from the market within a reasonable period as per the guidelines of the Central Pollution Control Board.

2.3 Management of E-Waste

Some of the methods to reduce the negative effects could be mitigated by use of alternate energy source, adaptation of technology transfer to bring existing infrastructure up to 21st century standard and taking remediation by advanced air capture. We also need to study the negative downstream effect of technological interventions.

Skinner et al (2010) have highlighted the need for regulation and enforcement of e-waste management, particularly with regard to WEEE exports, in the US and the EU. Bearing in mind the strengths and weaknesses of regulation in the EU and US, Indian e-waste regulation needs to be put in place. **Skinner et al (2010)** suggest further that a unified international definition for WEEE should be introduced and additional policy approaches should be considered, including more research into flexible mechanisms and regulations that not only provide specific methods of enforcement, but also address the economic incentives to export and handle e-waste illegally. Until the economic causes of illegal e-

waste export and handling are addressed worldwide, enforcing regulatory compliance and eliminating the health and environmental hazards related to e-waste dismantling will remain difficult.

A report by ***Chhaya Chengappa et al (2007)*** as part of the Basel Convention Partnership Programme and under the Pilot Project for the Environmentally Sound Management of Electrical and Electronic Waste in Asia and the Pacific which was launched in November 2005, highlights following issues:

- a) Regulating e-waste – need for India to formulate e-waste legislation.
- b) Extended Producer Responsibility – The producer should be directed to take back a product at the end of its useful life either directly or through a third party.
- c) Environmentally sound recycling – need for government to promote environmentally sound recycling in the country.
- d) E-waste collection centers for small consumers – Collection centers must be set up in different parts of the country to encourage collection from small generators.
- e) Awareness – Awareness raising activities should be taken with not only the consumers and small business establishments, but also the public sector undertakings and government organizations.
- f) Advance Recovery Fee (ARF) at present as India is collecting service tax and educational cess on all products, an additional charge can be imposed on the same.

It is seen that e-waste and its management are integrated in the **OECD** programme of work on waste, material resources, and circular economy. They are covered in several OECD guidance documents, including on Extended Producer Responsibility,

Environmentally Sound Management of Waste, and Strategic Waste Prevention. Data on e-waste has also long been covered in the OECD questionnaire on the state of the environment, although in a basic way (i.e. only the generation of e-waste). They are used in the OECD country Environmental Performance Reviews (EPRs) when an in-depth evaluation of waste and materials management is carried out. Questionnaires were sent to the OECD countries other than those covered by EU. Although the response rate to the 2015 ad-hoc data request sent to the was low and comparability across countries weak, the data compiled helped fill some gaps and was used in recent EPRs. However, further efforts are required to produce data of better quality, aligned with standardized definitions and concepts, and with a better understanding of recovery operations. To support the further development of e-waste statistics, the OECD intends to regularly update and validate related data with its member countries in cooperation with the global e-waste statistics partnership.

Since **February 2016, UNECE** runs the Secretariat of the Task Force on Waste Statistics, which was established under the auspices of the **Conference of European Statisticians**. The main objective of the Task Force is to develop a conceptual framework on waste statistics, which should be the future basis for a systematic production of statistics on waste, and to help solve the most important conceptual problems that currently exist in waste data collections. This framework will also provide the foundation for further integration of important emerging issues, such as e-waste, into official statistics.

In 2017, following the request of **UNU (United Nation University), UNSD (The United Nations Statistics Division)** conducted a pilot questionnaire on e-waste statistics. UNSD selected

a sample of 40 countries based on their communications with UNSD for the regular biennial **UNSD/UNEP (The United Nation Environment Programme)** Questionnaire on Environment Statistics, and their English language proficiency, since the pilot was only administered in English. Given the fact that an assessment of the data provided by countries to UNSD via this pilot in 2017 is still pending, variables on e-waste are to be considered included in the regular biennial UNSD/UNEP Questionnaire on Environment Statistics. If data becomes available in the near future, it would provide a much needed base.

Research Gap identification through Literature survey; some examples of:

Year	Author	Issue Discussed	Findings	Research Identified	Gap
2005	Hischier R.Wager P & Goughlofer. J	Prevention, recycle and reuse of e-waste	Need to tackle the fast increasing e-waste stream	Gap in directive for collection and Management	
2007	Kurian Joseph	International Waste Management and Landfill	The current practices of e-waste management in India suffer from a number of drawbacks like the difficulty in inventories	The result is difficulty in inventories, unhealthy conditions of informal recycling, inadequate legislation, poor awareness and reluctance on part of the corporate to address the critical issues. Thus, creating a gap in implementation.	
2007	Chhaya Chengappa	Electrical and Electronic Waste in Asia	Regulating e-waste, Extended Producer Responsibility, Environmentally sound recycling	Gap in legislation	
2010	UNEP	Recycling-From e-waste to	The overwhelming	Need for examining the feasibility of	

		Resources	dependence on life cycle approach	implementing an e-based intelligent control system and reduce gap between end of a product and its real expected life
2010	Lakshmi.R	Recycling Indian e-waste brings job to poor	New jobs for rag pickers	Gap in handling e-waste issues of health etc.
2014	Swati Kwatra	Legal Issues related to E-waste handling and Management	Users willing to pay extra. EPR and Sharing between consumers and producers	Gap in knowledge and awareness on e-waste handling.
2016	MoEF	Guidelines for environmentally sound Management of e-waste	Revised 2011 guidelines	Gaps remain in not addressing several issues related to disposal of heavy metals

Handling of e-waste in an environmentally friendly way is a hot topic in international as well as national forums. There is no lack of information about the ways it is generated, the regulatory framework across the countries, the threat it poses to human health and environment the advantages of recycling, role of formal and informal sectors, the challenges faced by developing countries and many other such issues. The authors worldwide including India have studied and written about e-waste and the challenges related to it. While as of June 2006, there were more than 500 scientific articles dealing with E- waste and its environmental effects **(Robinson, 2009)**, the number of articles increased exponentially during last few years. .

The distinction between e-waste and WEEE is becoming less sharp due to the advent of Pervasive computing **(Kohler and Erdmann, 2004)**, where programmable microprocessors are incorporated into electrical equipment, such as refrigerators,

which are not normally considered electronic items **(Hilty, 2005).** However, it is the rapid growth and short life cycle of computing devices that is driving generation of e-waste. **(Ladou and Lovegrove, 2008).**

It is also important to understand the importance of the average life cycle/ obsolescence rate of electronic goods which has been defined as the time span after which the electrical and electronic item comes to its **"End of Life " (UNEP 2007)** or in more clear terms , it has been depicted as:

Average life cycle/obsolescence rate=active life+passive life storage, whereas;

- Active life is the number of years, a machine can be effectively used
- Passive life is the time period for which it can be refurbished or reused, and
- Storage includes storage time before disposal and storage at repair shops before dismantling

The **UNEP (2007)** report further adds that in developed countries, average life cycle of electrical and electronic equipment is generally equivalent to "Active Life", while in developing countries, it is a sum of active life, passive life and storage. Therefore, in developing countries like India, a second hand market exists for e-waste after its active Life. However all the three parameters vary differently in different a geographical region which leads to different WEEE/ E-waste inventory.

The e-waste issue is difficult to grasp due to a lack of comprehensive data. Different countries define e-waste very

differently. For example, the United States only includes consumer

Electronic such as TVs and computers, whereas European nations include everything that has a battery or power cord in the e-waste category. Though there is lot of literature available in international domain about the negative environmental and health impacts. Through primitive recycling methods, but it is the quantitative and qualitative dimension associated with the e-waste problem that makes it more understandable and useful in better inform policy making at the private and public levels (**www.step-initiative.org/step-e-waste-world-map.html**). Also while the rich countries like US, EU, Japan, Australia have the data on e-waste readily available, the developing/poor countries like India, Africa, Latin America face problems in quantifying e-waste. The world produced nearly 42 million metric tons of used electrical and electronic products last year as per the (**[Balde et al, 2015](#)**).

A lead has been taken by the **STEP Initiative**, in this direction and it has created an online STEP E-waste world map, the first of its kind, an interactive online maps showing the data from 184 countries on the estimated amount of electrical and electronic Equipment that hits the market and how much e-waste it ultimately generates. Having this data could help governments and companies manage their e-waste more efficiently. The STEP Initiative forecasts that the world will produce about 65 million metrics tons of e-waste by 2017 and that amount weighs about 11 times as much as the great pyramid of Giza (**[www,unu,edu/media-relations/releases/step-launches-interactive-world-e-waste-map-html#info](http://www.unu.edu/media-relations/releases/step-launches-interactive-world-e-waste-map-html#info)**).

By providing a better sense of anticipated e-waste quantities, the initiative is expected to and companies plan e-waste management.

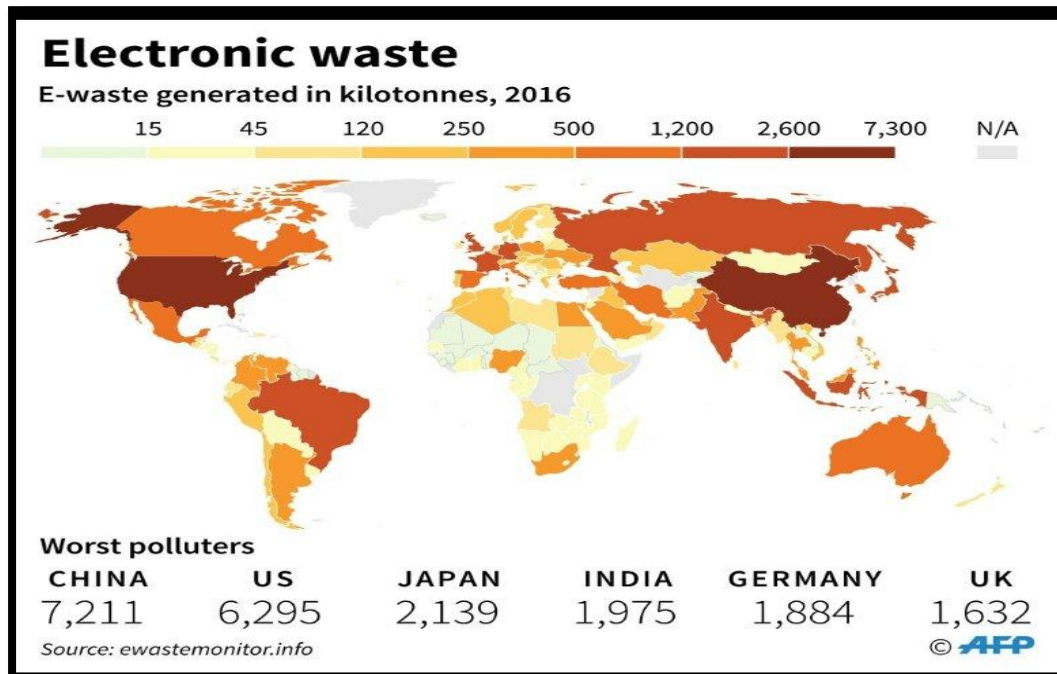


Fig.2.3: E-waste generated by Country (2016, total in Million Tons)

2.4 International Policies and Regulations

In the context of increasing globalization, concerns over the environmental impacts of international trade are mounting especially on the international trade of hazardous waste, including e-waste, causing damage to both the environment and human health. A range of legislation tries to control the transboundary movements of hazardous substances. The international conventions seeking to control the shipping of waste are the ***“Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their disposal (1989), Rotterdam Convention, on the Prior informed consent (PIC), procedure for Certain Hazardous Chemicals and Pesticides in international trade (1998) and Stockholm Convention” on Persistent Organic Pollutants (POC) (2001)”***.

Internationally the main regulation is *the Basel Convention* on the control of transboundary Movement of Hazardous Wastes and disposal, and ratification obliges countries to address the problem of transboundary movement and disposal of Dangerous hazardous wastes through international cooperation. The Basel Convention started to address e-waste issues since 2002. As per the convention, hazardous wastes like arsenic, Cadmium, Lead, mercury, Beryllium, selenium, etc. of the Convention cannot be passed between countries that have ratified the ban agreement (***www.ban.org***). However, the agreement does not restrict the import of such wastes from countries that have not ratified the Convention and illegal imports of e-waste from rich continue to be dumped in the developing countries. As of September 2010. The Convention had 178 signatories (***Basel Convention, 2011***).

Subsequent to these international conventions, various regional conventions have also been signed regulate hazardous waste movements. Complementing International and regional conventions, several international organizations like StEP initiative by ***UNEP, ITU-T (Study Group 5)9, GeSI (Global sustainability Initiative)*** 10 also have an important role to play in running programmes to reduce the impact of e-waste on human health and the environment. In addition there are many Non-Governmental Organisations

(NGOs) such as ***Greenpeace (www.greenpeace.org)***, ***the Silicon Valley Toxics Coalition (www.svtcsvtc.org)***, as well as the scientific communities that are active and increasingly drawing the attention of the countries towards the environmental effects of E-waste disposal.

In 2006, the eighth conference of parties (COP8) adopted the Nairobi ministerial declaration on the environmentally sound management of electronic and electrical waste, and called for urgent global action on e-waste with the aim to "create innovative solutions through the Basel Convention for the environmentally sound management of e-waste **(UNEP, 2007)**. This provided the mandate for a roadmap for future strategic action on e-waste globally.

There is a wide range of means and measures to influence e-waste generation, management and impacts, ranging from restricting its generation through better design, enhancing recycling and reuse schemes, introducing market forces into waste through product stewardship programmes. Such initiatives can be loosely termed 'policy and regulation', and range from sponsorship of voluntary schemes to legislation mandating particular courses of action **(Horne et al 2006)**. The countries of the European Union (EU) and other developed countries to an extent have addressed the issue of e-waste by taking policy initiatives and by adopting scientific methods of recycling and disposal of such waste. But the developing countries like India, China are struggling in handling the e-waste in environmentally sound manner. Some of the examples of International policies adopted by few countries are mentioned as under:

The European Union as well as individual member states and non-members have a relatively long history of research and policy development focused on WEEE. The European Union is one of the few regions in the world where there is uniform legislation regarding the collection and processing of e-waste. In the European Union, e-waste has been targeted regarding the prevention of environmental pollution, for the exploitation of

resources and the reduction of landfill use. The legislation developed by the **European Parliament** is based on three axes, the prevention, recycling and re-use of e-waste, so that the amount of the waste electrical and electronic equipment available is reduced (**Hischier, 2005**). The above are elaborated in two key related *EU Directives*:

The new **WEEE Directive 2012/19/EU entered into force on 13 August 2012** revised the earlier Directive 2002/96/EC on waste electrical and electronic equipment in order to tackle the fast increasing waste stream. The directive has been developed particularly to assist in reducing the waste electrical and electronic equipment "available in the landfills and encourage the more efficient use of resources through recycling and re-use. The specific directive measures for collection, management, recovery and recycling of all electrical and electronic products and focuses on the **"Extended Producer Responsibility (EPR). Waste Electrical and Electronic Equipment (WEEE)** imposes on producers and distributors "take-back" and recycling obligations, and related obligations to reduce waste from **EEE (www.ec.europa.eu/environment/waste/weee/index_en.htm)**.

Similarly, RoHS recast Directive 2011/65/EU that became effective on 3 January 2013 is the revision of the earlier Directive 2002/95/EC (**RoHS-Restriction of Hazardous Substances**). The directive restricts the use of hazardous substances introducing the requirement for change of substances causing the main environmental problems during the emplacement and recycling of the waste electrical and electronic equipment. According to this Directive, Restriction of Hazardous Substances (RoHS) bans the use of six substances in EEE to agreed levels. From 1st July 2006,

new EEE put on the market may not contain lead, mercury, cadmium, and hexavalent chromium, PBBs or PBDEs (***WWIN.ec,europa.eu/environment/waste/weee/index_en.htm***).

In Europe, the total e-waste generation was 11.6 Mt in 2014. In the directives, one of the targets is to collect 85 per cent of generated e-waste. In practice, most Member States do not reach that collection level yet. Only Sweden, Denmark and Bulgaria currently collect more than 60 per cent of their e-waste generated (***Balde et al, 2015***).

Switzerland was the first country in the world where an official e-waste management system was established and operated. Switzerland has been a pioneer in legislating e-waste management (***www.ewasteguide.info/swiss-e-waste-programme***). The legislation regarding e-waste management was introduced for the first time in 1998 through ***ORDEA law (Ordinance on "The Return, the Taking Back and the Disposal of Electrical and Electronic Appliances") (Widmer et al, 2005)***. Two e-waste recycling systems are active in the country. One is run by SWICO Recycling Guarantee (The Swiss association for Information, Communication and Organizational Technology) while the other is run by S.EN.S (*Stiftung Entsorgung Schweiz System*) (***Sinha et al, 2005***). The consumers are highly responsible in Switzerland in the sense that consumers return the e-waste, either through specified collection points, of retail companies or transporting. The waste straight to the recycling spots. The materials are transported from the collection points to the disassembly facilities, in order to disassemble and disinfect e-waste by removing the most toxic factors. In the recycling facilities, e-waste pass through an even more detailed

disassembly, shredding and sorting, resulting mostly to the collection of plastic, glass, steel, aluminium and copper. Most of the recycled materials are then sent to refineries or foundries for the final material recovery. The remaining materials that cannot be recovered are led into incinerators for energy Recovery and a small quantity, usually smaller than 2%, ends up to landfills.

In the *Swiss system*, producers are fully responsible for the application and operation of management system and the entire system is financed through a special recycling Charge included in the product's price **(Widmer et al, 2005).** Retailers, importers and manufacturers are obliged to take back their products free of charge and manage them In an environmentally sound manner.

United States Environment Protection Agency (EPA) initiated a green National Electronics Action Plan (NEAP) in 2005 in order to address environmental concerns arising out of the entire life cycle of electronics, including design, operation, reuse, recycling and disposal of equipment **(www.epa.gov/osw/rcclindex.htm).** Unlike the European Directives, the NEAP focuses mainly on computers, televisions and cell phones. Instead of emphasizing on the principle of the Extended Producer Responsibility, the EPA places responsibility for products on a broader group of entities, including manufacturers, retailers, users and disposers. The US is involved in a number of initiatives and programmes aimed at reducing e-waste. However, the US Government has signed the Basel Convention but has not yet ratified it **(Parties to Basel Convention, n.d.).** There is also no federal legislation in place prohibiting or regulating e-waste generation, disposal and export. Several States in the US such as California, Massachusetts, Maine and Minnesota have taken the initiatives, which have imposed strict and effective regulations on design, manufacture, reuse,

recovery and disposal of e-waste **(Wikipedia, 'Electronic Waste in the United States, E-waste in India, 2011).**

California has promulgated the Electronic Waste Recycling Act of 2003, which is considered landmark legislation for e-waste regulation and management. Electronic waste in California can neither be disposed of in a landfill nor be exported overseas. Unlike the EU regulations, the Californian law establishes the system of shifting the financial burden of recycling of e-waste on the consumer. The most significant provision of the regulation is the electronic waste recycling fee, which is to be collected at the Point sale of certain products. The law further lays down proper and fair procedure for distribution of recovery and recycling payments to qualified entities, covering the cost of electronic waste collection and recycling. It recommends environmentally preferred purchasing criteria for state agency purchases of certain electronic equipment. The California Integrated Waste Management Board (CIWMB) and the Department of Toxic substances Control (OTSC) have adopted several regulations to implement the Act in The most effective manner. A law in the state of Washington which took effect in January 2009 requires manufacturers of electronic goods to pay for recycling, and establishing a state-wide network of collection points. The programme, called 'E-Cycle Washington is managed by the Department of Ecology and the Washington Materials & Financing Authority **(Wikipedia, 'Electronic Waste in the United States, E-waste in India, 2011)**

The government of Japan has moved relatively swiftly in the development and implementation of their WEEE related policies and legislation. This has been further accompanied by strong support from consumers, producers and retailers. Equivalent legislation is in

force also for the collection and recycling of used electronic computers since 2003.

Japan was one of the first countries worldwide to implement an EPR (**Extended Producer Responsibility**) based system for e-waste, largely building on the strong existing framework for solid waste management (**Balde et al, 2015**). The legislation directs the manufacturers to recover their corresponding products after they have been used by their last owners. The Japanese system is an example for the individual responsibility of producers, from the moment they have the natural and financial responsibility for their products recycling. In the Japanese e-waste management system the withdrawal is not free of charge, but consumers pay an amount of money when they return used electronic products to the traders. The law in Japan specifies target rates and imposes strict penalties for non-compliance (**Widmer et al, 2005**).

Producers implement in their business strategy the e-waste management and have their own facilities or collaborate with other producers to create and operate such facilities. E-waste coming from residencies are collected when these products are not used anymore or When consumers buy new ones. The collected waste is transported to the intermediate e-waste collection points and eventually to the facilities through a distribution system (**Gaidajis et al 2010**).

A basic characteristic of the Japanese system is the use of the primary disassembly Procedure of big parts initially with a more accurate and brief process so that they handle residues in a more proper way. Therefore, the Japanese companies of electronic equipment were the first ones to evolve welding without insulation and the electrical panel board connections without

bromide compounds in relation to the European guidelines of the Directive RoHS, while they constantly aim at the designing of Lighter products, cheaper and easier to be recycled. They plan the disassembly by reducing the number of the plastic resins in their products and reuse their parts **(Gaidajis et al, 2008).**

This e-waste recycling system success in Japan is based on social responsibility, Environment sensitivity and general discipline of Japanese people vis-à-vis Regulations As a result, not only is there a strong legal framework, it is also backed by an advanced collection and take-back system and processing infrastructure.

Australian Governments operate primarily through the Environment Protection and heritage Council (EPHC) as a means of developing national WEEE related policies and programs The EPHC represents all Federal, State and Territory Environment Ministers and provides a national framework for identifying environmental priorities and actions across a range of areas and issues, including **WEEE**. Within the context of **WEEE**, the EPHC identified end-of-life IT equipment as priority waste streams in need of industry action particularly collection and processing.

Australia has a national regulation regarding the disposal of end-of-life computers and Televisions units. In Australia, waste management is primarily the responsibility of state and territorial governments and, through them, local governments. "The Product stewardship Act 2011" was enacted in 2011, which provides a legislative framework for national Television and Computer Recycling Scheme. A key element of how Australian move forward is guided by a 'product stewardship agreement' featuring specific targets and KPIs concerning collection, processing, recycling and

community awareness and action. The regulations require all importers and manufacturers of above threshold volume of televisions and computers to join and fund an approved co-regulatory arrangement. The regulations require the industry to fund collection and recycling activities to meet progressively increasing annual recycling targets, set as a proportion of the estimated total television and computer waste generation in Australia (**Balde et al, 2015**). These targets started at 30 per cent in 2012-13 and will increase to 80 per cent by 2021-22 (**Australian Government, National Waste Policy, 2014**).

In China, e-waste is dealt under the Regulations for the Administration of the Recovery and Disposal of Electronic Waste (2011) which require any disposal of e-waste to comply with State requirements for comprehensive resource utilization, environmental protection, labour safety and safeguarding of human health. E-waste is required to be sent to a government-authorized facility for processing before being recycled. Under the new regulations, the consumer is required to recycle electronic products. It also requires the recycling of unnecessary materials discarded in the manufacturing process. All items shipped to China now have to be marked as to whether the items contained in the box are compliant or noncompliant. The Electronic Information Products (EIP) logo or other label is used to mark parts and assemblies that do not contain acceptable amounts of substances identified by the regulations, and those that are environmentally safe. Units which contain hazardous substances are marked with the EIP logo including an Environment Friendly Use Period (EFUP) value in years. EFUP is the period of time before any of the RoHS direction's restricted substances are likely to leak out, causing possible harm to health and the environment (Administrative

Measure on the Control of Pollution Caused by Electronic Information Products, Ministry of Information Industry of people's Republic of China)

China has ratified both the Basel Convention and its BAN Amendment, 2011. However, the situation is grave in China due to widespread illegal activity. There is no lack of laws and regulations but, they are very often enacted without adequate resources allocated for enforcement. The Ministry of Environmental Protection (MEP) is designated as the competent authority to supervise and administer the prevention and control of pollution caused by e-waste **(Ni et al, 2009)**. Illegal activities are fined, and both manufacturers and importers are required to contribute to a fund for the recovery and disposal of e- waste **(People's Republic of China, State Council. 2009)**. The Informal sector has not yet been included in the legislative framework, and the effectiveness of available regulations on informal recyclers seems to be rather weak. The informal recycling operations in China are strong, pervasive and influence the pattern of e-waste recycling in the country. A number of local administrative measures have also been introduced in major regions such as Beijing, Shanghai, Nanjing and Guangdong Province to regulate the behaviour of enterprises, dealers and customers, and to build the local system of e-waste take back, reuse and recycling **(Chi, 2011)**.

The town of Guiyu has attracted much attention from non-governmental organizations (NGOs) and scientists as a booming e-waste town. It is probably the largest e-waste Recycling site in the world; it employs about 100,000 people in this activity **(Zhao et al, 2010)** representing about 80 per cent of the town's population **(Ni & Zeng, 2009)**.

Although China, enforces many laws and signed the Basel Convention (it was even one of the first global proponents of a total ban on the hazardous waste trade between developed and developing countries), the number of illegal shipments of e-waste to china to rise. Clearly, the reason illegal importation and handling of e-waste in china has been able to escalate is not due to the lack of laws and regulations but, rather to ineffective enforcement **(Ni & Zeng, 2009).**

China plays a key role in the global EEE industry, including the manufacturing, refurbishment, and reuse of EEE and recycling of e-waste. Under the progressive development of pilot projects and domestic e-waste legislation over the past five years, The formal e-waste recycling industry in China has shown considerable growth in both Treatment capacity and quality. However, due to a range of social and economic factors, the informal sector continues to play a major role in the collection and recycling of e-waste in china, and informal recycling often leads to detrimental effects on the environment and the health and safety of workers and local communities. The growth of the formal sector is important challenge in China for lessening the environmental and Health impacts of e-waste treatment in China. **(Balde et al, 2015).**

2.5 Research Gaps in Literature

Large number of gaps still exists in the material read. The kinds of effective rules and regulation, what kind of programmes can be launched to increase awareness, channels for effective collection and its popularization, how to manage the informal sect, how to enforce EPR on the manufacturers etc are all issues which need further deliberation. Can people be motivated to or procedures be put in place for effective management of products over their useful

life is a moot point since no effort can be successful without the involvement of the consumer. Some of the gaps identified are listed below:

- Regulatory capacity to identify, monitor & regulate players in the informal sector.
- Ability of PCBs to absorb the increased cost of providing the required regulation.
- Ability of the (already over-burdened) law enforcement framework to absorb the extra regulatory workload.
- Effectiveness of PRO & DRS in India (considering past record).
- Steps taken/required to increase consumer awareness about e-waste management.
- Proposed system / model for safe recycling of e-waste with specific reference to India.
- Formulation of comprehensive e-waste management rules addressing control over imports, health hazards and involvement of formal & informal sectors.
- Formulation of a plan for effective implementation of MOEF notified rules.

Chapter 3

IMPACT OF E-WASTE ON HEALTH AND ENVIRONMENT

E-waste composition is spatially and temporally heterogeneous. The chemical composition of e-waste varies with the type of item discarded and depending on when was it produced because the composition of e-waste keeps changing with the development of new technologies and also due to pressure from environmental organisations on electronics companies to find alternatives to environmentally damaging materials.

E-waste, if not properly handled can have detrimental effect on health and environment. **Banjont Kaur (2019)** writes about danger of E-waste in Down to Earth Magazine in the article **"Tsunami"** of e-waste to hit the world soon (**www.downtoearth.org**). She quotes UN report on this issue. Miles Park (2019) mentions about appalling condition of e-waste workers. **Miles Park and Alankrita Soni (2019)** mention as to how India's e-waste recycling "markets" have become toxic nightmares (**www.boingbong.net**) in the **conversation. Insightra (2019)** mentions about e-waste as looming crises for future. **V.Ranganathan (2018)** has covered hazards caused by unorganised e-waste disposal.

3.1 Potential contaminants associated with E-waste

E-waste contains valuable metals like Cu, platinum group as well as potential environmental contaminants, especially lead (Pb), antimony (Sb), Mercury (Hg), Cadmium (Cd), Nickel (Ni), Poly brominated diphenyl ethers (PBDEs), and polychlorinated biphenyls (PCBs). However, most e-waste is composed of a mixture of metals, particularly copper (Cu), aluminium (Al), and Iron (Fe), attached to, covered with, or mixed with various types of plastics and ceramics **(Hoffmann, 1992)**. For example, a discarded personal computer with a CRT monitor typically weighs 25 kg and consists of metal (43.7%), plastics (23.3%), electronic components (17.3%) and glass (15%) **(Berkhout and Hertin, 2004)**. The lighter e-waste items, such as laptop computers, mobiles contain high concentrations of flame retardants and heavy metals. Virtually all e-waste contains some valuable components or base materials, especially Cu. These are environmentally important, because they provide an incentive for recycling, which occurs predominantly in poor countries, but may result in a human health risk or environmental pollution. **Snehal Famandris (2018)** in Hindustan Times writes about effects of e-waste releasing toxic chemicals into soil in India's mentions **(www.hindustantimes .com/mumbai-news/)** The precious metal concentrations like gold, platinum, copper etc. in printed circuit boards is more than tenfold higher than commercially mined minerals **(Betts, 2008)**. **Basel convention** characterizes e-waste as hazardous when they contain mercury, lead, cadmium, polychlorinated biphenyl etc. E-wastes containing insulation or metal cables coated with plastics contaminated with or containing lead, coal tar, cadmium, Polychlorinated Biphenyl (PCB) etc. are also characterized as hazardous wastes. Also precious metal ash from printed circuit boards, glass waste from cathode-ray tubes, LCD screens and other

activated glasses are classified as hazardous wastes as per the **Basel convention** (www.ban.org).

As per **UNEP report 2006** on a local level, uncontrolled discarding or inappropriate waste management/recycling practices generates significant hazardous emissions, with severe impacts on health and environment. **Miles Parl (Feb 2019)** writes about health and environmental effects of e-waste recycling. She mentions about appalling condition of recyclers and lack of safety nets. As per the **UNEP, 2009** report, three levels of toxic emissions have to be distinguished:

- Primary emissions: Hazardous substances that are contained in e-waste e.g. lead, mercury, arsenic, polychlorinated biphenyls (PCBs), fluorinated cooling fluids etc.,
- Secondary emissions: Hazardous reaction products of e-waste substances as a result of improper treatment e.g. dioxins or furans formed by incineration/inappropriate smelting of plastics with halogenated flame retardants,
- Tertiary emissions: Hazardous substances or reagents that are used during recycling (e.g. cyanide or other leaching agents, mercury for gold amalgamation) and that are released because of inappropriate handling and treatment.

3.2 Pollutants in e-waste

Pollutants or toxins in e-waste are typically concentrated in circuit boards, batteries, plastics, and LCOs (liquid crystal displays). The table 3.1 shows the major pollutants occurring in waste electrical and electronic equipment.

Pollutants		Occurrence
Arsenic		Semiconductors, diodes, microwaves, LEOs (Light- emitting diodes), solar cells
Barium		Electron tubes, filler for plastic and rubber, lubricant additives
Brominated proofing agent	flame-	Casing, circuit boards (plastic), cables proofing agent agent and PVC cables
Cadmium		Batteries, pigments, solder, alloys, circuit boards, computer batteries, monitor cathode ray tubes (CRTs)
Chrome		Dyes/pigments, switches, solar
Copper		Conducted in cables, copper ribbons, coils, circuitry, pigments
Lead		Lead rechargeable batteries, solar, transistors, lithium batteries, PVC (polyvinyl chloride) stabilizers, lasers, LEOs, thermoelectric elements, circuit boards
Liquid Crystal		Displays
Lithium		Mobile telephones, photographic equipment, video equipment (batteries)
Mercury		Components in copper machines and steam irons; batteries in clocks and pocket calculators, switches, LCDs
Nickel		Alloys, batteries, relays, semiconductors, pigments
PCBs (polychlorinated Transformers, capacitors, softening agents for paint, Selenium		Transformers, capacitors, softening agents for paint glue, plastic Photoelectric cells, pigments, photocopiers, fax machines
Silver		Capacitors, switches (contacts), batteries, resistors
Zinc		Steel, brass, alloys, disposable and rechargeable batteries, luminous substances

Table 3.1 Pollutants and their occurrence in e-waste

(Source: Rakesh Johri, E-waste: Implications, regulations and management in India and current global best practices, TERI, New Delhi, 2008)

It is important to understand that that legislative approaches are very much required to restrict the use of hazardous substances

(e.g), **European Union's Directive 2002/95/EC** on the restriction of the use of certain hazardous substances in electrical and electronic equipment RoHS and India's **E-waste (Management and Handling Rules), 2011**) can address only primary emissions and partly secondary emissions. However, even the "cleanest/greenest" products cannot prevent tertiary emissions if inappropriate recycling technologies are used. The latter is the biggest challenge in particular in developing and transition countries, where "backyard recycling" with open sky incineration, cyanide leaching, "cooking" of circuit boards etc. lead to dramatic effects on health and environment.

3.3 Disposal of e-waste

E-wastes are generally disposed in following ways. Figure 3.1 explains the various routes of disposal of e-waste.

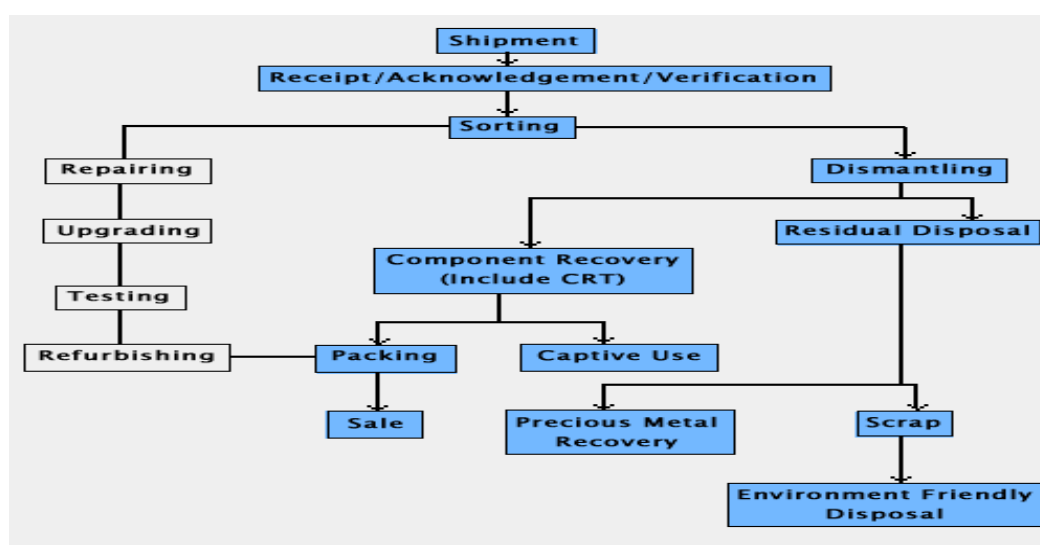


Fig.3.1: Disposal of E-waste: Routes and Destinations
(Source: Gaidajis et al, 2010)

3.3.1 Landfills The most common way of treating the e-waste globally is storing e-wastes in landfills, but it is replete with all the dangers of leaching, a natural process by which water soluble

substances are washed out from soil or wastes and enter in air/ water impacting nearby communities and the environment. Even a small amount of e-waste entering the residual waste introduces relatively high amount. of heavy metals and halogenated substances. Such harmful substances leach into the surrounding soil, water and air during waste treatment or when they are dumped in landfills or left to lie around near it. Sooner or later they adversely affect human health and ecology. An article in insights **on India (Jan 2019)** warns of a looming crisis for humanity and calls for immediate action (**www.insighsonindia.com/2019/01/25/8**)

The hazardous effects are far worse in the older or less stringently maintained landfills or dumpsites. As per **UNEP (2009)** report, about 70 per cent of heavy metals (including mercury and cadmium) found in landfills come from electronic discards in US only. In many European countries, regulations have been introduced to prevent electronic waste being dumped in landfills due to its hazardous content. However, the practice continues in many countries especially the developing countries.

3.3.2 Incineration Another method commonly used for disposal of e-waste is to incinerate or burn the goods concerned. But this process releases heavy metals such as lead, cadmium and mercury into the atmosphere in the form of ashes. Burning E-waste may generate dioxins, furans, polycyclic aromatic hydrocarbons (PAHs), Polyhalogenated Aromatic Hydrocarbons (PHAHs), and hydrogen chloride. Mercury released into the atmosphere can bio accumulate in the food chain, particularly in fish - the major route of exposure for the general public. If the products contain PVC plastic, highly toxic dioxins and furans are also released. For example the burning of insulated wire, which typically occurs in

open iron barrels, generates 100 times more dioxins than burning domestic waste (**Gullett et al., 2007**). Many a times the e-waste is burnt along with the municipal wastes and becomes the source heavy metal contamination of the atmosphere.

3.3.3 Reuse is another way of dealing with e-waste and it is a good way to increase a product's lifespan. They have been preferable because it implies less waste over time by way of reuse. Re-use constitutes direct second hand use, or use after slight modifications are made to the original functioning equipment like memory upgrades, etc. However, eventually they also end up as waste as they have limited life span and are dumped after a short period of use. The reuse of second-hand electronic goods in the developing world including India falls in this category, where the waste ends up locally and where there is no adequate facility and competence to deal with them appropriately.

3.3.4 Recycling while recycling appears to be a safe method to utilize or dispose e-wastes, it can be a misleading characterization of disparate practices-including dismantling, shredding, burning, exporting, etc. which are mostly unregulated and often create additional hazards itself. It harms workers in the recycling yards, as well as their neighbouring communities and environment. Recycling of hazardous wastes, even under the best of circumstances, also moves the hazards into secondary products that eventually have to be disposed of. Recycling along with redesigning of the products by using non-hazardous materials is best solution. On the other hand, the Toxics Link, NGO based in Delhi holds that recycling isn't just good for the environment but also good business practice. Recycling is therefore an important solution, especially if we consider that e-waste contains many valuable and rare materials (**E-waste in India, 2011**).

In developed countries, electronics recycling takes place in purpose-built recycling plants under controlled conditions. In many EU states for example, plastics from e-waste are not recycled to avoid brominated furans and dioxins being released into the atmosphere. In developing countries however, there are no such controls. Recycling is done by hand in scrap yards, often by women and children.

3.4 Effect on health and environment

Most electronic goods contain significant quantities of toxic metals and chemicals like mercury, which is currently being phased out in the developed countries. Mercury is mobile and poisonous in any form whether it is inorganic, organic or elemental.

According to the United Nations Environment Programme's **(UNEP) Global Mercury Assessment Report**, even miniscule increases in methyl mercury exposures can affect the cardiovascular system. **(E-waste in India, 2011)**. Effects of some of the prime hazardous components in of e- waste are mentioned in below:

Effects of few hazardous components found in e-waste on health:

Arsenic - Can affect skin and can decrease nerve conduction Velocity. Chronic exposure to arsenic may cause lung cancer and sometimes be fatal.

Lead - A neurotoxin that affects the kidneys and the reproductive system. High quantities can be fatal. It affects mental development in children. Mechanical breaking of CRTs (cathode ray tubes) and removing solder from microchips release lead as powder and fumes

Chromium - Used to protect metal housings and plates. Computer from corrosion. Inhaling hexavalent chromium or chromium 6 can damage liver and kidneys and cause bronchial maladies including asthmatic bronchitis and lung cancer.

Beryllium - Found in switch boards and printed circuit boards. It is carcinogenic and causes lung diseases Mercury Affects the central nervous system, kidneys and immune system. It impairs foetus growth and harms infants through mother's milk. It is released while breaking and burning of circuit boards and switches. Mercury in water bodies can form methylated mercury through microbial activity. Methylated mercury is toxic and can enter the human food chain through aquatic.

Cadmium - A carcinogenic, Long-term exposure causes Its a disease, which causes severe pain in the joints and spine. It affects the kidneys and softens bones. Cadmium is released into the environment as powder. While crushing and milling of plastics, CRTs and circuit boards. Cadmium may be released with dust, entering surface water and groundwater.

Acids - Sulphuric and hydrochloric acids are used to separate metals from circuit boards. Fumes contain chlorine and sulphur dioxide, which cause respiratory problems. They are corrosive to the eye and skin.

Dioxins - These are highly toxic to animals and can lead to malfunction of foetus, decreased reproduction and growth rates, affect immune system.

(Source: 'IT's underbelly, Down to Earth, Vol. 19, No.I, May 16-31, 2010).

Unless suitable safety measures are taken, these toxic substances can critically affect the health of employees and others

in the vicinity who manually sort and treat the waste by entering their body through respiratory tracts, through the skin, or through the mucous membrane of the mouth and the digestive tract **(IT's underbelly, 2010)**. Therefore, the health impact of e-waste is evident. This impact is found to be worse in developing countries like India where people engaged in recycling e-waste are mostly in the unorganized sector, living in close proximity to dumps or landfills of untreated e- waste and working without any protection or safeguards. Many workers engaged in these recycling operations are the urban poor and unaware of the hazards associated with them. For instance, such recycling activities lead to the deterioration of local drinking water which can result in serious illnesses. It was found that a river water sample from the Lianjiang river near a Chinese "recycling village" had lead levels that were 2400 times higher than the World Health Organization Drinking Water Guidelines thereby involving a serious health hazard **(Schwarzer et al, 2005)**.

Although recycling may remove some contaminants from the e-waste, large amounts may still end up concentrated in landfills or e-waste recycling centres, where they may adversely affect human health or the environment and would pose a risk to ecosystems. The flux of these contaminants on a global scale is that most e-waste is not recycled, because e-waste items tend to go out with household waste and receive no special treatment **(Ladou and Love grove, 2008)**. Of that which is collected, some 80% is exported to poor countries **(Schmidt, 2006)**. Electronic equipment that is no longer of use to the original purchaser may be reused, effectively extending its lifespan. Reuse is ultimately the source of some e-waste in many poor countries that accept donations of equipment considered obsolete in rich countries **(Puckett et al.,**

2005). Old yet functional electronic equipment is often shipped to developing countries by well-meaning donors in the West. Unscrupulous organisations in rich countries use donations of obsolete electronic equipment as a loop-hole in the Basel Convention to export both functioning and non-functioning electronic equipment **(Ladou and Lovegrove, 2008).** Brokers who arrange the export of functioning products often pad shipping containers with irreparable waste, which may account for up to 75% of deliveries. Most of this ends up in landfills and informal dumps **(Schmidt, 2006).** China receives some 70% of all exported e-waste. **(Uu et al., 2006).** while significant quantities are also exported to India, Pakistan, Vietnam, the Philippines, Malaysia, Nigeria and Ghana **(Puckett et al., 2005).** and possibly to Brazil and Mexico. Due to the semi-clandestine nature of these operations, the actual mass of e-waste being exported is impossible to quantify. NGOs such as Greenpeace keep campaigning against this "hidden flow" of E-waste **(Cobbing, 2008).**

E-waste is characterised by the difficulties associated with determining its mass and flux at both local and global scales. Contamination associated with e-waste has already caused considerable environmental degradation in poor countries and negatively affected the health of the people who live there. Cleansing of such large contaminated sites is probably unfeasible, since they have been heavily contaminated with numerous contaminants, many of which are poorly studied. However, the negative effects of the contaminants at these sites may be reduced using standard remediation technologies. There is limited knowledge on the ecological effects, human health risks and remediation options for some e-waste contaminants, such as Li and Sb, since they are not normally environmental pollutants. Rich

countries have self-interest in mitigating the negative environmental effects of e-waste because it will negatively affect the quality and quantity of food and manufactured goods that are imported from poor countries.

Most e-waste is disposed in landfills. Effective reprocessing technology, which recovers the valuable materials with minimal environmental impact, is expensive. Consequently, although illegal under the Basel Convention, rich countries export an unknown quantity of E-waste to poor countries, where recycling techniques include burning and dissolution in strong acids with few measures to protect human health and the environment. Such reprocessing initially results in extreme localised contamination followed by migration of the contaminants into receiving waters and food chains. E-waste workers suffer negative health effects through skin contact and inhalation, while the wider community are exposed to the contaminants through smoke, dust, drinking water and food. There are evidences that E-waste associated contaminants may be present in some agricultural or manufactured products for export.

(Robinson 2009)

Besides all this, the demand in Asia for electronic waste began to grow when scrap yards found they could extract valuable substances such as copper, iron, silicon, nickel and gold, during the recycling process. A mobile phone, for example, is 19 percent' copper and eight percent iron.

India is also one of the largest waste importing countries in the world. All types of wastes are imported into the country, in the form of cheap raw materials including hazardous and toxic wastes. Data released by the Customs Department reveal imports of even prohibited wastes like clinical waste, incineration ash, municipal

waste and e-waste, all of which exceed 50 lakh tonnes annually. In 2009, India generated 5.9 million tonnes of hazardous waste domestically and imported 6.4 million tonnes **(Sanghal, 2010).**

3.5 Hazards of e-waste due to informal sector in India

India has the label of being the second largest e-waste generator in Asia where more than 90 per cent of the e-waste generated in the country ends up in the unorganized market for recycling and disposal as stated before. The unorganized sector! informal sector mainly consists of the urban slums of the metros and mini-metros, where recycling operations are carried out by the unskilled employees using the most rudimentary methods to reduce cost. A study by the Basel Action Network (BAN) in partnership with the Toxic Link has revealed that e-waste is received and processed in India in similar manner as is done in China, or the condition could be even worse. The unorganised sector consists of an assortment of small and informal businesses not governed by any stringent health and environmental regulations. Workers face dangerous working conditions as they may be without protection like gloves or masks. Released gases, acid solutions, toxic smoke and contaminated ashes are some of the most dangerous threats for the workers and for the local environment **(Schwarzer, 2005).** Many workers function from homes to reprocess waste, further exposing themselves, their families and the environment to dangerous toxins. For instance, to extract metals from circuit boards, gas torches are used to heat a board just enough to melt the solder, which separates the metal parts from the boards. Metals are also extracted by soaking the circuit boards in open acid bath followed by manual scrapping to extract copper and precious materials next to open drains.

One example of recycling of circuit board informally can explain how this process is harmful for the ecosystem as a whole. The circuit board recycling process involves either open burning of the circuit boards or using acid stripping. Very often child labour is employed to separate the parts from the circuit boards, utilizing wire cutters and pliers. After some pin straightening, some of the Integrated Circuits (IC) chips and components are sold for reuse. The items that are not worthy of re-use go directly to the open fires to reduce them to metals. Following the chip extraction and burning, the boards themselves are burned in an open pit to retrieve the rest of the metal solder and copper. After burning, the ashes are floated in water to remove lighter ash. Another process involves utilizing nitric acid on the circuit boards to remove gold and platinum. Both methods, open burning and acid baths, are fraught with occupational health risks as well as risks to the people living in the surrounding community.

The circuit boards are sourced from the computer monitors, CPUs, keyboards, television and remote control sets, radios, cell phones and other electrical appliances (E-waste in India, 2011). It is estimated that about half the circuit boards used in the appliances in India end up in Moradabad (Uttar Pradesh), an e-waste recycling hub also called Peetal Nagri or the brass city (**IT's Underbelly, 2010**). It is also mentioned that the locality is full of one room houses with dismantled parts of circuit boards strewn all over and nearly every family here specializes in one of the processes to extract metals from circuit boards but under the environment of smoke, the noise and the smell their work produces.



Fig.3.2: Informal Recycling hub in Moradabad
(Source: The e-afterlife in The Indian Express)

Unlike the informal recyclers, the formal recyclers do not use any chemicals or incinerations and use environmentally sound processes. Clients of the formal recyclers are generally multinational companies which have to keep up with an environment friendly image and those which do not want their products to enter the grey market and compete with their own new products. Unlike the organized sector, the informal dealers refurbish and sell a computer, even if it can be classified as e-waste, with some parts of it in working condition. Selling any part of a computer that is functional would fetch more money than selling it as metal parts.

The degree of hazard posed to workers and the environment varies greatly depending on the individuals involved and the nature of operations. Informal sector e-waste activities are also a crucial source of environment-to food-chain contamination, as contaminants may accumulate in agricultural lands and be available for uptake by grazing livestock. E-waste is a major problem for health **Rohan Hooda (2017)** In addition, most chemicals of concern have a slow metabolic rate in animals, and may bio accumulate in tissues and be excreted in edible products such as eggs and milk. E-waste related toxic. Effects can be exacerbated

throughout a person's lifetime and across generations **(Lundgren, 2012).** E-waste therefore constitutes a significant global environmental and health emergency, with implications far broader than occupational exposure and involving vulnerable groups and generations to come.

E-waste are health hazards for unorganised e-waste disposal, **V.Ranganathan (2018)** as Rubicon Global (2018) has identified how big the e-waste problem and what are its occupational hazards.

Chapter 4

ECONOMIC BENEFITS OF E-WASTE RECYCLING

There is need to study economics of e-waste recycling as the e-waste consisting of computers, laptops, televisions and mobile phones can bring benefits to the consumers and society at large. **A article in Financial express on January 2019**, Managing e-waste “Making cash from electronic waste”, highlights the need and methods to make money from e-waste.

With e-waste generation increasing globally and with advances in technology making rapid. Strides, Economic benefits of e-waste become all the more important.

Some of the economic benefits of e-waste recycling process are enumerated below:

4.1 Source of Employment

The e-waste recycling process not only saves the eco-system from harmful toxics but it also supports the economy of a country in the form of generating a reliable source of employment. It requires a lot of manpower to carry out the recycling processes which promises reputable jobs to many skilled people and supports the economy. However, there are flip sides to this when e-wastes are not disposed appropriately **(E-waste business 2018)** “Did you

know you could make money out of e-waste” (***www.norcalcompacters.net***).

4.2 Cost Minimization

Without the e-waste recycling processes, most of the electronic waste is dumped in landfills which are scarce in every country. As a result the scrap is required to be shipped to land a dump overseas which incurs heavy costs of management and transportation.

In a web article on "***Recycling Economics***" the need for cost minimization is effectively brought out. (***www.elimicalfreedom.com***)

The indigenous e-waste recycling facilities not only save these domestic costs but will also reduce burden on the foreign country where the scrap was supposed to be dumped otherwise.

4.3 Monetary Incentives

BBC news in its report on ***6th July 2018*** mentions why e-waste recycling could be a good business.

There have been a lot of pressures from global environmental groups on electronics manufacturers. As a result, most of the manufacturers offer financial incentives to e-waste recycling facilities by ***buying the old electronics product*** that comes to them in large quantities.

Also it helps in cutting the cost of raw material at the manufacturer's end. As a result the cost of the final product becomes more affordable, rising the average standard of living of the masses.

So this has far more than expected benefits to the consumers and manufacturers too.

4.4 Resource Conservation

The e-waste recycling process also makes the scarce resources available to manufacturers that not only supports sustainable development but also reduces the burden on a country's economy. This also averts the extraction costs in the form of mining and processing the extracted minerals and raw materials.

4.5 Energy Efficiency

The e-waste recycling process is much more energy efficient than the mining of the raw materials itself. This incurs less costs than that required to extract them from the Earth's crust. This also leads to less pollution and less dependence on the already scarce minerals.

4.6 Provides Good Business Opportunities

Heather Tuninous(2013) "The Indian company turning e-waste into mounds of profit "Mentions about Business opportunities of recycling around the world with particular reference to India.

The e-waste recycling can be a great business opportunity. There are not many e-waste recycling facilities available worldwide yet. A e-waste facility can earn benefits in the form of incentives and raw materials. It is a great venture in a developing country as these recycling processes are of more vitality in these growing economics which have both the resources and the manpower to make it feasible.

4.7 Scope of Research

The e-waste development sphere also has a huge scope of improvement. It provides a promising subject for industry and environmental research too. There is a prospect of many new projects that concern innovating efficient and more profitable recycling processes. Research can strengthen the national economy. **Abhishek Awasthi and Mengmeng Wang (2018)** have highlighted the need for e-waste management and research on the subject (**www.journals.sagepub.com**).

Thus, there are many benefits in terms of financial and economic betterment of a nation. This makes the e-waste recycling processes and facilities even more necessary worldwide. **Brandy Dunseith, 2017** "Waste Management in India; investment opportunities (**www.indiabreaking.com**) highlights some of these users.

4.8 Koh, Cucchiella, D'Adamo, and Paolo

In an award winning article "Recycling of WEEE's: An economic assessment of present and future e-waste streams' in 2015" has mentioned that the European Union has made it a priority to work for the amount of embedded value and precious materials in the electronic products toward a circular economy, in which wastes are increasingly recognized as resources. Koh and her colleagues estimate potential revenues from recycled e-waste at more than two billion Euros in the year 2014 for the European market alone. Considering the fact that smartphones, tablets and other popular electronic products contain precious materials, including gold, copper, palladium, silver, platinum, cobalt, and more, the value associated with those recycled resources has been estimated to rise by the year 2020 to more than 3.5 billion

Euros in the article. This clearly depicts the economy residing in e-waste.

Syed Farz Ahamad, 2016 in "The global cost of electronic waste published in the Atlantic Jour. (www.theatlantic.com) is more circumspect on the use of e-waste for economic benefits.

4.9 Rare Earth Elements in e-waste

Urban Mining A rare earth element (REE) as defined by International Union of Pure and Applied Chemistry (IUPAC), is one of a set of seventeen chemical elements in the periodic table, specifically the fifteen lanthanides, as well as scandium and yttrium. The rare earth elements are all metals, and the group is often referred to as the "rare earths metals and have similar properties (www.geology.com/articles/rare-earth-elements). Rare earth metals and alloys that contain them are used in many devices that people use every day such as computer memory, DVDs, rechargeable batteries, cell phones, magnets, fluorescent lighting and much more. Material wastes have become extremely significant over the past decade because of the presence of valuable materials in it. In present and into the future there will be an ever increasing reliance on critical materials, rare earth and precious materials i.e. rare earth elements (**REE**). With innovation, the demand for these materials has exponentially increased, but the rate of supply is restricted because of the availability of the limited resources for certain types of materials in the world.

Urban mining means recovering valuable metals such as gold, silver, copper and palladium from the growing heaps of e-waste. Although REEs are abundant in the earth's crust, they rarely occur in concentrated forms. Mining of ore-containing REEs produces

extensive potentially toxic waste. Further impacts occur in the production and processing of REEs through grinding or acid digestion, which create contaminated waste materials. Disposal of mine tailings or process waste water creates still other environmental issues. The problem is exacerbated by the fact that the primary mining of REEs is conducted almost exclusively in developing countries or in parts of developed countries where environmental regulations, if any, may be loosely enforced **(Hieronymi et al, 2013)**. Besides this, the sharp increase in the price of most rare earth elements since 2009 played an important role in the increased level of research and in some cases investments in REE recycling over the last years. **(www.fortune.com/2014/06/26/blueoak-urban-mining-ewaste)**

Given all this, recycling of e-waste, which contain REEs, becomes clearly advantageous not only from environmental but also from economic perspectives. Historically, e-waste has been managed almost exclusively by disposal, but now recycling and reuse are globally being recognized as having several environmental advantages over disposal **(Smith, 2015)**.

More collection of electronic appliances allows for more efficient recycling, keeps valuable e-waste components (e.g. metals) in the economy and safely disposes of its harmful components in order to prevent risks to human health and the environment. Therefore, increased take-back and efficient and innovative recycling technologies at the different steps of the recycling chain can generate genuinely sustainable products and services and can create new markets.

4.10 Economy in Recycling

Koh et al, 2015 has listed the factors which affect the potential revenue obtained from e- waste as under:

- Material's market price.
- Material's weight within a product.
- Material's purity level obtained by the recycling process.
- Volumes of generated wastes.
- Percentage of collected versus generated wastes.

With the technological evolution of products, the e-waste generation increases and the higher waste collection rates provide a significant market for recycling while the revenues seem to be strictly related to the presence or not of precious metals and even more by volumes.

It is reported in **fortune magazine by Bradoo** that nearly 7% and 10% of the world's gold and 30% of the silver produced goes into electronics. It is also mentioned that, roughly 10 ounces of gold can be extracted from every ton of printed circuit boards, and to get the same amount from mine to process 100 tons of gold ore or more to get the same amount (**www.fortune.com/2014/06/26/blueoak-urban-mining-ewaste**). But only 15% of the 40 million metric tons of e-waste created globally each year undergoes any recycling. Instead, the vast majority of devices are dumped in landfills or exported to countries where e-waste is hand-picked over open fires.

It has become crucial that industries operating in manufacturing of electronic equipment look at new and more efficient ways of recycling, new ways of improving material

resource efficiency, and implementing the idea of circular economy in order to recover valuable waste from these products so that they can be purified and rooted back into the supply chain. New Industry are emerging globally to tap into this growing market of recycling, which is growing at a rate of three to five percent every year internationally (**UNEP, 2009**).

Europe has long been ahead in its e-waste solutions because of its emphasis on recycling but also to infrastructure already in place there. As mentioned above, **Koh et al, 2015** in her paper has mentioned that the potential revenue from the recycling of e- waste in EU is more than 2 billion Euros and it's projected to grow significantly to more than 3 billion Euros by 2020 by virtue of growth in the market for recycling of e-waste. **Koh et al** recognises this absolutely phenomenal opportunity in this sector. She also says that out of all other recycling materials gold is having the highest influence in this recycling economy. Gold accounts for more than half of the revenue from e-waste materials. She also adds that the number of gold mines available is limited and they are often in particular geographic locations where there have been political tensions. Economic uncertainty can influence the availability of gold and the demand for gold continues to increase in a lot of products as the consumption is rising. Gold is one of the top ten materials which is taken out from recycling besides copper, palladium, plastic, silver and aluminium.

Koh et al also stresses on the fact that recycling of electronic waste products also helps in reducing environmental pollution by conserving virgin resources, which are required for the manufacturing of high-tech consumer products. As the demand for these limited resources continues to rise, industry will

be left with little choice but to capture recycled materials for manufacturing and to meet the demand for their new products.

4.11 The objectives of e-waste recycling

- Take care of hazardous/toxic substances contained in e-waste in an environmentally sound manner while preventing secondary and tertiary emissions (as explained in Chapter-3),
- Recover valuable materials as effectively as possible,
- Create economically and environmentally sustainable businesses (optimize eco efficiency),
- Consider the social implications and the local context of operations (e.g. employment opportunities, available skills and education etc.).

Considering the above objectives, the identification of technologies needs to be based upon an evaluation to what extent a specific technology contributes to achieving these objectives as a whole, also taking into account the regional and social context and the steps in the recycling chain it addresses. A technology can be considered sufficient only when it is just not only clean with respect to environment, but also efficient in recovering valuable materials and economic too at the same time. And finally, the recycling technologies have to take the regional context into account say ,what could be a highly effective technology/solution in e.g. a Western European (highly industrialized) context can be a completely misguided approach in Africa or Asia (developing, industrializing context) and vice versa. Implementing a high-tech, capital intensive recycling process will not be suitable in every country **(UNEP 2009).**

The recycling of e-waste especially in developing countries is to be viewed from the angle of social compliance affecting the impact on employment and public wealth, current recycling infrastructure, involvement of existing informal structures, legislative framework etc.

4.12 Recycling Chain

The recycling chain for e-waste consists of three main subsequent steps:

- i) collection,
- ii) Sorting/dismantling and pre-processing which also dismantling, mechanical treatment and includes sorting, end-processing including refining and disposal
- iii) Separated components & fractions

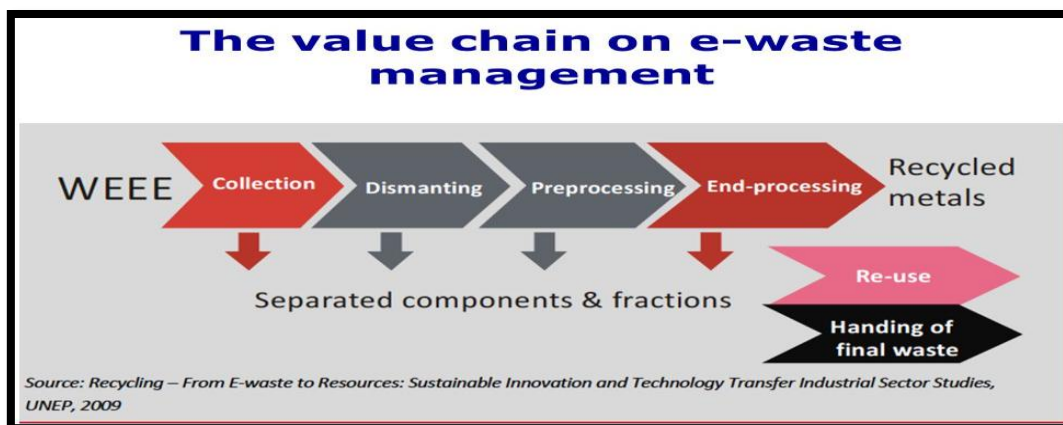


Fig.4.1: Recycling Chain
(Source: UNEP, 2009)

The efficiency of the entire recycling chain depends on the efficiency of each step and on how well the interfaces between these interdependent steps are managed for example, for a certain device/metal the efficiency of collection is 50%, the combined dismantling pre-processing efficiency is 70% and the materials recovery efficiency 95%, the resulting net metal yield along the chain would be only 33% **(UNEP, 2009).**

Collection of e-waste is of crucial importance as this determines the amount of material that is actually available for recovery. When the devices are not collected, the feed material to dismantling, pre-processing and end-processing facilities is lacking and a recycling chain cannot be established. The efficiency of collection programmes varies from place to place and also depends on the device. Improvement of collection rates depends more on many social factors.

The purpose of dismantling and pre-processing is to liberate the materials and direct them to adequate subsequent final treatment processes. Hazardous substances have to be removed and treated safely while valuable components/materials need to be taken out for reuse or to be directed to efficient recovery processes. This includes removal of batteries, capacitors etc. prior to further mechanical pre-treatment. The batteries from the devices can be further sent to dedicated facilities for the recovery of cobalt, nickel and copper. The circuit boards present in latest equipment and televisions contain most of the precious and special metals as well as lead (solders) and flame retardant containing resins. They can be removed from the devices by manual dismantling, mechanical treatment (shredding and sorting) or a combination of both. But in many cases pre- processing of e-waste is not always necessary for example small, highly complex electronic devices such as mobile phones, MP3 players etc. can (after removal of the battery) also be treated directly by an end-processor to recover the metals.

Last in the chain is the end processing which means final metals recovery from output fractions after pre-treatment takes place at three main destinations. Ferrous fractions are directed to steel plants for recovery of iron, aluminium fractions are sent to

aluminium smelters, while copper lead fractions, circuit boards and other precious metals containing fractions are directed to integrated metal smelters, which recover precious metals, copper and other non-ferrous metals, while isolating the hazardous substances.

As mentioned before, every single step in the recycling chain is closely interlinked in both an upstream and downstream direction. Furthermore, the recycling chain itself is linked to other steps in the product life cycle such as the product design, manufacturing and product use. What is done in dismantling and pre-processing affects the subsequent steps of material recovery, while technological advances in final materials/metals recovery might imply new requirements for the output fractions of preceding steps.

A close interaction and communication among the participants/stakeholders in the recycling chain is thus crucial to achieve a good overall efficiency and to be able to anticipate future developments. Moreover, transparency, accuracy and verification of the actual flows of materials along the recycling chain are important for all stakeholders. Authorities and manufacturers need certainty about the actual performance of the involved recycling operations in achieving resource efficiency and environmental compliance, so that the legal or producer responsibility obligations of authorities and manufacturers are fulfilled.

4.13 Benefits of recycling in reduction of GHG

Reduction of e-waste through reuse and recycling play a significant role in GHG- emission reduction. From a climate perspective, the benefits of both reuse and recycling are realized

in avoiding GHG emissions from waste treatment and disposal. The benefit in reduction of GHG is achieved through avoiding resource extraction (are mining) and by avoiding the disposal of e-waste in landfills. The recycling e-waste from landfills reduces methane emissions, which are 25 times more potent than carbon dioxide at trapping heat in the atmosphere. Recycling instead of producing new materials also reduces overall energy consumption, avoiding direct greenhouse gas emissions, and reducing the environmental impact of natural resources extraction (***E-waste: from toxic to Green, n.d.***). Primary production, i.e. mining, concentrating, smelting and refining, especially of precious and special metals has a significant carbon dioxide (CO₂) impact due to the low concentration of these metals in the ores and often difficult mining conditions. While "Mining" the old computers to recover the contained metals if done in an environmentally sound or correct manner needs only a fraction of energy compared to mining ores in nature (***Koh et al, 2015***). Waste prevention and recycling help address global climate change by decreasing the amount of greenhouse gas emissions and saving energy. In a way, the recycling of e-waste may help in earning the carbon credits for the country.

The entire value chain of e-waste should grow and create an ecosystem that supports the overall recycling and recovery of as much value as possible from electronics products in such a way that it is not treated as a waste stream. Notwithstanding different approaches and levels of innovativeness in technologies, boundary conditions, social attributes like job creation, or economic factors like capital intensiveness play the most crucial role that could hamper the effectiveness of any technology or approach of recycling in any country. Fully automated technologies and

environmentally sound end- processing technologies require high investment cost compared to pre-processing technologies, as well as a considerable tonnage to operate such processes economically.

4.14 Recycling in Developed versus Developing countries

The process of e-waste recycling in developed countries begins with a collection point. Typically, these points are organized by local or national governmental entities, contracted out to private waste management companies, or through retailers of personal electronic devices. At those collection points, members of the community are encouraged to bring all of their e-waste. From there the materials are typically sent to a sorting facility where the e-waste is sorted based on the types of products and materials that make up the e-waste. For example, CRTs can be sorted into one bin and smart phones into another. From that point the materials are broken down into their component parts where the valuable materials present in the e-waste are extracted. This process of breaking down the materials can occur through an automated system in more formal and advanced settings **(Hieronymi et al, 2013).**

In developing countries, informal (*or backyard*) methods are more prevalent. Individuals are typically responsible for breaking the component parts down by hand and then extracting the materials using rudimentary processes like open burning pits **(Hieronymi et al, 2013).** Such practices can be harmful not only to the environment, but also hazardous to individuals doing the extracting. Recovered materials are then resold on a secondary market and eventually make their way into other electronic devices or similar products.

Besides there are many socio economic characteristics which drive the way recycling of e-waste is handled differently in the developed versus developing countries. Trade economics drives the e-waste trade value chain in all the countries. In majority of developed countries, "polluter pays principle" is applied to drive the e-waste trade economics, where "Recycling Fee" is charged to the consumer and passed on to the "Producer Responsibility Organisations" (PROs). PRO is a body of producers! manufacturers, responsible for collection, transportation and recycling of WEEEI E-waste based on the fundamental principles of Extended Producers Responsibility both legally and operationally. While in developing countries, e-waste collection, transportation and recycling has become a profitable business in the unorganised! informal sector, where the e-waste trader collector recycler pay the consumer for the e- waste item. Since low level of investment is required in unorganised informal sector, small investors find e-waste trade as attractive business proposition, where the main incentive is financial benefit irrespective of environmental, occupational and health issues **(UNEP 2009).**

Informal collection and manual dismantling activities do not necessarily need to be transformed to formalized processes and often have advantages over the introduction of new technologies from a sustainability point of view due to the large volumes and high investments needed to establish state-of-the-art end-processing facilities **(Rochat et al 2008).** Also the abundant workforce and low labour costs are the additional factors which make the informal sector important in developing countries. The informal collection system is rather efficient in countries like India and China because the daily informal collectors are penetrating

into each community of the city to collect e-waste from house to house.

A comparative analysis of a few selected developing countries has been done with respect to the dimension of the formal and informal e-waste recycling sector in the **UNEP, 2009** report '**Recycling- From E-waste to Resources**'. All selected developing countries feature a formal and informal e-waste recycling sector. These findings were analysed qualitatively based on the specific country background and to show the dimension of the recycling sectors (**Fig. 4.2**).

The graph is divided into four quadrants representing different shares of the recycling market between the informal and the formal sector. Normally, a sustainable recycling system should grow towards the upper right corner of the graph, where most of the established recycling schemes in Europe are located now. In Europe the informal sector only exists as an exceptional case, if at all. Depending on the socio-economic and cultural context of a country, a sustainable recycling system could include an organized informal collection system and the first steps of informal pre-processing as well.

Fig. 4.2 Comparative analysis of selected developing countries regarding the dimension of the formal and informal e-waste recycling sector

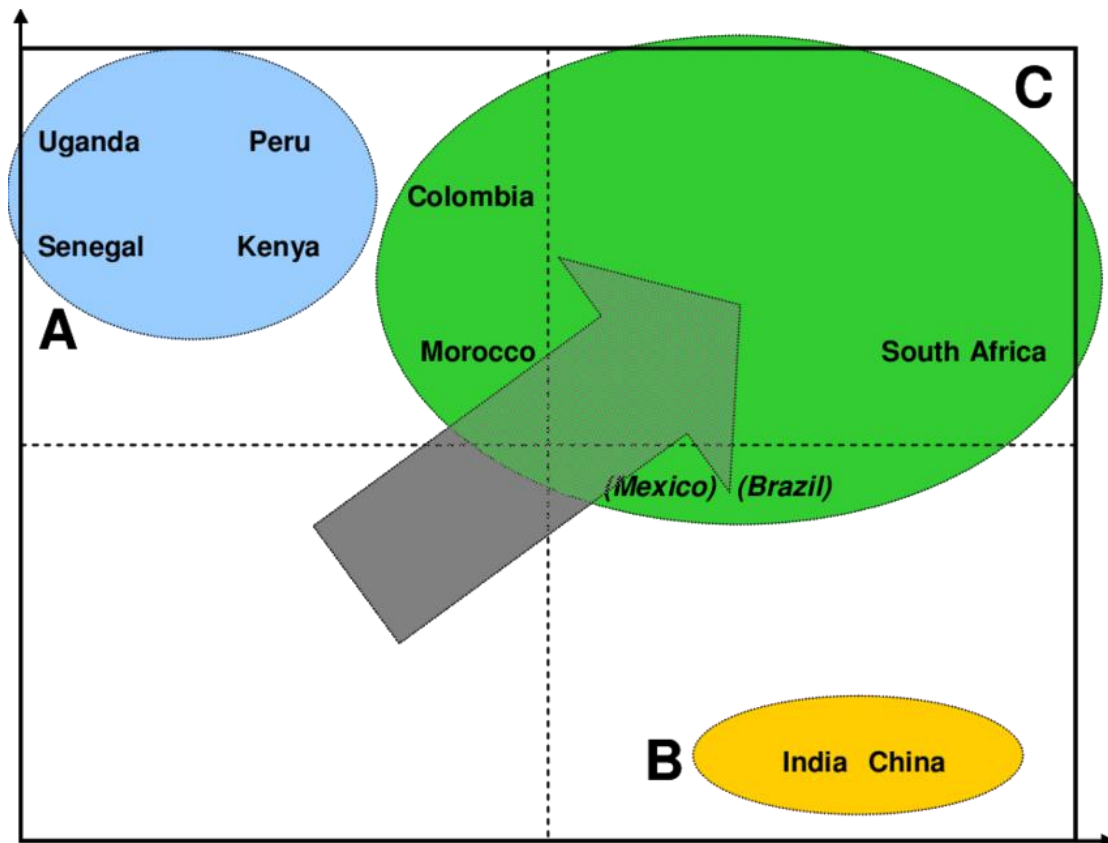


Fig.4.2: Comparative analysis of selected developing countries regarding the dimension of the formal and informal e-waste recycling sector (Source: UNEP, 2009; Recycling- From E-waste to Resources)

It can be seen that none of the selected countries feature an established informal recycling sector while not having an established formal recycling sector at the same time. It is observed in emerging and large economies like India and China both sectors depend on each other.

Group A represents Kenya, Uganda, Senegal, and Peru and includes countries featuring the formal and informal sector on a small scale. E-waste volumes are too small for the formation of informal or formal recycling activities. As e-waste volumes also increase over time, those countries typically may move towards more informal activities if appropriate measures are not taken.

Group B represents India and China and includes the countries featuring an established informal and formal sector. E-

waste volumes are large here and in turn a well-organized informal sector has formed. The formal sector operates as a downstream partner and is not able to establish itself as a competitor for activities typically performed by the informal sector. The report further emphasises that provided a better control of the informal sector, these countries can have the technological and economical capacity to adapt sustainable recycling technologies.

Group C represents South Africa, Morocco, Colombia, Mexico, and Brazil and includes countries featuring a currently developing or already established formal recycling sector, while informal activities remain on a small or medium scale.

4.15 Economics of E-waste in India

As said earlier, India is the second largest e-waste generator in Asia where more than 90 per cent of the e-waste generated in the country is handled by informal sector. This sector mainly consists of the (a) urban slums of the metros and mini-metros, where recycling operations are carried out by the unskilled employees using the most rudimentary methods to reduce cost or (b) an assortment of small and informal businesses not governed by any stringent health and environmental regulations. A study by the **Basel Action Network (BAN)** in partnership with the Toxic Link reveals that e- waste is received and processed in India where many workers function from homes to reprocess waste, further exposing themselves, their families and the environment to dangerous toxins. Released gases, acid solutions, toxic smoke and contaminated ashes are some of the most dangerous threats for the workers and for the local environment.

In the formal sector in India, organized recyclers formed the e-waste recycler's association but facing stiff competition from the unorganized sectors, they have been able to capture only 10 per cent of the total share of the e-waste market. A problem facing the organized sector is the lack of proper collection and disposal mechanisms and also appropriate technologies in the face of a large informal sector. Due to lack of proper collection systems, households and institutions at times end up storing obsolete products in their warehouses or storerooms. Even when these are sold or exchanged, they are refurbished and then resold. Only a small proportion of obsolete electronics products actually find its way into the e-waste processing stream. As per the report *E-waste in India, 2011*, this is the dilemma facing the formal e-waste dismantling unit in Noida, Uttar Pradesh spread in 10,000 sq. ft. belonging to the ***TIC Group India Pvt. Ltd*** which can process up to 500 tonnes of e-waste annually. But since June 2008, when it was launched, the unit processed only 200 tonnes. **Similarly, the Attero recycling unit in Roorkee (Uttarakhand)** is a 35 crore plant which can process 36,000 tonnes of waste in a year although it is getting only 600 tonnes currently. The formal sector also lack refineries for precious metals recovery. Therefore, according to the e-waste recyclers' association formed by organized recyclers in July, 2009, the only way to sustain formal business in the current scenario is the license to import so that they have volumes e- waste to sustain. Currently, the ***Attero recycling unit*** is the only recognized recycling facility for e-waste in India which has the license to import e-waste from the developed countries **(E-waste in India, 2011)**.

But there are different opinions on the issue of license to import as the only way to sustain formal business in the current

scenario. The Toxics Link holds that the aim of e- waste management should be safeguarding environment rather than sustaining businesses. Allowing imports would mean many non-recyclable hazardous materials dumped in our landfills, which should not be allowed. The country generates very large quantities of waste and the critical need was to establish a sound collection mechanism and not permit waste import to sustain capacity utilization of plants as per Toxic Link report.

The table **4.1 provides** a comprehensive insight into the methods, safeguards, capital Investments and earnings involved in the e-waste business in formal and informal sector in India. Introduction of pre-end and processing technologies with a strong support in capacity building in the informal sector. Like EU, the India should made the recycling of e-waste a priority to work toward a circular economy, in which wastes are increasingly recognized as resources in its economy, and it's clear that such an effort makes good sense when it comes to economics as e-waste is a cheap source of raw materials.

Commenting on the benefit of safe recycling, the former President of India, **Dr. A.P.J. Abdul Kalam** also said at the inauguration of the Attera Recycling Plant in Roorkee in January 2010: *"With metal prices rising, recycling will help in sustaining our economy as it is much cheaper than extracting metals from its ore"* **(E-waste in India, 2011).** The future scenario has, indeed, presented both challenges and opportunities in terms of minimizing wants, managing e-waste as well as developing cleaner and more sustainable products. It is, therefore, important that viable solutions are found to address the problem of the e-waste involving skilled manpower from the informal sector of the economy and the use of appropriate technology.

4.16 Challenges in recycling of e-waste

The Future of e-waste Management is shifting from disposal to recycling and reuse, a trend not likely to end. Given the current and foreseeable circumstances, it would seem that disposal may become a less and less relevant management approach. Whatever different variations develop for recycling and reuse, some of the major challenges still need to be addressed. Addressing these challenges will require effort and cooperation on a global scale. Beyond the practical issues of e-waste management that exist today, there are some of the common challenges which affect efficient recycling of e-waste in many countries.

I) One of the biggest challenges in dealing with circular economy of e-waste is that the design of products is becoming increasingly sophisticated, smaller, and more compact on a nano scale. This increases the complexity in recovering precious, rare earth materials. Technological development in this area is important in order to deal with complicated products and nano scale materials to be recovered. For all this to happen, the recycling plants should have flexibility to cope with multi waste streams **(Koh et al, 2015).**

II) Due to high labour costs, and tough environmental regulations, rich countries generally tend not to recycle e-waste. Instead, it is either land filled, or exported from rich countries to poor countries, where it may be recycled using primitive techniques and little regard for worker safety or environmental protection **(Cobbing, 2008).** Although illegal under the **Basel Convention of 1992,** e-waste exportation continues through clandestine operations, legal loopholes, and by countries that have not ratified the convention **(Robinson, 2009).** Moreover, the

developing countries do not have proper financial and infrastructure support to overcome the barriers for innovative and sustainable e-waste recycling technologies.

III) A sufficient number of collection points at a particular location are again a challenge for efficient recycling. Simultaneously the consumer unawareness about these collection points is again what adds to this challenge. A proper collection point system would not require significant upfront costs or additional infrastructure to handle the movement of the e-waste; rather, it would require a form of partnership between informal and formal recyclers whereby the two could work with each other for the benefit of both. Such a system exists, in part, today in developed countries where formal recyclers leave many of the collection efforts to informal recyclers who then resell the bulk e-waste to formal recyclers who are then responsible for the dismantling and extraction processes.

IV) Another challenge for recycling of e-waste is the effective implementation of extended producer responsibility (EPR) practices. EPR makes the manufacturer of the product responsible for the entire life-cycle of the product, including its take-back, recycling, and final disposal. The objective of EPR is to ensure that the costs of end-of-use management are born by the producers and consumers, rather than externalized onto society as a whole. The costs are thrust upon producers through regulation or government mandate and this makes the recycling a costlier business affair. While EPR sounds simple enough in the sense that the producers of electronic devices should be responsible for the environmental attributes of their products but in practice, implementing EPR has faced significant hurdles in the adoption and implementation of

regulations and in the subsequent enforcement of regulations on producers.

V) Domestically, disposal of e-waste in landfills is the most convenient way of disposal of e-waste generally which is environmentally unacceptable. Despite the regulation of disposal practices at landfills, e-waste makes up a fairly good percentage of waste at municipal solid waste (MSW) landfills. So a concern among policy makers, and regulators is that disposal of e-waste through MSW collection poses a significant environmental risk while REEs in e-waste are also lost in the process.

Despite above, it is a well-known fact as the turnover of electronic devices increases, the supply chain volume for e-waste will increase as well. Effective recycling of the metals/materials is crucial to keep them available for the manufacture of new products, be it electronics, renewable energy applications or applications not invented yet. In this manner the primary metal and energy resources can be conserved for future generations.

Given that e-waste recycling requires employees with only minimal skills, all indications are that the industry will continue to grow and thrive, producing more revenue and jobs **(Hieronymi, 2013)**. Given this trend, it would appear to be in the best interests of all stakeholders that the growth occurs largely through an infrastructure assuring operation in a responsible fashion. Sustainability is no longer a platitude but reality for an industry which is more and more reliant on mined materials that are finite and expensive to extract. This reality is bringing together the ordinarily divergent interests of industry and environment into what could be a unified approach to dealing with the issue of managing e-waste by way of recycling.

Chapter 5

E-WASTE IN INDIA

India produces 1.85m tonnes per year of e-waste and is the fifth largest producer of e-waste (***Saptarshi Dutta, 2017***) of these 95% of India's e-waste comes from unorganised sector most of which illegal. A joint study done by CPCB and UPPCB found a number of illegal e-waste centres in U.P. This number of could be much higher as this inspection was continued to upper reaches of Ramganga River.

India being the second most populous country in the world, with over 1.2 billion people, has overtaken China to become the world's fastest growing, big economy in the as per the World Bank (***Wall Street Journal, Jan 2019***), Information technology sector in India has increased its contribution to India's GDP from 1,2% in 1998 to 7,5% in 2012 (***NASSCOM, 2012***), Government of India launched its flagship program of 'Digital India' with a vision to transform India into a digitally empowered society and knowledge economy and to give IT a secured position inside & outside India (***www.digitalindia.gov.in***), With the progressive stride that the country has made in the information technology sector and the electronic industry, the issue of e-waste and its handling and disposal is continuously gaining significance. There exists an urgent need for a detailed assessment of the current and future scenario for the environmentally sound management of e-waste.

Recent studies of e-waste in India have been correlated by **Harshini Vakkalanka 2018 (The Hindu, 18th June, 2018)** in an article on "A-Z of e-waste Management in India"

The **Business world, 4th March 2019** carried a lead story on "E-waste in India highlighting that India will consume **\$ 400b** worth of Electronic goods by 2020 generating a huge growth in end of life products while the e-waste huge environmental and health hazards.

2019 has been a year of literary articles on e-waste in India. At the India international e-waste exposition, 2019 at Bangalore between 28th February to 1st March 2019, a number of companies showed their interest in e-waste recycling in India (**[www.recyclingmagazine.com/India institutional e-waste 2019](http://www.recyclingmagazine.com/India_institutional_e-waste_2019)**). There have been both a mix of positive and negative impacts of recycling within India.

A social story in Think Change India dated 26th February 2019 writes about a 60 year old differently abled man from Gujarat recycle e-waste to build bikes ([yourstory.com/social_story/2019/02 "60 Years old builds e-bike from e-waste"](http://yourstory.com/social_story/2019/02_60_Years_old_builds_e-bike_from_e-waste)).

Mites Parl (February 2019) has extensively worked on the condition of recycling workers in India and their appalling state (**[theconversation.com/electronic waste-is-recycle in appalling conditions in India - 110363](http://theconversation.com/electronic_waste-is-recycle_in_appalling_conditions_in_India_-_110363)**). He mentions about the need for change and imbibing newer and safer technologies.

Dinesh Raj Bandela (2018) in a blog on Down to Earth magazine mentions that 82% of India's e-waste comes from personal devices.

Snehal Famandris (2018) writing in Hindustan times speaks about e-waste releasing toxic chemicals into soil in India's metro's.

5.1 Background and Regulatory Framework for e-waste in India

It would be worthwhile mentioning that there has been a stupendous growth in mobile phone users in India. As per figures by ASSOCHAM-KPMG number of mobile users in India was 4 times more than USA and just inarguably behind China. These numbers are changing exponentially as India is moving digitally ahead of many countries. "Sadly e-waste is something which gets good media coverage but about which awareness is very low" as per ***Ashok Kumar Das author of "E-waste Management in India current scenario"***.

The issue was brought to the notice of Parliament and Government when a Member Shri Vijay J. Darda, from Maharashtra introduced a bill on 'The Electronic Waste (Handling and Disposal) Bill, 2005' in Rajya Sabha on 23 December 2005, The Bill had recognized the fact that there was no proper law or guideline on the handling and disposal of electronic waste in the country by that time. According to the Hon'ble Member the bill was placed on the justification that nearly every home in India had a number of electronic products, and once these goods became obsolete or discarded, they were either thrown in the garbage or found their way to scrap dealers through the 'Kabariwalas', These local 'Kabariwalas' dismantle the gadgets, keep what was useful and threw the rest in landfills, The Bill called for a regulation of electronic waste disposal before reaching the alarming proportions. The Bill sought to provide for proper handling and disposal of millions of tonnes of electronic waste being generated by discarded electronic devices by prescribing norms and fixing responsibilities and duties on manufacturers, recyclers and consumers with regard to the disposal of electronic waste and for all matters connected to

it. The Bill, however, lapsed in July 2010 with the expiry of the tenure of the hon'ble member in the Rajya Sabha (E-waste in India, 2011).

In India, the Constitution assigns the management of solid waste as a primary responsibility to the Municipalities under the twelfth Schedule **(Constitution of India, 12th Schedule)**.

Article 243W empowers the State Legislatures to frame legislations in respect of waste management. **The Municipal Solid Wastes (Management & Handling) Rules, 2000** were enacted by the Central Government which came into force from 25 September 2000. Some of the guidelines for handling municipal solid wastes provided in the Schedules were relevant for the management of e-waste, It may be mentioned that after the enactment of the Environment **Protection Act, 1986, the Central Pollution Control Board (CPCB)** was delegated the functions to implement rules on hazardous wastes, bio-medical wastes, municipal solid wastes and plastic wastes. Under the purview of the CPCB, the division of Hazardous Waste Management has been overseeing the management of e-waste **(E-waste in India, 2011)**.

In India, there were no specific environmental laws for e-waste till 2008. The existing environmental laws did not have any direct reference to electronic waste or refer to its handling as hazardous in nature. Since e-waste or its constituents fell under the category of 'hazardous' and 'non-hazardous waste', they were covered under the purview of **'The Hazardous Waste Management Rules, 2003'**. To tackle the concerns pertaining to management of e-waste in India, the Government of India has enacted several regulations in recent years including guidelines for managing the e-waste in an environmentally friendly way and E-

waste Rules, 2011 (***Subsequently amended in 2016, 2018***) worked on pre legislative era (***Sinha et al, 2011***). The brief of these policy frameworks is summarised below:

E-Waste (Management and Handling) Rules, 2011, (amended in 2016, 2018) issued by Ministry of Environment and forest are operational from May 2012. The rules notified to channelize the e-waste generated in the country for environmentally sound recycling. As per the rules the producer will be responsible for collection of E-waste generated from the 'end of life' of their products and will ensure that such e-waste are channelized to registered dismantler or recycler. The rules placed responsibility of e-waste management on the producers of the electrical and electronic equipment by introducing the concept of "extended producer responsibility" (EPR) by e-waste confections, recycling and raising awareness. EPR is one main feature of the rules, where the producers manage e-waste after its 'end of life' by financing and organizing a system to comply with EPR.

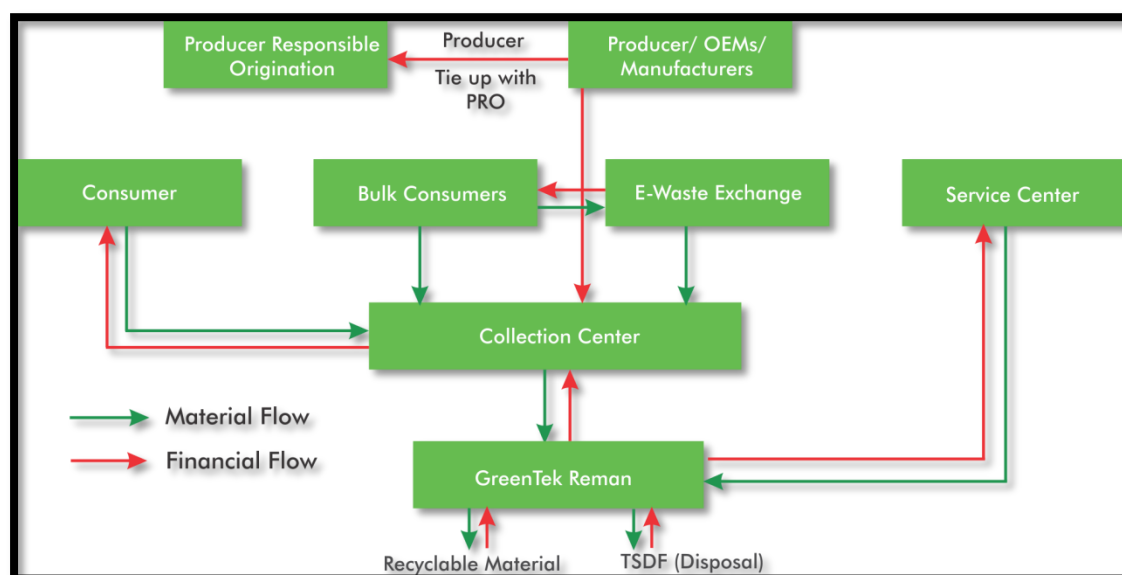


Fig.5.1: Implementation of EPR

Source: E-waste Management Rules – 2016; <http://www.greentekreman.com>

5.2 What is EPR?

EPR includes policies from mandatory or voluntary take-back to recycling fees and fees on disposal in a new era of industrial ecology and environmental sustainability **(Halluite et al, 2005)**. It shifts the responsibility upstream from municipalities to producers **(Yu, Welford & Hills, 2006)**. EPR is usually conceived as a comprehensive policy package, combining various instruments to achieve three distinct objectives simultaneously **(Tyson, 2009)**. These three objectives can be described in the following manner:

Improved waste management and resource recovery by establishing effective collection of end-of-life products from consumers, promoting environmentally sound treatment and efficient recycling, and reducing the amount of wastes for final disposal, integrating environmental externalities into consumption and production by transferring the burden of waste management on manufacturers, and -Design for the environment i.e. the producers to make design changes towards easier recycling In an effective EPR scheme, the true cost of waste management is internalized within the retail price by the producer. The aim is to provide an incentive to produce less toxic equipment that is cheap and easy to recycle. Companies are further pressured to address the life cycle issues of products, especially end-of-life issues. This, in turn, drives innovation, such as in business models, take-back logistics and design changes, to reduce the environmental impact of products. This policy is radically different from traditional recycling practices as it extends the producer's responsibility throughout the entire life cycle of the product chain from production through to end-of-life waste management. Thus the producers are also motivated for reducing use of virgin materials, designing changes to reduce-waste

generation, increasing resource efficiency and thus leading to sustainable development **(Nimpuno & Scruggs, 2011).**

EPR policies could drive green design of products because it is assumed that if producers have to deal with their own product waste they will have more incentive to use recyclable materials or materials that will not generate the costs of hazardous waste management **(Nimpuno & Scruggs, 2011).**

(I) For implementation of the provisions of the rules, a guidance document was framed to help producers, consumers, collection centres, dismantlers, recyclers and regulatory agencies for effective compliance. Although the government has understood the importance of the role of the manufacturer within the waste disposal process, yet it has failed to provide further clarity on the mechanism with respect to the same. Also, the fact that there is a huge chunk of E-waste being imported in India without much regulation, and that the lack of checks on this issue makes the need for revision of the rules all the more necessary.

(II) Guidelines for Environmentally Sound Management of Electronic Waste as approved by Ministry of Environment and Forests **(MoEF)** were issued by the CPCB in 2008. The guidelines apply to all those who handle the e-waste with the objective of providing guidance and broad outline for identification of various sources of e-waste and procedures for handling e-waste in an environmentally sound manner. These Guidelines are reference document for the management, handling and disposal of e-wastes. These Guidelines provide the very basics of e-wastes like definition, nature, the way to recycle, reuse etc. In nutshell, these guidelines besides giving the broad overview of e-waste in India also specify the minimum practice required to be followed in the management of

e-wastes like the approach and Methodology to determine the hazardousness. **(Guidelines for Environmentally Sound Management of Electronic Waste, 2008).**

(III) Guidelines for Implementation of E-Waste Rules 2011 is a guidance document for implementation of the provisions of the **E-Waste (Management & Handling) Rules, 2011 (as amended 2016, 2018)** that may help the Producers, Consumer & bulk Consumers, Collection Centres, Dismantlers, Recyclers and Regulatory agencies (SPCBs/CPCB) for effective compliance/implementation of these rules. As the **E-Waste (Management & Handling) Rules, 2011 (Amended 2016, 2018)** put main responsibility of e-waste management on the producers of the electrical and electronic equipment by way of EPR, this document provides guidance on setting up collection mechanism, dismantling and recycling operations as mentioned in. The guidelines greatly help the stakeholders in understanding the scope of implementing such EPRs. (Implementation of E-waste Rules, 2011) **(As amended 2016, 2018).**

Sonia Henam (2016) Down to earth magazine **(www.down to earth.org.in)** and **Auroshree (2018)** "E-waste Management Rules amended" has examined critically the factors that would play an important part in e-waste management **(www.blog.scconline.com).**

Overall, the E-Waste (Management & Handling) Rules, 2011 and its subsequent epic guidelines present a policy framework for giving the manufacturer a very broad role for the necessary disposal of the generated E-waste.

Saptarishi Dutta 2018 has voiced concern on dilution of e-waste targets **(Swachchindra.ndtv.com)** white **D.A Bureau,**

2018 has examined a number of issues in an article in digianalysis (www.digianalysys.com).

(IV) **Hazardous Waste (Management, Handling and Trans boundary Movement) Rules, 2008:** The Ministry of Environment and Forests is the nodal Ministry to deal with the trans boundary movement of the hazardous wastes and to grant permission for transit of the hazardous wastes through any part of India. Hazardous Waste Management Rules are to ensure safe handling generation, processing, treatment, package, storage, transportation, use reprocessing, collection, conversion, and offering for sale, destruction and disposal of Hazardous Waste. It has placed import of hazardous waste items under three categories; substances that can be imported with prior approval, free imports under Open General Licence and substances which are prohibited for importing into the country. The first category includes metal and metal- bearing wastes of antimony, lead, galvanic sludge and waste lead acid batteries, whole or crushed. The list in the second category comprises materials such as iron, steel and zinc scrap; lead scrap except lead acid batteries; waste of copper and its alloys. The third category prohibits import of waste containing mercury, beryllium, arsenic, selenium, thallium, hexavalent chromium compounds, etc. most commonly found in e-waste. ([www.cpcb.nic.in /Hazardous_waste.php](http://www.cpcb.nic.in/Hazardous_waste.php)). Since e-waste or its constituents fall under the category of 'hazardous' and 'non-hazardous waste', they have been covered under its purview.

(V) **Basel Convention:** India has ratified the Basel Convention but not the BAN Amendment, and officially opposes its enforcement (BAN, 2011). The regulations banning the importation of hazardous waste for disposal are weak and imported e-waste still finds its way into the country (**Montrose, 2011**).

(VI) **Environment (Protection) Act, 1986:** The first comprehensive environmental law was the Environment (Protection) Act, which was enacted in 1986, after the Bhopal gas tragedy. The potential scope of the Act is broad, with "environment" defined to include water, air and land and the inter-relationships which exist among water, air and land, and human beings and other living creatures, plants, micro-organisms and property. The [Rules under the EPA gives upon the Union Government comprehensive powers to "take all such measures as is necessary or expedient for the purposes of protecting and improving the quality of environment and preventing, controlling and abating environmental pollution" as per the act **(The Environment (Protection) Act, 1986)**. As discussed in chapter 3, e-waste is also such a waste stream which harms the environment in multiple ways.

Penalty and punishment for non-compliance of the law are in accordance with section 15 and 16 of the Environment (Protection) Act, 1986 which says that whoever fails to comply with the rules will be punishable with imprisonment for a term which may extend to 5 years or with fine which may extend to Rs 1 lakh. In case of continued violations an additional fine of up to Rs 5,000 can be imposed each day. Though the rules and guidelines put the onus of verification of manufacturing, recycling and collecting plants on the SPCBs, no guidance has been provided on the modalities of the same. (The Environment (Protection) Act, 1986)

5.3 Agencies for implementation of e-waste management

The main regulatory authorities active in the enforcement of e-waste management in India are:

- Ministry of Environment and Forest (MoEF),
- Central Pollution Control Board (CPCB) under MoEF,

- State Pollution Control Boards (SPCB),
- Pollution Control Committees (PCCs),
- The Directorate General Of Foreign Trade (DGFT).

While the Ministry of Environment and Forests (MoEF) is the nodal agency for policy, planning, promoting and coordinating the rules and guidelines referring to the e-waste, CPCB has been given the responsibility to evolve the guidelines for implementation, oversee the progress made in implementing the Rules and also to implement Restriction of Hazardous Substances (RoHS) compliance. The State Pollution Control Boards/Committees SPCBs/PCCs have been given the responsibility as regulatory agencies for implementing the E-waste Rules in respective states. SPC's are responsible for the authorization/registration of producers, dismantlers and recyclers in the state. In addition to public notices, the SPCBs also issue official circular to the bulk consumers and producers enunciating their roles, responsibilities under the E-waste Rules. The Directorate General of Foreign Trade (DGFT) is the certifying authority for permitting imports of second-hand goods and to grant or refuse licence for hazardous wastes prohibited for imports under the Environment (protection) Act, 1986.

5.4 Non Government Organisations working in e-waste

There are also a number of Non- Government Organisations /Associations working on this waste stream in India. A few of the active players are mentioned below:

I) **MAIT:** Manufacturer Association of Information Technology was set up in 1982 for purposes of scientific, educational and IT Industry promotion. The association has been playing a key role in

promoting sustainability & environmentally sound management of e- Waste (www.mait.com/about).

II) **GTZ:** The German government-owned GTI (Deutsche Gesellschaft für Technische Zusammenarbeit) operates in the field of technical cooperation. It is a Government agency providing technical assistance with funding throughout the major regions of the world. Experts are responsible for cooperation with individual countries, to ensure that the technical solutions and management methods used in the projects match the social cultural and economic conditions of the partner countries. GTZ works in 30 development activity areas, Water, waste management, and resource conservation is one of them. There are many studies done together by MAIT in association with GTZ in the field of e-waste in India.

www.web.mit.edu/urbanupgrading/upgrading/resources/organizations/gtz.html

III) **GIZ:** The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH or GIZ in short, is a company that specializes in international development in various fields. One of its field of activity is Environment and infrastructure (including activities such as waste, energy and water management etc. For over 60 years, GIZ has been working jointly with partners in India, in sustainable economic, environmental and social development (www.giz.de/en/worldwide/368.html). The key focal areas of Indo- German cooperation are currently energy, the environment, sustainable economic development.

IV) **Chintan:** Chintan, an Indian NGO, works with waste pickers and other recyclers, and converts waste to social wealth, to reduce ecological footprints. Chintan is involved in addressing the issues

with informal sector collaborations. Chintan works for environmental justice in partnership with people and groups from diverse sections of society for ensuring equitable and sustainable production and consumption of materials, and improved disposal of waste. **(www.chintan-india.org)**.

V) **Toxics Link:** Toxics Link is an environmental NGO, dedicated to bring toxics related information into the public domain engaged in disseminating information. to help strengthen campaigns against toxic pollution, provide cleaner environment. One of their focussed activities is in the area of e-waste and they have done many assessment studies of e-waste scenarios in major metros in India **(www.toxicslink.org)**. Toxic Link also runs India environmental portal **(www.indiaenvironmentportal.org.in)**.

VI) **WEEE Recycle:** It is a project taken with a vision to institutionalise a collection system and channelization of e-waste for recycling using environmentally sound technologies involving SMEs in informal sector. This project aims at improving the situation of e-waste management in India by involving producers, recyclers (informal and formal) encompassing small and medium scale Enterprises (SMEs) and other stakeholders in the value chain. The project has many partners out of which MAIT, Toxics Link, GIZ are some of them. The project is co-financed by the European Commission where European partner is Adelphi Research and the German Ministry for Economic Cooperation and Development (BMZ) where GIZ is the lead implementing agency working on behalf of the BMZ. The Indian partners are the Manufacturers 'Association for Information Technology (MAIT) and Toxics Link. **(www.weeerecycle.in)**

5.5 Status of e-waste in India

India has emerging as a significant generator of E-waste in its own right. With 1.7 million tons of electronic waste generated in 2014, India now stands as the fifth largest e-Waste generator in the world behind US, China, Japan, Germany (***Balde et al, 2015***) as mentioned earlier. The ICT sector accounts for 34 per cent of this.

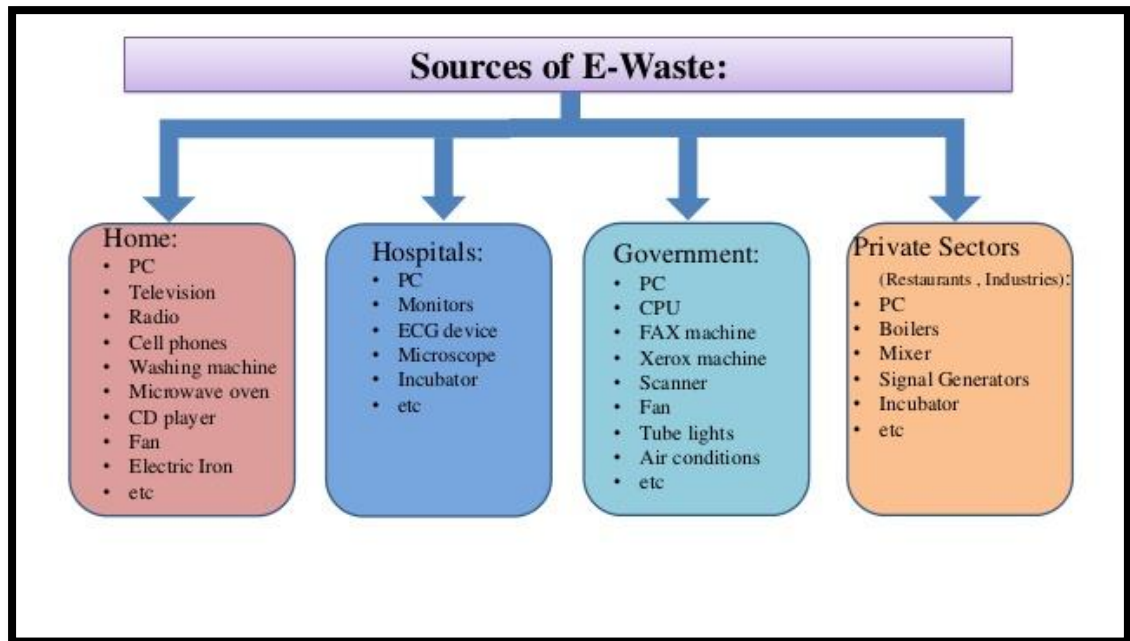


Fig.5.2: Source of e-waste in India.
Source: MAIT 2013.

5.6 Sources of e-waste

(a) The main domestic sources of E-waste in India are the government, public and private (industrial) sectors, which account for almost 70% of total generation (E-waste in India, 2011). The contribution of individual households is relatively small at about 15%; 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 (E- waste in India, 2011). Source of E-waste are shown in ***Fig. 5.3.***

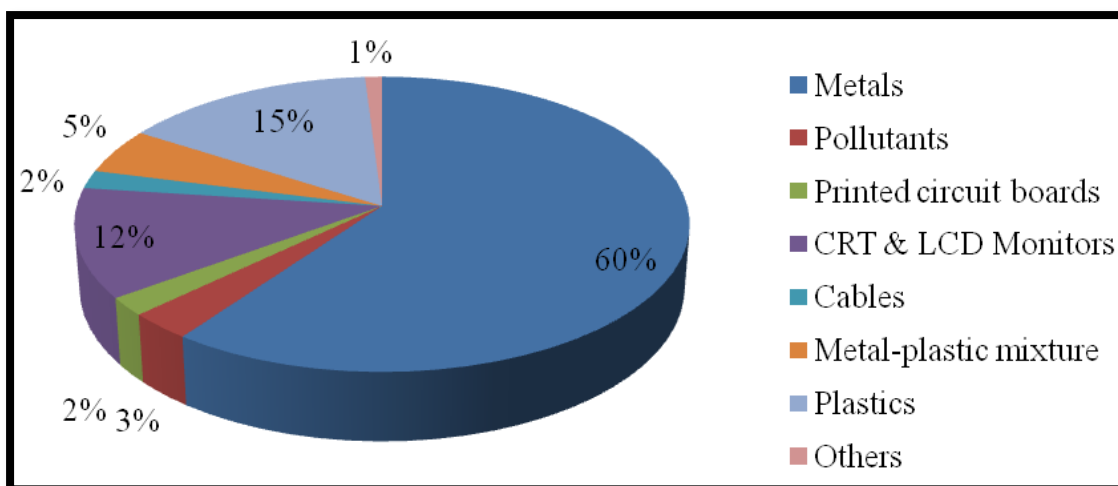


Fig.5.3: Source of e-waste

(Source: E-waste in transition from Pollution to Resource by Daniel Mmereki, Bairhan Li, Andrw Baldwin and Liu Hond, 29th June 2016)

The report ***E-waste in India, 2011*** has observed that there are 10 States that contribute to 70 per cent of the total E-waste generated in the country, while 65 cities generate more than 60 per cent of the total E-waste.

Among the 10 largest E-waste generating States, Maharashtra ranks first followed by Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab. Among the top ten cities generating E-waste, Mumbai ranks first followed by Delhi, Bengaluru, Chennai, Kolkata, Ahmedabad, Hyderabad, Pune, Surat and Nagpur **(See Figure 5.4) (E-waste in India, 2011).**

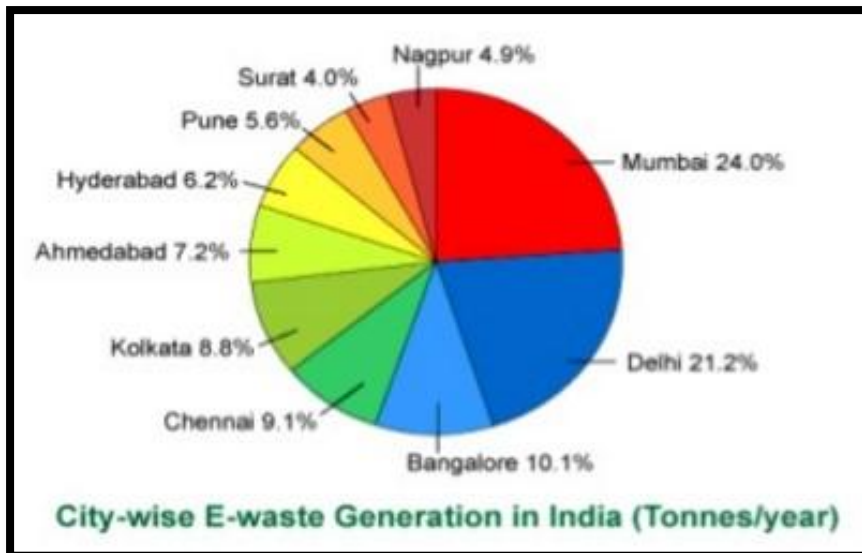


Fig.5.4: City wise E-waste generation in India (% of total e-waste)
(Source: E-waste in India, Rajya Sabha 2011)

(b) The other source of E-waste in India is dumping of e-waste by the developed countries. While the majority of Indian e-waste is generated domestically, imports still account for a substantial amount. About 80 per cent of imported e-waste is imported from the US and the remaining share comes mainly from the EU ***(Skinner et al 2010)***. These electronics have very high repair capability and high raw material demand, this result in high accumulations of residue in poor areas in the absence of strong environmental laws. Major reasons for these exports are cheap labour and lack of environmental and occupational standards in India.

Not only does the e-waste originate from a number of different sources, but the different stakeholders involved in the value chain are also interlinked with each other. Consequently, the e-waste does not follow one set path. They represent the link between the formal and informal sectors. Direct relations between the informal and formal sector less commonly occurs ***(Skinner et al 2010)***. Most e-waste ends up with scrap traders and dealers

who, for economic reasons, commonly transfer it on to the informal sector. The flow of e-waste follows a path involving preliminary, secondary and tertiary stages (Guidelines for environmentally sound management of e-waste, MOEF, 2008). Preliminary e-waste workers obtain e-waste from the formal organized market composed of manufacturers, importers, offices and so on. These stakeholders are mainly scrap dealers and dismantlers who have the ability to bid for and store large amounts of e-waste **(Sinha et al 2011)**. As they have limited interest in dismantling the e-waste, it is segregated and dismantled by secondary e-waste workers, who have limited financial capacity. Finally, tertiary e-waste workers not only dismantle and segregate the e-waste but also try to extract the valuable materials from it.

While this situation describes the most common practice, there is a broad variety of other routes by which e-waste might travel. The e-waste may change hands among, several of the above stakeholders and one stakeholder might be engaged with more than one activity **(Skinner et al, 2010)**. It is commonly found that actors at the top of the chain derive the highest profits whilst the tertiary workers subsist on less than a couple of US dollars a day **(Kalra,2004)**. It is argued that the formalization of e-waste recycling would decrease environmental damage and increase worker welfare. The complexity of the e-waste flow within India is **shown in figure 5.5**

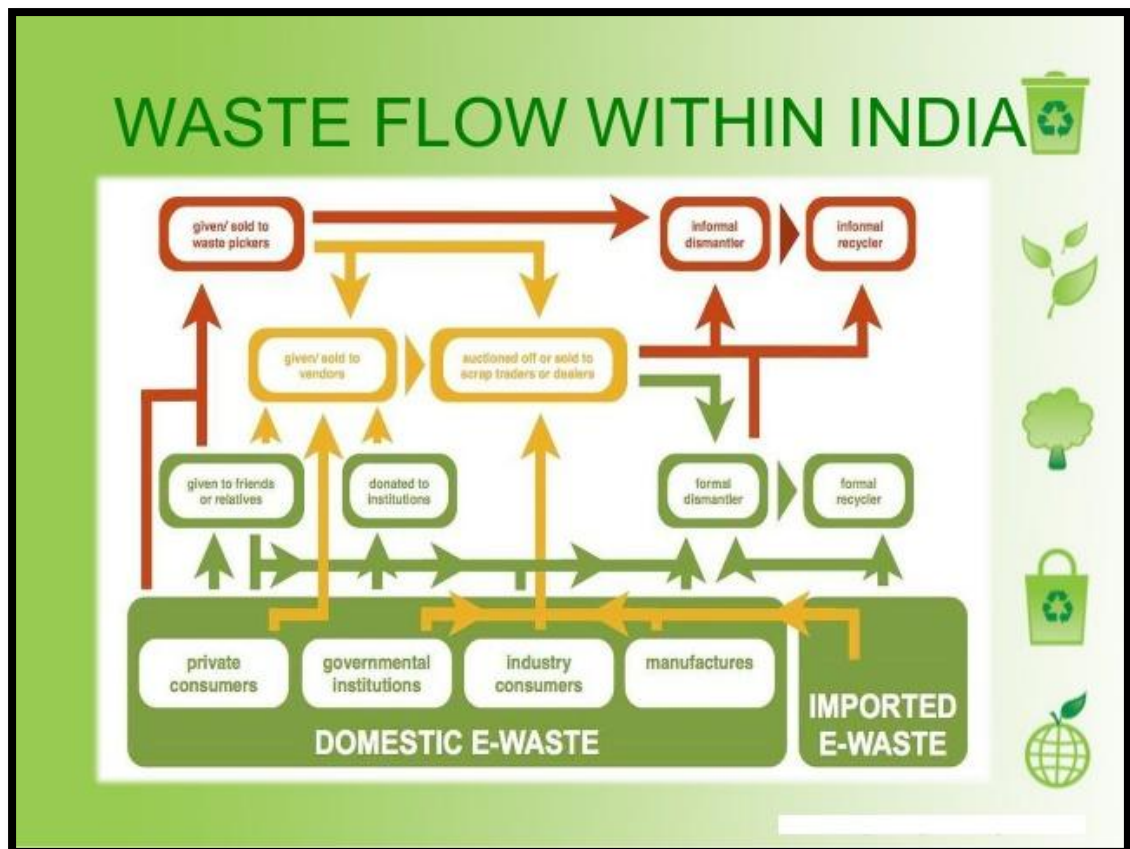


Fig.5.5: E-waste flow within India

Source: (Skinner et al, 2010)

Thus, e-waste recycling industry in India is dominated by the informal sector accounting for more than 90 per cent of all recycling is unregulated but well networked (**UNEP, 2009**).

The financial flow in the sector is highly organized and the huge network of collectors, traders and recyclers make financial gain through re-use, refurbishment and recycling. The low infrastructure set-up and operational costs enable them to make profit and dominate the market. The size of the informal sector continues to grow. Informal recycling centres have tended to move away from major cities such as Delhi, Mumbai, Bangalore, Chennai and Kolkata, and are quickly spreading into smaller peripheral towns (**Sinha et al 2011**). The formal recycling sector is still small in India; currently there are 243 units licensed by the Central

Pollution Control Board (CPCB), and most of them do only partial processing and recycling. (http://www.cpcb.nic.in/Ewaste_Registration_List.pdf)

As mentioned in the Chapter 4, Attero is the first formal recycler in India to use state-of-the-art technology. It pays unskilled workers 30-40 per cent above the minimum wage (**Lundgren, 2012**). This amount is comparable with wages earned in informal recycling although discrimination and ethnic segregation hinder social advancement in the informal sector, and changes in metal prices cause fluctuations in wages. Adult male workers in the informal sector are estimated to earn almost twice as much as women and children (**Skinner et al, 2010**).

But the condition of workers handling e-waste in informal sector is too harsh at the same time. The informal recycling sector employs mostly unskilled migrant labour and those from marginalized groups. Most migrants come from poorer Indian states such as Uttar Pradesh, Bihar, Orissa and West Bengal or are immigrants from neighbouring countries such as Bangladesh. Women and children also constitute a significant proportion of the workforce. Work carries on for 12-14 hours a day with workers sitting on the ground amongst piles of electronics parts. Most work is carried out with bare hands, without the use of masks, cleaning, crushing or heating the parts (**Kalra, 2004**). Many workers also sit cramped in unventilated rooms with inadequate lighting and no clean drinking water or toilets. Many of these workers complain of eye irritation, breathing problems and constant headaches. Most people involved in informal recycling are the urban poor with low literacy levels, and hence have very little awareness regarding the hazards of e-waste and the recycling processes (**Sinha et al, 2011**).

5.7 India and e-waste in cities

Based on the literature reviewed, details of top two e-waste generating cities in India are briefly summarised as below. Some of the good practices followed in the states to which these cities belong to are also mentioned.

5.7.1 Mumbai

Among Indian cities, Mumbai ranks first among top ten cities generating e-waste in India **(E-waste in India, 2011)**. Mumbai, the financial nerve centre of India, is also India's largest port city. The Mumbai-Pune industrial belt is one of the electronic items manufacturing hubs of the country. As a result, Mumbai is not only the port of import for new and used electronics; it is also home to a large user and manufacturer base, both generating large volumes of e-waste. The e-waste recycling market exists in a major way in Mumbai. The market of e-waste in Mumbai is not concentrated in a single place, but spread over different areas, each handling a different aspect of recycling. The city has a large network of scrap traders, with the main centres in Kurla, Saki Naka, Kamthipura-Grant Road, Jogeshwari and Malad **(Toxics Link, 2007)**. In spite of the absence of proper technology, each component is disassembled and recycled or reused in Mumbai. Most of the e-waste generated in the Pune and Pimpri Chinchwad Region is transported to the Mumbai Metropolitan Region (MMR) for further treatment and distribution.

The urgent need to have a well-coordinated mechanism on the collection, treatment and disposal of the e-waste in the MMR (Mumbai Metropolitan Region) has been recognized. E-waste has been identified as a priority area by the MPCB (Mumbai Pollution

Control Board) and it has initiated certain initiatives to create awareness among various stakeholders on the e-waste.

5.7.2 Good practices in Maharashtra

(a) Maharashtra IT Policy, 2009: To promote greener electronics and phasing out of hazardous metals used for manufacturing hardware, the Maharashtra IT policy, 2009 has laid down certain specifications. The policy proposes path-breaking initiatives to promote 'green' IT and electronic hardware, as well as E-waste recycling. (www.maharashtra.gov.in/PDFfitpolicy.pdf)



Fig.5.6: State-wise E-waste Generation in India

Source: E-waste in transition from Pollution to Resource by Vidyadhar Ari, 2015

- Awards will be instituted for demonstrated, efficient natural-resource management by IT units. The development of comprehensive E-waste collection and recycling systems and their use by the state as well as private agencies for the disposal of IT products will be promoted.

- While procuring IT products, the government will give preference to firms that have an expressed end-of-life product, take-back policy, and E-waste recycling processes.
- Government departments and agencies will give preference to 'green' and energy efficient IT products in their procurement.
- In consultation with the Environment Department, and with the approval from the empowered committee, norms will be determined to facilitate 'green' IT parks.

The Maharashtra Pollution Control Board has developed a roadmap in this regard. The Board envisages to link with its regional offices in the state and municipal corporations and committees to intensify activities on ground. Some initiatives in the state have yielded desired participation from stakeholders. The Board recommends that replication of such initiatives and documentation of the lessons learnt will be key to success. The need to quantify the amount of E-waste generated and recycled would be undertaken.

(b) PPP model of Pune at Pimpri Chinwad **(Hashimoto and Sathe, 2015)**

The twin-cities Pimpri and Chinwad along with Pune are the second highest generator of e-waste after Mumbai in Maharashtra, according to a study; It - Report on Assessment of Electronic Wastes in Mumbai-Pune Area jointly conducted by the **Maharashtra Pollution Control Board (MPCB)** Pune and **Pimpri-Chinchwad Municipal Corporation (PCMC)**. The public private partnership (PPP) model of Pimpri Chinwad has proved to be a good model for management of waste in the area.

In 1993, waste pickers and itinerant waste buyers in Pune and Pimpri Chinchwad came together to form **KKPKP (Kagad Kach Patra Kashtakari Panchayat)**, a membership- based trade union

of rag pickers working in Pune. In the past, all the waste was placed in bins on the roadside and the municipal trucks would regularly come to empty them and take the waste to the dump. In 2005, KKPKP, launched a pilot programme in collaboration with the Pune Municipal Corporation (PMC), where waste pickers were integrated in **Door-to-Door waste collection (DTDC)** work. This paved the way for the formal institution, SWaCH, (a wholly-owned workers' cooperative and an autonomous enterprise providing frontend waste management services through waste collectors as its members) as a Pro-poor Public Private Partnership (PPP) to undertake such work. The SWaCH DTDC model was based on recovery of user fees from service users and provision of infrastructure and management support from the municipality which was also to play an enabling role.

The pilot scheme implemented enabled 1500 waste pickers to become service providers for the door-to-door collection of waste from 1, 25,000 households in Pune city. This considerably improved their conditions of work and upgraded their livelihoods, effectively bridging the gap between households and the municipal waste collection service. The initiative brought together two interests - the waste pickers' interest in upgrading their livelihood and the municipality's interest in sustainable Solid Waste Management. 2008. The doorstep collection work got institutionalised under the aegis of SWaCH which was specifically registered for this purpose. With time, SWaCH diversified into vertical as well as extended its service delivery to another city. Today, apart from SWaCH PMC there is also SWaCH Plus. SWaCH Pills includes all the livelihood up gradation an income enhancement activities with respect to waste management, that go beyond Door to Door collection, such as V-Collect events where citizens can dispose of their un-use household

items/clothes; composting; e-waste collecting and disposing through the correct channels; awareness raising events, etc. SWaCH via doorstep collection cooperative ***(Resulted from the joint effort with Pune Municipal Corporation)*** reformed not only solid waste management and service delivery across Pune, but it has improved the lives, incomes and working conditions of the waste-pickers themselves addressing the issues of both poverty and public sanitation. Collectively, waste picker in Pune and Pimpri (including non-SWaCH members) contribute 185 million rupees to the economy per year. ***(Chikarmane, Narayan, 2010).***

5.7.3 Bengaluru

In Bengaluru, the Silicon capital of India, e-waste recycling is a multi-crore market where e-waste is received in Gowripalya and Nayandahalli. According to industry survey 8,000 to 10,000 tonnes of e-waste is generated each year by IT firms and electrical manufacturers in and around Bengaluru. While the larger companies have warehouse for storing the waste, others sell them to small-time scrap dealers. The dealers are concentrated around Mysore Road, often employ women and children to deal with scrap and remove usable metal. What cannot be used at all is thrown into fields channels or burned under unsafe conditions ***(E-waste in India, 2011).***

The e-waste scrap dealers send the segregated and dismantled e-waste parts to and Mumbai every alternative day. The e-waste recyclers earn around Rs. 2-3 lakh month from selling the dismantled e-waste to Delhi. There are a few recycling centre in Karnataka like e- Wardd, e- Parisara, K.G. Nandini Recyclers, Ash Recyclers"New Computer Services India Pvt. Ltd. Recyclers and E-R3 Solutions Pvt. Ltd. in the sector.

Good Practices: Some Good practices followed in Bengaluru need special mention here.

(i) E-Parisara is one such recycling unit that has been encouraged by the Central and State Pollution Control Board which may be replicated in all major cities in the country. E-Parisaraa is an e-waste recycling unit situated in Dobaspet; Bangalore. It is one of authorized e-waste recycler by Government of Karnataka. The e-waste is collected from the companies using a pickup truck or the company drops off the waste at the plant. The plant is equipped with innovative indigenous machines to cut down costs. No incineration is done hence no toxic gases are let out in the open air. The computer wastes are either shredded or reused. The shredded wastes are ground to powder form from which metals are collected through the method of gravity separation. Only one percent of the waste coming into the company is sent to the landfills. **(Gupta and Shekhar, 2009)**

(ii) Another one such good Practice observed in Bangalore is "SANKYA- A which is a collaborative project between Rotary Club, Bangalore South and a few major IT Companies (HP, Azim Premji Foundation, Microsoft, Microserv, Phoenix Login Solutions, Valtech and VXL Instruments) to promote donation of used Computers and Reduce E-Waste" i.e. by way of reuse. Rotary, Bangalore South, helps IT Companies dispose of their discarded computer systems through donations to deserving schools and NGO's, at the same time help reduce generation of e-waste. **(Guptha and Shekhar, 2009, www.Sankyaa.net)**

SANKYA, is a proactive effort having the following Methodology (**www.Sankya.net**)

- Collection and deployment of used computers from the industry.
- Requirements and support through local Rotary clubs

As part of the program, Sankya advises its beneficiaries on responsible e-waste management of the donated hardware so that beneficiaries are aware of how they can responsibly dispose of hardware when the time comes. Sankya committed to Government's e-waste program has undertaken to send all the donated computers to e- waste at the end of their life or 3 years whichever is earlier (www.sankya.net).

The Karnataka Pollution Control Board envisages that due diligence and quality check of these data would contribute to effective implementation of the Rules. The state of

Karnataka had witnessed the formalization of recyclers from the informal sector. The Boards' initiative attempts to carefully recycle old computers, their components and other e-waste, generated by both IT companies and electronic manufacturers. The Board observes that regular monitoring and evaluation of the performance and compliance of the authorized dismantling and recycling entities in the near future will be critical to building trust and confidence among stakeholders.

Chapter 6

CASE STUDY OF NCR ON E-WASTE PROCESSES AND THEIR HANDLING: AN ANALYSIS

6.1 Introduction

NCR with Delhi's status as the capital and its good transport links to all parts of the country has made it an ideal site for waste collection. As a result, there has been a large increase in the number of small units treating e-waste although, due to a recent crackdown on informal activities, only a few centres have survived in central Delhi. Activities have recently shifted to satellite towns such as Saharan pur and Meerut; however the trade still continues in the city. **(Waste Management World, 2011)**. Some of the informal recycling locations in Delhi are listed in the following Table no 6.1

Table 6.1: Informal Recycling Locations in Delhi

Location	Type of Waste recycled
Turkman Gate	Computer and CRT breaking
Mundka	Various electrical goods
Seelampur	Various electrical goods
Shastri Park	Computer and CRT breaking
Loni (Ghaziabad)	Various electrical goods
Mandoli (Ghaziabad)	Various electrical goods

Mandawali	Metal Recovery Work
Bawana	Various electrical goods
Narela	Various electrical goods
Meerut (Near Delhi)	Gold Recovery
Tila Byetha (Village in outskirts)	Various electrical goods

Source: Jha 2008, Lakshmi 2010

A report by the Toxics Link in 2004 found that 70 per cent of electronic waste collected at recycling units in New Delhi was actually exported or dumped by the developed countries. According to the last survey conducted by Toxic Link in 2007 on the quantity of waste being produced in Delhi, it was estimated that about 5,000 metric tonnes (MT) of hazardous waste was produced annually. The amount of e-waste generated annually is about 12,000 tonnes. Though not the leading generator, Delhi is the leading processing centre of e-waste in the country. According to the study conducted by the GTZ in 2007, there were about 25,000 workers refurbishing 10,000-20,000 tonnes of e- waste annually. The work takes place in small illegal units where neither regulations nor environment or health safeguards are in place. Delhi has the tag of a wholesale scrap market where not only all kinds of waste are brought in but also stored and pre- processed before being sent out to other parts of the country. Once e-waste is imported, e-waste dealers in Delhi make bids on the sea-going containers at the inland depot situated at Okhla.



Fig.6.1: Photos of informal recycling unit in Shastri Nagar, New Delhi during the visit to dismantling Areas

The material is taken out, sorted and distributed between various recyclers according to the areas of specialization. Electronic waste in Delhi is mostly processed in Shastri Nagar, Turkman Gate, Seelampur, Mauzpur and Mustafabad. Eastern parts of Delhi like Mandwali are the epicentres of e-waste recycling. Mandawali is known for all its metal work recovery while areas like Bawana and Narela are huge centres for all kinds of recycling and pre-processing work. It is said that only dismantling is done in Delhi. But, as per the reports of the Taxies Link, all the waste created from the pre-processing work gets dumped into the river or drains, posing risks to health and environment. The Government's sealing drive and crackdown by the Environment Department over the past few years resulted in major part of the recycling work shifting out to the satellite towns like Muzzafarnagar, Saharanpur, Meerut, etc. **(Jha 2008, Lakshmi 2010).**

6.2 Factors that contribute to the thriving e-waste recycling business in Delhi and NCR

its status as the capital and hence its connectivity to all parts of the country; the many satellite towns around it where several hundreds of small units treat waste; and availability of cheap migrant labour **(Neha Lalchandani, 2010)** The e-waste hub on the north-eastern fringe of Delhi, the Seelampur market is also called the largest electronics dismantling market in the country, where over 50 per cent of used computers end up for sale and recycling. Seelampur gets e-waste from across northern India and even as far as Bengaluru. The job of the dismantlers involves getting computers, breaking them into its basic parts and selling motherboards to traders in Moradabad. Apart from e-waste imports and supply from the neighbouring regions, another source of domestic supply of e-waste is the kabadiwalas (waste pickers) who buy scrapped electronics from households. Auction News, a biweekly journal in Delhi also publishes advertisements on scrap that offices or the Government departments want to auction. When recyclers gather in the offices concerned, auctions are held. In some cases, scrap is sold by inviting tenders **(Neha Lalchandani, 2010)**. Since waste processing is illegal in Delhi, the Government does not have an exact estimate of how much waste is produced in the city or how much is brought in for recycling. Even though officials claim that the units have moved out of Delhi, they cannot be sure of the numbers as the work largely takes place in the unorganized sector.

6.3 Good Practices in Delhi and NCR areas

Some of the good practices followed in Delhi are:

(a) In Delhi there are few collection centres duly registered. One such example is about HRA e-waste private limited, a company formed in 2010 through the initiative of a group of informal sector e-waste collectors and recyclers in and around Delhi with technical support from GIZ. Realizing the need and importance of formalization and through the motivation of GIZ, the e-waste collectors took the step to form a company, authorized by the Delhi Government, making their work safer and more organized. This company collects segregates and stores e-waste from some 250 informal collectors and dismantlers, who source directly from households and businesses. It auctions the e-waste to formal recyclers, giving profits back to the informal collectors, less a percentage for overhead costs. (www.mait.com/ewaste/collection-centers.html)



Fig.6.2: Photos of stacking done by informal recycling unit in Turkmaan Gate, New Delhi during the visit to recycling Areas



Fig.6.3: Photos of stacking done by informal recycling unit in Mundka, New Delhi during the visit to recycling Areas

(b) Chintan an Indian NGO, in cooperation with Delhi's Pollution Control Committee (DPCC) and the city's Department of Environment, created a partnership with Safai Sena, a registered association of waste pickers to improve collection, segregation and storage of e-waste. They then joined forces with companies in India that safely recover metals and plastics from e-waste. The initiative trains waste pickers to collect e-waste using safe e-waste handling practices to reduce their exposure to dangerous toxins. After it is collected, the e-waste is safely stored at Chintan's authorized collection centre and sent to recyclers for safe disposal/recycling. Chintan seeks to improve post- consumer e-waste handling by advocating for better policies, organizing and building the capacity of e-waste handlers for green jobs, and by telling the story constantly to engage the larger public via online videos to understand the issue better (***www.chintan-india.scavengers_to_managers.htm***).

6.4 A Survey for Consumers of Electronic Products

In an era of digitalization where knowledge is all pervasive it was felt that no survey would be complete without a survey of the consumers.

A large survey base of 505 respondents was taken:

6.4.1 Guidelines for Consumers

While the E-waste handling Rules 2011 state that the Consumers should channelise their e-waste through collection centre or dealer of authorised producer or dismantler or recycler or through the designated take back service provider of the producer to authorised dismantler/recycler, there is hardly any awareness about the same.

The guidelines state that the consumer should not throw e-waste in municipal bins. The consumers shall ensure that they do not throw end of life fluorescent and other mercury containing lamp in the municipal bin but hands them over (in a properly packed form) to take back system / collection and channelisation system of producer or to a collection centre of an authorised recycler who is part of producer channelisation system. For example the end of life intact fluorescent and other mercury containing lamp needs to be stored either in the same boxes in which new lamps are brought or other boxes of similar size. They should be sorted upright. Due precaution needs to be taken make the consumers aware about e-waste rules, policies, so as not to cause the possibility of environmental damage and loss of health and life.

6.4.2 Details about gender survey of consumers

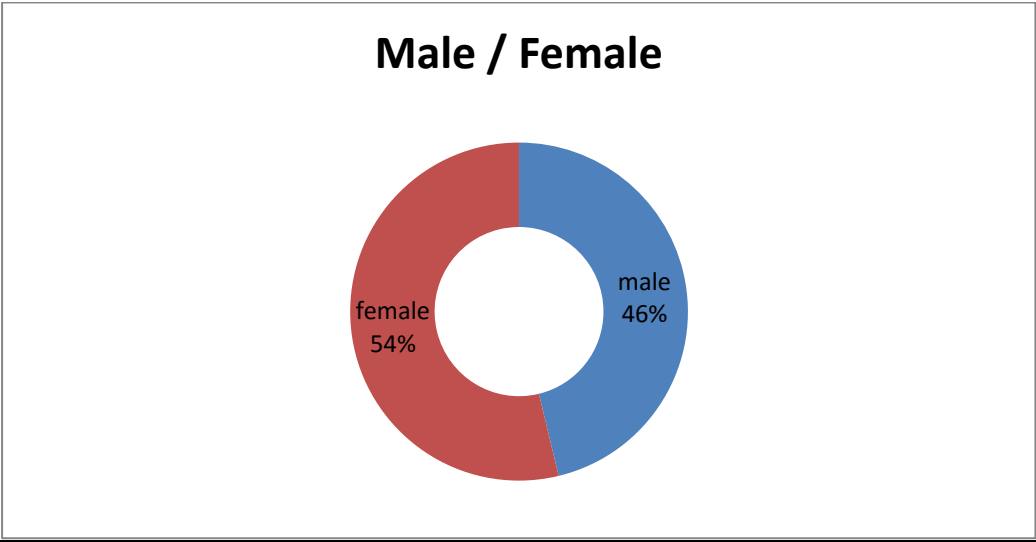


Fig.6.4: Chart showing gender segregation of consumer survey

The consumer survey highlighted the awareness about e-waste amongst the various sectors of the population.

A large survey base of 505 respondents was chosen. The female respondents formed 54% of the survey and the Male 46%.

6.4.3 Number of electronics products used by the consumer

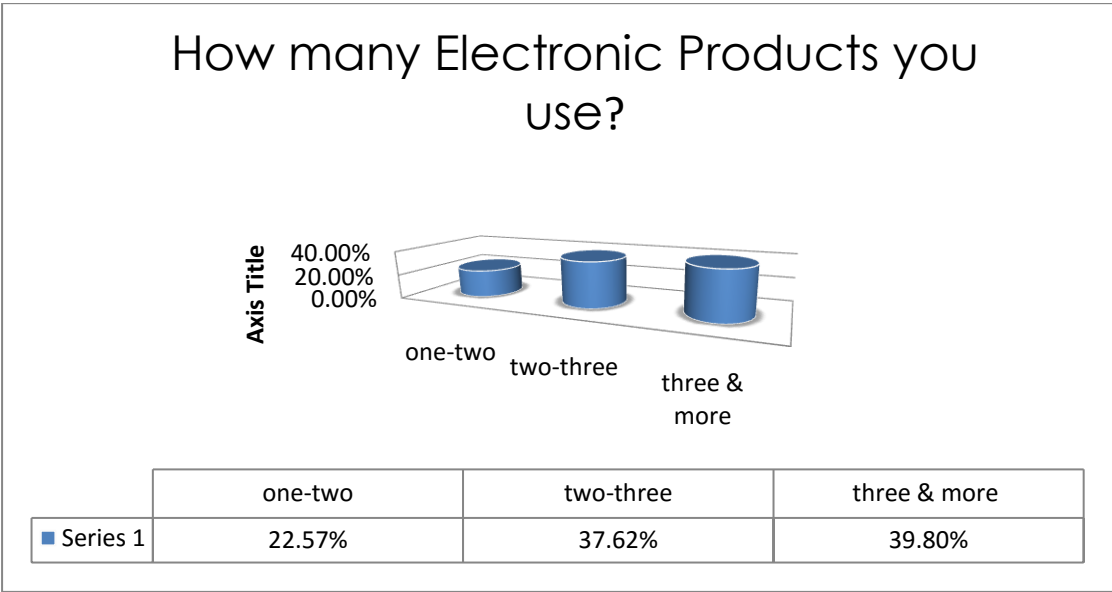


Fig.6.5: Graph showing number of electronics products used by the consumer

Table 6.2: Number of electronic products used by male and female consumer

Q. How many Electronic Products you use?

Gender	1-2	2-3	3 or more	Total
MALE	53	74	106	233
FEMALE	61	115	95	271
Missing	0	1	0	1
Total	114	190	201	505

Digitalisation has pervaded the masses could be felt by the survey results 39.80% of respondents used 3 or more electronic products while 37.62% of the respondents used two to three products.

6.4.4 Consumer response when products are not working

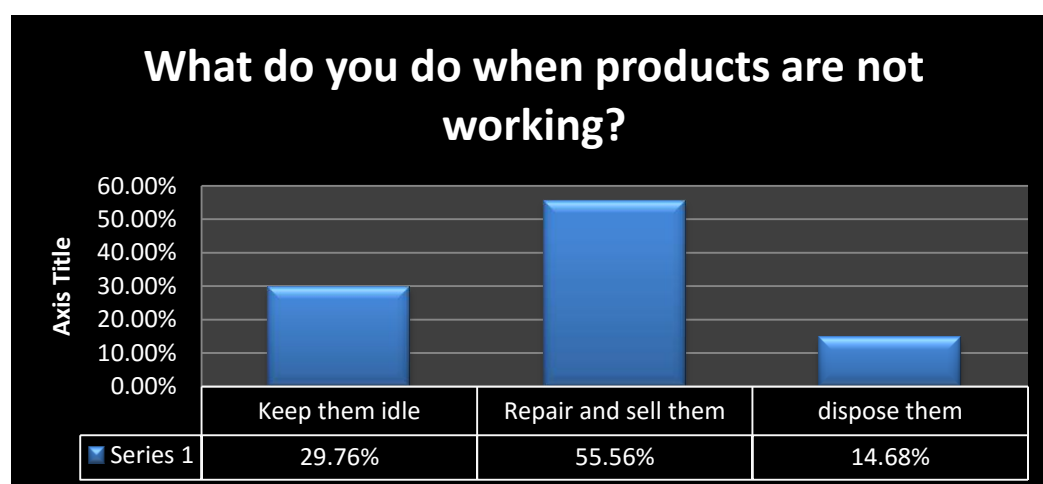


Fig.6.6: Showing details when products are not working

Table 6.3: Consumer response when products are not working.

Q. What do you do when products are not working?

Gender		keep them idle	repair and sell them	dispose them	Total
MALE	1	63	130	39	233
FEMALE	0	87	149	35	271
missing	0	0	1	0	1
Total	1	150	280	74	505

6.4.5 Consumer Awareness about e-waste

While the life of an electronic product is important to an Indian consumer it is seen that a majority of the consumer 55.56% seek to repair and use or repair and sell the electronic products.

It is also to be noted that a very large number of 29.76% kept the electronic goods in custody leading to obsolescence while 14.58% disposed the products on as in where is basis.

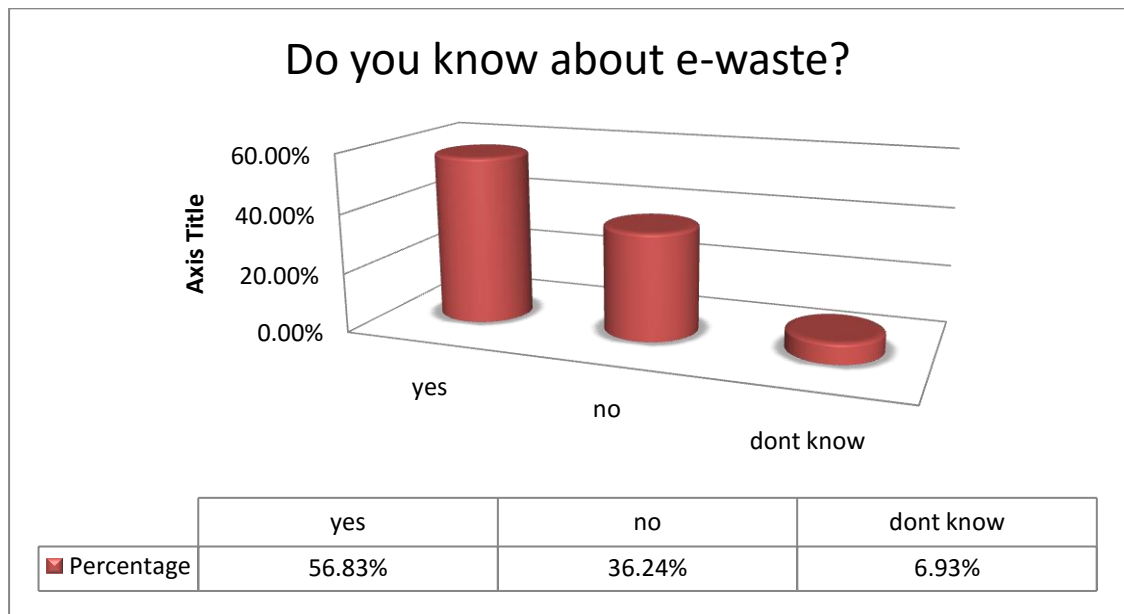


Fig.6.7: Awareness about e-waste

Table 6.4: Consumer awareness about e-Waste

Q. Do you know about e-waste?

Gender	Yes	No	Don't know	
MALE	120	92	21	233
FEMALE	166	91	14	271
missing	1	0	0	1
Total	287	183	35	505

It was heartening to note that 56.83% of the respondents were aware about e-waste.

6.4.6 Consumer knowledge about e-waste policy

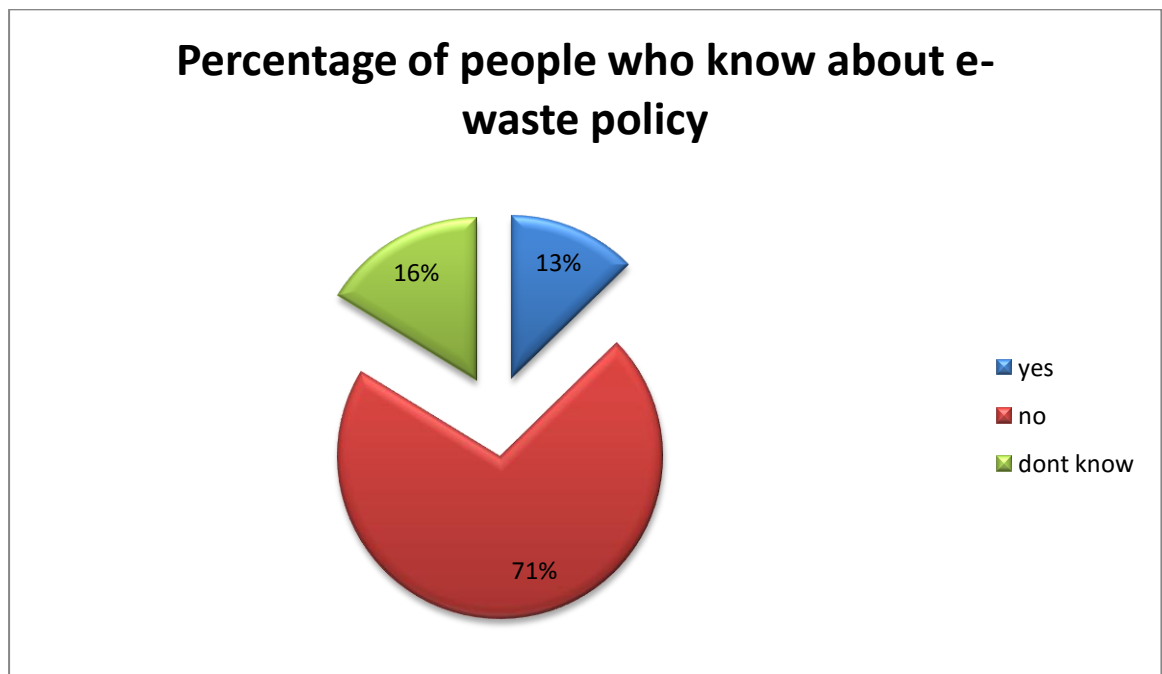


Fig.6.8: Percentage of people aware of e-policy.

Table 6.5: Consumer awareness about e-Waste policy

Q. Have you heard about e-waste Policy?

Gender		Yes	No	Don't know	Total
MALE	1	33	169	30	233
FEMALE	0	30	189	52	271
missing	0	1	0	0	1
Total	1	64	358	82	505

A significantly large number of respondents 87% were not aware about the e-waste policy which includes 71% who said a categorical "No"

6.4.7 Consumer response on how they discard their electric products

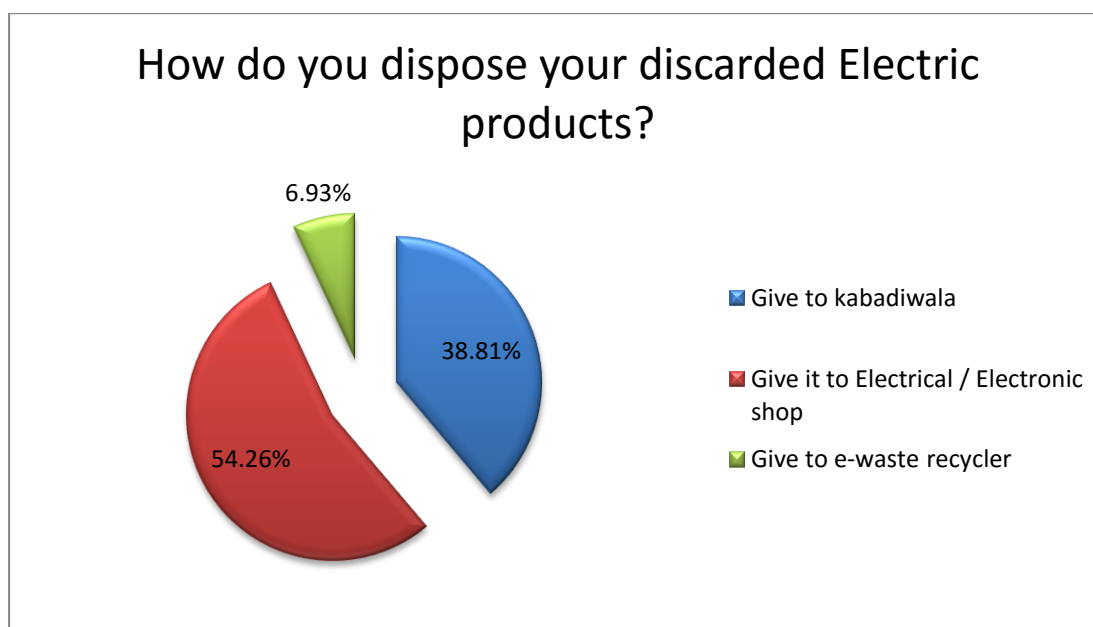


Fig.6.9: How electrical products are disposed

Table 6.6: How consumer discard the electric products.

Q. How do you dispose your discarded Electric products?

Gender	Give to kabadiwala	Give it to Electrical / Electronic shop	Give to e-waste recycler	Total
MALE	90	125	18	233
FEMALE	106	148	17	271
missing	0	1	0	1
Total	196	274	35	505

It was heartening to note that 6.93% of respondents were able to sell the products to a recycler. However, a significantly higher number 54% sold it to a Electric / Electronic shop.

This is in consonance with the previous question.

6.4.8 Consumer awareness about harmful effects on environment of e-waste

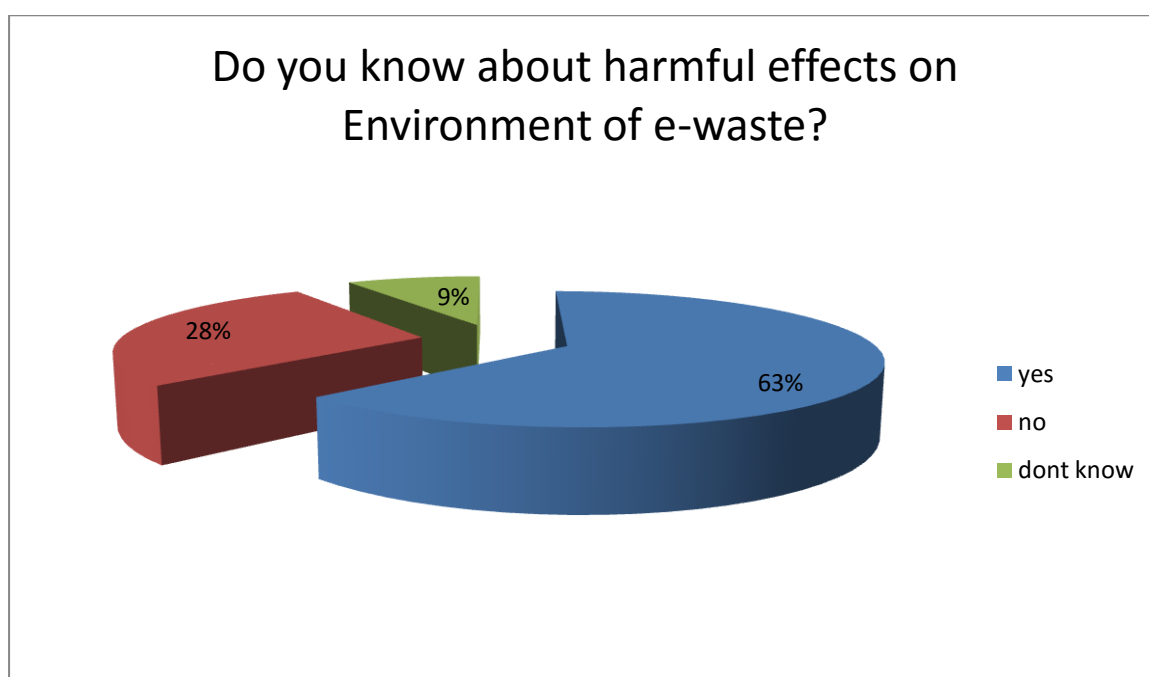


Fig.6.10: Harmful effects of e-waste

Table 6.7: Consumer awareness about harmful effects on Environment on e-waste

Q. Do you know about harmful effects on Environment of e-waste?

Gender	Yes	No	Don''t know	Total
MALE	141	64	28	233
FEMALE	177	78	16	271
missing	1	0	0	1
Total	319	142	44	505

63% of the respondents said that they were aware about the harmful effects of e-waste.

6.4.9 Consumer knowledge about take back program

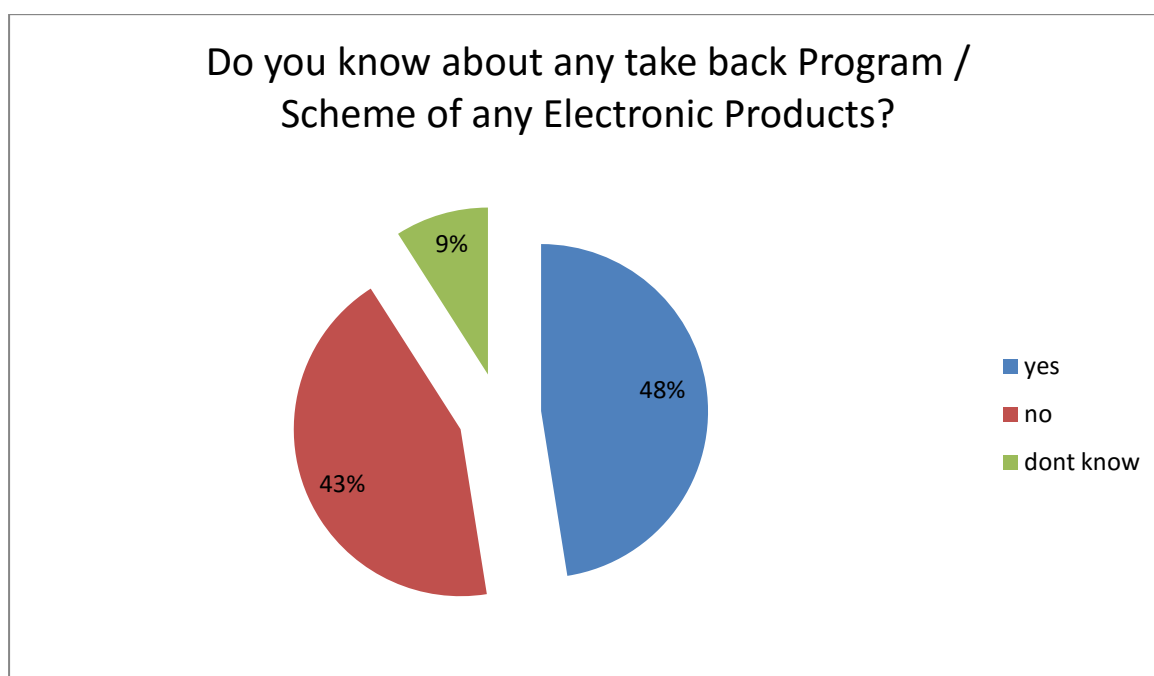


Fig.6.11: Take back scheme of Electronic products

Table 6.8: Consumer knowledge about take back programme on electronic products

Q. Do you know about any take back Program / Scheme of any Electronic Products?

Gender	Yes	No	Don't know	Total
MALE	108	97	28	233
FEMALE	127	119	25	271
missing	1	0	0	1
Total	236	216	53	505

48% of the respondents were aware about the take back program of Electronic products by the producer. While 52% were either ignorant or not aware.

6.4.10 Consumer knowledge about buy back scheme by seller

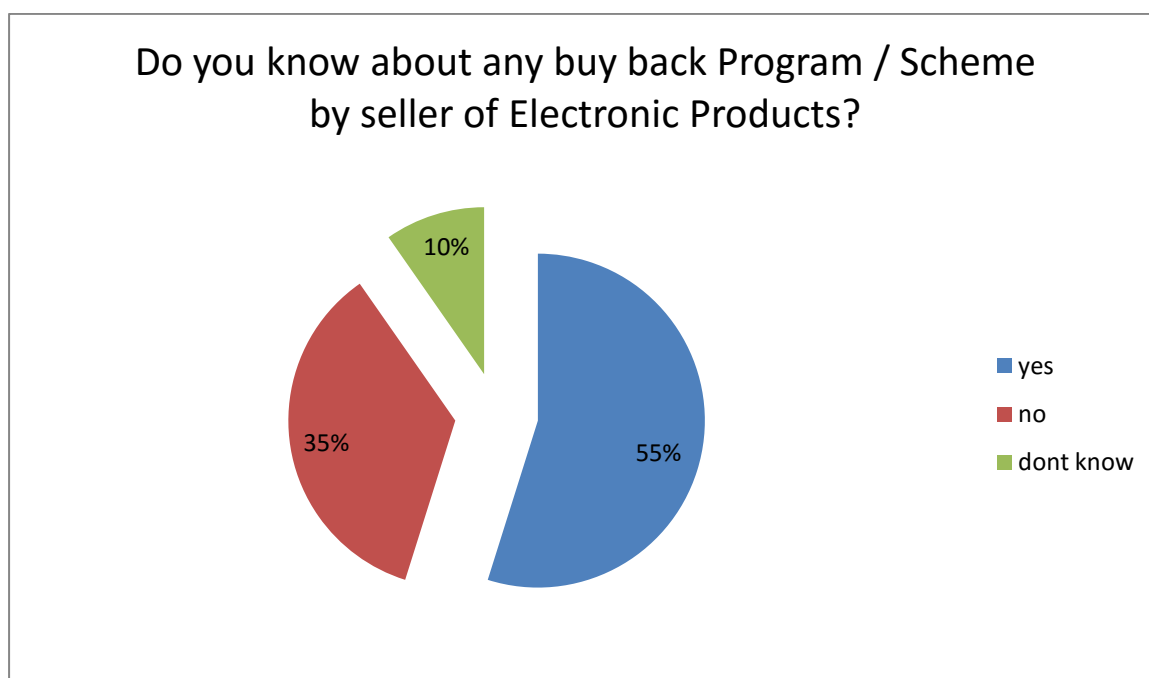


Fig.6.12: Buy back program of seller

Table 6.9: Consumer knowledge about buyback scheme by seller of electronic products

Q. Do you know about any buy back Scheme by seller of Electronic Products?

Gender	Yes	No	Don't know	Total
MALE	124	78	31	233
FEMALE	152	101	18	271
missing	1	0	0	1
Total	277	179	49	505

However a higher 55% of respondents were aware about the take back program from a dealer / sales point which shows that dealers had this as a sales or marketing point to boost up the sales.

6.4.11 Consumer response to whether they had availed of the buyback scheme

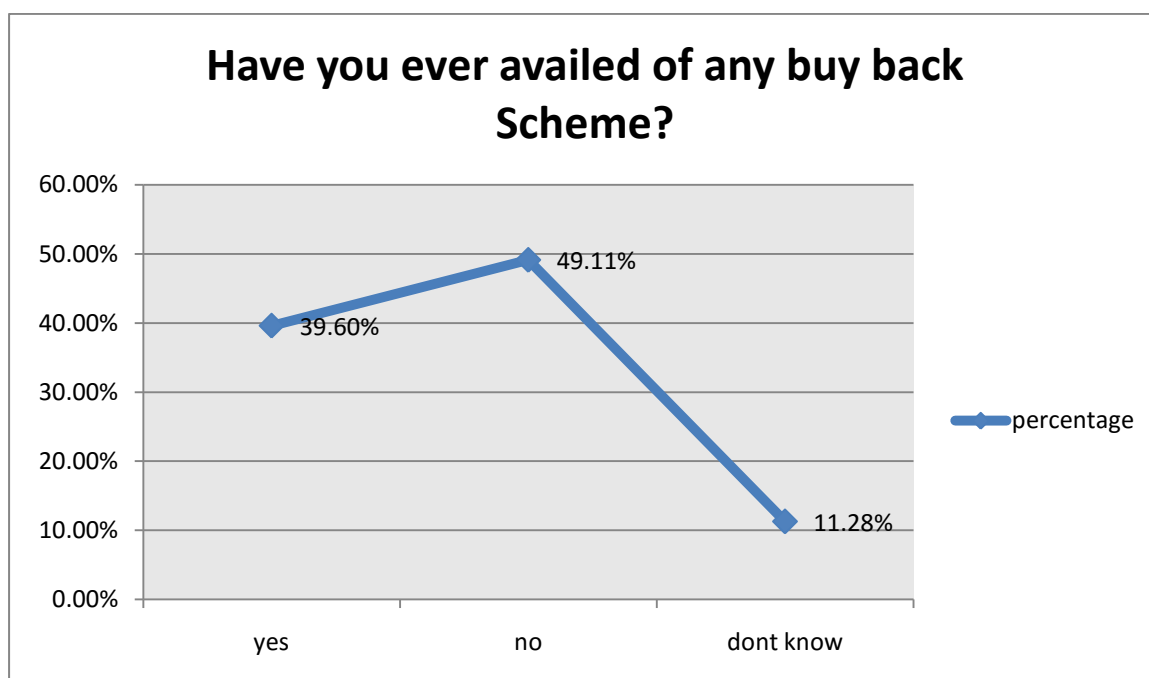


Fig.6.13: Availment of buyback scheme

Table 6.10: Whether consumers have availed of any buy back scheme

Q. Have you ever availed of any buy back Scheme?

Gender	Yes	No	Don't know	Total
MALE	80	117	36	233
FEMALE	119	131	21	271
missing	1	0	0	1
Total	200	248	57	505

This data is also in consonance with the previous question and leads us to the question of higher support for popularising the buyback scheme both by sellers and producers. Further this shows that the EPR has to be extended in right spirit.

6.4.12 Consumer felt need for more awareness about e-waste

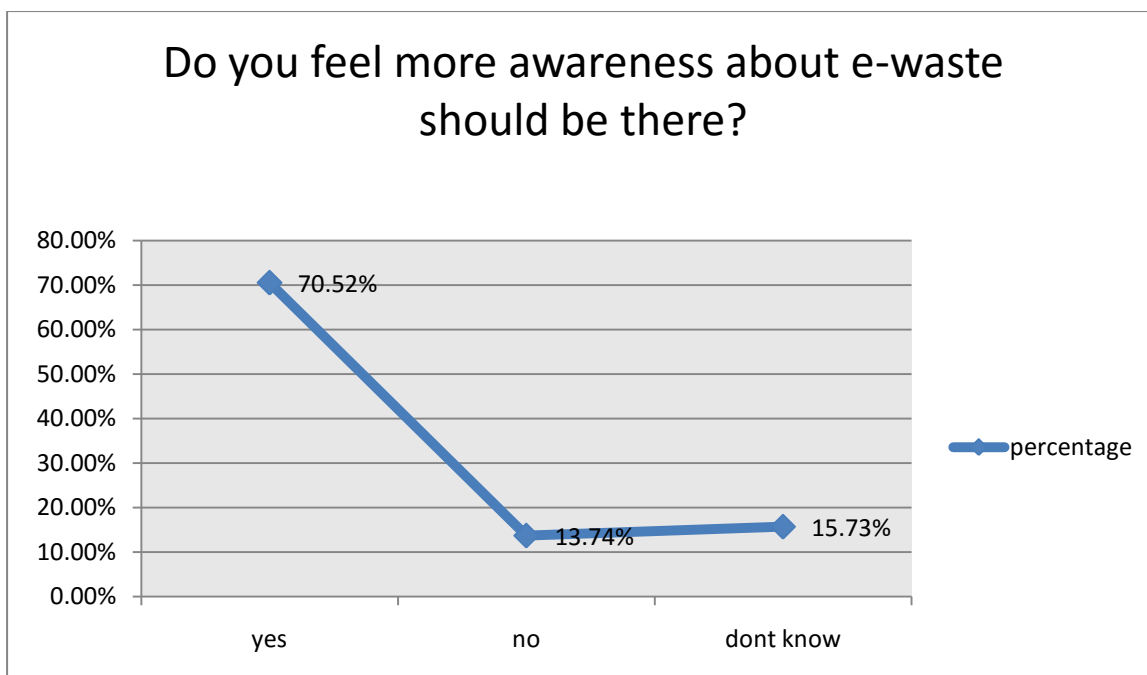


Fig.6.14: Need for awareness about e-waste

Table 6.11: Need for more awareness about e-waste

Q. Do you feel more awareness about e-waste should be there?

Gender		Yes	No	Don't know	Total
MALE	1	134	46	52	233
FEMALE	2	219	23	27	271
missing	0	1	0	0	1
Total	3	354	69	79	505

While Govt. of India has taken extensive steps to popularise awareness about e-waste, still 70.52% respondents felt that there is a need to bring more awareness about e-waste.

6.4.13 Consumer survey on whether they are part of RWA

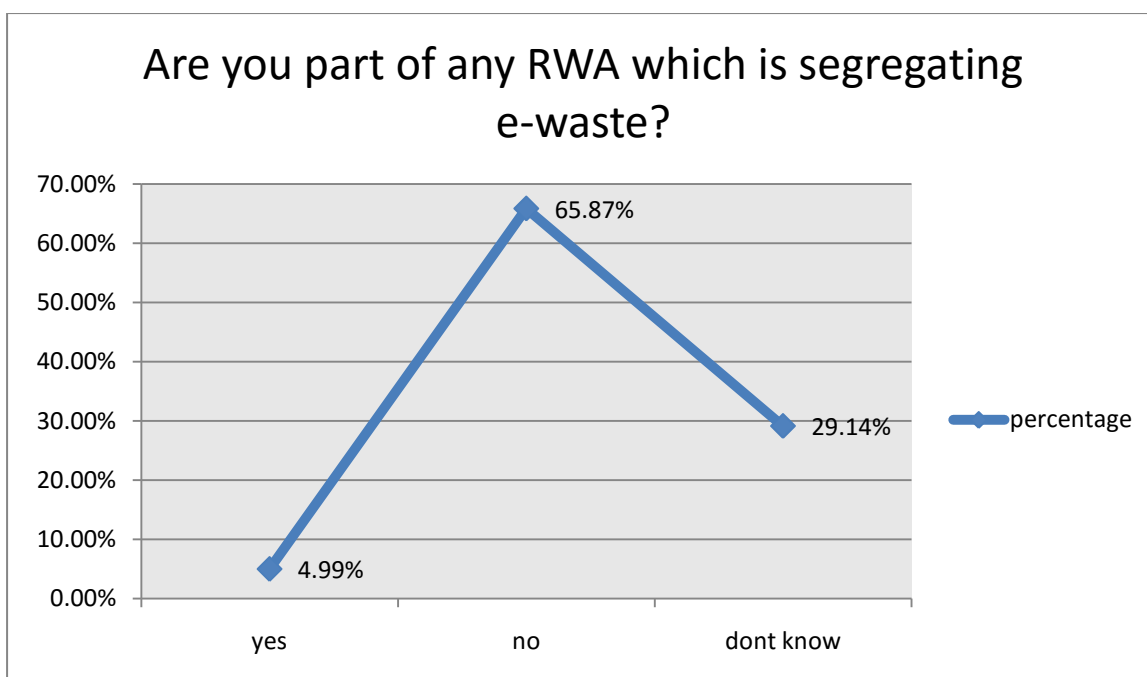


Fig.6.15: Consumer as part of RWA

Table 6.12: Consumers as part of RWA

Q. Are you part of any RWA which is segregating e-waste?

Gender		Yes	No	Don't know	Total
MALE	1	13	135	84	233
FEMALE	3	12	194	62	271
missing	0	0	1	0	1
Total	4	25	330	146	505

Only 4.99% of respondents were part of RWA's which is segregating e-waste.

There is this need for bringing awareness about e-waste segregation to Municipal bodies, workers, elected representatives and RWA's to maximize collection of e-waste in a safe manner.

6.4.14 Consumer response on whether Govt. should do more on e-waste

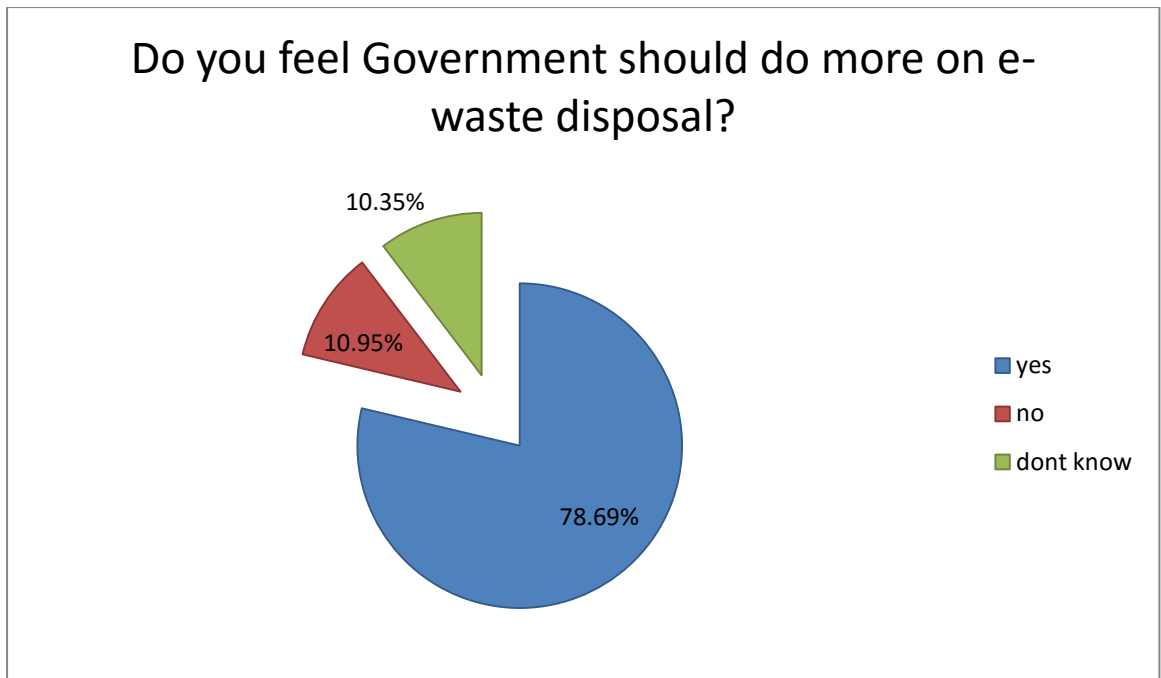


Fig.6.16: Government need for more awareness

Table 6.13: Consumers desire for Government intervention

Q. Do you feel Government should do more on e-waste disposal?

Gender		Yes	No	Don't know	Total
MALE	1	172	28	32	233
FEMALE	2	222	27	20	271
missing	0	1	0	0	1
Total	3	395	55	52	505

While talking about awareness, 78.69% felt that the Government should make more efforts on educating the workers segregation and recycling of e-waste.

6.4.15 Consumer response on whether use of electronic products affect health

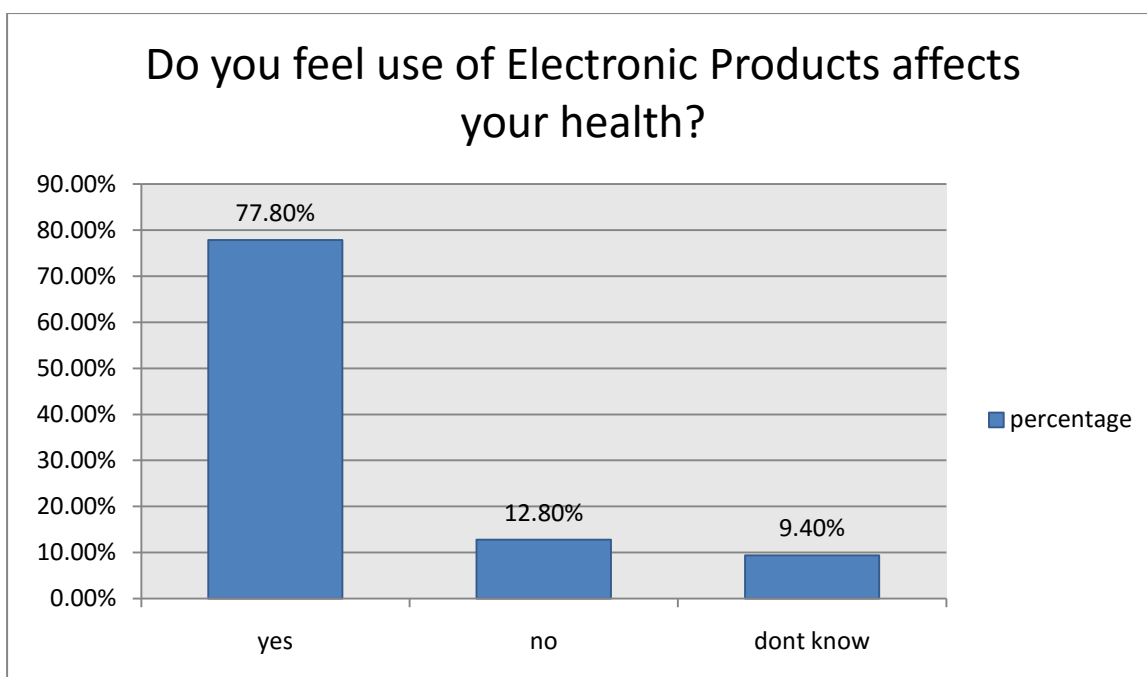


Fig.6.17: Electronic Products affecting health

Table 6.14: Consumer survey on Health

Q. Do you feel use of Electronic Products affects your health?

Gender		Yes	No	Don't know	Total
MALE	1	180	33	19	233
FEMALE	4	208	31	28	271
missing	0	1	0	0	1
Total	5	389	64	47	505

It is also significant to note that 77.80% of the respondents felt that use of Electronic products affects their health.

6.4.16 Consumer awareness about electronic products containing hazardous substances

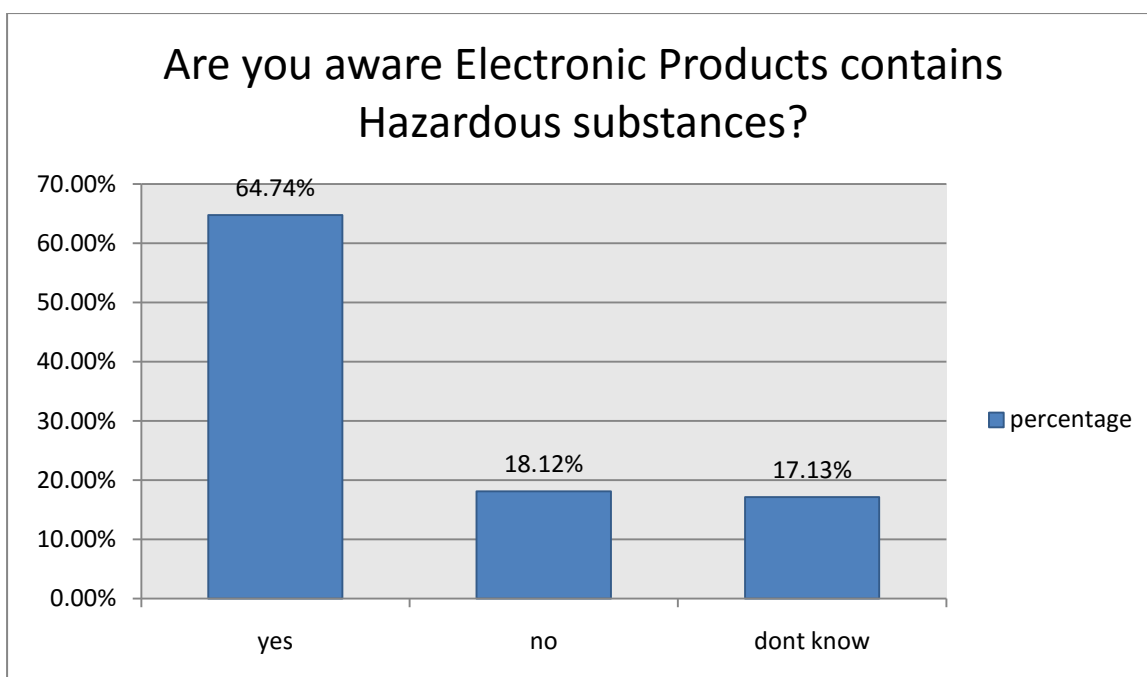


Fig.6.18: Electronic products containing hazardous substances

Table 6.15: Consumer awareness about electronics products containing hazardous substances

Q. Are you aware Electronic Products contains Hazardous substances?

Gender		Yes	No	Don't know	Total
MALE	1	139	46	47	233
FEMALE	2	185	45	39	271
missing	0	1	0	0	1
Total	3	325	91	86	505

It was a surprise to note that 64.74% of respondents were aware that Electronic products contain hazardous substances.

6.4.17 Consumer survey on need for more awareness about e-waste on health

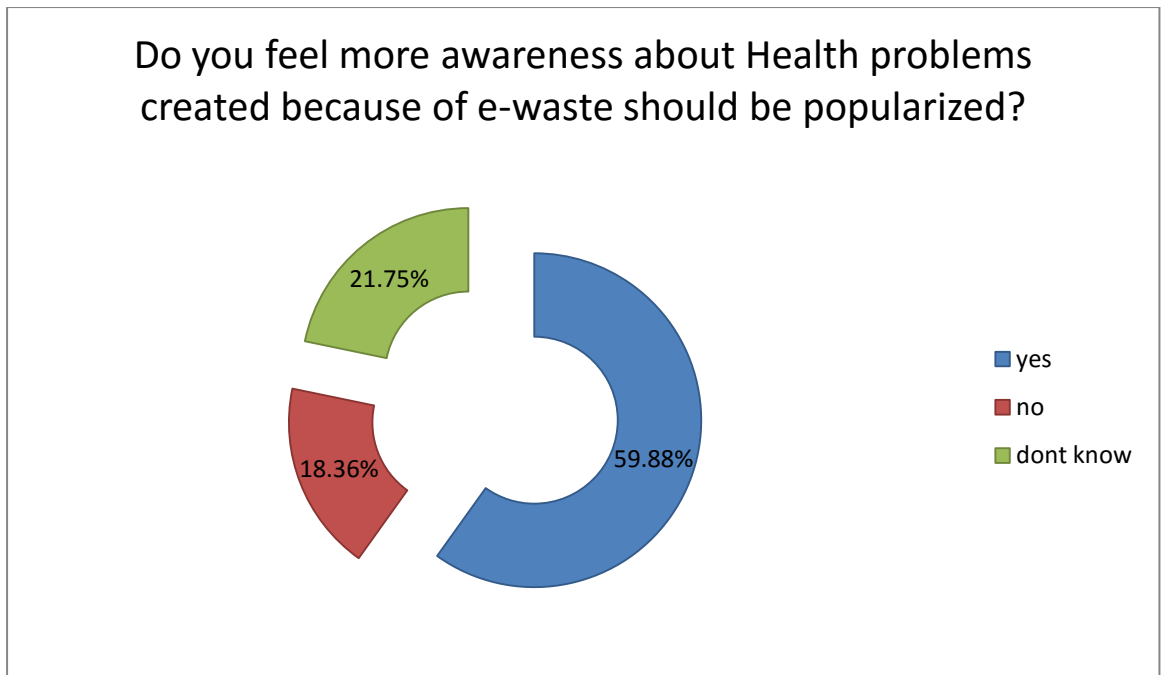


Fig.6.19: Awareness about health problems

Table 6.16: Consumers need for more awareness about health problems created by e-waste.

Q. Do you feel more awareness about Health problems created because of e-waste should be popularized?

Gender		Yes	No	Don't know	Total
MALE	1	135	48	49	233
FEMALE	3	164	44	60	271
missing	0	1	0	0	1
Total	4	300	92	109	505

On the specific question of knowledge of health users created by e-waste a guarded response was there as 57.88% felt that awareness about health users needs to be highlighters.

6.5 Testing of Hypothesis for Consumer Data through SPSS

While framing the research methodology three hypothesis were postulated for consumer data which detailed statistical analysis was done through SPSS which are enclosed below:

6.5.1 Null Hypothesis: 1

Ho= consumer are not aware about e-waste

H1 = consumer are aware about e-waste

Table 6.17: Awareness about e-waste.

Q. Do you know about e-waste?

Gender	Yes	No	Don't know	Total
MALE	120	92	21	233
FEMALE	166	91	14	271
missing	1	0	0	1
Total	287	183	35	505

We can confirm this computation with the results in the **Chi-**

Square Tests Table:

Table 6.18: Result of chi-square test performed on awareness of e-waste for Hypothesis 1

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.973 ^a	2	.050
Likelihood Ratio	5.978	2	.050
Linear-by-Linear Association	5.946	1	.015
N of Valid Cases	504		

The row of interest here is **Pearson Chi-Square** and its footnote.

- The value of the test statistic is 5.973.
- The footnote for this statistic pertains to the expected cell count assumption (i.e., expected cell counts are all greater than 5): 0 no of cells had an expected count less than 5, so this assumption was met.
- Because the crosstabulation is a 3x3 table, the degrees of freedom (df) for the test statistic is

$$df = (R-1) * (C-1) = (2-1) * (2-1) = 1 \quad df = (R-1) * (C-1) = (2-1) * (2-1) = 4$$

- The corresponding p-value of the test statistic is so small that it is cut off from display. Instead of writing "p = 0.000", we instead write the mathematically correct statement $p < 0$.

Decision and Conclusions

Since the p-value(0.050) equal to our chosen significance level $\alpha = 0.05$, we can reject the null hypothesis, and conclude that there is an association between consumer and awareness about e-waste.

Based on the results, we can state the following:

There was a significant association between consumer and awareness about e-waste.

$$(X^2(1) = 5.973, p < .050)$$

It was surprising to see that significant no. of consumer were aware about e-waste.

Data shows that while they were aware about e-waste, they were not aware about e-waste policy.

6.5.2 Null Hypothesis: 2

H₀= consumer are not aware about harmful effects of e-waste

H₁ = consumer are aware about harmful effects of e-waste

Table 6.19: Consumer awareness about harmful effects of e-waste on environment

Q. Do you know about harmful effects on Environment of e-waste?

Gender	Yes	No	Don't know	Total
MALE	141	64	28	233
FEMALE	177	78	16	271
missing	1	0	0	1
Total	319	142	44	505

We can confirm this computation with the results in the **Chi-Square Tests** table:

Table 6.20: Result of chi-square test performed on awareness of harmful effects on e-waste for Hypothesis 2

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.897 ^a	2	.052
Likelihood Ratio	5.914	2	.052
Linear-by-Linear Association	3.522	1	.061
N of Valid Cases	504		

- a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 20.34.

The row of interest here is **Pearson Chi-Square** and its footnote.

- The value of the test statistic is 5.892.
- The footnote for this statistic pertains to the expected cell count assumption (i.e., expected cell counts are all greater than 5): 0 no of cells had an expected count less than 5, so this assumption was met.
- Because the cross tabulation is a 3x3 table, the degrees of freedom (df) for the test statistic is

$$df = (R-1) * (C-1) = (2-1) * (2-1) = 1$$

$$df = (R-1) * (C-1) = (2-1) * (2-1) = 4$$
- The corresponding p-value of the test statistic is so small that it is cut off from display. Instead of writing "p = 0.000", we instead write the mathematically correct statement $p < 0$.

Decision and Conclusions

Since the p-value is (0.052) around our chosen significance level $\alpha = 0.05$, we can reject the null hypothesis, and conclude that there is an association between consumer and awareness about harmful effects of e-waste.

Based on the results, we can state the following:

There was a significant association between consumer and awareness about harmful effects of e-waste.

$$(\chi^2(1) = 5.897, p < .052)$$

Physical survey points to the fact that 60% of consumer were aware of the harmful effects of e-waste.

6.5.3 Null Hypothesis: 3

Ho= consumer are not aware of buy back scheme under EPR

H1 = consumer are aware of buy back scheme under EPR

Table 6.21: Consumer response for availing any buy back scheme.

Q. Have you ever availed of any buy back Scheme?

Gender	Yes	No	Don't know	Total
MALE	80	117	36	233
FEMALE	119	131	21	271
missing	1	0	0	1
Total	200	248	57	505

We can confirm this computation with the results in the **Chi-Square Tests** table:

Table 6.22: Result of chi-square test performed on response of consumers for availing any buy back scheme for Hypothesis 3

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.570 ^a	2	.008
Likelihood Ratio	9.610	2	.008
Linear-by-Linear Association	8.710	1	.003
N of Valid Cases	504		

The row of interest here is **Pearson Chi-Square** and its footnote.

The value of the test statistic is 9.570.

The footnote for this statistic pertains to the expected cell count assumption (i.e., expected cell counts are all greater than 5): 0 no of cells had an expected count less than 5, so this assumption was met.

Because the crosstabulation is a 3x3 table, the degrees of freedom (df) for the test statistic is

$$df = (R-1) * (C-1) = (2-1) * (2-1) = 1 \quad df = (R-1) * (C-1) = (2-1) * (2-1) = 1$$

The corresponding p-value of the test statistic is so small that it is cut off from display. Instead of writing "p = 0.000", we instead write the mathematically correct statement $p < 0$.

Decision and Conclusions

Since the p-value(0.0081) is less than our chosen significance level $\alpha = 0.05$, we can reject the null hypothesis, and conclude that there is an association between consumer and their knowledge about buy back scheme

Based on the results, we can state the following:

There was a significant association between consumer and their knowledge about buy back scheme

$$(X^2(1) = 9.570, p < .008).$$

Significantly large no of consumer (around 40%) were aware about the buyback scheme.

6.6 A Survey for Dismantlers of E-waste

6.6.1 Dismantling of E-wastes

To study the dismantling processes it was necessary to visit the sites where dismantling processes were happening. The study of dismantling process was conducted in the following manner

- a) To study the guidelines in force for dismantlers and the dismantling processes.

- b) To visit areas where dismantling processes are happening in the field
- c) To interact with the dismantlers and elicit their response through an oral and written questionnaire
- d) To analyse the results using statistical tools

6.6.2 Who is a Dismantler?

Any person or organisation or a registered society or a designated agency or a company or an association who engages in the dismantling of e-waste into their components by obtaining authorisation from the respective SPCBs/PCCs is called a dismantler.



Fig.6.20: Dismantler at work, Seelampur, Delhi

6.6.3 Guidelines for Dismantlers and dismantling processes

As per E-waste management rules 2016 (amended in 2018) the Dismantlers may set up their collection centre, details of which shall be entered in their authorisation. These collection centres shall not require separate authorisation. A dismantler shall be connected to either Producers or PRO or e-waste exchange or takeback system

or authorised recycler. A dismantler has to obtain consent to establish from SPCBs/PCCs under the Water (Prevention and Control of Pollution) Act, 1974 and the Air (Prevention and Control of Pollution) Act, 1981. A dismantler has to obtain consent to operate from SPCBs/PCCs under the Water (Prevention and Control of Pollution) Act, 1974 and the Air (Prevention and Control of Pollution) Act, 1981. A dismantler has to obtain authorisation from SPCBs/PCCs under E-Waste (Management) Rules, 2016, provided that any person authorised/registered under the provisions of the Hazardous Wastes (Management, Handling and Trans boundary Movements) Rules, 2008, and the E-waste (Management & Handling) Rules, 2011 prior to the date of coming into force of these rules shall not be required to make an application for authorisation till the period of expiry of such authorisation/registration.

A dismantler should have weighbridge and other appropriate weighing equipment for weighing each delivery received by it and maintain a record in this regard. The unloading of e-waste/end of life products should be carried out in such a way that there should not be any damage to health, environment and to the product itself. Unloading of Cathode Ray Tubes (CRT), LCD / LED / Plasma TV, refrigerator, air conditioners and fluorescent and other mercury-containing lamps should be carried out under supervision in such a way to avoid breakage. A dismantler should have facilities for destroying or permanently deleting data stored in the memory of the end of life products (Hard Disk, Telephones, Mobile phones) either through hammering or through data eraser.

Guidelines on Implementation of E-Waste (Management) Rules, 2016 HWM Division, CPCB Page 14 of 33 6.2

Dismantling Process Dismantling operation is essentially manual operation for segregating various components/ parts and sending

them to respective users/ recyclers. Directly usable components can be sent only to an authorised refurbisher. The other parts can be sent to recyclers having valid CTO / authorised waste recyclers depending upon the nature of the part. For example, steel or aluminium part which contains no hazardous constituents can be sent to respective recyclers. Other parts which may contain hazardous constituents have to be sent to authorised e-waste recyclers.

Dismantlers may perform the following operations

(i) De-dusting

(ii) Manual Dismantling operation shall comprise of physical separation and segregation after opening the electrical and electronic equipment into the component by manual operations. Dismantler may use screwdrivers, wrenches, pliers, wire cutters, tongs and hammers etc. for dismantling. The dismantled components should be sent to authorised e-waste recyclers or recyclers having valid consent to operate (CTO). Manual dismantling operations should be carried out over the dismantling table with space de-dusting system so as to maintain desirable work zone air quality as per the Factories Act as amended from time to time. The degusting system should consist of suction hoods over dismantling table connected with a cyclone, bag filter and venting through a chimney of three-meter height above roof level. Collection boxes should be placed near dismantling table for keeping the dismantled components.

The workers involved in dismantling operation should have appropriate equipment such as screwdrivers, wrenches, pliers, wire cutters, tongs and hammers etc. for dismantling the e-waste. During dismantling operations, the workers should use proper

personal protective equipment such as goggles, masks, gloves, helmet and gumboot etc. The following dismantled items and components must be removed from end of life products and stored in a safe manner for **transportation to recyclers:**

- (i) Batteries
- (ii) Printed Circuit Boards (PCBs) of EEE
- (iii) Toner cartridges Guidelines on Implementation of E-Waste (Management) Rules, 2016 HWM Division, CPCB Page 15 of 33
- (iv) Plastic
- (v) External Electrical Cables Volume/Size reduction may be carried out after dismantling operations for the parts like steel/aluminium/plastic, for ease of transportation.

Dismantled and segregated plastic from e-waste shall only be given to registered plastic recyclers having a registration under Plastic Waste (Management) Rules, 2016. During the volume/size reduction of dismantled steel/aluminium/plastic parts, the dismantlers should have an arrangement for dust and noise controls. These operations should be under acoustic enclosure for noise reduction.



Fig.6.21: Floppy Drive at dismantling site in Turkman Gate, Delhi

Dismantlers shall not carry out shredding/crushing/ fine grinding/wet grinding/ enrichment operations and gravity/ magnetic/density/eddy current separation of printed circuit board or the components attached with the circuit board. Dismantlers shall not be permitted for dismantling of fluorescent and other mercury-containing lamps, CRT / LCD / Plasma TV.

Dismantlers shall not be permitted for chemical leaching or heating process or melting the material. In the case of dismantling refrigerators and air conditioners, only skilled manpower having required tools and personal protective equipment (PPE) must be deployed to manually separate compressors. Prior to dismantling the compressors, adequate facilities should be provide for collection of coolant/refrigerant gases and compressor oil. Dismantled circuit boards, capacitors, batteries, capacitors containing PCBs (Polychlorinated biphenyls) or PCTs (Polychlorinated terphenyls) etc. shall not be stored in open. Dismantlers should have adequate facilities for managing leakage of compressor oils, coolant/refrigerant gases such as CFCs/HCFCs and mercury from

end of life fluorescent and other mercury containing lamp etc. Spills involving broken Fluorescent lamps, Oils spills should first be contained to prevent spread of the material to other areas. This may involve the use of dry sand, proprietary booms / absorbent pads, stabilizing chemicals etc. for subsequent transfer to hazardous waste TSDFs. **The premise for dismantling operation should fulfil the following requirements:**

- a) Water proof roofing and impermeable surfaces.
- b) Storage space for dissembled spare parts.
- c) Separate containers for storage of batteries, capacitors containing PCBs (Polychlorinated biphenyls) or PCTs (Polychlorinated terphenyls) Guidelines on Implementation of E-Waste (Management) Rules, 2016 HWM Division, CPCB Page 16.

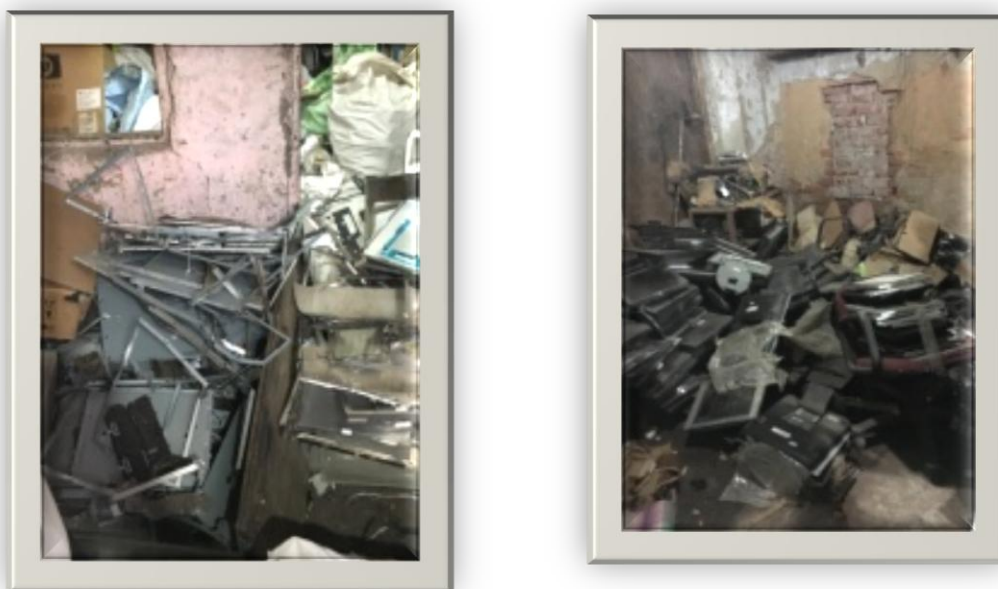
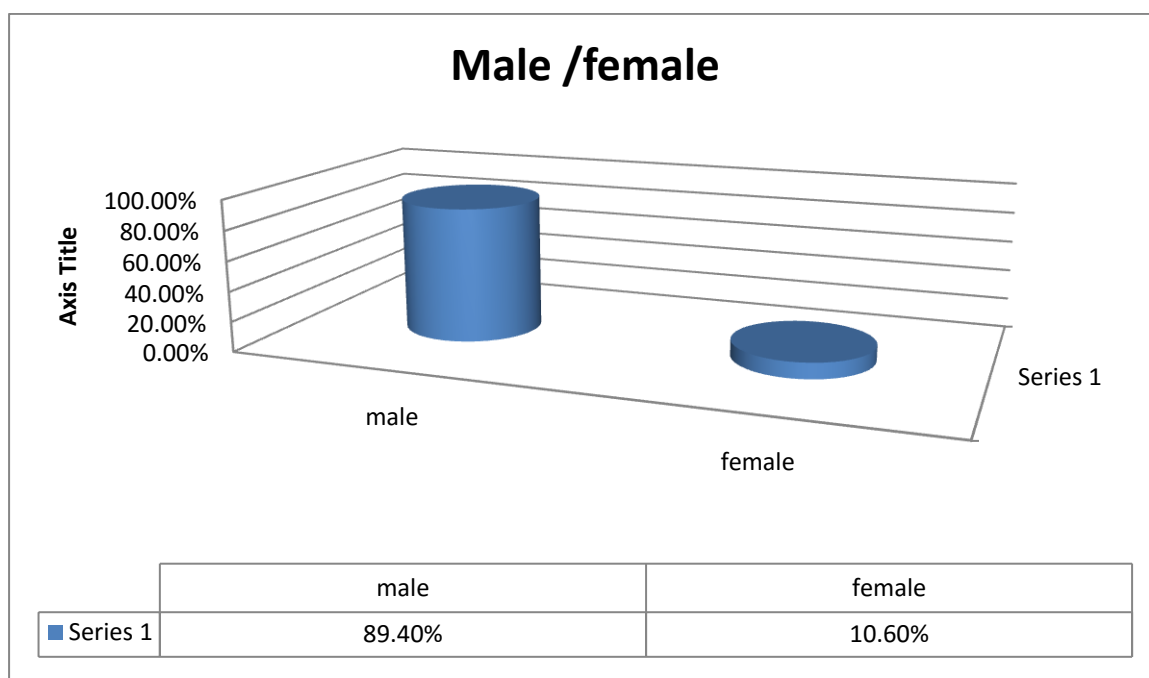


Fig.6.22: Loosely stacked e-waste at a dismantling site at Shastri Park, New Delhi.

6.6.4 Survey showing Dismantlers segregation based on gender



- During the survey and questionnaire addressed it was seen that the work force of dismantlers primarily consisted of Male workers who accounted for 89.6% of the dismantlers work force. Female workers were less and few and largely in the upper age group. Female workers comprised 10.6% of the dismantlers.
- Another discerning feature was the religious dispersion of the dismantlers. Around 80% belonged to Muslim community and rest were Hindus.

6.6.5 Dismantlers qualification based on survey

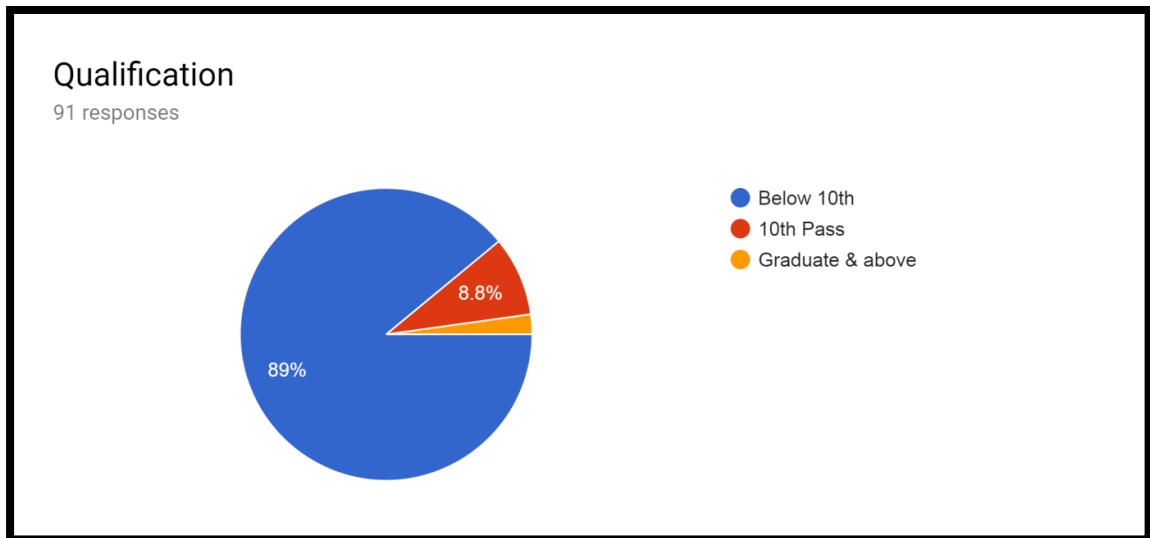


Fig.6.23: Pie chart showing qualification

Of the dismantlers so engaged in the e-waste recycling industry the study revealed that:

- (a) Only 2% were graduates who were primarily doing the liasing work.
- (b) Majority of dismantlers (89%) were not educated, school dropouts and had not passed class 10th .
- (c) 8.8% dismantlers had passed class 10th .
- (d) There was a general feeling amongst the dismantlers that jobs were not forthcoming after passing class 10th and they had to perform these jobs to earn their livelihood.

6.6.6 Survey showing number of days for which dismantlers work in an year

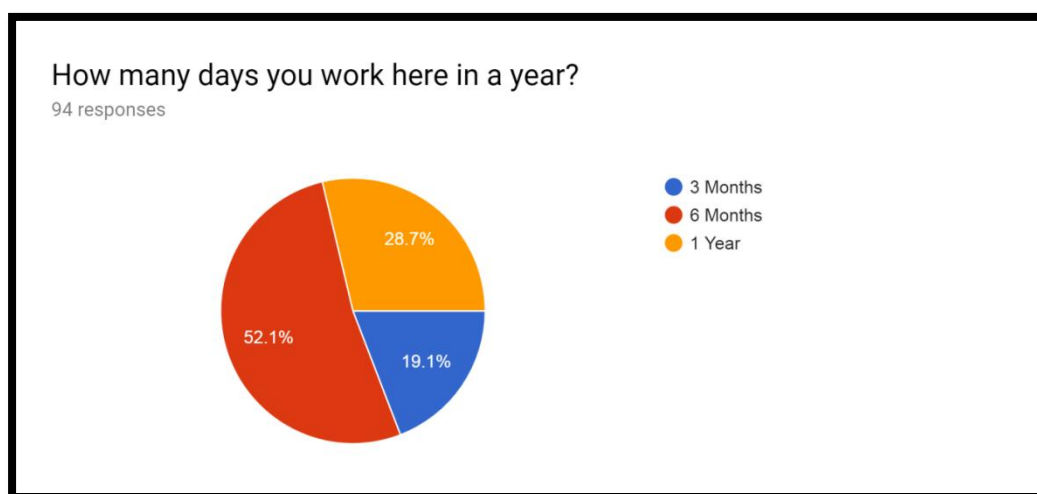


Fig.6.24: Number of days of employment for dismantlers.

Table 6.23: Number of days for which dismantler work in a year

Q. How many days you work here in a year?

Gender	3 months	3-6 months	1 year	Total
Male	10	47	27	84
Female	8	2	0	10
Total	18	49	27	94

Table 6.24: qualification of dismantlers and number of days for which they work in a year

Q. How many days you work here in a year?

Qualification	3 months	3-6 months	1 year	Total
	2	0	1	3
10th Pass	1	4	3	8
Below 10th	15	44	22	81
Graduate & above	0	1	1	2
Total	18	49	27	94

(a) While dismantling of electronic products was done as a measure of job security it was strange to see that only 28.7% dismantlers got work for the full year.

(b) While 52.5 worked between 3-6 months.

(c) 19.1% worked for only 3 months in a year.

The study was not conclusive as to whether dismantlers in (b) and (c) category did work on any other job.

6.6.7 Dismantlers data showing use of safety measures like gloves

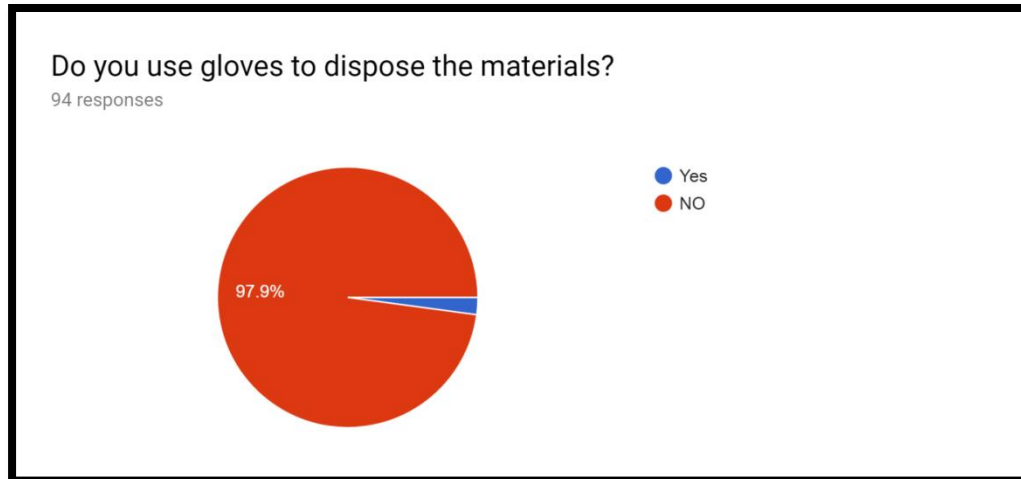


Fig.6.25: Use of safety products - gloves

Table 6.25: Whether dismantler use gloves

Q. Do you use gloves to dispose the materials?

Gender	Yes	No	Total
MALE	2	82	84
FEMALE	0	10	10
Total	2	92	94

Table 6.26: Qualification wise dismantler using the gloves

Q. Do you use gloves to dispose the materials?

Qualification	Yes	No	Total
	0	3	3
10th Pass	0	8	8
Below 10th	2	79	81
Graduate & above	0	2	2
Total	2	92	94

The results of this question was expected lines with 97.9% of dismantler not using gloves.



Fig.6.26: Author with the dismantlers at dismantling site, Shastri Park, New Delhi

Even the 2.1% who were using gloves were using them intermittently.

There is a need to utilize safe and secure methods for recycling dismantling, physical dismantling and separation of electronic products.

6.6.8 Dismantler data showing use of safety products like shoes

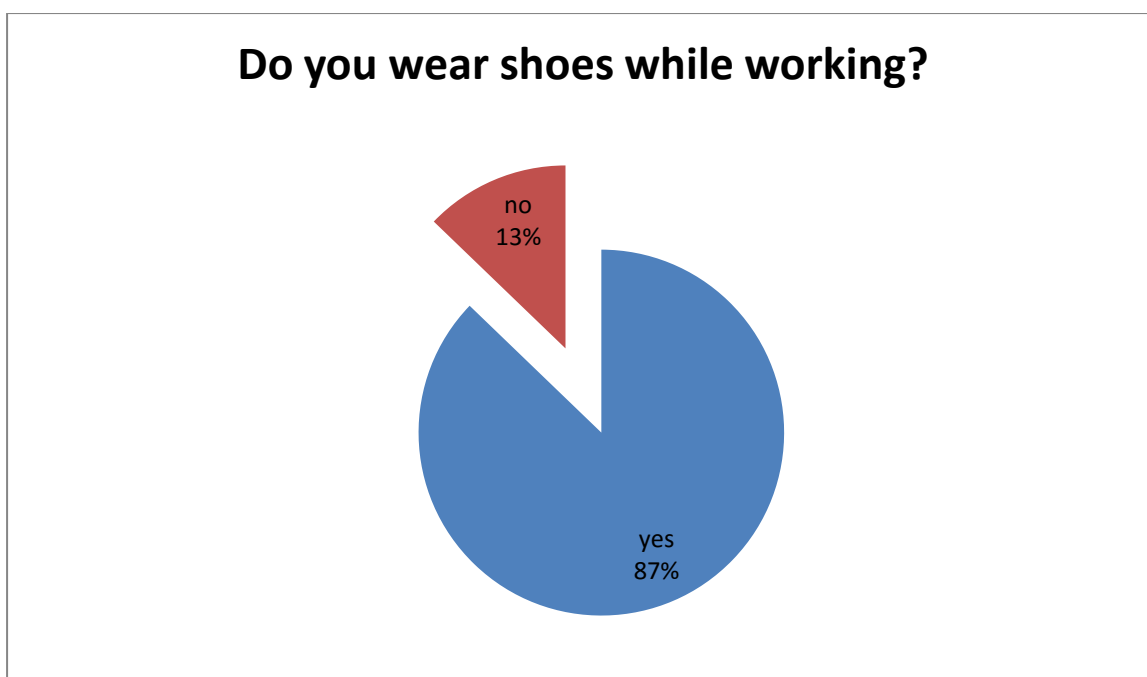


Fig.6.27: use of safety products-shoes

Table 6.27: Dismantler using shoes while working.

Q. Do you wear shoes while working?

		Do you wear shoes while working?		Total
		Yes	No	
Male / Female	Male	12	72	84
	Female	0	10	10
Total		12	82	94

Table 6.28: Qualification wise dismantlers using shoes while working

Q. Do you wear shoes while working?

		Do you wear shoes while working?		Total
		Yes	No	
Qualification		0	3	3
	10th Pass	3	5	8
	Below 10th	8	73	81
	Graduate & above	1	1	2
Total		12	82	94

Dismantlers sitting on hard desk, motherboard, server parts was a common sight.

During the visit hardly anybody was seen working with a shoe through 12.8% said that they wear shoes while working.

87.2% wear shoes while dismantling.

6.6.9 Dismantler data showing use of safety products like masks

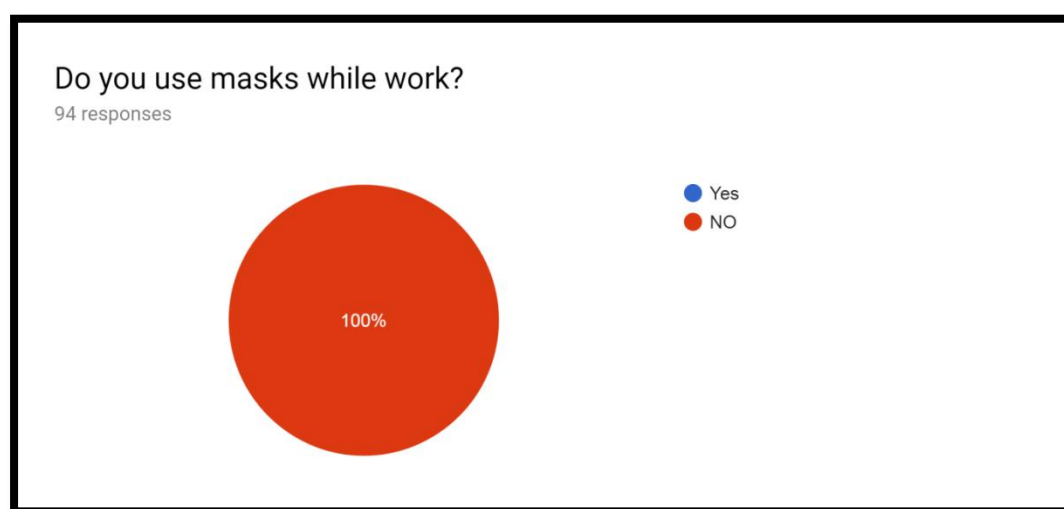


Fig.6.28: Use of safety products-masks

Table 6.29: Dismantlers using mask while working

Q. Do you use masks while work?

		Do you use masks while work?	Total
		No	
Male / Female	Male	84	84
	Female	10	10
Total		94	94

Table 6.30: Qualification wise dismantlers using mask while working

Q. Do you use masks while work?

	Do you use masks while work?	Total

		no	
Qualification		3	3
	10th Pass	8	8
	Below 10th	81	81
	Graduate & above	2	2
Total		94	94

Masks were a strict no-no and 100% of these surveyed said that they never wear masks.

In case of excessive dust they cover their faces with a cloth or a towel, which we found was more contaminated.

6.6.10 Survey results on Dismantlers status on periodic health checkups

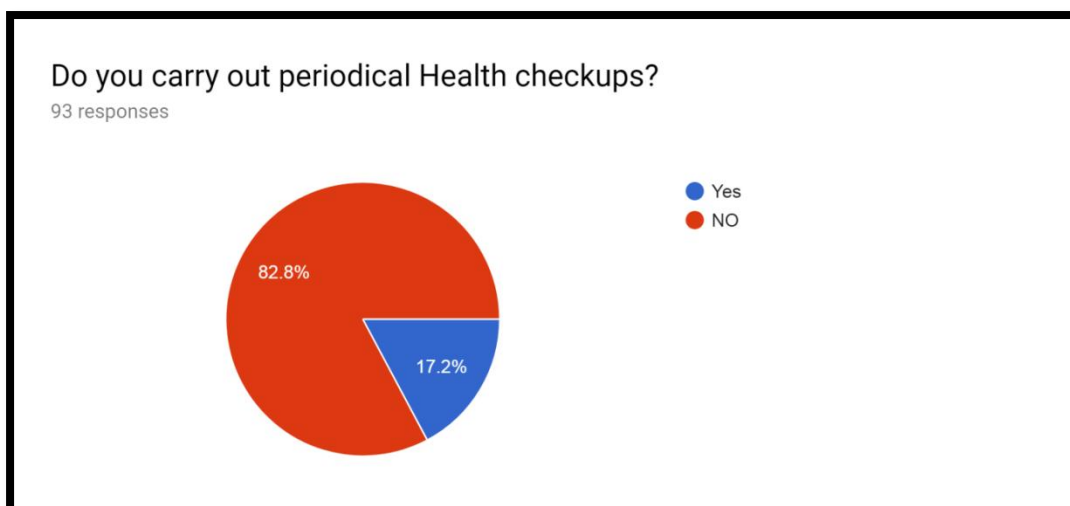


Fig.6.29: Periodical Health checkups

Table 6.31: Dismantlers status on periodic health check up

Q. Do you carry out periodical Health checkups?

		Do you carry out periodical Health checkups?		Total
		yes	no	
Male	/ Male	12	71	83
Female	Female	4	6	10
Total		16	77	93

Table 6.32: Qualification wise dismantlers status on periodic health check up

Q. Do you carry out periodical Health checkups?

		Do you carry out periodical Health checkups?		Total
		Yes	No	
Qualification		0	3	3
	10th Pass	2	5	7
	Below 10th	14	67	81
	Graduate & above	0	2	2
Total		16	77	93

The results of health status was no less surprising as 82.8% did not carry out periodical health checks.

While working many of them used lead batteries, acids, asbestos material, hazardous substances and other electronic materials yet they were not subjected to any health checkup.

6.6.11 Status of dismantlers family working in the unit

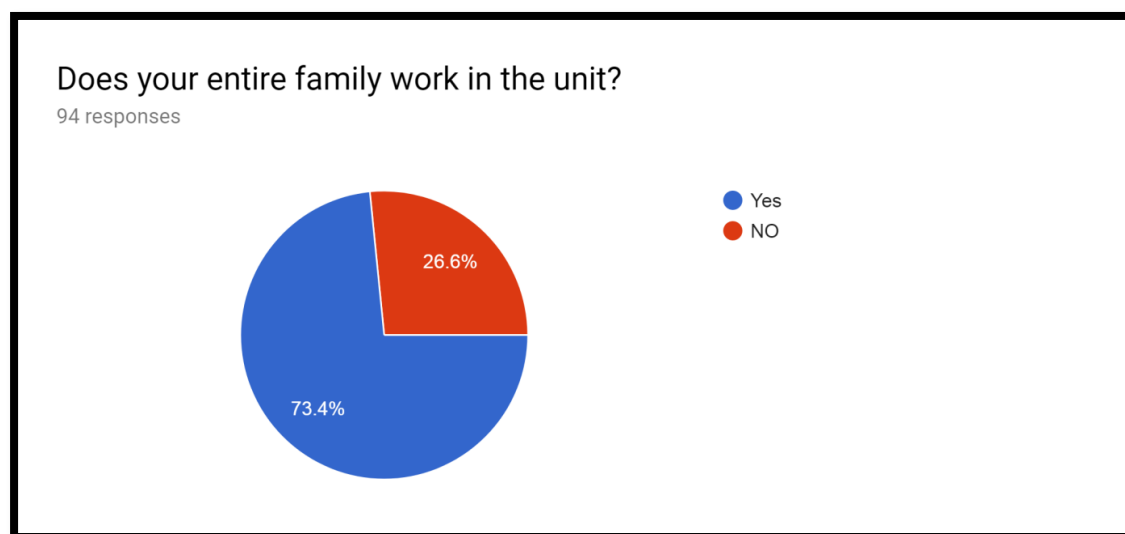


Fig.6.30: Family members working in a unit

Table 6.33: Status of dismantlers family working in the unit

Q. Does your entire family work in the unit?

	Does your entire family work in the unit?		Total
	Yes	No	

Male	/	Male	59	25	84
Female		Female	10	0	10
Total			69	25	94

Table 6.34: Status of qualification wise dismantlers family working in the unit

Q. Does your entire family work in the unit?

		Does your entire family work in the unit?		Total
		Yes	No	
Qualification		2	1	3
	10th Pass	5	3	8
	Below 10th	62	19	81
	Graduate & above	0	2	2
Total		69	25	94

26.5% of the workers said that their entire family worked on e-waste.

6.6.11 Health Disease status of dismantlers

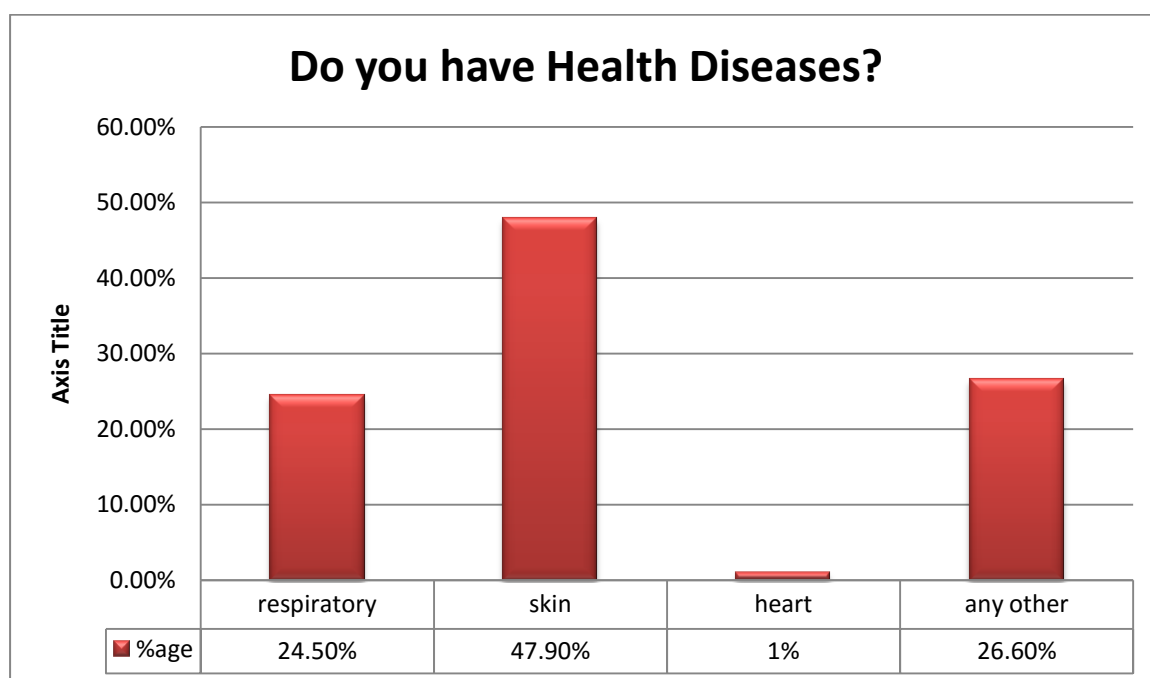


Fig.6.31: Health Diseases status for Dismantlers

Table 6.35: Health diseases status of dismantlers

Q. Do you have Health Diseases?

		Do you have Health Diseases?				Total
		Respiratory	Skin	Heart	Any other	
Male	Male	20	39	1	24	84
Female	Female	3	6	0	1	10
Total		23	45	1	25	94

Table 6.36: Qualification wise health diseases status of dismantlers

Q. Do you have Health Diseases?

Count		Do you have Health Diseases?				Total
		respiratory	skin	heart	any other	
Qualification		0	2	0	1	3
	10th Pass	3	3	0	2	8
	Below 10th	19	39	1	22	81
	Graduate & above	1	1	0	0	2
Total		23	45	1	25	94

The survey revealed that;

- 47.9% suffered from skin diseases
- 24.5% had respiratory symptoms and
- 26.6% contacted other diseases

6.6.12 Status of dismantlers admitted to hospital

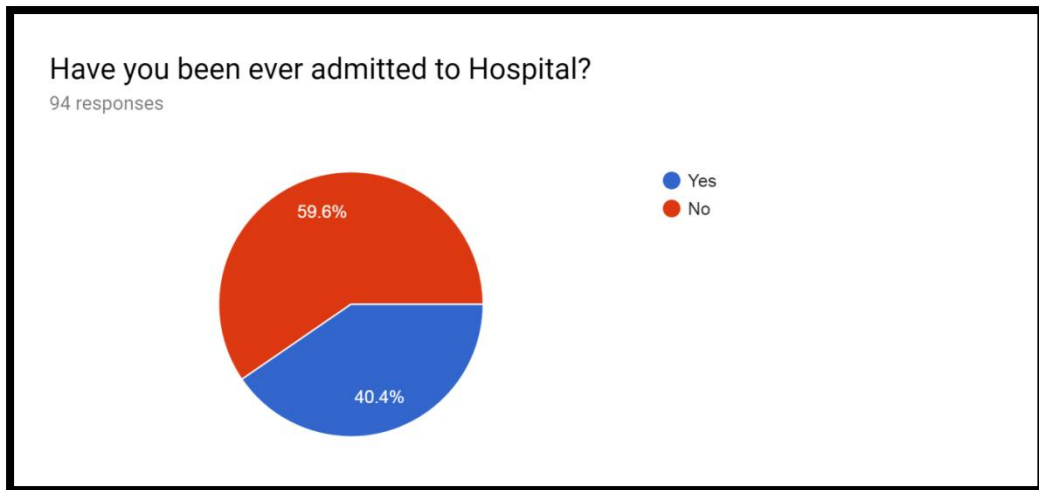


Fig.6.32: Admission to hospitals

Table 6.37: Status of dismantlers admitted to hospital

Q. Have you been ever admitted to Hospital?

Count			Have you been ever admitted to Hospital?		Total
			yes	no	
Male	/	Male	32	52	84
Female		Female	6	4	10
Total			38	56	94

Table 6.38: Qualification wise status of dismantlers admitted to hospital.

Q. Have you been ever admitted to Hospital?

		Have you been ever admitted to Hospital?		Total
		Yes	No	
Qualification		0	3	3
	10th Pass	6	2	8
	Below 10th	31	50	81
	Graduate & above	1	1	2
Total		38	56	94

While a majority of 59.6% were never admitted to hospital, yet a higher percentage (40.4%) were admitted.

No direct correlation between dismantling related admission and/ or otherwise was established as it was not part of the study but a correlation with lack of safety measures points to a dismal picture.

6.6.13 Number of boards dismantled by dismantlers per day

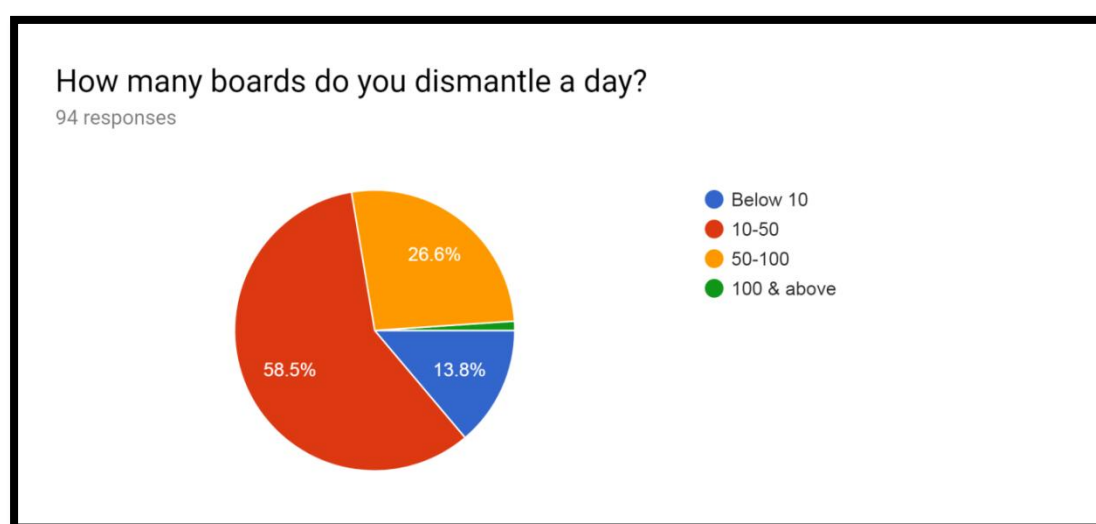


Fig.6.33: Number of boards dismantled per day

Table 6.39: Number of boards dismantled per day by the dismantler

Q. How many boards do you dismantle a day?

		How many boards do you dismantle a day?				Total
		1.0	2.0	3.0	4.0	
Male	Male	11	47	25	1	84
Female	Female	2	8	0	0	10
Total		13	55	25	1	94

Table 6.40: Qualification wise number of boards dismantled per day by the dismantler

Q. Qualification * How many boards do you dismantle a day?

		How many boards do you dismantle a day?				Total
		1.0	2.0	3.0	4.0	
Qualification		0	3	0	0	3

	10th Pass	2	2	3	1	8
	Below 10th	10	49	22	0	81
	Graduate & above	1	1	0	0	2
Total		13	55	25	1	94

Majority of people (58.5%) dismantled between 10-50 boards a day.

Few (1.1%) were dismantling 100 or more boards.

Significantly higher number of dismantlers (26.6%) were dismantling between 50-100 boards.

6.6.14 Survey on number of dismantlers using acid

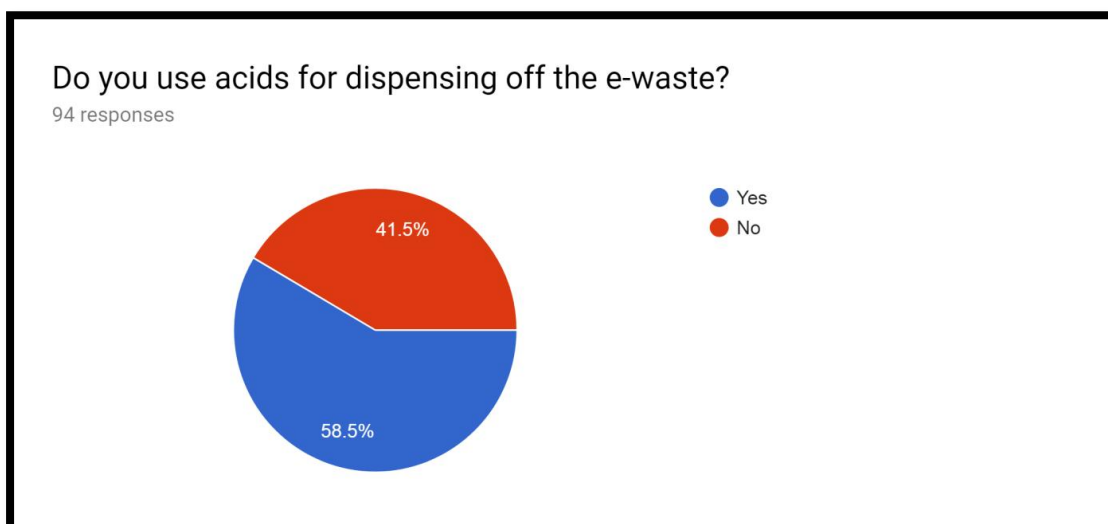


Fig.6.34: Use of Acids for dismantling

Table 6.41: Number of dismantler using acids for dispensing off the e-waste

Q. Do you use acids for dispensing off the e-waste?

		Do you use acids for dispensing off the e-waste?		Total
		yes	no	
Male	/	49	35	84
Female		6	4	10
Total		55	39	94

Table 6.42: Qualification wise number of dismantler using acids for disposing off the e-waste

Q. Do you use acids for disposing off the e-waste?

		Do you use acids for disposing off the e-waste?		Total
		Yes	No	
Qualification		0	3	3
	10th Pass	7	1	8
	Below 10th	46	35	81
	Graduate & above	2	0	2
Total		55	39	94

While 58.5% admitted to using acids 41.5% did not use acids in the processes involved.

6.6.15 Waste disposal by Dismantler

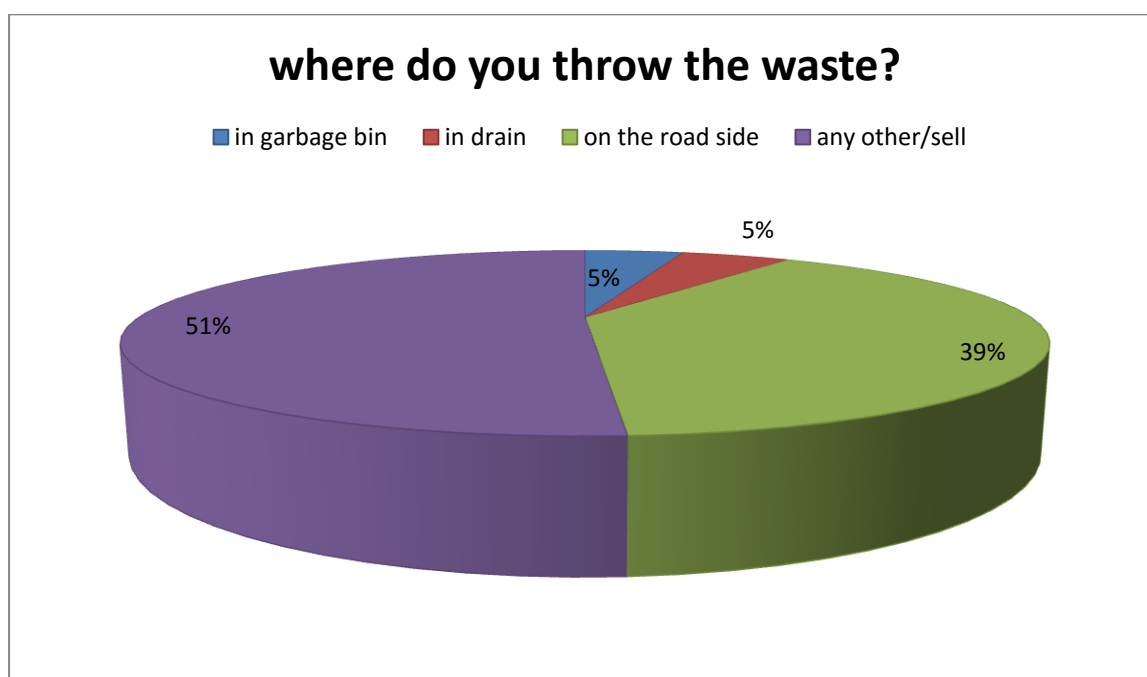


Fig.6.35: **Disposal of waste**

Table 6.43: Waste disposal by dismantler

Q. Where do you throw the waste?

	Where do you throw the waste?				Total
	In	In	On	Any	

		Garbage bin	Drain	Road Side	Other	
Male	/	3	4	32	45	84
Female	Female	1	1	5	3	10
Total		4	5	37	48	94

Table 6.44: Qualification wise waste disposal by dismantler

Q. Where do you throw the waste?

		In Garbage bin	In Drain	On Road Side	Any Other	Total
Qualification		0	0	2	1	3
	10th Pass	1	1	3	3	8
	Below 10th	2	4	31	44	81
	Graduate & above	1	0	1	0	2
Total		4	5	37	48	94

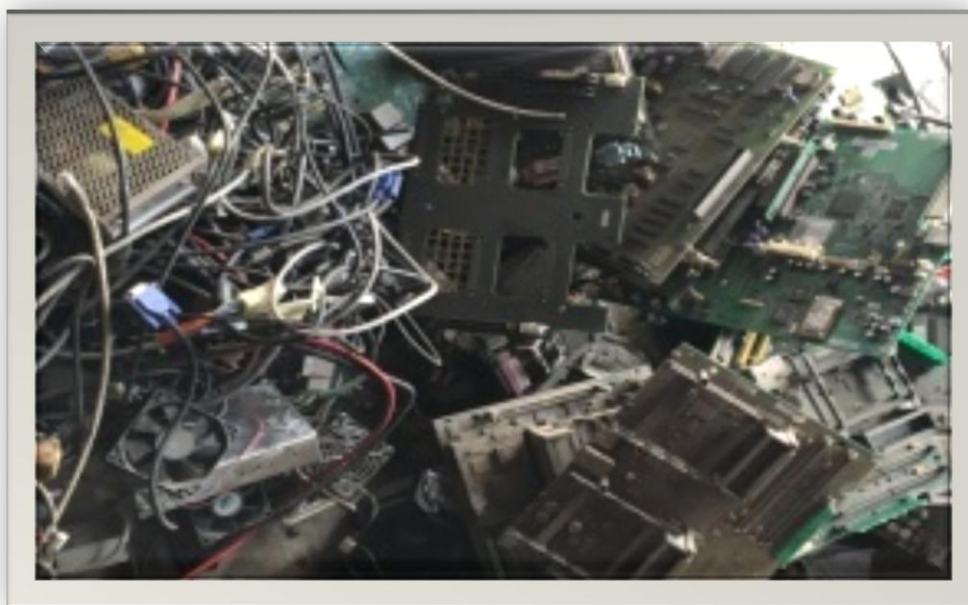


Fig.6.36: E-waste stacks loosely kept at a dismantling site, Mundaka, Delhi



Fig.6.37: E-waste scrap at a dismantling site Turkeman Gate, Delhi

51.1% of dismantlers said that they sold different waste material as scrap and did not throw the waste, as it was a resource.

38.4% threw the wastes on the roadside after dismantling.

The visit to the areas it was seen that waste material was thrown on waste land, drains and garbage bins.

6.6.16 Number of dismantlers who got hurt while dismantling

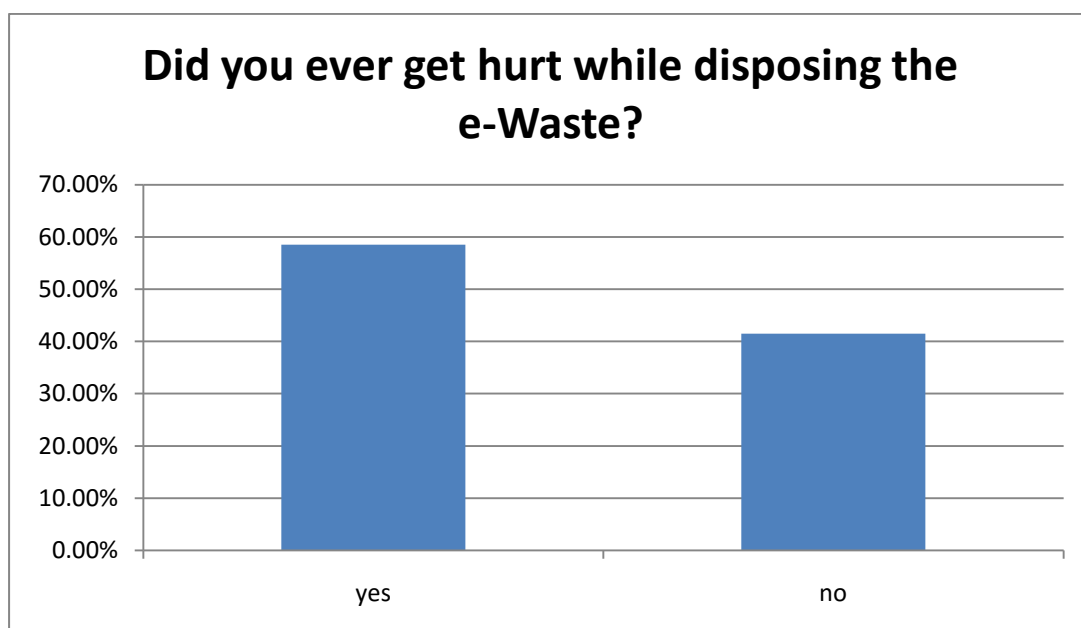


Fig.6.38: Number of Dismantlers who get hurt

Table 6.45: Number of dismantler who get hurt while disposing the e-waste

Q. Did you ever get hurt while disposing the e-waste?

		Did you ever get hurt while dispensing the e-waste?		Total
		Yes	No	
Male /	Male	47	37	84
Female	Female	8	2	10
Total		55	39	94

Table 6.46: Qualification wise number of dismantler who get hurt while disposing the e-waste

Q. Did you ever get hurt while dispensing the e-waste?

		Did you ever get hurt while dispensing the e-waste?		Total
		Yes	No	
Qualificati on		2	1	3
	10th Pass	6	2	8
	Below 10th	46	35	81
	Graduate &	1	1	2

	above			
Total		55	39	94

41.5% of dismantlers said they got hurt while dismantling the waste which correlates well with the admission to the hospital.

6.6.17 Survey showing children of dismantlers working in the units

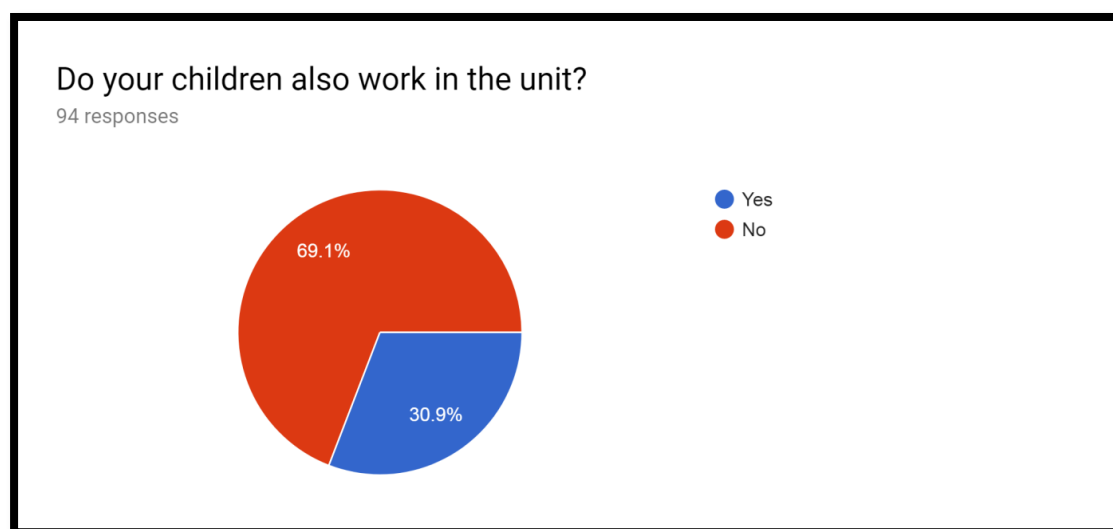


Fig.6.39: Children of Dismantlers working

Table 6.47: Number of children of dismantler working in the unit

Q. Do your children also work in the unit?

		Do your children also work in the unit?		Total
		Yes	No	
Male	Male	21	63	84
Female	Female	8	2	10
Total		29	65	94

Table 6.48: Qualification wise number of children of dismantler working in the unit

Q. Do your children also work in the unit?

		Do your children also work in the unit?		Total
		Yes	No	
Qualification		1	2	3
	10th Pass	2	6	8

	Below 10th	25	56	81
	Graduate & above	1	1	2
Total		29	65	94

Children of 30.9% of the dismantlers also worked in the units.

6.6.18 Disposal of scrap by dismantlers

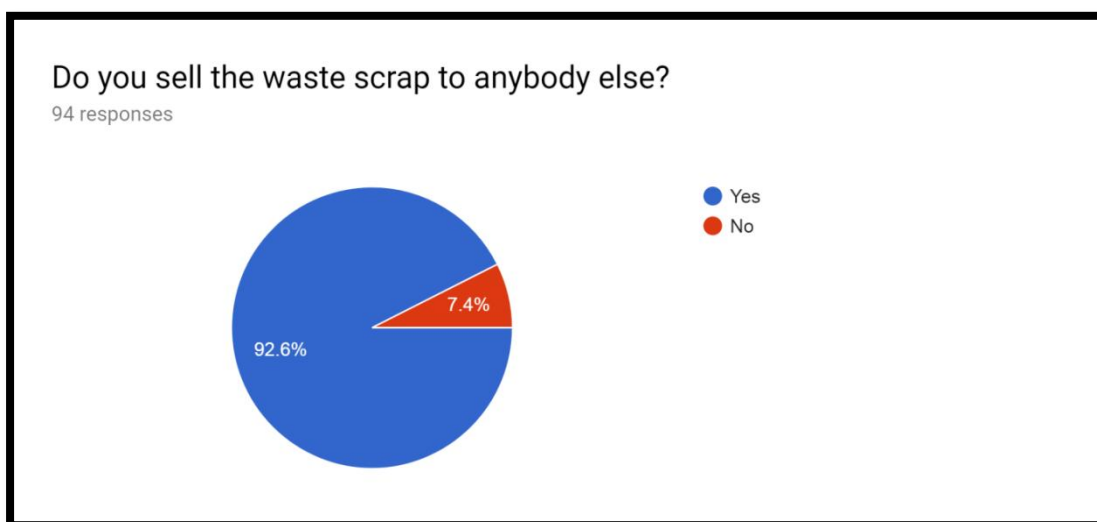


Fig.6.40: Selling waste scrap

Table 6.49: Disposal of scrap by dismantler to others

Q. Do you sell the waste scrap to anybody else?

		Do you sell the waste scrap to anybody else?		Total
		Yes	No	
Male	Male	77	7	84
Female	Female	10	0	10
Total		87	7	94

Table 6.50: Qualification wise disposal of scrap by dismantler to others

Q. Do you sell the waste scrap to anybody else?

		Do you sell the waste scrap to anybody else?		Total
		Yes	No	
Qualification		3	0	3
	10th Pass	8	0	8
	Below 10th	74	7	81

	Graduate & above	2	0	2
Total		87	7	94

92.50% of the respondents sold the Waste Scrap to different dealers.

6.6.19 Survey on feel safe factor of dismantlers

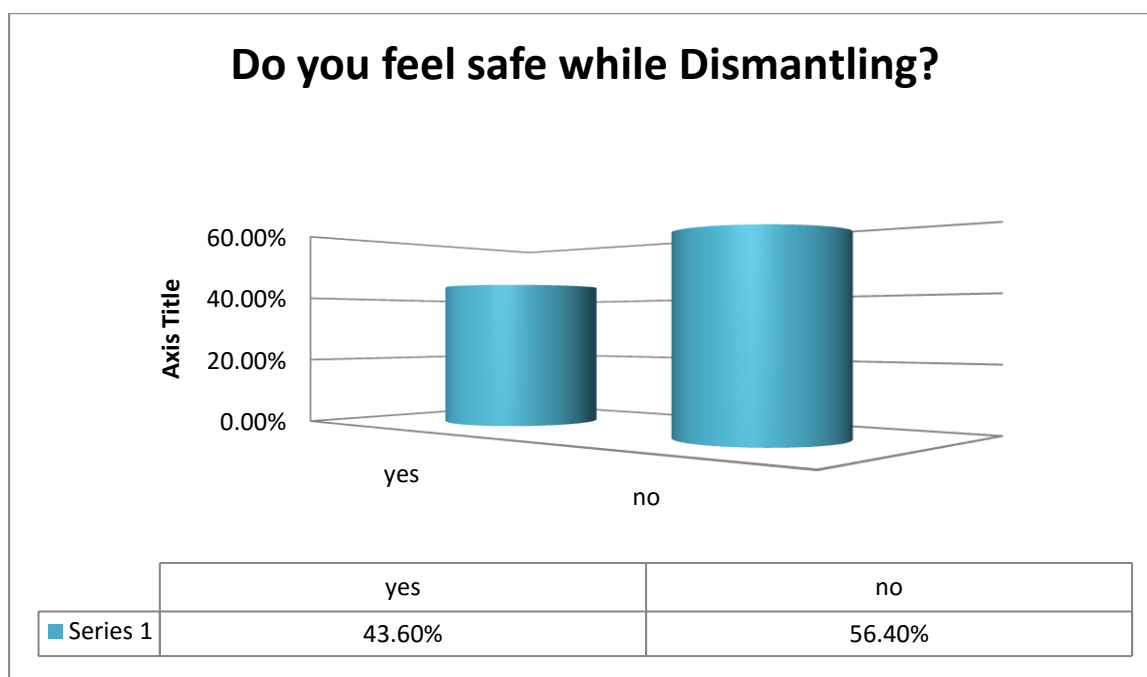


Fig.6.41: Dismantlers feeling safe

Table 6.51: Whether dismantler felt safe while working

Q. Do you feel safe while dismantling?

		Do you feel safe while dismantling?		Total
		Yes	No	
Male / Female	Male	41	43	84
	Female	0	10	10
Total		41	53	94

Table 6.52: Qualification wise safety felt by dismantler while working

Q. Do you feel safe while dismantling?

	Do you feel safe while dismantling?	Total

		Yes	No	
Qualification		0	3	3
	10th Pass	6	2	8
	Below 10th	33	48	81
	Graduate & above	2	0	2
Total		41	53	94

A majority of 56.4% felt that dismantling work was not safe.

6.7 Testing of Hypothesis for Data on Dismantlers through SPSS

While framing the research methodology two hypothesis were postulated for data of dismantlers for which detailed statistical analysis was done through SPSS which are enclosed below:

6.7.1 Null Hypothesis: 4

Ho= Dismantlers do not face any safety issues.

H1 Dismantler have safety issues.

Table 6.53: Whether dismantler felt safe while working

Q. Do you feel safe while dismantling?

		Do you feel safe while dismantling?		Total
		yes	no	
Male /	male	41	43	84
Female	female	0	10	10
Total		41	53	94

Table 6.54: Qualification wise safety felt by dismantler while working

Q. Do you feel safe while dismantling?

		Do you feel safe while dismantling?		Total
		yes	no	
Qualification		0	3	3
	10th Pass	6	2	8

	Below 10th	33	48	81
	Graduate & above	2	0	2
Total		41	53	94

We can confirm this computation with the results in the **Chi-Square Tests** table:

Table 6.55: Result of chi-square test performed on response of dismantlers as to the safety factor while their working for Hypothesis 4

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	8.456 ^a	1	.004		
Continuity Correction ^b	6.605	1	.010		
Likelihood Ratio	12.148	1	.000		
Fisher's Exact Test				.004	.002
Linear-by-Linear Association	8.366	1	.004		
N of Valid Cases	93				

The row of interest here is **Pearson Chi-Square** and its footnote.

- The value of the test statistic is 8.456.
- The footnote for this statistic pertains to the expected cell count assumption (i.e., expected cell counts are all greater than 5): 1 no of cells had an expected count less than 5, so this assumption was met.
- Because the cross tabulation is a 4x2 table, the degrees of freedom (df) for the test statistic is

$$df = (R - 1) * (C - 1) = (2 - 1) * (2 - 1) = 1$$

$$df = (R - 1) * (C - 1) = (2 - 1) * (2 - 1) = 1$$

$$= 1$$

- The corresponding p-value of the test statistic is so small that it is cut off from display. Instead of writing " $p = 0.000$ ", we instead write the mathematically correct statement $p < 0$.

Decision and Conclusions

Since the p-value (0.004) is less than our chosen significance level $\alpha = 0.05$, we can reject the null hypothesis, and conclude that there is an association between dismantlers and safety issues.

Based on the results, we can state the following:

There was a significant association between dismantlers and safety issues.

- ($\chi^2(1) = 8.456, p < 0.004$).

This is in conformity with the physical survey wherein about 56.38% of dismantlers did not feel safe

6.7.2 Null Hypothesis: 5

H₀= Dismantlers do not have periodicals health checks-ups

H₁= Dismantlers have periodicals health checks-ups

Table 6.56: Periodical health checkups done by dismantlers

Q. Do you carry out periodical Health checkups?

		Do you carry out periodical Health checkups?		Total
		yes	no	
Male	male	12	71	83
Female	female	4	6	10
Total		16	77	93

Table 6.57: Qualification wise periodical health checkups done by dismantlers

Q. Do you carry out periodical Health checkups?

		Do you carry out periodical Health checkups?		Total
		yes	no	
Qualification		0	3	3
	10th Pass	2	5	7
	Below 10th	14	67	81
	Graduate & above	0	2	2
Total		16	77	93

We can confirm this computation with the results in the **Chi-Square Tests** table:

Table 6.58: Result of chi-square test performed on response of dismantlers to the health checkups while working Hypothesis 5

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.088 ^a	1	.043		
Continuity Correction ^b	2.491	1	.114		
Likelihood Ratio	3.345	1	.067		
Fisher's Exact Test				.066	.066
Linear-by-Linear Association	4.044	1	.044		
N of Valid Cases	93				

The row of interest here is **Pearson Chi-Square** and its footnote.

- The value of the test statistic is 4.088
- The footnote for this statistic pertains to the expected cell count assumption (i.e., expected cell counts are all greater than 5): 1 no of cells had an expected count less than 5, so this assumption was met.
- Because the cross tabulation is a 4x2 table, the degrees of freedom (df) for the test statistic is

$$df=(R-1)*(C-1)=(2-1)*(2-1)=1 \quad df=(R-1)*(C-1)=(2-1)*(2-1)=3$$

The corresponding p-value of the test statistic is so small that it is cut off from display. Instead of writing " $p = 0.000$ ", we instead write the mathematically correct statement $p < 0$.

Decision and Conclusions

Since the p-value (0.043) is less than our chosen significance level $\alpha = 0.05$, we can reject the null hypothesis, and conclude that there is an association Dismantlers and their health checkups.

Based on the results, we can state the following:

There was a significant association between association Dismantlers and their health checkups.

$$(X^2(1) = 4.088, p < 0.043)$$

The results are corroborated by the fact that dismantlers suffer from a number of diseases which has come out in the questionnaire.

6.8 A Survey for Recyclers of E-waste

To study the recycling process a field study was made and a number of recycling industries were visited.

The study of recycling activity was conducted in the following manner:

- (i) To study the guidelines in force for the recyclers.
- (ii) To visit a few recycling units.
- (iii) To interact with the recyclers and elicit their response through oral and written questionnaires
- (iv) To analyze the tools using statistical methods.

6.8.1 Who is a Recycler

As per guidelines for Environmentally Sound Recycling of E-Waste recycler is any person who is engaged in recycling and reprocessing of waste electrical and electronic equipment or assemblies or their component.

6.8.2 Guidelines for Recyclers

Recyclers may set up their collection centres, details of which shall be entered in their authorisation. These collection centres shall not require separate authorisation. Recyclers can obtain raw material such as waste electrical and electronic assemblies or components or used components from producers/PRO/e-waste exchange/dismantlers and consumers / bulk consumers. The Product of recyclers has to be sent or sold to users or other recyclers having valid CTO from SPCBs/PCCs.

Any hazardous waste generated during the recycling processing will be sent to TSDF' a recycler should be part of producer's channelisation system.

A recycler has to obtain consent to establish from SPCBs/PCCs under the Water ***(Prevention and Control of Pollution) Act, 1974 and the Air (Prevention and Control of Pollution) Act, 1981*** ***A recycler has to obtain consent to operate from SPCBs/PCCs under the Water (Prevention and Control of Pollution) Act, 1974 and the Air (Prevention and Control of Pollution) Act, 1981*** A recycler has to obtain authorisation from SPCBs/PCCs under E Waste (Management) Rules, 2016, provided that any person authorised/registered under the provisions of the Hazardous Wastes (Management, Handling and Transboundary Movements) Rules, 2008, and the E-waste (Management &

Handling) Rules, 2011 prior to the date of coming into force of these rules shall not be required to make an application for authorisation till the period of expiry of such authorisation/registration. A recycler should have weigh bridge and other appropriate weighing equipment for weighing each delivery received by it and maintain a record in this regard. The unloading of end of life product should be carried out in such a way that there should not be any damage to health, environment and to the product itself. Unloading of Cathode Ray Tubes (CRT), LCD/LED/Plasma TV, Refrigerator, Air Conditioners and fluorescent and other mercury containing lamps should be carried out under supervision in such a way to avoid breakage.

A recycler should have facilities for destroying or permanently deleting data stored in the memory of end of life products (Hard Disk, Telephones, Mobile phones) either through shredding or grinding or through data eraser.

6.8.3 Recycling Process

The functions of the recyclers include dismantling along with recovery operation. There shall be no restriction on degree of operations that can be permitted for recyclers provided they have requisite facilities. ***The following processes should be employed by recyclers:***

- (i) Manual / semi- automatic / automatic dismantling operations
- (ii) Shredding / crushing / fine grinding/wet grinding/ enrichment operations, gravity/ magnetic/density/eddy current separation
- (iii) Pyro metallurgical operations - Smelting furnace
- (iv) Hydro metallurgical operations

(v) Electro-metallurgical operations

(vi) Chemical leaching

(vii) CRT/LCD/Plasma processing

(viii) Toner cartridge recycling

(ix) Melting, casting, moulding operations (for metals and plastics)

A recycling facility may accept e-waste and even those electrical and electronic assemblies or components not listed in Schedule- I for recycling, provided that they do not contain any radioactive materials and same shall be declared while taking the authorisation from concerned SPCBs/PCCs; The recycling facilities shall comply with the requirements as specified for dismantlers in the ***guidelines for dismantling in section 6.0***. A recycling facility shall install adequate wastewater treatment facilities for process wastewater and air pollution control equipment (off gas treatment, wet/alkaline/packed bed scrubber and carbon filters) depending on type of operations undertaken. De dusting equipment such as suction hood shall be installed where manual dismantling is carried out. Fume hoods connected with bag dust collectors followed wet (chemical) scrubbers and carbon filters shall be installed for control of fugitive emissions from furnaces or reactor. Noise control arrangement for equipment like crusher, grinder and shredder needs to be provided. Guidelines on Implementation of E-Waste ***(Management) Rules, 2016 HWM Division, CPCB***. The discharges from the facility shall comply with general standards ***under E (P) Act, 1986*** for discharge of wastewater. Discharge standard are at Annexure IV In case of air emissions, the unit shall comply with emission norms prescribed under ***Air (Prevention and Control of Pollution) Act, 1981***. In case of furnace, a minimum stack height of 30 meter shall be installed depending on emission

rate of SO₂. Emission Standards are at Annexure V. The workers involved in recycling operations shall use proper personal protective equipment such as goggles, masks, gloves, helmet and gumboot etc. Adequate facilities for onsite collection and storage of bag filter residues, floor cleaning dust and other hazardous material shall be provided and sent to secure landfill by obtaining membership of TSDF. The CRT / LCD / Plasma TV should be processed only at a recycler's facility. For recycling of CRT monitor and TVs care should be taken to contain release of harmful substances. ***The steps for processing of CRT are as below:*** (i) CRT monitors and TVs should be manually removed from plastic/ wooden casing. The CRT should be split into funnel and panel glass using different splitting technology such as Ni-Chrome hot wire cutting, Diamond wire method or Diamond saw separation in a closed chamber under low vacuum conditions (650 mm of Hg).

(ii) The funnel section is then lifted off from the panel glass section and the internal metal gasket is removed for facilitating the removal of internal phosphor coating.

(iii) The internal phosphor coating from the inner side of panel glass is removed by using an abrasive wire brush with suction arrangement under low pressure as given above at.

(iv) The extracted air is cleaned through high efficiency bag-filter system and collected in appropriate labelled containers and then disposed at an authorised TSDF.

(v) Manual shredding, cutting, and segregation operations for CRTs should be carried out in low vacuum (650 mm of Hg) chambers where the dust is extracted through cyclones, bag filters, ID fan and a suitable chimney.

(vi) Segregated CRTs can also be shredded in mechanical/automatic shredding machines connected with dust control systems. The mixed shredded glass is separated into leaded glass and glass cullet using electro-magnetic field or by density separation. For LCD and Plasma TV a recycler should have sealed vacuum dismantling platform for dismantling of LCD / Plasma panels. The LCD / Plasma TV should be dismantled piece by piece, starting with the removal of the plastic backing shell, printed circuit boards, aluminium or steel frame, screen, PET plastics, LCD Panel and backlight. The metal frame, wire, other metallic material and plastic backing cabinet may be sent to recyclers with valid CTO. Printed Circuit Board and LCD panel may be recycled or in case recycling facility is not available then sent to respective authorised recycling facility. The user of the products obtained in the recycler facility should be identified and an agreement may be entered with them for selling of the products obtained in these recycling facilities. This is for tracking the product of recycling, to ascertain where the products are going. Recovery of resource and particularly of precious metals present in the e-waste should be given importance. For fluorescent and other mercury containing lamp recycling, the unit shall have at least following systems:

(i) Mechanical feeding system.

(ii) Mercury spill collection system.

(iii) Lamp Crushing System, under vacuum, for separation of mercury-contaminated phosphor powder & mercury vapors from other crushed components, so as not to cause release of any pollutant, including mercury vapor.

(iv) System for segregation of mercury vapour from the phosphor powder through a distillation system for separation & recovery of mercury.

(v) Air pollution control system (APCS) which shall include HEPA (High Efficiency Particulate Arrestor) filter system or activated carbon filter system or any other equivalent efficient system for separation/ removal of mercury vapor from mercury contaminated phosphor powder'

(vi) Arrangement for disposal of mercury contaminated filter pads to TSDF.

(vii) On line mercury monitoring system, to have check on emission of mercury, which has to be in compliance to the consented norms. The fluorescent and other mercury containing lamp recycling unit shall have following obligations:

(i) The emission outlet shall comply with the norms for mercury prescribed in the consent document. The norm for mercury emission is 0.2 mg/m³ (Normal) as prescribed under E (P) Act, 1986 for mercury emission from other category of industries.

(ii) For discharge of effluent the limit for mercury as (Hg) should be less than equal to 0.01mg /liter as prescribed under E (P) Act, 1986.

(iii) The unit shall have trained / skilled manpower to handle hazardous substances such as mercury mixed phosphor in respect of treatment/recycling.

(iv) The unit shall dispose all the unrecoverable wastes from the treatment site, to a TSDF

(v) The unit shall maintain record of used fluorescent and other mercury containing lamp collected & recycled, recovery of mercury and other components. It shall, also, maintain the records pertaining to the generation, storage, transport and disposal of the wastes generated in the process.



Fig.6.42: E-waste (ATM's) arriving in a van at a Recycler site, Delhi

(vi) The unit shall take up ambient air quality monitoring, particularly, in reference to mercury levels with a frequency of once in a month through a recognized laboratory, for third party verification. 7.3 Space requirement for Recyclers As a general rule a recycler of capacity of 1 Ton per day shall require a minimum of 500 square meters area. Authorisation to recyclers may be preferred if they have minimum operational capacity of 5 MT/day with an area of about 2500 square meter.

6.8.4 Survey showing qualification of Recyclers

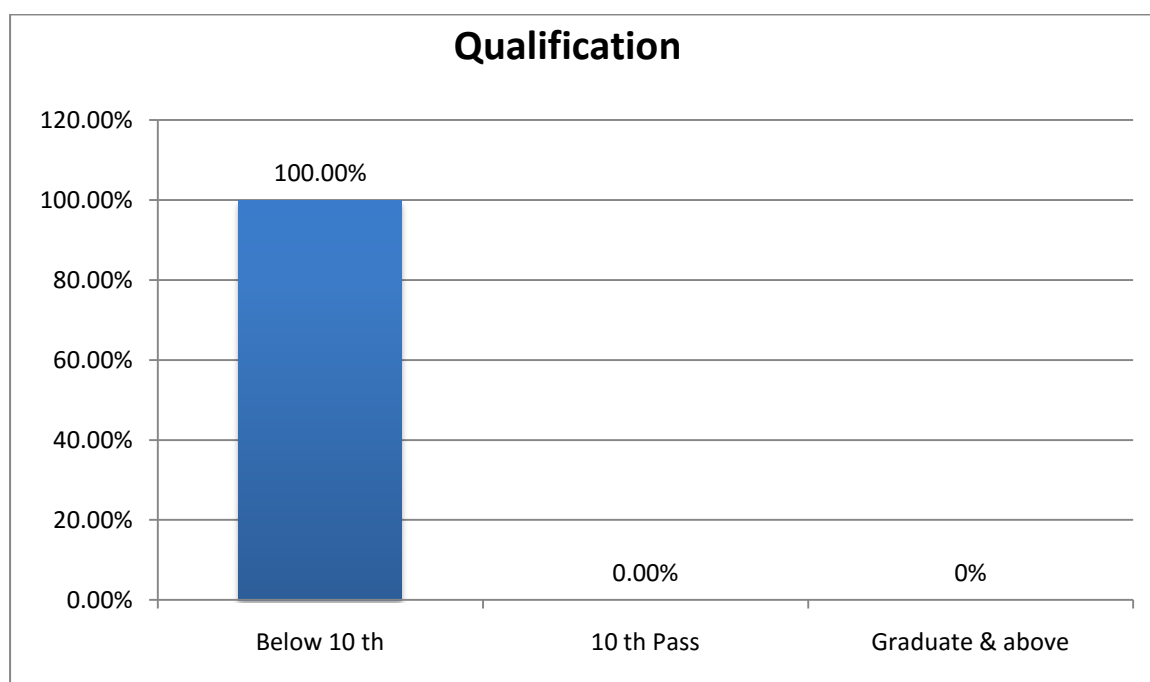


Fig.6.43: Qualification of Recyclers

The recyclers were most uneducated.



Fig 6.42 Author with the recyclers at their location, Delhi

6.8.5 Data on recyclers taking clearances from regulatory Agencies.

Do you have environmental clearances from the State Pollution Control Boards and other local agencies?

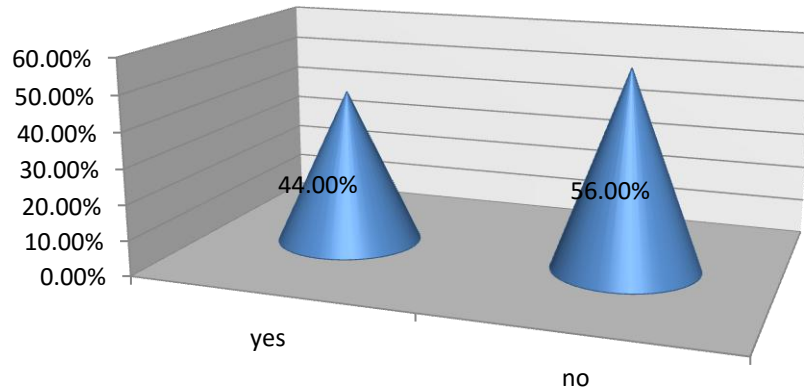


Fig.6.44: Recyclers obtaining environmental clearance

Table 6.59: Recyclers obtaining environmental clearances from agencies

Q. Do you have environmental clearances from the State Pollution Control Boards and other local agencies?

		Do you have environmental clearances from the State Pollution Control Boards and other local agencies?		Total
		yes	no]	
Do you have S.S.I. registration?	Yes	10	14	24
	No	1	0	1
Total		11	14	25

Only 44% of recyclers had environmental clearance from SPCB, and other state agencies.

6.8.6 Survey details of Recyclers having S.S.I registration

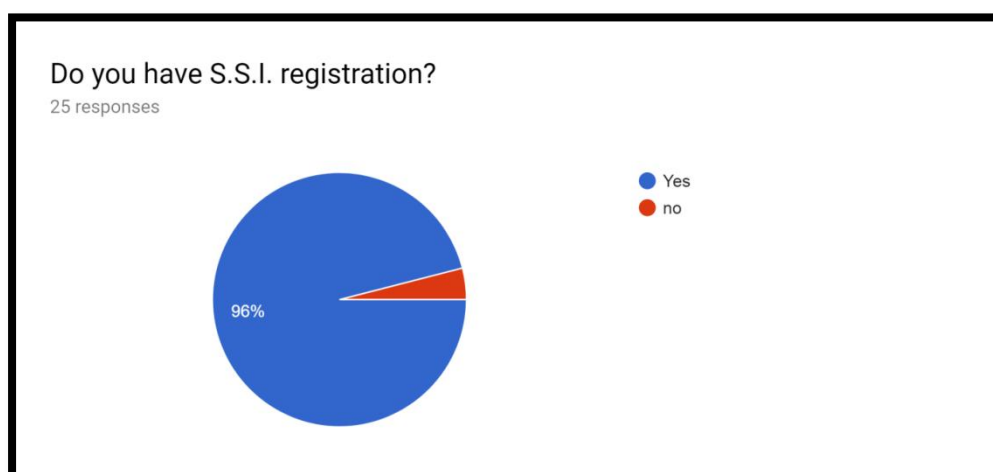


Fig.6.45: Recyclers with S.S.I registration

90% of the recyclers had a S.S.I registration which was a positive sign.

6.8.7 Recyclers list of equipment technologies and facilities

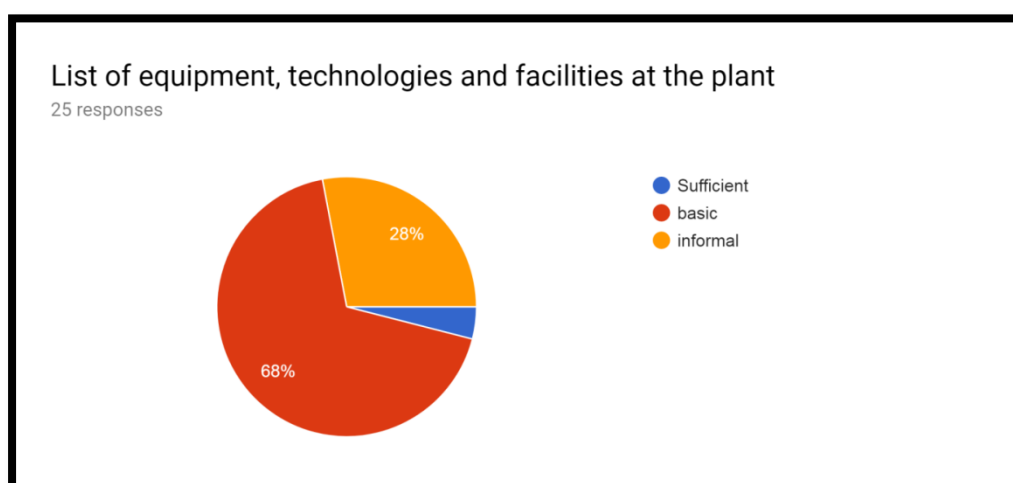


Fig.6.46: List of equipment at a plant

Table 6.60: Recyclers List of equipment, technologies and facilities at the plant

Q. List of equipment, technologies and facilities at the plant.

				List of equipment, technologies and facilities at the plant			Total
				Sufficient	basic	informal	
Do	you	have	yes	1	16	7	24

S.S.I. registration?	no]	0	1	0	1
Total		1	17	7	25

68% of the recyclers said they had basic equipments and facilities while 28% said that they had informal facility only.

6.8.8 Recyclers collection centres

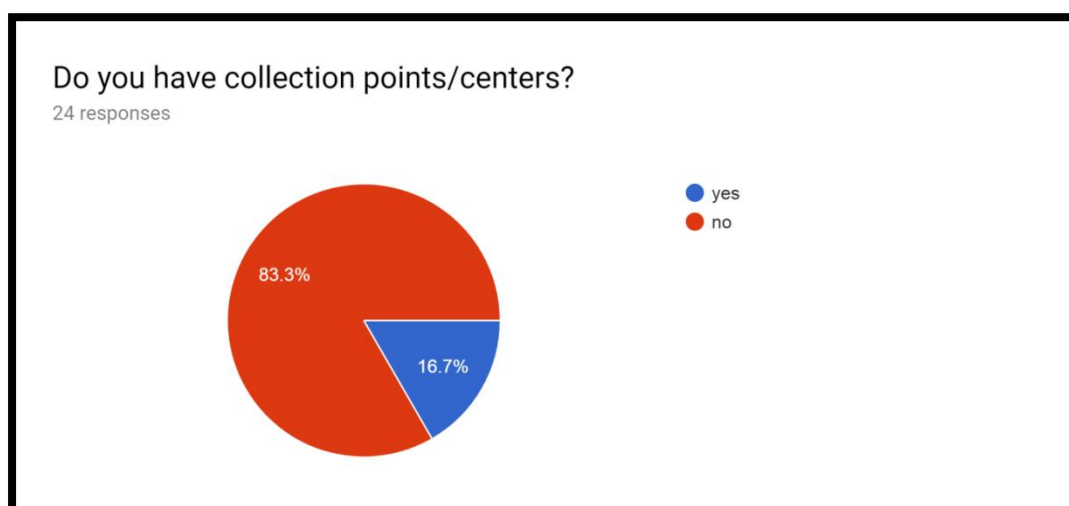


Fig.6.47: Recyclers having collection centres

Table 6.61: Recycler's collection centres

Q. Do you have collection points/centres?

				Total
Do you have collection points/centres?				
Yes				No
Do you have S.S.I. registration?	yes	3	20	23
	no]	1	0	1
Total		4	20	24

Only 16.7% of the recyclers had collection centres while rest depended on work through producers, auctions etc.

6.8.9 Details about Minimum wages etc. of the recyclers.

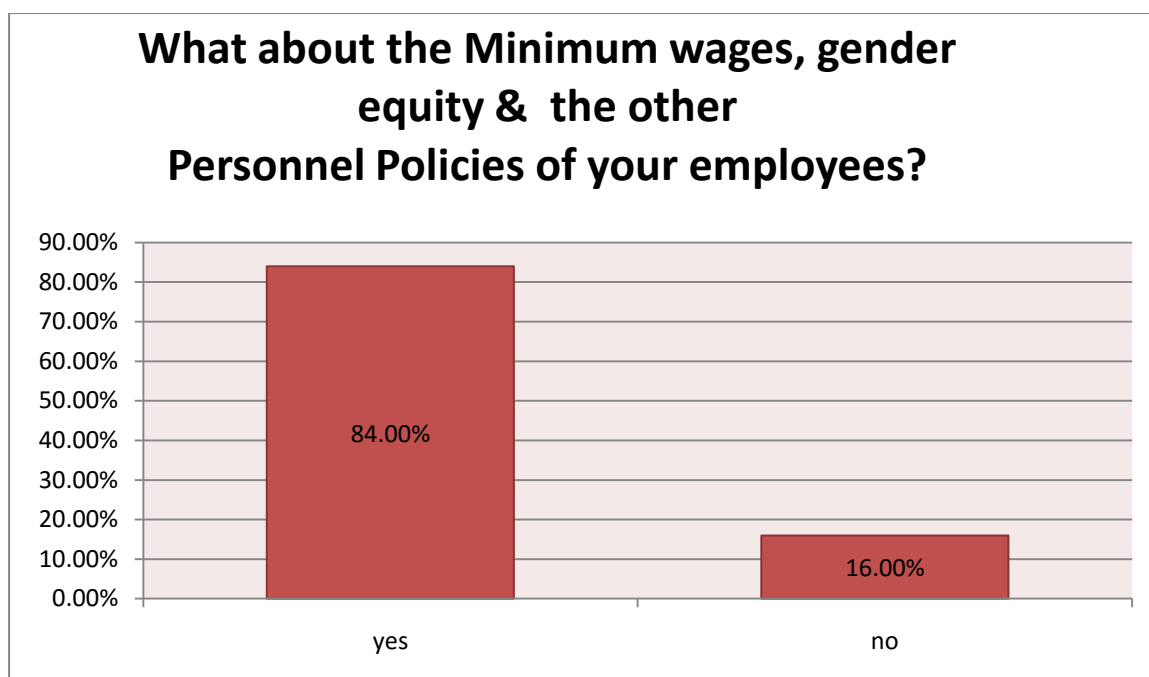


Fig.6.48: Minimum wages of Recyclers

While 84% admitted to following minimum wages they were ignorant about gender equity and other personal policies

Table 6.62: Minimum wages, etc. given by recyclers

Q. Do you have S.S.I. registration? * What about the Minimum wages, gender equity & the other Personnel Policies of your employees?

		What about the Minimum wages, gender equity & the other Personnel Policies of your employees?		Total
		Yes	No	
Do you have S.S.I. registration?	Yes	20	4	24
	No	1	0	1
Total		21	4	25

6.8.10 Survey details showing GMP's followed by recyclers

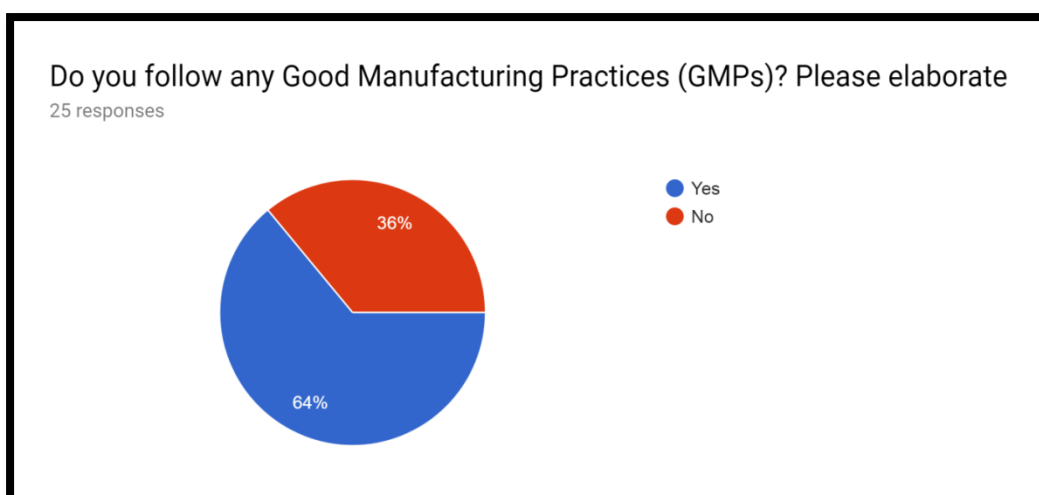


Fig.6.49: Recyclers using GMP's

Table 6.63: Good manufacturing practices done by recyclers

Q. Do you follow any Good Manufacturing Practices (GMPs)? Please elaborate.

		Do you follow any Good Manufacturing Practices (GMPs)? Please elaborate		Total
		Yes	No	
Do you have S.S.I. registration?	Yes	15	9	24
	No	1	0	1
Total		16	9	25

64% of recyclers said they used good manufacturing practices while 36% had either no idea or did not use (GMPs).

6.8.11 Data showing whether layout plan facilitates GMP's

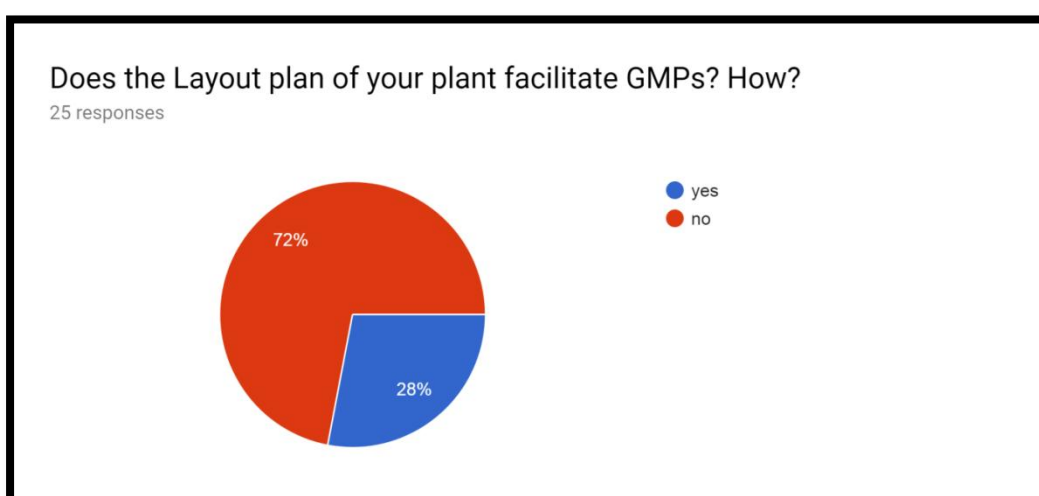


Fig.6.50: Layout plan supporting GMP's

Table 6.64: Whether recycler have layout plan of good manufacturing practices

Q. Does the Layout plan of your plant facilitate GMPs? How?

		Does the Layout plan of your plant facilitate GMPs? How?		Total
		Yes	No	
Do you have S.S.I. registration?	Yes	7	17	24
	No	0	1	1
Total		7	18	25

28% said that the layout of then plant supported GMP's 72% were constrained for lack of space.

6.8.12 Data showing qualifications of recycler employees

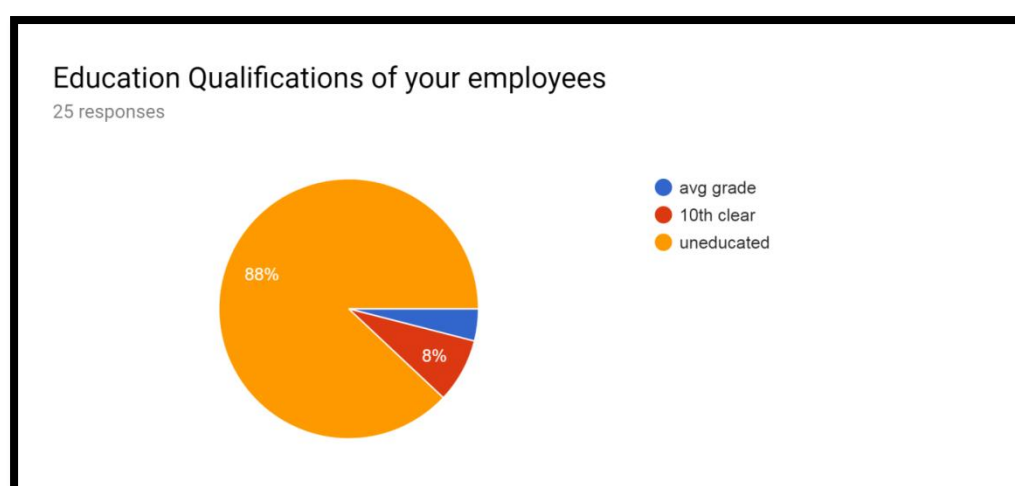


Fig.6.51: Qualification of Recycler employees

Table 6.65: Qualification of recycler employees

Q. Education Qualifications of your employees.

		Education Qualifications of your employees			Total
		Avg. grade	10th clear	Uneducated	
Do you have S.S.I. registration?	Yes	1	2	21	24
	No	0	0	1	1
Total		1	2	22	25

88% of the employees of recyclers were uneducated.

6.8.13 Data Showing awareness program for environment safe recycling

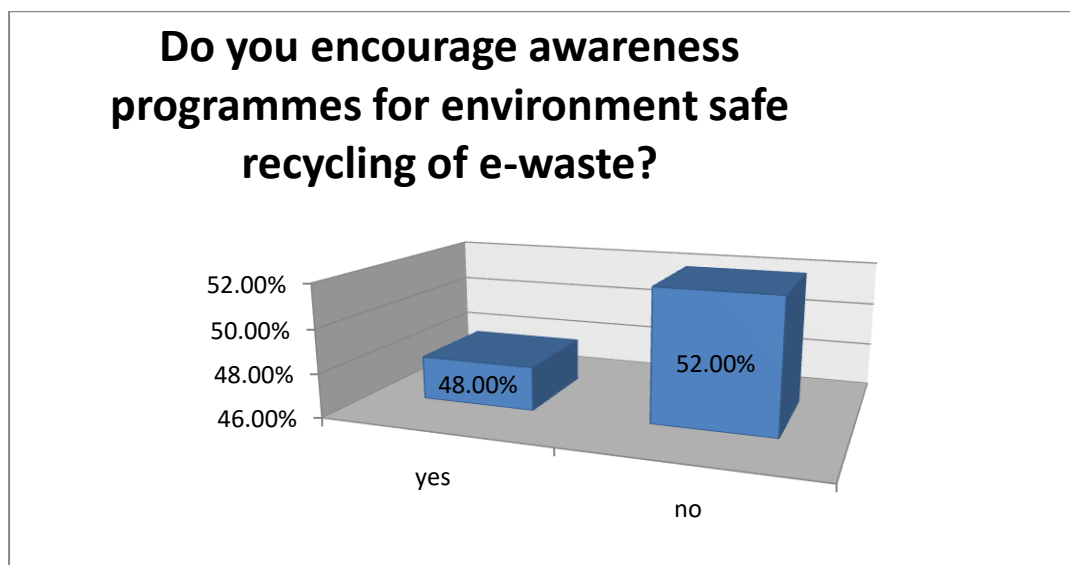


Fig.6.52: Awareness program for safe Recycling

Table 6.66: Awareness programme for environment safe recycling of e-waste

Q. Do you encourage awareness programmes for environment safe recycling of e-waste?

		Do you encourage awareness programmes for environment safe recycling of e-waste?		Total
		Yes	No	
Do you have S.S.I. registration?	Yes	11	13	24
	No	1	0	1
Total		12	13	25

Awareness about safe recycling polices was low though 48% claimed that they encourage awareness programme for safe environment recycling.

6.8.14 Recyclers dealing with Noble metals

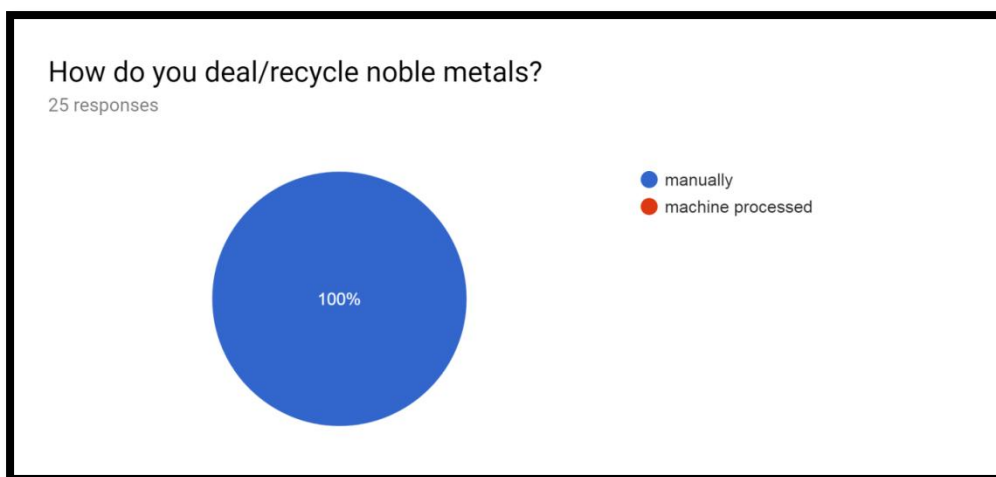


Fig.6.53: Recycling of Noble metals

Table 6.67: Whether noble metals are recycled or not.

Q. How do you deal/recycle noble metals?

		How do you deal/recycle noble metals?	Total
		Manually	
Do you have S.S.I. registration?	Yes	24	24
	No	1	1
Total		25	25

Recycling of noble metals is done manually by all 100% recyclers which is a cause of concern.

6.8.15 Data showing how the recyclers manage the residues

How do you manage the residues (Solid and Liquid) of your plant?

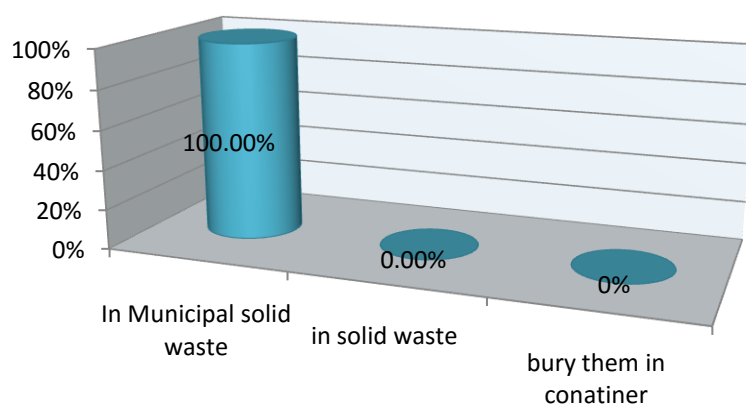


Fig.6.54: Management of Residues

Table 6.68: How the recycler manage the residues (Solid and Liquid) of your plant?

Q. How do you manage the residues (Solid and Liquid) of your plant?

		In Municipal solid waste	Total
Do you have S.S.I. registration?	Yes	24	24
	No	1	1
Total		25	25



Fig.6.55: Waste thrown on open Municipal ground by a recycler, Delhi

6.8.16 Details of Recyclers having D.G.Sets

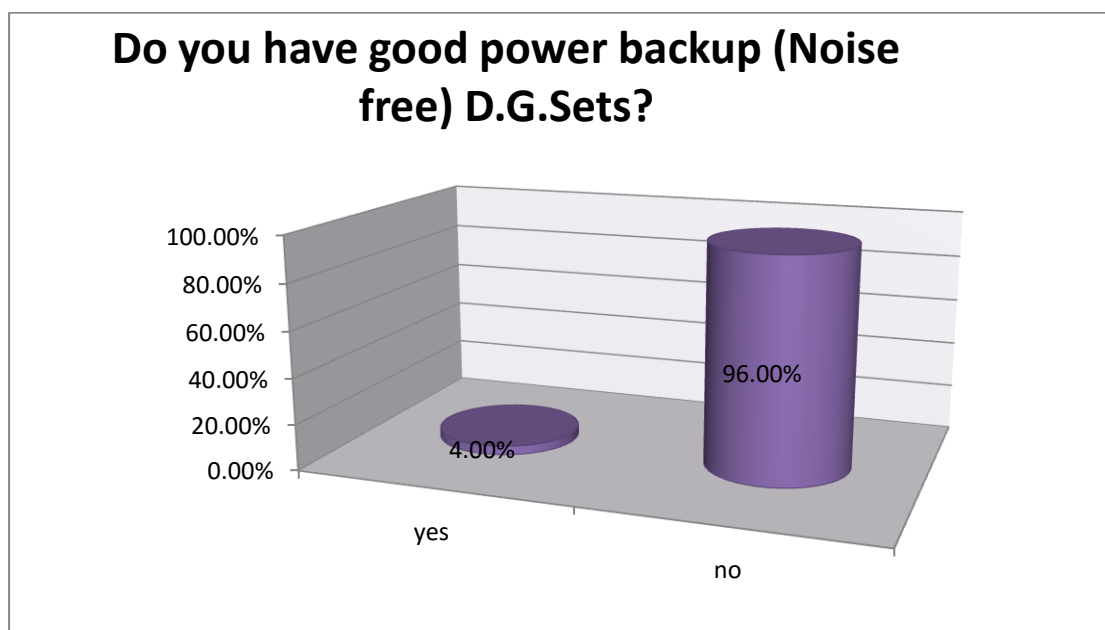


Fig.6.56: Recyclers having D.G.sets

Table 6.69: Whether recycler have a DG Set

Q. Do you have good power backup (noise free) D.G.Sets?

		Do you have good power backup (noise free) D.G.Sets?		Total
		Yes	No	
Do you have S.S.I. registration?	Yes	0	24	24
	No	1	0	1
Total		1	24	25

96% of the recycler did not have DG sets

6.8.17 Transportation of e-waste by Recyclers

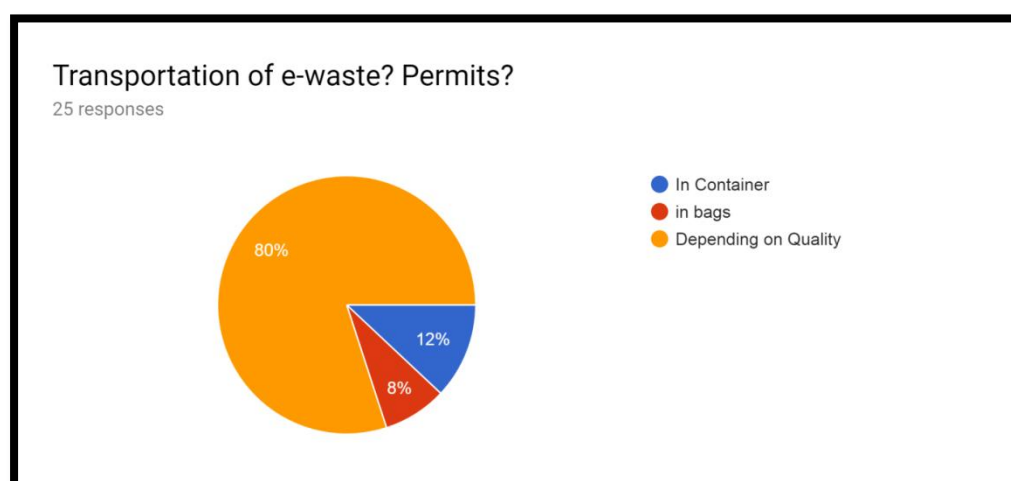


Fig.6.57: Transportation of e-wastes

Table 6.70: Hhow recyclers do transportation

Q. Do you have S.S.I. registration? * Transportation of e-waste? Permits?

		Transportation of e-waste? Permits?			Total
		In container	In bag	Depending on Quality	
Do you have S.S.I. registration?	Yes	2	2	20	24
	No	1	0	0	1
Total		3	2	20	25

Transportation of e-waste was done on case to case basis. The field visits showed that most of the e-waste was brought in open containers.

6.8.18 Data on comfort level of Recyclers in filling up forms

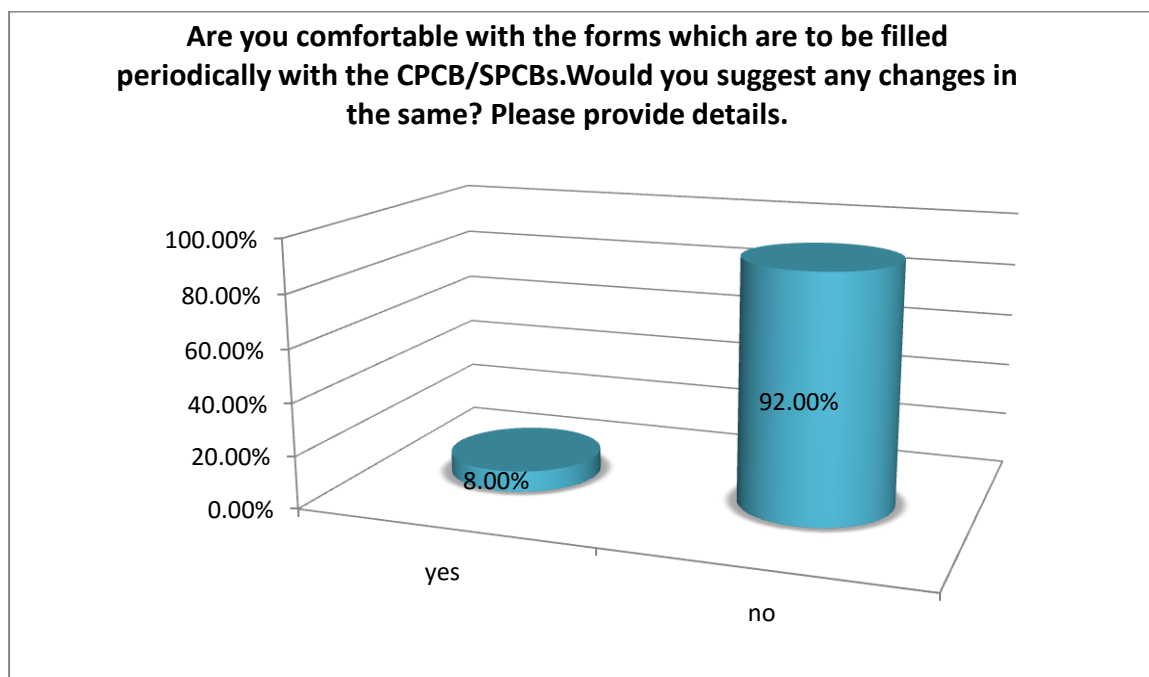


Fig.6.58: Recyclers comfort with filling of forms

Table 6.71: Comfort level of recyclers in filling up a form which are to be filled periodically with the CPCB/SPCBs. Would you suggest any changes in the same? Please provide details.

		Yes	No	Total
Do you have S.S.I. registration?	yes	1	23	24
	no]	1	0	1
Total		2	23	25

92% of the recycler expressed difficulties in filling the forms of CPCB/SPCB. Thus compliance was affected.

6.8.19 Number of Recyclers undergone R2 Certification

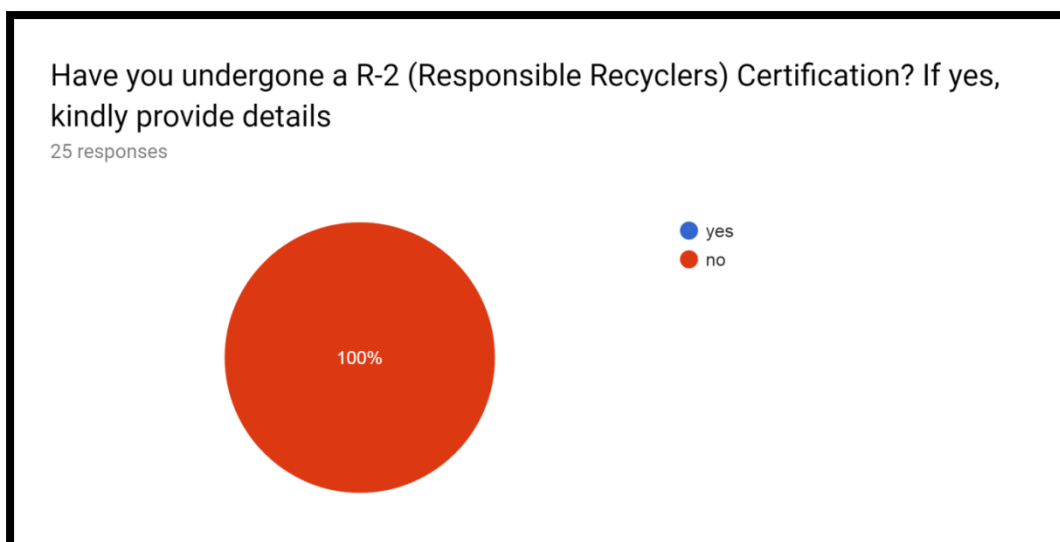


Fig.6.59: Recyclers undergone R-2 Certification

Table 6.72: Whether recycler has undergone R-2 certification

Q. Have you undergone a R-2 (Responsible Recyclers) Certification? If yes, kindly provide details.

		Have you undergone a R-2 (Responsible Recyclers) Certification? If yes, kindly provide details	Total
		No	
Do you have S.S.I. registration?	Yes	24	24
	No	1	1
Total		25	25

6.8.20 Recyclers tie up with producers as part of EPR

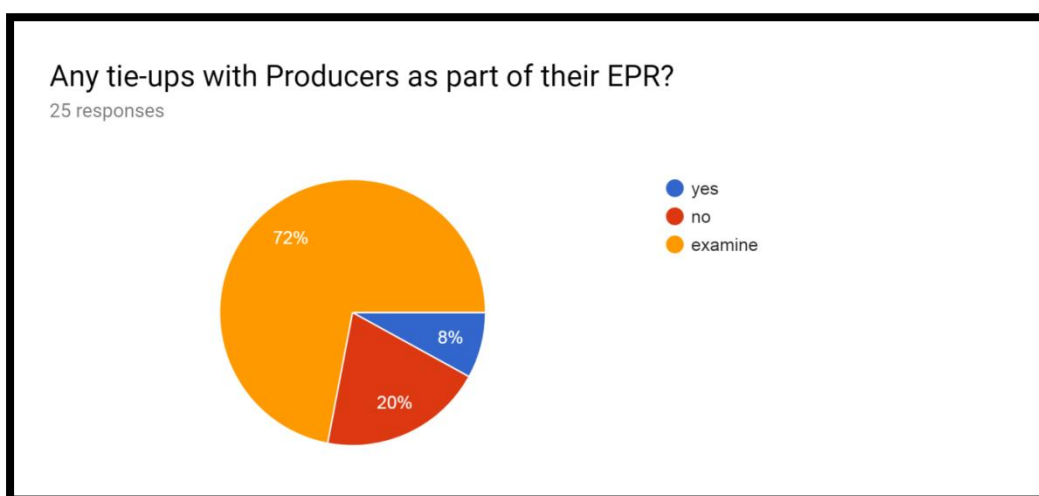


Fig.6.60: Recyclers tie up with producers for EPR

Table 6.73: Whether recycler has any tie-up with producers as part of the EPR.

Q. Any tie-ups with Producers as part of their EPR?

		Any tie-ups with Producers as part of their EPR?			Total
		Yes	No	Examine	
Do you have S.S.I. registration?	Yes	2	4	18	24
	No	0	1	0	1
Total		2	5	18	25

72% were not aware about this. While 20% said a categorical “No” only 8% recyclers had a tie up with producers as part of EPR.

6.8.21 Linkages with recognized refurbishers

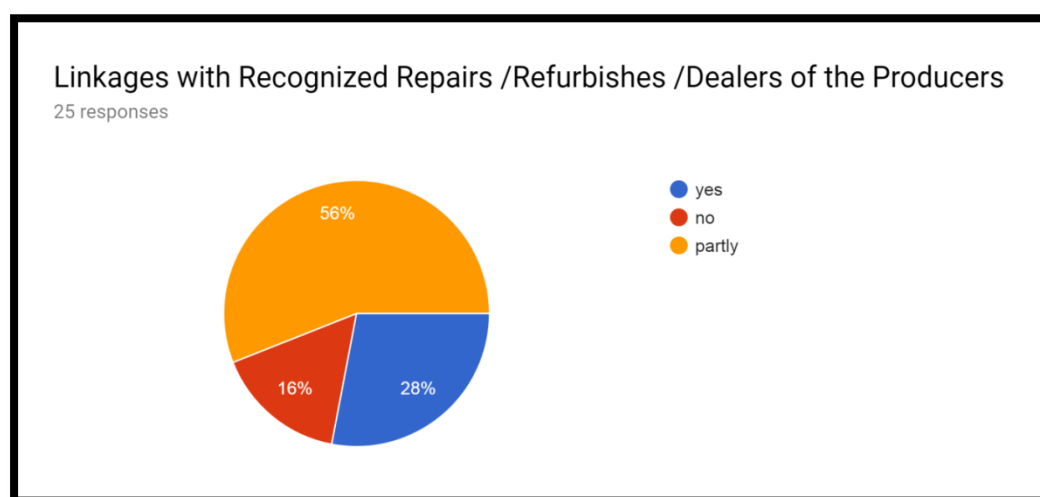


Fig.6.61: Linkages with recognized refurbishers

Table 6.74: Linkage with whether recycler has any tie-up with producers as part of the EPR

Q. Linkages with Recognized Repairs /Refurbishes /Dealers of the Producers.

		Linkages with Recognized Repairs /Refurbishes /Dealers of the Producers			Total
		Yes	No	Partly	
Do you have S.S.I. registration?	Yes	6	4	14	24
	No	1	0	0	1
Total		7	4	14	25

Most of them had linkages with recognized refurbishes, dealers etc. either partly or fully.

6.9 Testing of Hypothesis for Data on Recyclers through SPSS

While framing the research methodology two hypothesis were postulated for data on recyclers for which detailed statistical analysis was done through SPSS which are enclosed below:

6.91 Null Hypothesis: 6

H₀= Recyclers do not comply with statutory regulation of E-waste management rule, 2011

H₁ = Recyclers comply with statutory regulation of E-waste management rule, 2011

Table 6.75: Recycler is comfortable with filling up a form

Q. Do you have S.S.I. registration? * Are you comfortable with the forms which are to be filled periodically with the CPCB/SPCBs. Would you suggest any changes in the same? Please provide details.

		Are you comfortable with the forms which are to be filled periodically with the CPCB/SPCBs. Would you suggest any changes in the same? Please provide details.		Total
		Yes	No	
Do you have S.S.I. registration?	Yes	1	23	24
	No	1	0	1
Total		2	23	25

We can confirm this computation with the results in the **Chi-Square Tests** table:

Table 6.76: Result of chi-square test performed on recyclers and their following regulatory norms for Hypothesis 6

	Value	df	Asymptotic	Exact	Exact

			Significance (2-sided)	Sig. (2- sided)	Sig. (1- sided)
Pearson Chi-Square	11.979 ^a	1	.001		
Continuity Correction ^b	2.497	1	.114		
Likelihood Ratio	5.625	1	.018		
Fisher's Exact Test				.080	.080
Linear-by-Linear Association	11.500	1	.001		
N of Valid Cases	25				

The row of interest here is **Pearson Chi-Square** and its footnote.

- The value of the test statistic is 11.979
- The footnote for this statistic pertains to the expected cell count assumption (i.e., expected cell counts are all greater than 5): 3 no of cells had an expected count less than 5, so this assumption was met.
- Because the crosstabulation is a 2x2 table, the degrees of freedom (df) for the test statistic is

$$df = (R-1)*(C-1) = (2-1)*(2-1) = 1$$

$$df = (R-1)*(C-1) = (2-1)*(2-1) = 1$$
- The corresponding p-value of the test statistic is so small that it is cut off from display. Instead of writing "p = 0.000", we instead write the mathematically correct statement $p < 0$.

Decision and Conclusions

Since the p-value is less than our chosen significance level $\alpha = 0.05$, we can reject the null hypothesis, and conclude that there is an association between recycler and compliance with necessary regulatory procedures.

Based on the results, we can state the following:

There was a significant association between recycler and compliance with necessary regulatory procedures ($\chi^2(1) = 11.979, p < 0.01$).

Thus while the recyclers comply with the statutory requirements of E-Waste management tools they are not comfortable with filing this form periodically.

6.9.2 Null Hypothesis: 7

H₀= Recyclers do not do safe transportation of E-waste

H₁ = Recyclers do safe transportation of E-waste

Table 6.77: Recycler linkage with transportation of e-waste

Q. Do you have S.S.I. registration? Transportation of e-waste? Permits?

		Transportation of e-waste? Permits?			Total
		in container	in bag	depending on quantity	
Do you have S.S.I. registration?	yes	2	2	20	24
	no	1	0	0	1
Total		3	2	20	25

We can confirm this computation with the results in the **Chi-Square Tests** table:

Table 6.78: Result of chi-square test performed on recyclers and the transportation of e-waste for Hypothesis 7

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	7.639 ^a	2	.022
Likelihood Ratio	4.578	2	.101
Linear-by-Linear Association	6.168	1	.013
N of Valid Cases	25		

The row of interest here is **Pearson Chi-Square** and its footnote.

- The value of the test statistic is 7.639.
- The footnote for this statistic pertains to the expected cell count assumption (i.e., expected cell counts are all greater than 5): 5 no of cells had an expected count less than 5, so this assumption was met.

- Because the cross tabulation is a 2x3 table, the degrees of freedom (df) for the test statistic is

$$df = (R-1)*(C-1) = (2-1)*(2-1) = 1$$

$$df = (R-1)*(C-1) = (2-1)*(2-1) = 1$$

$$= 1$$
- The corresponding p-value of the test statistic is so small that it is cut off from display. Instead of writing "p = 0.000", we instead write the mathematically correct statement $p < 0$.

Decision and Conclusions

Since the p-value (0.022) is less than our chosen significance level $\alpha = 0.05$, we can reject the null hypothesis, and conclude that there is an association between Recyclers & transport of e-waste.

Based on the results, we can state the following:

- There was a significant association between Recyclers & transport of e-waste ($X^2(1) = 7.639, p < .022$).
- This is corroborated by the field unit in which no of recyclers are disposing waste in containers, bag etc

6.10 A Survey for Bulk Consumers of Electronic Equipments

To study whether Bulk consumers comply with registration with various bodies survey of bulk consumer was done in the following manner:

- (i) To study the guidelines for bulk consumers
- (ii) To visit areas where recycling is happening
- (iii) To interact with recyclers.
- (iv) To analyze the result using Statistical tools.

6.10.1 Guidelines for Bulk Consumers

The bulk consumers may ensure that e waste generated by them is handed over only to producer take back system or to authorised dismantler/recycler who is part of producers take back/channelisation system. The bulk consumers should ensure that used lamps are not disposed in the municipal bin but handed over (in a properly packed form) to take back system / collection and

channelisation system of producer or to a collection centre of an authorised recycler who is part of producer channelisation system.

The bulk consumers must create special type of disposal bins (suitable for the purpose) at site for depositing the end of life intact fluorescent and other mercury containing lamp only.

The management of the institute may issue necessary instructions, to ensure this, to staff and workers handling such lamps. The end of life intact fluorescent and other mercury containing lamp, as collected above, may be stored either in the same boxes in which new lamps are brought or other boxes of similar size. They should be stored upright. The due precaution may be taken while packing more than one used lamps, so as not to cause the possibility of breakage during the storage and transportation. Bulk consumer need to follow compliances with different regulatory agencies.

6.10.2 Qualifications of Bulk Consumers

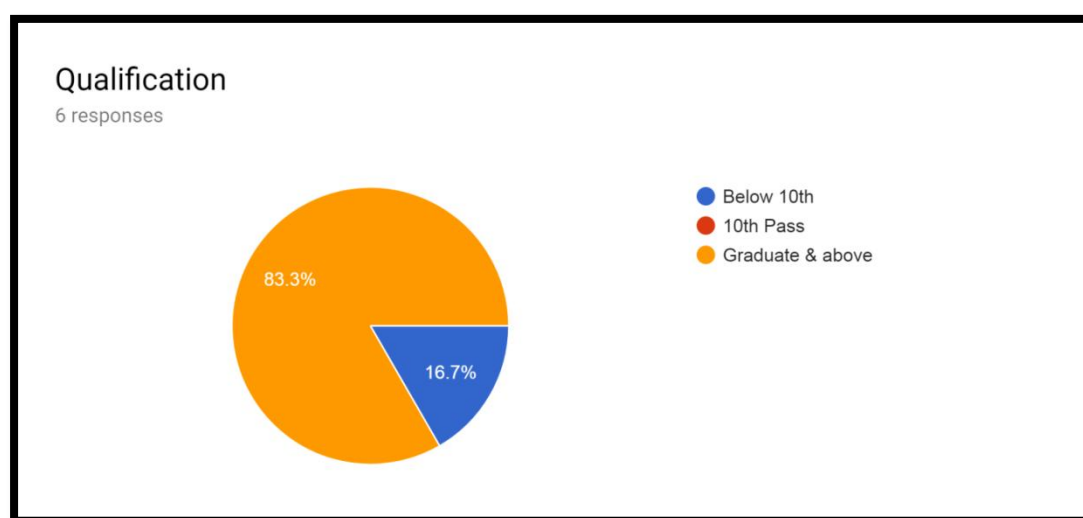


Fig.6.62: Qualifications of Bulk Consumers

Not relevant

6.10.3 Gender profile of Bulk Consumers

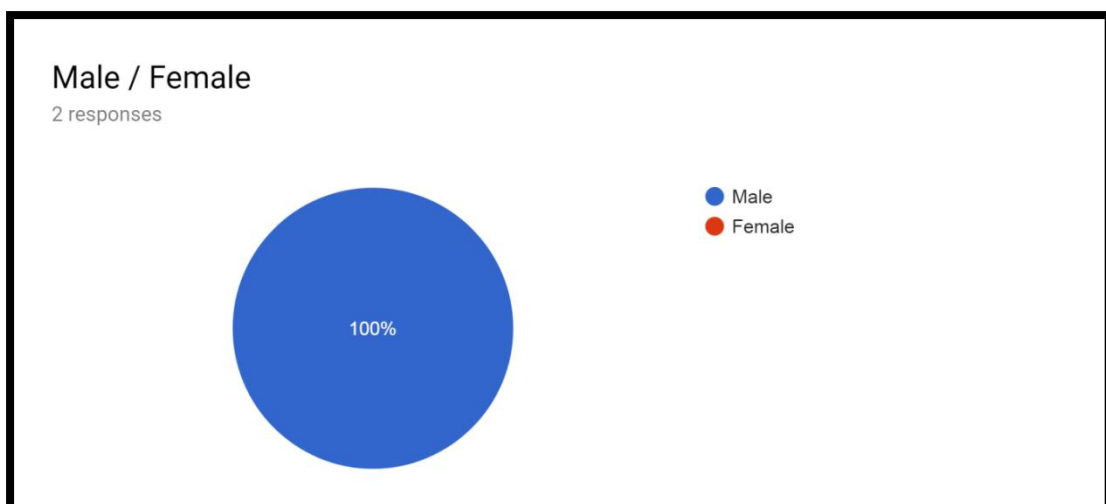


Fig.6.63: Gender of Bulk Consumers

6.10.4 Is Bulk Consumers registered with SPCB

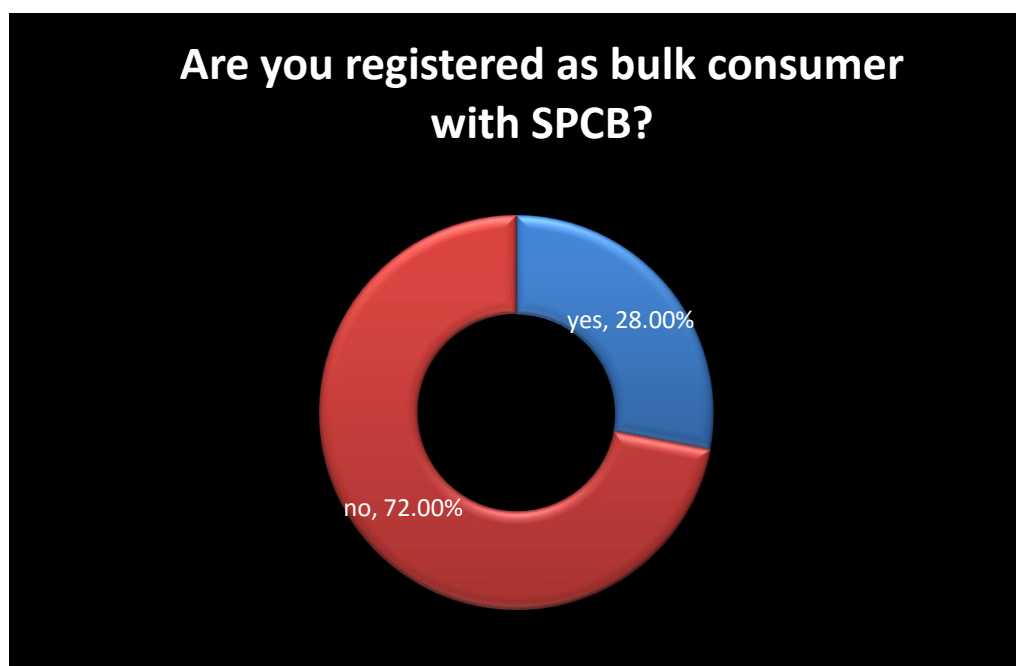


Fig.6.64: Bulk Consumers registered with SPCB

Table 6.79: Registration of Bulk consumer with SPCB

Q. Are you registered as a Bulk Consumer with SPCB? Please elaborate.

	Are you registered as a Bulk Consumer with SPCB? Please elaborate		Total
	Yes	No	

Female	5	18	23
Male	2	0	2
Total	7	18	25

A very high 72% of the bulk consumers were not registered with SPCB. Infact they were not aware that they had to be regulated.

6.10.5 Range of products used by Bulk Consumer

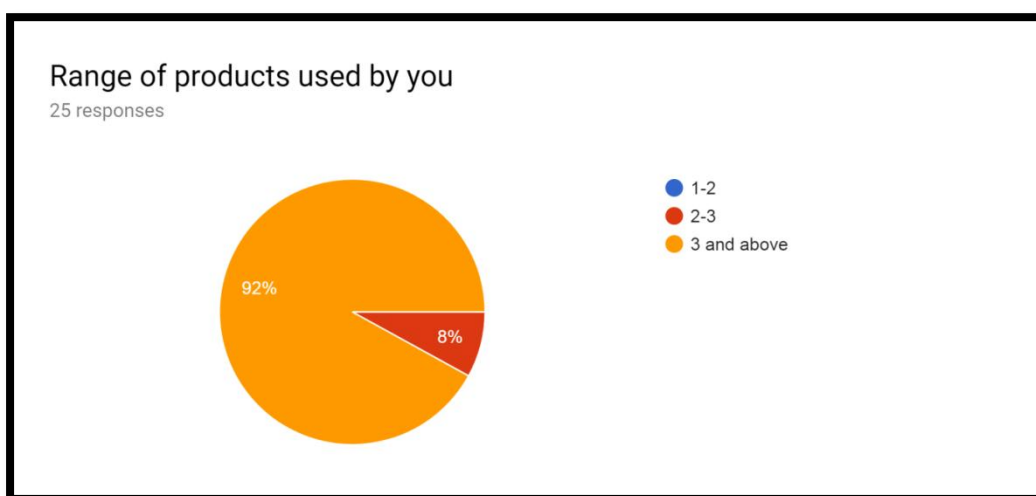


Fig.6.65: Products used by Bulk Consumers

Table 6.80: Range of Products used Bulk Consumers

Q. Range of products used by you.

	Range of products used by you		Total
	2-3	3 & above	
Female	2	21	23
Male	0	2	2
Total	2	23	25

6.10.6 Number of products of companies used by Bulk Consumers

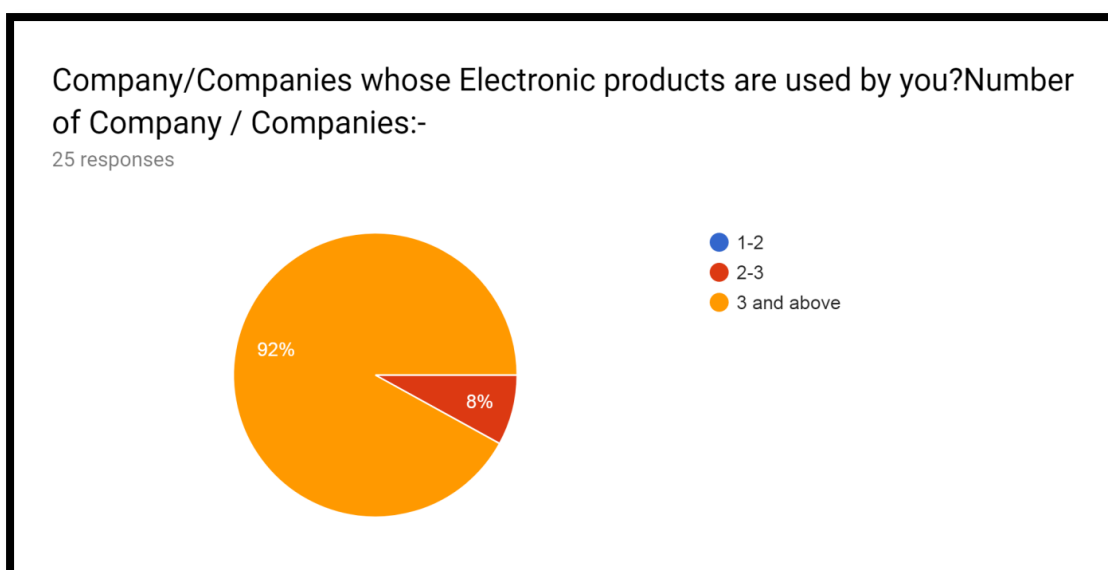


Fig.6.66: Number of companies whose products are used

Table 6.81: E-waste in opinion of Bulk Consumer

Q. Company/Companies whose Electronic products are used by you? Number of Company / Companies:

	Company/Companies whose Electronic products are used by you? Number of Company / Companies:		Total
	2-3	3 & above	
Female	2	21	23
Male	0	2	2
Total	2	23	25

It was also heartening to know that 92.3% of the bulk consumer used products from a wide mix of companies i.e. 3 and above. It reflects on efficiency and better scientific use of products based on merit.

6.10.7 Categerisation of e-waste for Bulk Consumers

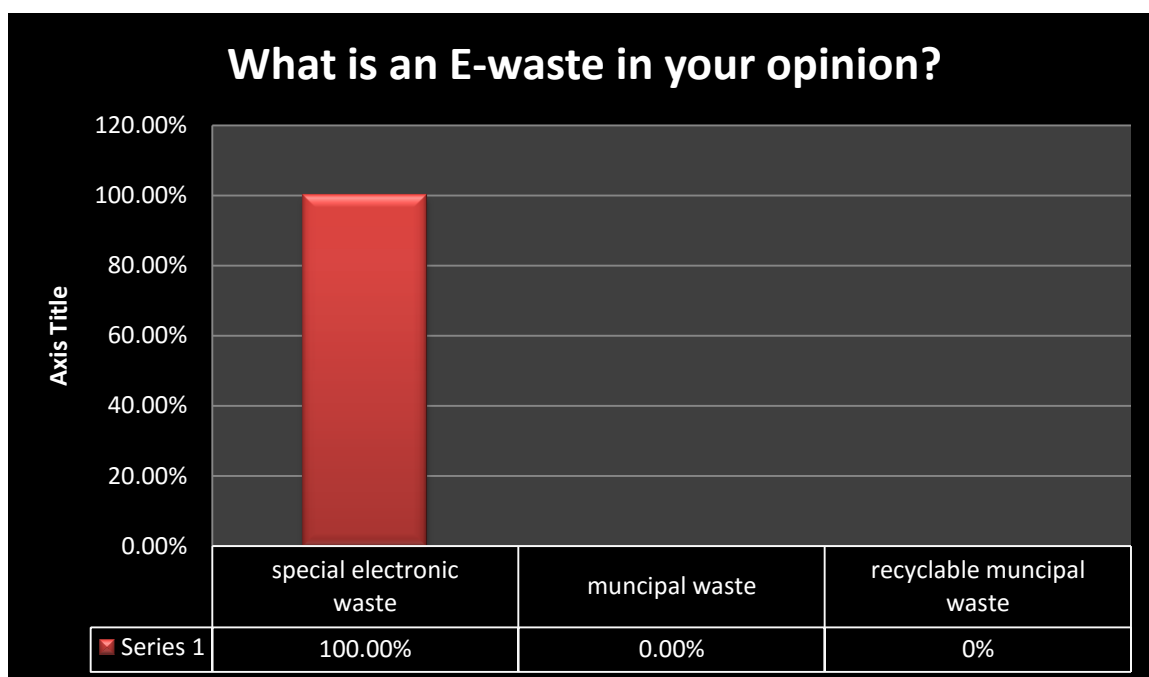


Fig.6.67: Categorisation of e-waste

Table 6.82: E-waste in opinion of Bulk Consumers

Q. What is an e-waste in your opinion?

	What is an e-waste in your opinion? (Special electronic waste)	Total
Female	23	23
Male	2	2
Total	25	25

There was however clarity amongst institutional buyers as to what characterising e-waste.

6.10.8 Bulk Consumer knowledge about EPR policy of producers

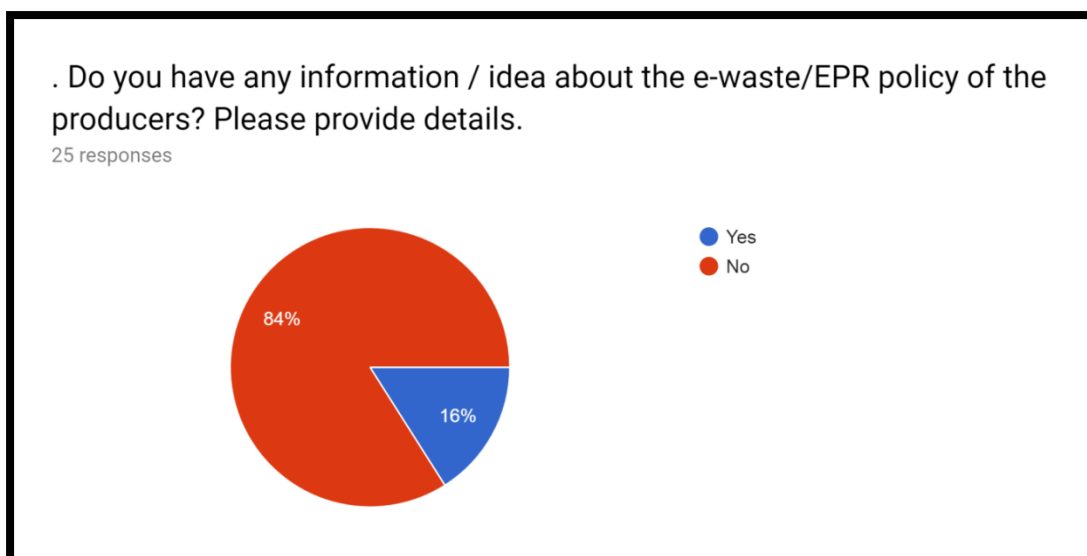


Fig.6.68: Idea about EPR Policy

Table 6.83: Opinion on e-waste Policy of Bulk Consumers

Q. Do you have any information / idea about the e-waste/EPR policy of the producers? Please provide details.

	Do you have any information / idea about the e-waste/EPR policy of the producers? Please provide details.		Total
	Yes	No	
Female	3	20	23
Male	1	1	2
Total	4	21	25

6.10.9 How do Bulk Consumers deal with discarded products?

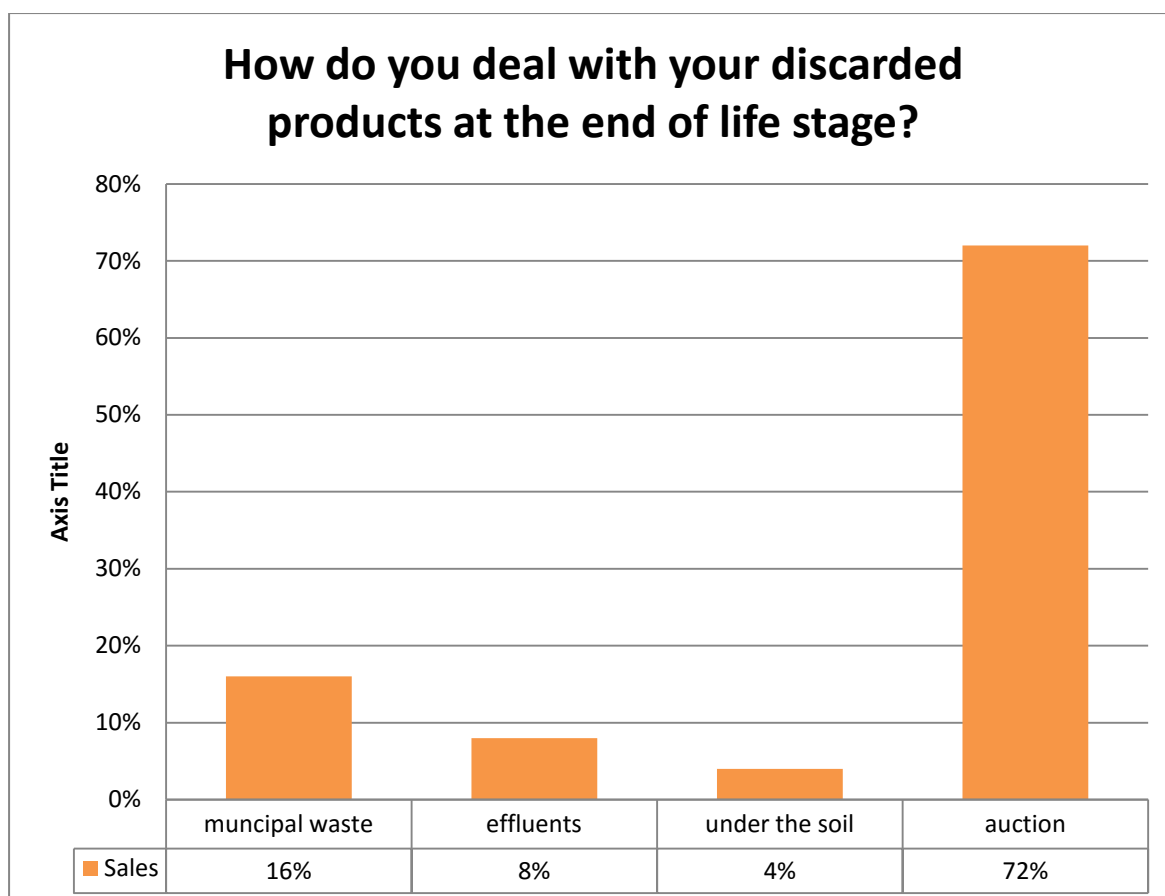


Fig.6.69: Deal with discarded products at the end of life stage

6.10.9 How do Bulk Consumers deal with discarded products

Table 6.84: How Bulk Consumers deal with discarded products

Q. How do you deal with your discarded products at the end-of life stage? Kindly elaborate.

	How do you deal with your discarded products at the end-of life stage? Kindly elaborate			Total
	Municipal solid waste	Effluents	Under the soil	
Male / Female	4	2	1	7
Total	4	2	1	7

Only 16% of bulk consumers were disposing e-waste as part of Municipal waste. A significantly high percentage (72%) of bulk consumer was auctioning the discarded products.

6.10.10 Whom do they give their discarded e-waste

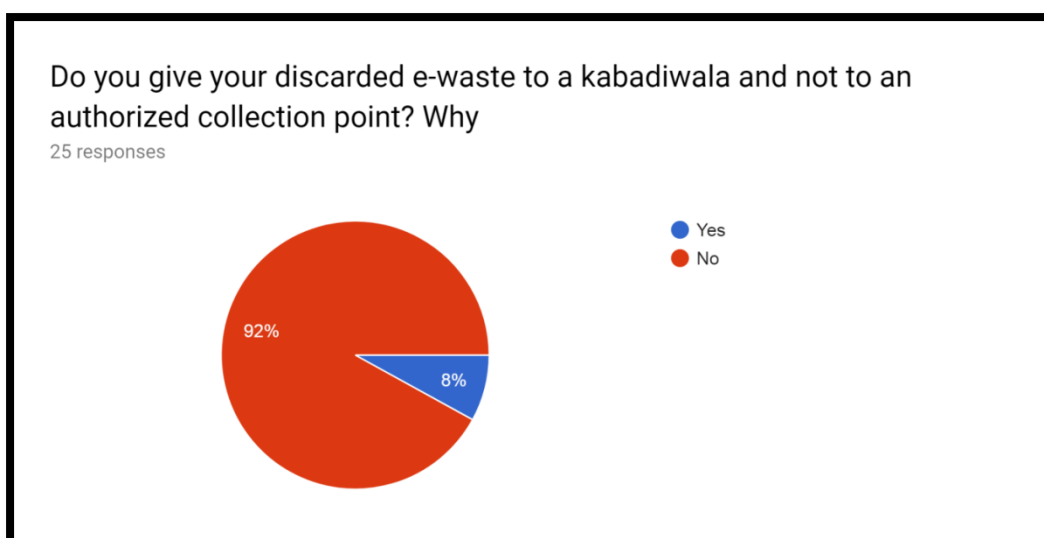


Fig.6.70: Disposal of discarded products

Table 6.85: How Bulk consumers deal with discarded products

Q. Do you give your discarded e-waste to a kabadiwala and not to an authorized collection point? Why?

	Do you give your discarded e-waste to a kabadiwala and not to an authorized collection point? Why		Total
	yes	no	
Female	2	21	23
Male	0	2	2
Total	2	23	25

92% of the bulk consumers were selling the Electrical / Electronics waste to the collection point.

6.10.11 Awareness about take back program

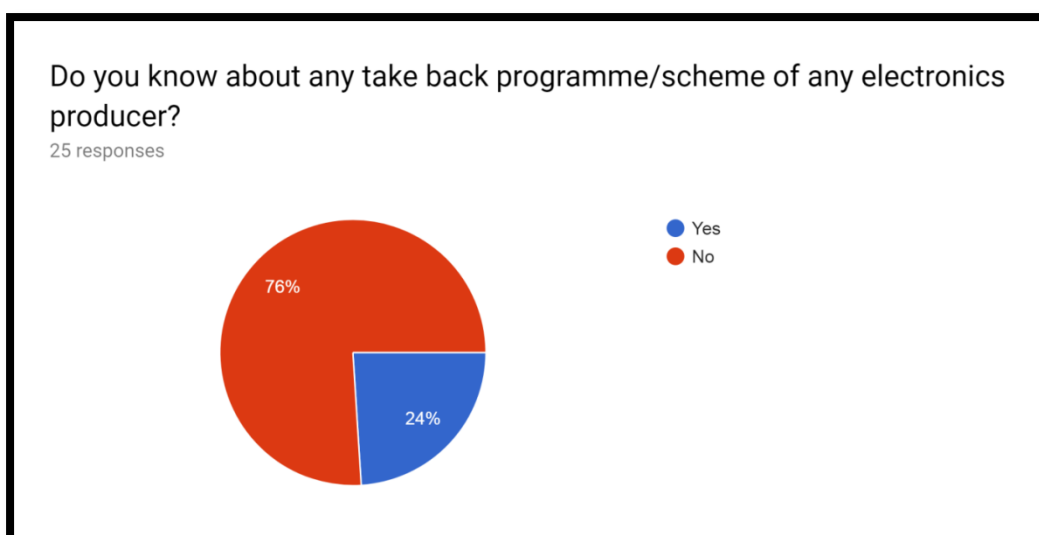


Fig.6.71: Knowledge about take back program

Table 6.86: Bulk consumers and take back program

Q. Do you know about any take back programme/scheme of any electronics producer?

	Do you know about any take back programme/scheme of any electronics producer?		Total
	Yes	No	
Female	5	18	23
Male	1	1	2
Total	6	19	25

While 70% of the bulk consumer were aware about take back program they were not utilizing it as most of there were auctoing the discarded products.

6.10.12 Bulk Consumers availed of any give back scheme

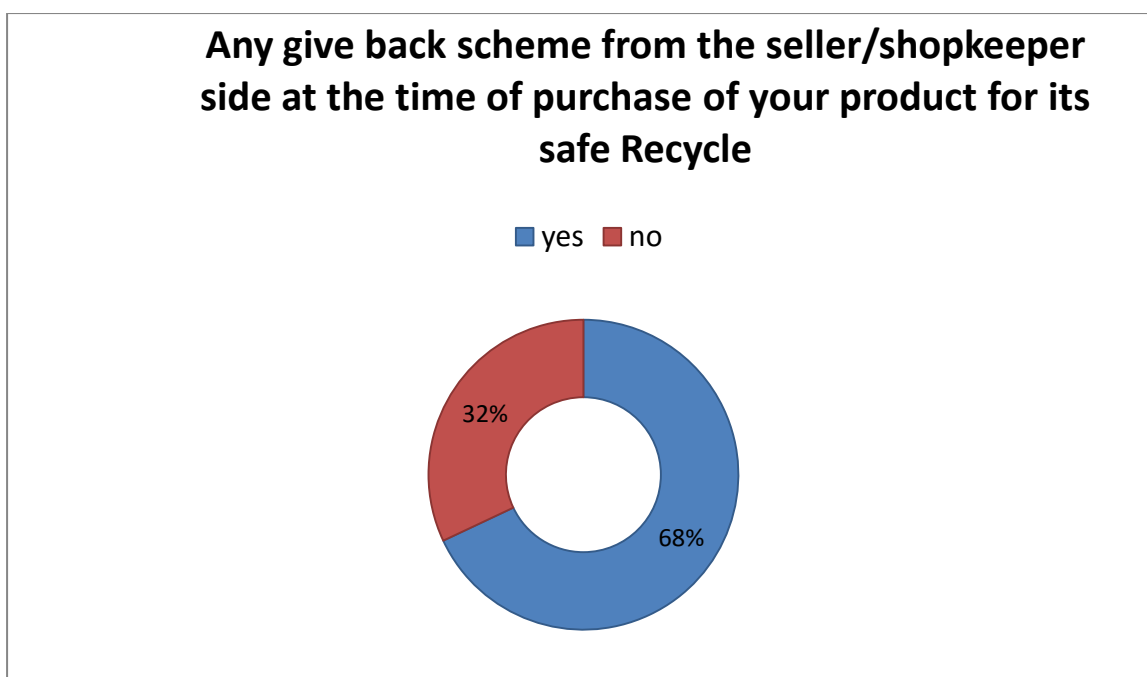


Fig.6.72: Take back scheme of seller

Table 6.87: Take Back scheme availed.

Q. Any give back scheme from the seller/shopkeeper side at the time of purchase of your product for its safe Recycle.

	Any give back scheme from the seller/shopkeeper side at the time of purchase of your product for its safe Recycle		Total
	Yes	No	
Female	15	8	23
Male	2	0	2
Total	17	8	25

6.10.13 Do bulk consumers carry out any technical and financial evaluation of Recyclers

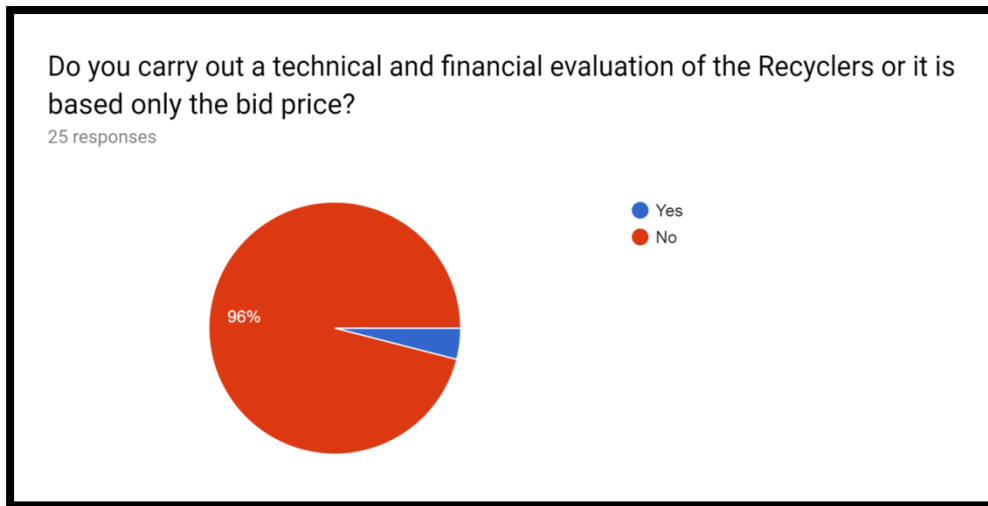


Fig.6.73: Technical & Financial evaluation

Table 6.88: Technical and Financial Evaluation carried out by Bulk consumers

Q. Do you carry out a technical and financial evaluation of the Recyclers or it is based only the bid price?

	Do you carry out a technical and financial evaluation of the Recyclers or it is based only the bid price?		Total
	Yes	No	
Female	1	22	23
Male	0	2	2
Total	1	24	25

96% of the bulk consumers were auctioning the e-waste after technical and financial appraisal of the recycler which is a big positive.

6.10.14 Broad Criterion for choosing a recycler

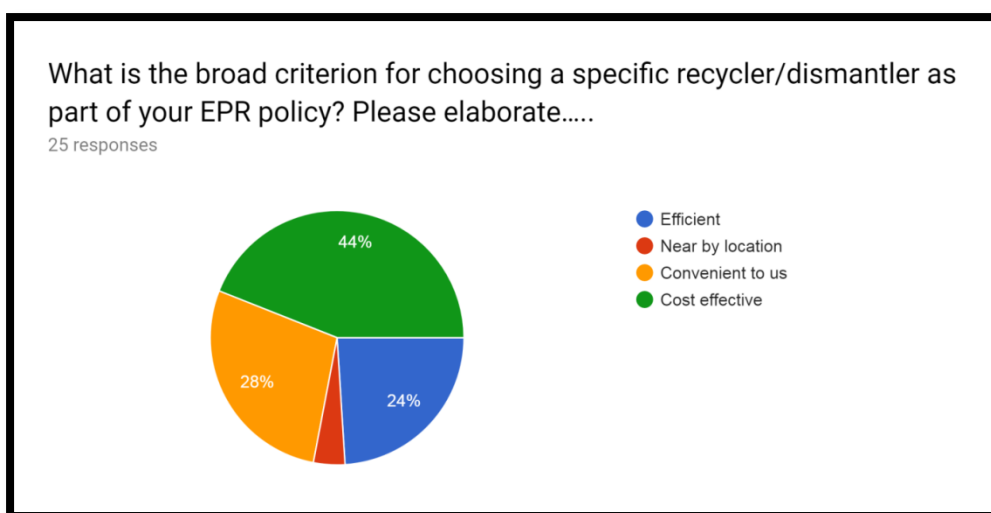


Fig.6.74: Criterion for choosing specific recycler

Table 6.89: Broad criterion for choosing specific recycler

Q. What is the broad criterion for choosing a specific recycler/dismantler as part of your EPR policy? Please elaborate.

	Efficient	Near by location	Convenient to us	Cost effective	Total
Female	5	1	7	10	23
Male	1	0	0	1	2
Total	6	1	7	11	25

Efficiency got a big thumb up while choosing recyclers while cost effectiveness and location factors were also kept in view while finalising technical parameters.

6.11 Testing of Hypothesis for Data on Bulk Consumers through SPSS

While framing the research methodology a hypothesis was postulated for data on bulk consumers for which detailed statistical analysis was done through SPSS which are enclosed below:

6.11.1 Null Hypothesis: 8

Ho= Bulk consumers are not registered with pollution/environmental regulatory Agency

H1 = Bulk consumers are registered with pollution/environmental regulatory Agency

Are you registered as a Bulk Consumer with SPCB? Please elaborate.

Table 6.90: Bulk consumers regulated with SPCB

		Are you registered as a Bulk Consumer with SPCB? Please elaborate		Total
		yes	no	
		5	18	23
		2	0	2
Total		7	18	25

We can confirm this computation with the results in the **Chi-Square Tests** table:

Chi-Square Tests

Table 6.91: Chi Square test of hypothesis

		Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square		5.590 ^a	1	.018		
Continuity Correction		2.382	1	.123		
Likelihood Ratio		5.563	1	.018		
Fisher's Exact Test					.070	.070
N of Valid Cases		25				

The row of interest here is **Pearson Chi-Square** and its footnote.

- The value of the test statistic is 5.590.
- The footnote for this statistic pertains to the expected cell count assumption (i.e., expected cell counts are all greater than 5): 2

no of cells had an expected count less than 5, so this assumption was met.

- Because the crosstabulation is a 2x2 table, the degrees of freedom (df) for the test statistic is

$$df=(R-1)*(C-1)=(2-1)*(2-1)=1$$

- The corresponding p-value of the test statistic is so small that it is cut off from the display. Instead of writing "p = 0.000", we instead write the mathematically correct statement $p < 0$.

Decision and Conclusions

Since the p-value (0.018) is around our chosen significance level $\alpha = 0.05$, we can reject the null hypothesis, and conclude that there is an association between bulk consumer and their registration with SPCB

Based on the results, we can state the following:

There was a significant association between bulk consumer and their regulator ($X^2(1) = 5.590, p < .018$).

This shows that a significant number of bulk consumers are registered with SPCB which is a positive trend and its need to be encouraged.

6.12A Survey for Producers of Electronic Equipments

The survey for producers was done in the following manner:

- (i) To study the guidelines in force.
- (ii) To elicit response of producers through a questionnaire.
- (iii) To analyse the results using statistical tools.

6.12.1 Guidelines for Implementing Extended Producer Responsibility

Extended Producer Responsibility (EPR) is the responsibility of every producer of electrical and electronic equipment (EEE) for channelisation of e-waste to an authorised dismantler / recycler to ensure environmentally sound management of such waste. EPR authorisation is mandatory and has to be obtained by all the producers including importers, e-retailers/on-line sellers/e-bay etc. of EEE covered in E-Waste (Management) Rules, 2016. A producer can implement its EPR either through take-back system or by setting up collection centres or both for channelisation of e-waste/end of life products to authorised dismantlers/recyclers. The producers are required to have arrangements with authorised dismantlers/recyclers either individually or collectively or through a Producer Responsibility Organisation (PRO) or E-Waste Exchange system as spelt in their EPR Plan which is approved/authorised by Central Pollution Control Board (CPCB). Selling or placing of EEE in the market by any producer without EPR Authorisation shall be considered as violation of the Rules and causing damage to the environment, which shall attract provisions under E (P) Act, 1986.

2.1

6.12.2 Extended Producer Responsibility Plan (EPR- Plan)

EPR Plan is an implementation plan of the producer where the producer gives its overall scheme to fulfil its Extended Producer Responsibility for achieving targets and details out the mechanism for collection and channelisation of e-waste generated by the producer. The EPR plan requires estimating the quantity of E-waste generated from their end-of-life products, outlining a scheme for collection and channelization of their end-of-life products or products with same EEE code to authorised dismantlers/recyclers, estimated budget for implementing EPR, outline the scheme of creating awareness, declaration on ROHS compliance and

submission of documents in this regard. Every producer should make an application seeking EPR authorisation in Form-1 of the E-Waste (M) Rules, 2016 addressed to the Member Secretary, Central Pollution Control Board. Form-1 should contain the relevant information pertaining to collection and channelization of their end-of-life products as detailed in sections 2.1.1 to 2.1.7. The Producers has liberty to revise their EPR Plan from time to time with information to CPCB. In such cases the EPR authorisation need amendments.

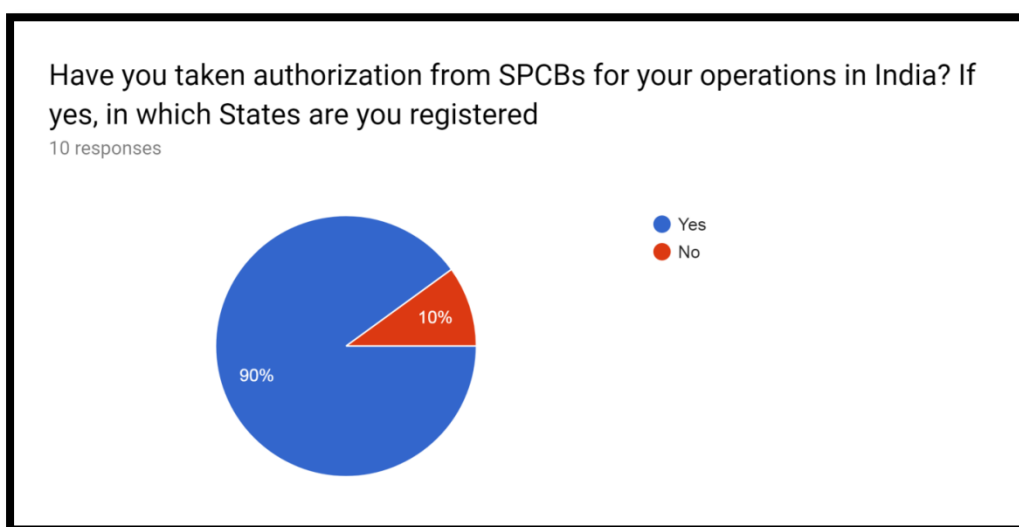


Fig.6.75: Authorisation from SPCB

90% producers had taken authorization from SPCB's. This is in strong contrast to recyclers and Bulk consumers where many of them had not taken authorization from SPCBs.

6.12.3 Producers facing problems while taking authorisation

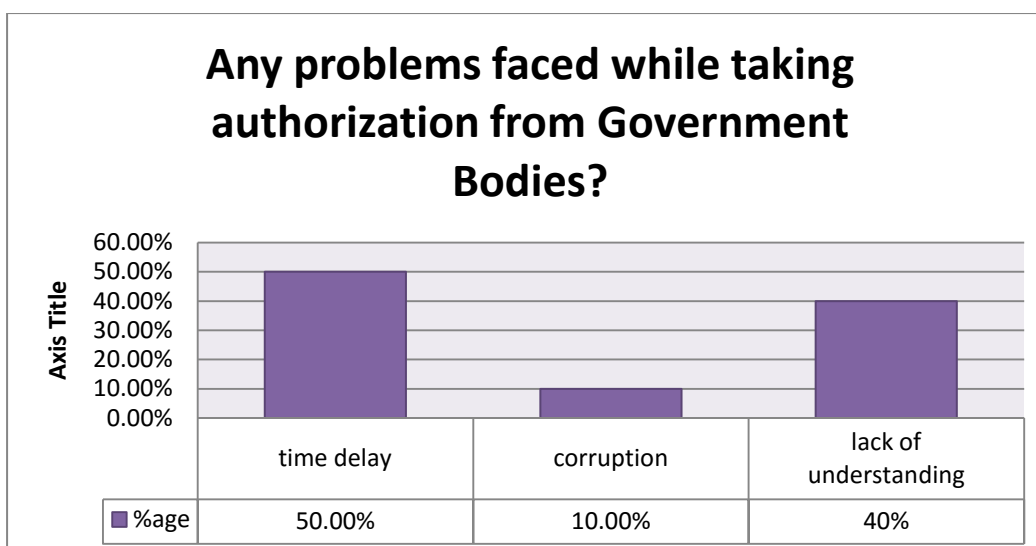


Fig.6.76: Problem faced while taking authorization

Table 6.92: Showing registration of producers with SPCB.

Q. Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered? Any problems faced while taking authorization from Government Bodies?

		Any problems faced while taking authorization from Government Bodies?			Total
		time delay	Corruption	Lack of understanding	
Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered	Yes	4	1	4	9
	No	1	0	0	1
Total		5	1	4	10

The producer felt that Government bodies were very lax in giving approvals and authorisation with 50% citing time delay as the major factor. 40% producers felt that there was lack of understanding amongst Govt. functionaries about the processes.

6.12.4 Do they have an EPR POLICY?



Fig.6.77: Do producer have an EPR policy

Table 6.93: Producers having EPR Policy

Q. Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered? Do you have an e-waste/EPR policy for you organization? Please provide details?

		Do you have an e-waste/EPR policy for you organization? Please provide details?		Total
		Yes	No	
Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered	Yes	6	2	8
	No	0	1	1
Total		6	3	9

Table 6.94: producers registered with SPCB having EPR Policy

Q. Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered? Do you have any designated Focal person for handling issues related to EPR/e-wastes Management?

	Do you have any designated Focal person for handling issues related to EPR/e-wastes	Total

		Management?		
		Yes	No	
Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered	Yes	5	4	9
	No	1	0	1
Total		6	4	10

60% of the producers had a focal point of contact for dealing with EPR / e-waste management issues.

6.12.5 Do producers have any policy of taking back end of life products?

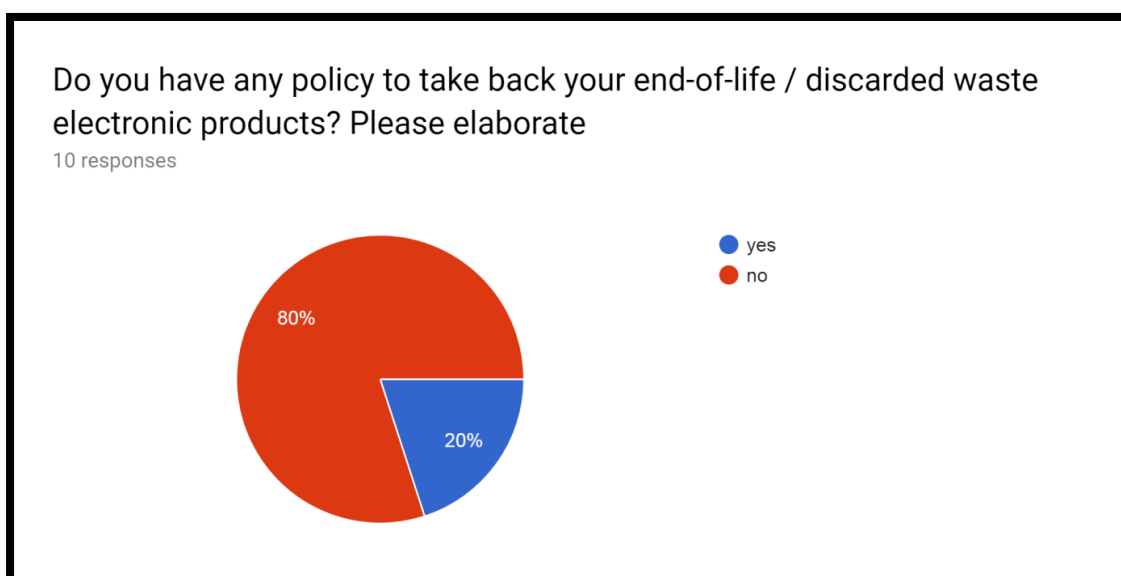


Fig.6.78: Do producer have any policy to back their end-of-life/discarded waster electroic products

Table 6.95: Producer Policy for end of life products and policy on take back

Q: Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered * Do you have any policy to take back your end-of-life / discarded waste electronic products? Please elaborate.

	Do you have any policy to take back your end-of-life / discarded waste electronic products? Please elaborate	Total

		Yes	No	
Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered	Yes	2	7	9
	No	0	1	1
Total		2	8	10

80% of the producers said that they had a policy on taking back end of life / discarded products.

6.12.6 How do producers deal with defective products

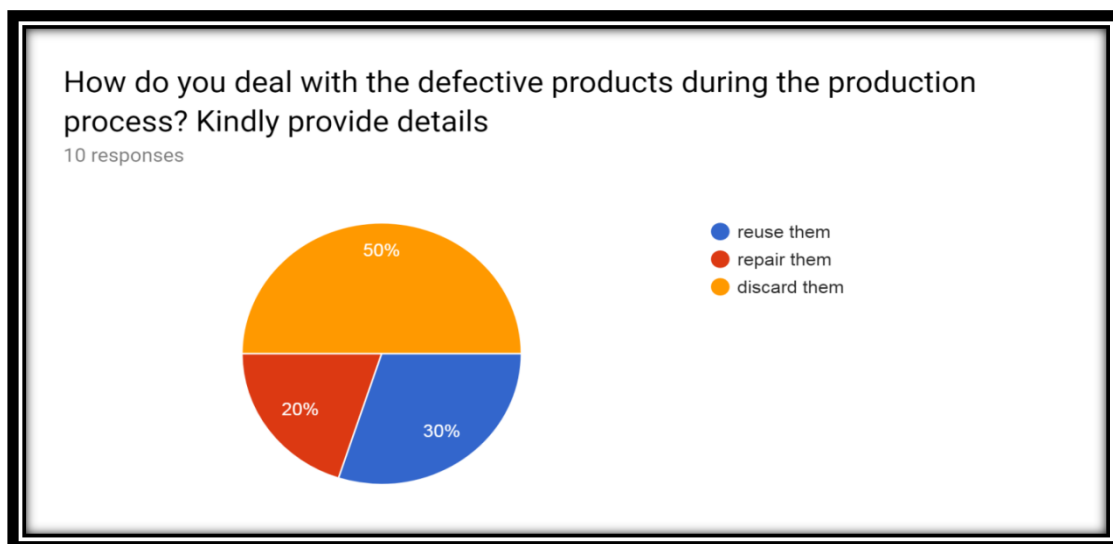


Fig.6.79: Policy of defective products

Table 6.96: How producers deal with defective products

Q. Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered? How do you deal with the defective products during the production process? Kindly provide details.

		How do you deal with the defective products during the production process? Kindly provide details			Total
		Reuse them	Repair them	Discard them	
Have you taken	Yes	2	2	5	9

authorization from SPCBs for your operations in India? If yes, in which States are you registered	No				
		1	0	0	1
Total		3	2	5	10

50% of the producers discarded defective products as they felt that it affects their brand. However 20% repaired them and then sold them and 30% reused the components.

6.12.7 Do producers have any policy to take back end of life products?

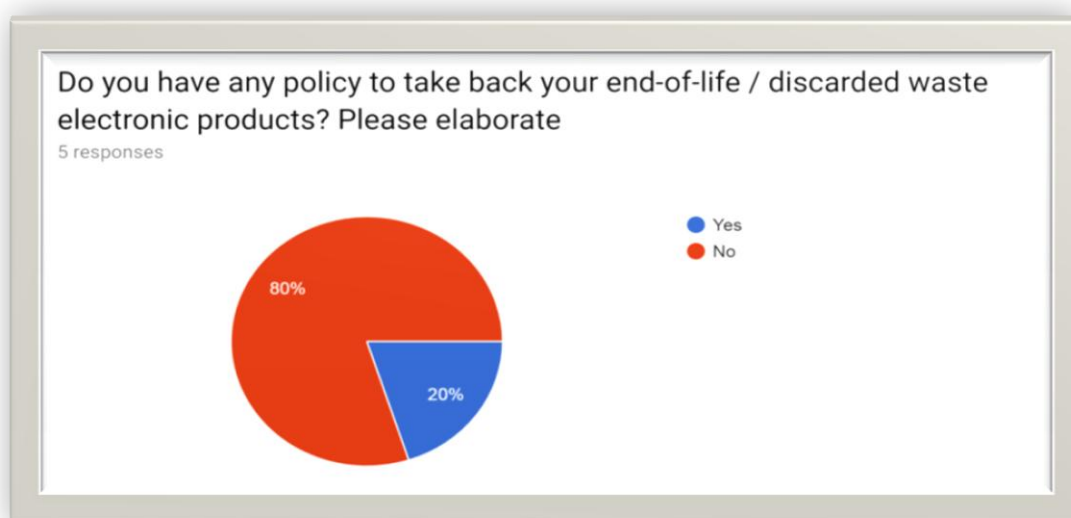


Fig.6.80: Policy on Tack Back

Table 6.97: Do producers have policy for end of life products.

Q. Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered? Do you have any policy to take back your end-of-life / discarded waste electronic products? Please elaborate.

	Do you have any policy to take back your end-of-life / discarded waste electronic products?	Total

		Please elaborate		
		Yes	No	
Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered	Yes	1	4	5
Total		1	4	5

80% of producers did not have a policy to take back end of life/discarded products.

6.12.8 Do producers use service of any e-waste recyclers?

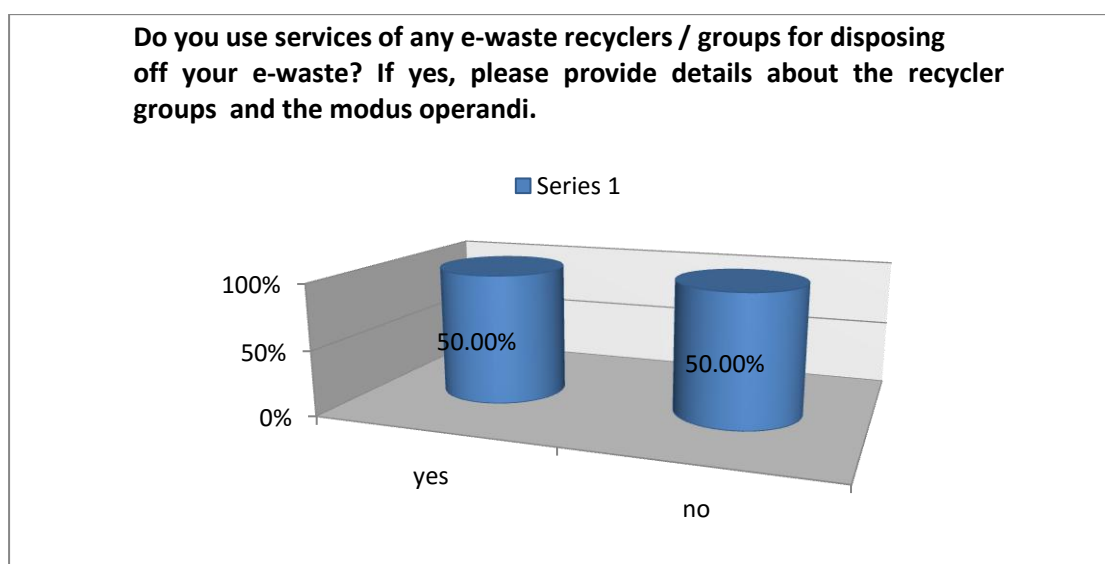


Fig.6.81: using service of Recyclers / Dismantlers

Table 6.98: Producers using service of recyclers

Q. Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered? Do you use services of any e-waste recyclers / groups for disposing off your e-waste? If yes, please provide details about the recycler groups and the modus operandi.

	Do you use services of any e-waste recyclers / groups for disposing off your e-	Total

		waste? If yes, please provide details about the recycler groups and the modus operandi.		
		Yes	No	
Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered	Yes	5	4	9
	No	0	1	1
Total		5	5	10

There was mixed response to this question as 50% used the services of e-waste recycler groups and the rest did not. There is thus a need to reference EPR policies within the producers' domain.

6.12.9 How do producers make sure that e-waste is given to authorized collection centres?

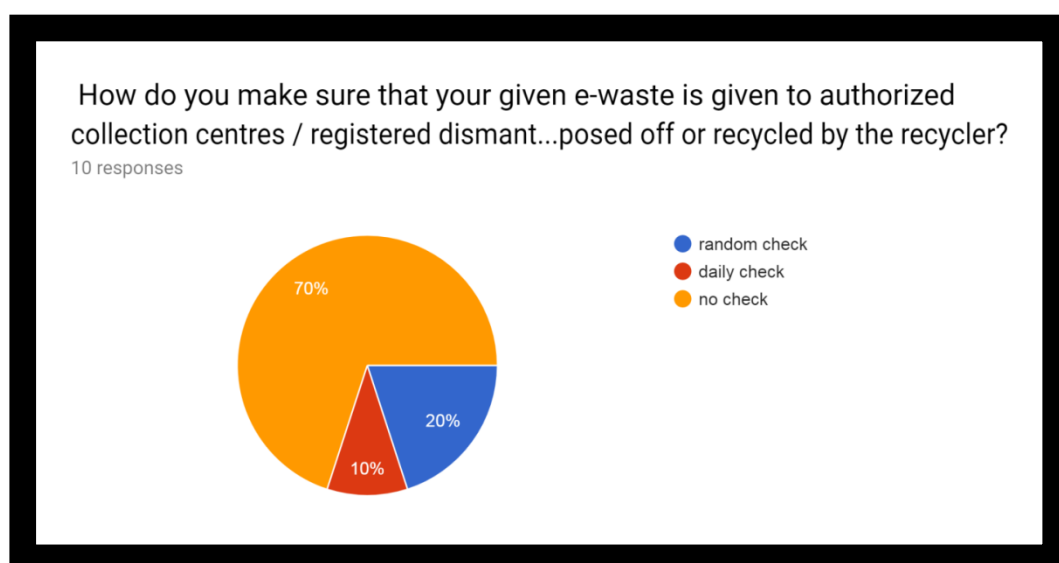


Fig.6.82: E-waste given to collection centres-verification

Table 6.99: E-waste given to collection centres

Q. Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered? How do you make sure that your given e-waste is given to authorized collection centres / registered dismantlers or recyclers and is safely disposed off or recycled by the recycler?

		How do you make sure that your given e-waste is given to authorized collection centres / registered dismantlers or recyclers and is safely disposed off or recycled by the recycler?			Total
		Random check	Daily check	No check	
Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered	Yes	2	1	6	9
	No	0	0	1	1
Total		2	1	7	10

There seems to be no system of check on material given to recycler as 70% felt that it saved the responsibility of the recyclers. 20% producers however did a random check to know the recycling process.

6.12.10 Do producers maintain documentary evidence of products recyclers

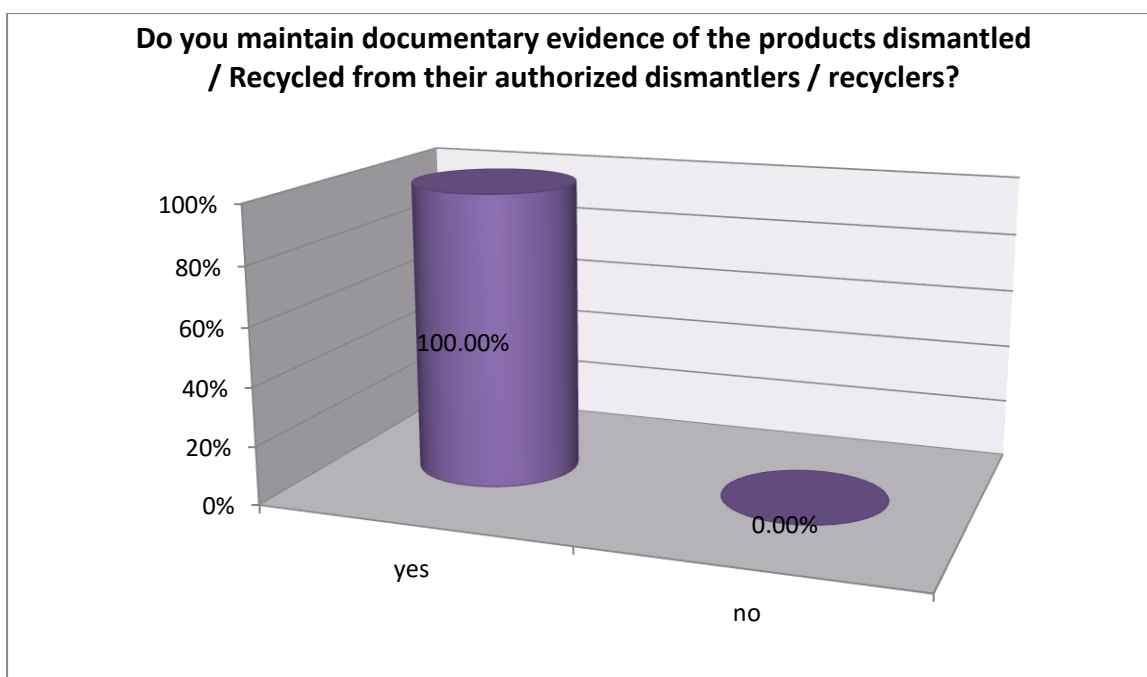


Fig.6.83: Documentary evidence of products dismantled

Table 6.100: Documentary evidence of dismantled products

Q. Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered? Do you maintain documentary evidence of the products dismantled / Recycled from their authorized dismantlers / recyclers?

		Do you maintain documentary evidence of the products dismantled / Recycled from their authorized dismantlers / recyclers?	Total
		No	
Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered	Yes	9	9
	No	1	1
Total		10	10

Again 100% producers said that they maintain a record of documentary evidence of products recycled / dismantlers.

6.12.11 Have producers established collection centres

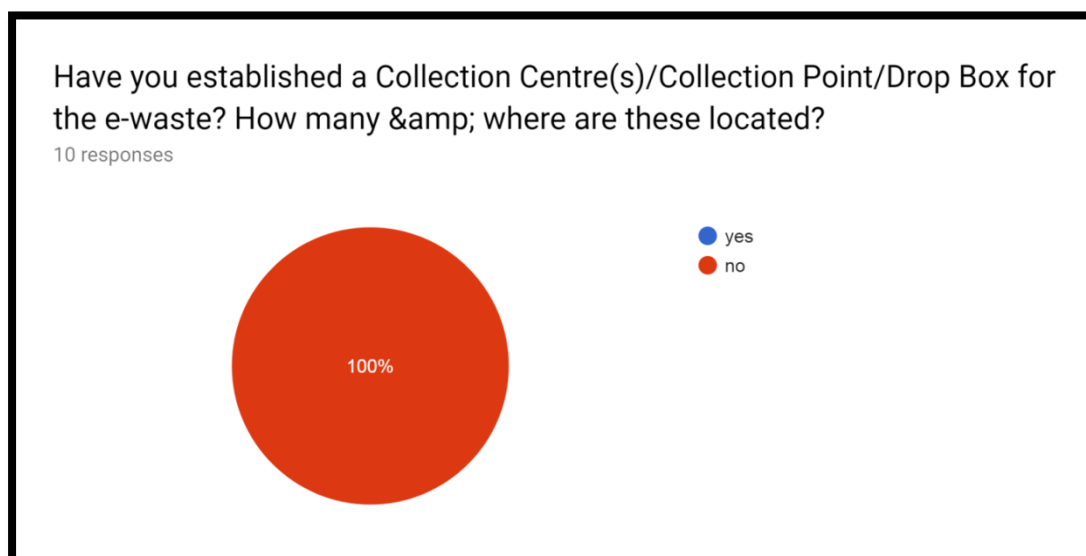


Fig.6.84: Collection Centres established by producers

Table 6.101: Have producers established collection centres

Q. Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered? Have you established a Collection Centre(s)/Collection Point/Drop Box for the e-waste? How many & where are these located?

		Have you established a Collection Centre(s)/Collection Point/Drop Box for the e-waste? How many & where are these located?	Total
		No	
Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered	Yes	9	9
	No	1	1
Total		10	10

While 100% said that they had a drop box location of there are neither available on their sites or on products.

6.12.12 How do producers motivate users to drop their discarded products

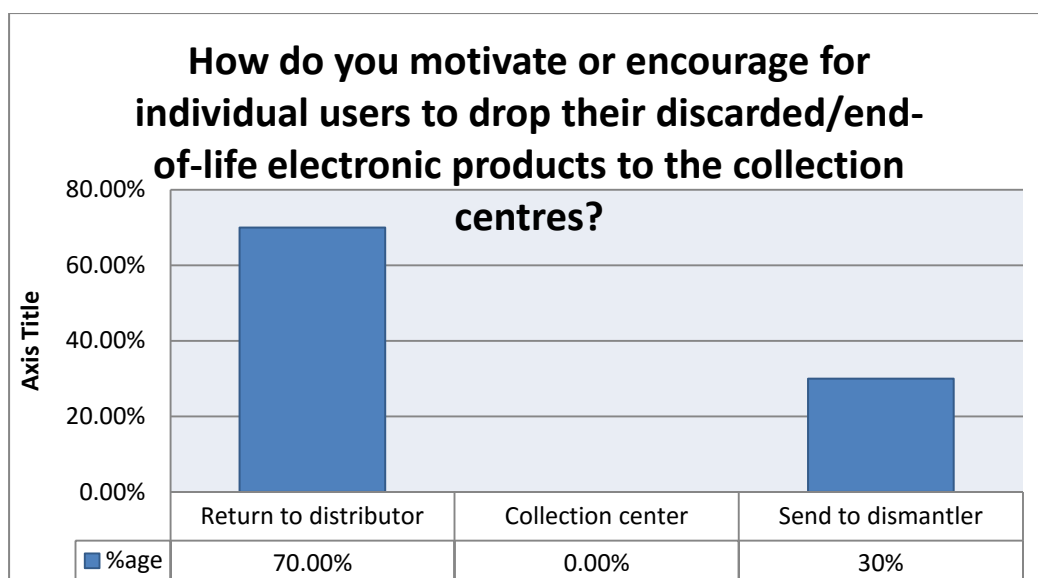


Fig.6.85: How do producers motivate users

Table 6.102: How producers motivate individual users

Q. Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered * How do you motivate or encourage for individual users to drop their discarded/end-of-life electronic products to the collection centres?

		How do you motivate or encourage for individual users to drop their discarded/end-of-life electronic products to the collection centres?		Total
		Return to Distributor	Sent to Dismantler	
Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered	Yes	6	3	9
	No	1	0	1
Total		7	3	10

None of the producers had their collection centre. However 70% of the producers encouraged users to drop their discarded / end of life electronic products to distributors and 30% advised them to send to dismantlers.

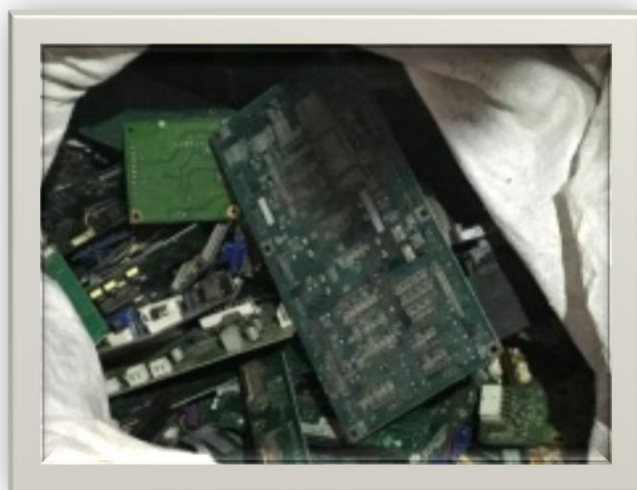


Fig.6.86: Photo of e-waste with recyclers

6.12.13 How do producers train / do capacity building of employees

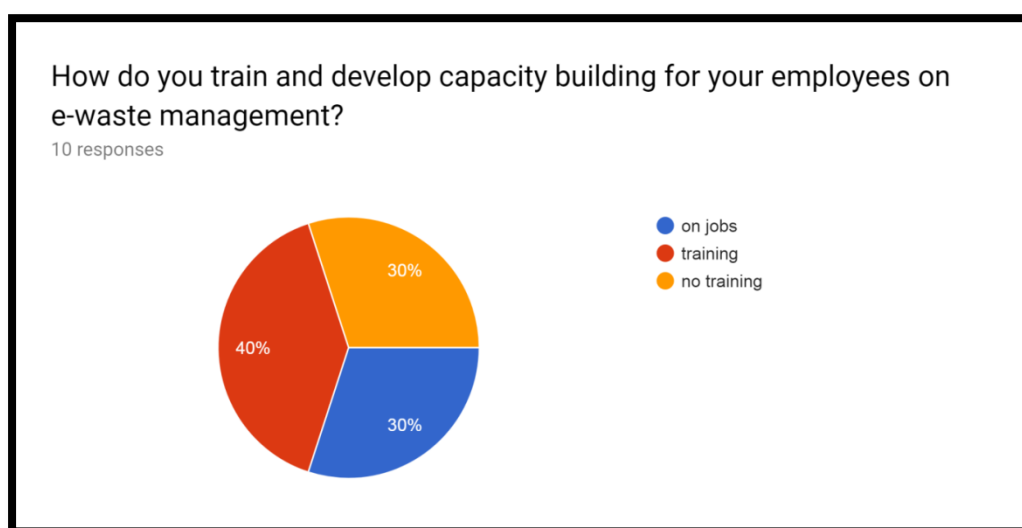


Fig.6.87: How do producers do training

Table 6.103: How producers train & develop capacity building

Q. Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered? How do you train and develop capacity building for your employees on e-waste management?

		How do you train and develop capacity building for your employees on e-waste management?			Total
		On Job	Training	No Training	
Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered	Yes	3	3	3	9
	No	0	1	0	1
Total		3	4	3	10

While 30% of producer did not provide any training on e-waste to their employees 70% producers did educate their either through a training program or on the job training.

6.12.14 Do producers make a distinction between Recyclers and dismantlers

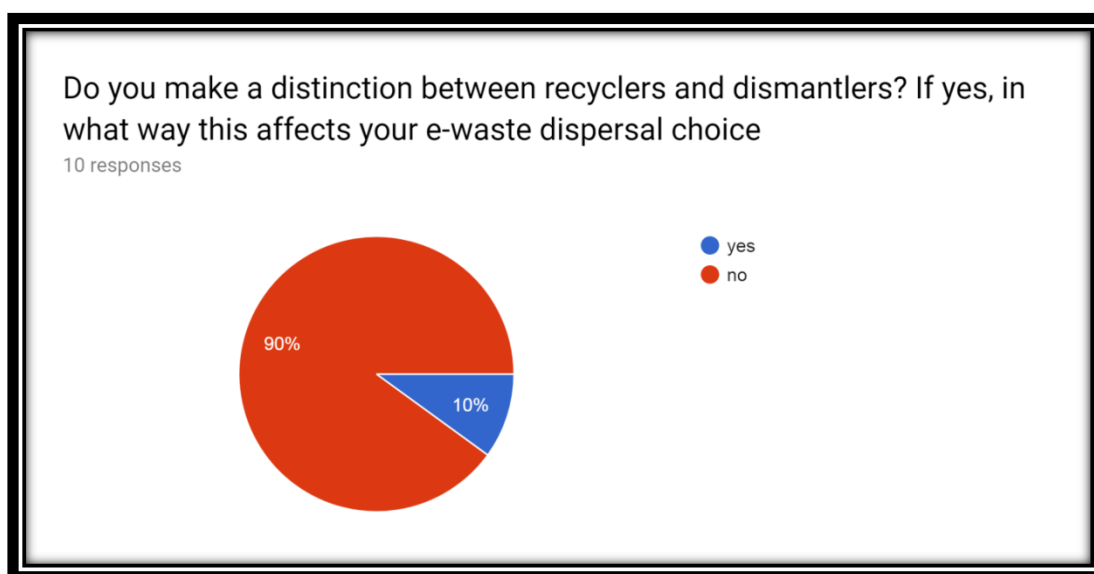


Fig.6.88: Distinction between producers and recyclers

Table 6.104: Do producers make a distinction between recyclers and dismantlers

Q. Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered? Do you make a distinction between recyclers and dismantlers? If yes, in what way this affects your e-waste dispersal choice.

		Do you make a distinction between recyclers and dismantlers? If yes, in what way this affects your e-waste dispersal choice		Total
		Yes	No	
Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered	Yes	1	8	9
	No	0	1	1
Total		1	9	10

90% producers did not distinction between recyclers and dismantlers.

6.12.15 Do producers have a policy on RoHS

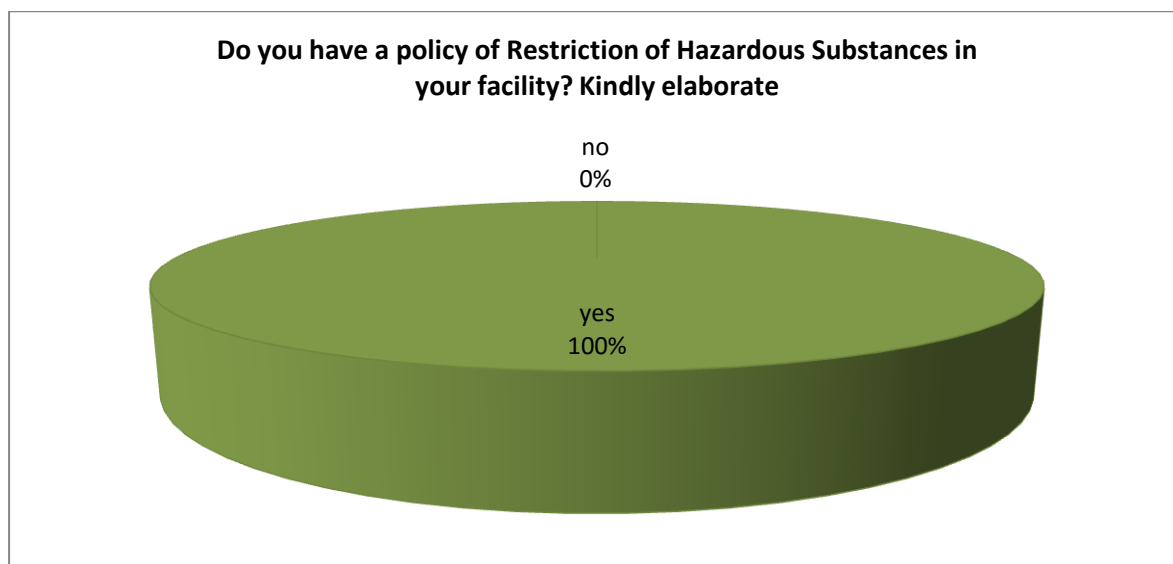


Fig.6.89: Policy of RoHS

Table 6.105: Do producers have a policy of RoHS

Q. Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered? Do you have a policy of Restriction of Hazardous Substances in your facility? Kindly elaborate.

		Do you have a policy of Restriction of Hazardous Substances in your facility? Kindly elaborate	Total
		Yes	
Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered	Yes	9	9
	No	1	1
Total		10	10

100% of producers showed compliance on RoHS in their facilities which was a positive sign.

6.12.16 GMP's followed by producers



Fig.6.90: GMP's followed by producers

Table 6.106: Kind of GMP's followed by producers

Q. Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered * What kind of Good Manufacturing Practices (GMPs) are followed at your facility?

		What kind of Good Manufacturing Practices (GMPs) are followed at your facility? Please provide		Total
		Safe & Hygiene	Safe	
Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered	Yes	4	5	9
	No	1	0	1
Total		5	5	10

50% of producers laid emphasis on hygiene alongwith safety as part of their product cycle.

6.12.17 Impediments for implementation of EPR

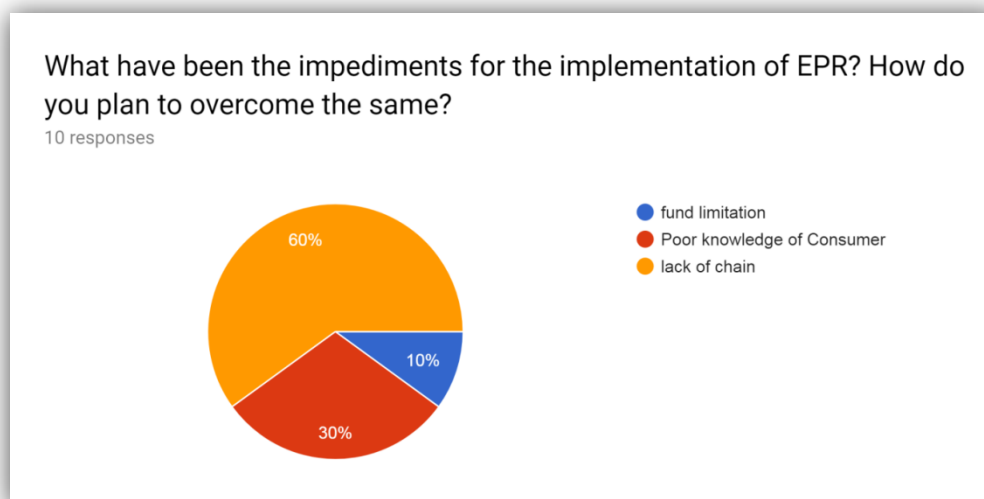


Fig.6.91: Impediments for implementation of EPR

Table 6.107: Impediments to implementation of EPR

Q. Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered? What have been the impediments for the implementation of EPR? How do you plan to overcome the same?

		What have been the impediments for the implementation of EPR? How do you plan to overcome the same?			Total
		Fund limitation	Poor knowledge of Consumer	Lack of chain	
Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered	Yes	1	3	5	9
	No	0	0	1	1
Total		1	3	6	10

The manor impediments cited by the producer for implementation of EPR was lack of chain (60%). They also cited fund limitation (10%) and poor knowledge of consumer (30%) as stumbling blocks.

6.12.18 How to make e-waste management(Rules) more effective



Fig.6.92: Feedback on e-waste rules

Table 6.108: Feedback on E-waste Management Rules

Q. Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered? Your feedback on the e-waste (Management and Handling) Rules, 2012 to make it more effective?

		Your feedback on the e-waste (Management and Handling) Rules, 2012 to make it more effective?		Total
		Need to make it people centric	More awareness required	
Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered	Yes	3	6	9
	No	1	0	1
Total		4	6	10

The producers felt that Government needs to put in more efforts to popularise the **E-waste Management and Handling Rules 2012 (Amdnded in 2018)**. 60% felt that this awareness needs to be sealed up.

40% felt that the rules need to be made more simpler and people be integrated into the awareness programme.

6.12.19 Linkages of producers with Recyclers and dealers

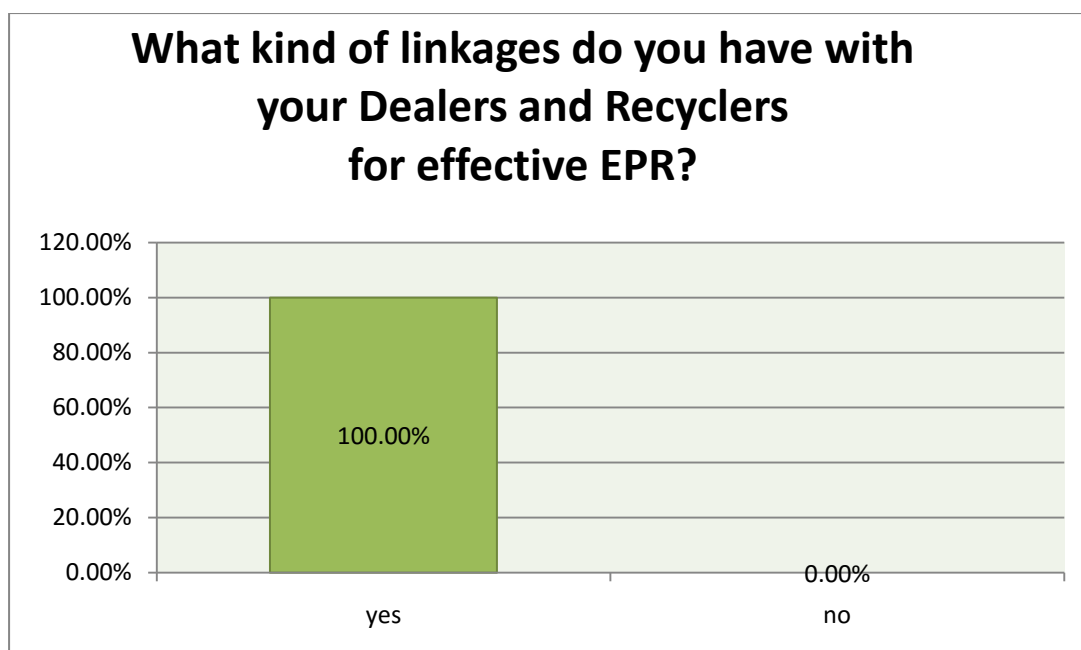


Fig.6.93: Linkages with Recyclers

Table 6.109: Kind of linkages you have with recyclers

Q. Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered? What kind of linkages do you have with your Dealers and Recyclers for effective EPR?

		What kind of linkages do you have with your Dealers and Recyclers for effective EPR?	Total
		Middlemen	
Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered	Yes	9	9
	No	1	1
Total		10	10

While 100% of producers demand a direct linkage with their dealers and recyclers. There is no documentary evidence provided by them. 100% producers had direct linkage with their dealers and middlemen.

6.13 Testing of Hypothesis for Data on Producers through SPSS

While framing the research methodology a hypothesis was postulated for data of producers for which detailed statistical analysis was done through SPSS which are enclosed below:

6.13.1 Null Hypothesis: 9

Ho= Producer do not have direct access to recyclers and dismantlers for implementation of EPR

H1 = Producer have direct access to recyclers and dismantlers for implementation of EPR

Table 6.110: Kind of linkages with dealers and recyclers

Q. Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered. What kind of linkages do you have with your Dealers and Recyclers for effective EPR?

		What kind of linkages do you have with your Dealers and Recyclers for effective EPR?	Total
		middlemen	
Have you taken authorization from SPCBs for your operations in India? If yes, in which States are you registered	yes	9	9
	no]	1	1
Total		10	10

Table 6.111: Chi Square test of Hypothesis 9

	Value
Pearson Chi-Square	. ^a
N of Valid Cases	10

a. No statistics are computed because What kind of linkages do you have with your Dealers and Recyclers for effective EPR? Is a constant.

The hypothesis remained inconclusive through SPSS.

However physical examination of data shows that 100% of the producer were using middlemen to have linkage with the recyclers and dismantlers on a daily basis.

Chapter 7

FINDINGS AND ANALYSIS

7.1 Basis of Findings

- A) Literature survey and secondary data analysis.
- B) Case study & primary data analysis

7.2 Findings based on literature survey & secondary data

The current e-waste scenario in India, points to be the fact that the amount of e- waste generated is rising rapidly with the increasing dependence on electronic and electrical equipment. However, the management of the same is a major challenge being faced by the country. The extensive literature reviewed under chapter 2 has led to the understanding of the following salient aspects:

- Main Sources of E-waste in India
- Magnitude of the Problem with respect to the Indian scenario
- Policy level initiatives by the Government
- Health and Environmental Implications of E waste especially in Informal Sector
- Current Management practices of E-waste in India including some good practices

The literature reviewed also presents some of the relevant examples of policy initiatives and recent trends in various countries

around the world in e-waste management. It also highlights the kind of efforts being taken by various international organisations for paving the way for e-waste management in environmentally sound manner.

The findings from literature reviewed highlights mismatch between the typical policy responses to e-waste problems in India and the capacity for successful implementation of such policies. The policy initiatives taken by India are based on the practices adopted in the developed countries. At present, the e-waste management regulation in India is an EPR program and is based on regulatory approach e.g. mandatory producer participation, and certification that recycling is done in accordance with environmentally sound management guidelines. But for most part, the participants in this sector are not aware of environmental and health risks, do not know best practices or have no access to investment capital to finance safety measures. In addition, there are no viable alternative, safer methods or practices being explored looking at problems, pollution, risk and so on in the context of informal e-waste recycling.

It was also noted that the e-waste situation in developing Asian countries like India is further complicated by a number of additional factors, such as difficulties in identifying producers, import of used electronic products and e-waste (sometimes illegal), and the existence of a strong informal waste sector. The policies and the rules do not differentiate between formal and informal sector. The informal recycling operations in India like in China are strong, pervasive and influence the pattern of e-waste recycling in the country.

7.2.1 Policy Framework An exclusive notification on E-waste (Management and Handling) Rules, 2011 under the Environment (Protection) Act, 1986 notified on 12th May 2011. This was amended in 2016 & 2018. Besides CPCB guidelines for environmentally sound management of e-waste are there to guide the stakeholders.

The rules address the safe and environment friendly handling, transporting, storing, and recycling of e-waste and also measures to reduce the use of hazardous substances during manufacturing of EEE. The legislation mandating electronic manufacturers and importers to take-back used electronic products at their end-of-life (EoL) based on the principle of extended producer responsibility (EPR) has been borrowed from the developed countries. CPCB released guidelines for environmentally sound management of e-waste, which apply to all those who handle e-waste dealing specifically with prevention, management, treatment, recycling, and disposal of e-waste in India.

E-waste Rules 2016 do cover almost all stakeholders making the scope wider so as to have better management of e-waste in the country. Simplification of authorisation and registration process, demarcation of role of producers and manufacturers, EPR explained in detail are some of the features of the 2016 rules. But the rules are silent on as to how to include the informal sector into the mainstream.

7.2.2 EPR Implementation The implementation of EPR in the context of e-waste is poor in the country. The Ministry of MSME has also commented that it may not be practically feasible for the producers to collect the e-waste generated at the end of life of the electrical and electronic products, because the consumers may be

located in different parts of the country, not known to the producers. **(Sthiannopkao et al, 2013).**

7.2.3 EPR Application Most analysis on EPR application has been done in the context of developed countries and there is limited understanding and shared experience on implementation of EPR in developing countries despite the fact that EPR has become a guiding principle in many Asian countries, such as China, Malaysia, and India.

7.2.4 Collection of E-waste Collection of e-waste is very poor in the country. The waste most of the e-waste is collected by the local collection mechanisms by informal sector.

7.2.5 Existing System The existing system of e-waste recycling is highly Recycling unorganized in all parts of Informal sector. More than 90% of the recycling of e-waste is being done by the Informal sector in India. Formal sector is only recycling less than 10% of the e-waste in the country despite there being large formal e-waste recycling facilities with high capacity. This is because most of the e-waste goes to the crude backyard recycling in informal sector. **(Strothmann, 2010)**

7.2.6 Stakeholders There are too many stakeholders in the e-waste value chain which includes manufacturers, producers, Importers, Traders, consumers, scrap dealers, formal and informal recyclers, dismantlers, Government, CPCB/SPCBs/PCCs, NGOs, associations like MAIT/GTZ etc.

7.2.7 Awareness about the policies, disposal, harmful effects of e-waste on environment and human health is very poor in the country. This is one of the areas which need to be pushed up very hard and need wide publicity.

Some conferences/seminars are being organised by the well-known associations from time to time but these efforts fail to reach the consumers and in the informal sector. Even awareness about the policy initiatives is restricted to the registered stakeholders and some of the bulk consumers (YES Bank online Survey).

Especially the consumers/bulk consumers need special awareness program so as to educate them about the harmful effects of e-waste and why its proper disposal is important for the environment.

7.2.8 Role of SMEs is very limited in this area as of today because of the fact that an environmentally sound recycling unit generally involves heavy investment because of the technology involved.

7.2.9 Inventory of e- waste As per the e-waste rules, 2011,(amended in 2016,2018) there is a defined procedure to fill the form by all the registered stakeholders under the e-waste rules, 2011 for maintaining the comprehensive data by SPCB/CPCB. But e-waste inventory is very poor in the country. Most of the data on e-waste is based on the estimation. The reason for this is that 90 % of the e-waste is being handled by informal sector which are not registered or authorised under the regulation.

7.2.10 Legal restriction Imports of e-waste are legally prohibited though not 100% on E imports waste implemented. Very few firms are there which import the e- waste under license. Most of the imports of e-waste in India are illegal. About 80 per cent of imported e-waste is imported majorly coming from the US and the remaining share comes mainly from the EU (***Skinner ET ai, 2010***). Environmental activists opine that India does not have the appropriate technology to ascertain the quantum and quality of e-

wastes in the imported items as Indian ports do not have mechanism to scan the imported consignments.

(Source: Based on Literature Review)

7.3 Implementation of e-waste Rules

The Manufacturers' Association for Information Technology (MAIT) has stressed that the implementation of the E-waste rules would be a major challenge because of the "complexity of the issues and involvement of too many stakeholders in the E-waste value chain" which includes a large number of people working in the informal (unorganized) sector. Almost 90 per cent of the E-waste in the country goes to the informal sector and is dismantled and recycled in the remote colonies of our cities that have no awareness of safe disposing methods; policies of the government, thus necessitating a dire need to reach out to people in this space. While the socio economic factors for both the formal/informal sector varies to a great extent, this needs to be taken into account while implementing the rules/regulations on e-waste. Therefore, the comprehensive EPR policy measures may not prove to be sufficient enough to take care of existing e-waste challenges.

7.4 An analysis of survey data

7.4.1 Analysis of survey done for consumers

- The consumer survey highlighted the awareness about e-waste amongst the various sectors of the population.
- A large survey base of 505 respondents was chosen. The female respondents formed 54% of the survey.
- That Digitalisation has pervaded the masses could be felt by the survey results 39.80% of respondents used 3 or more

electronic products while 37.62% of the respondents used two to three. While the life of an electronic product is important to an Indian consumer, it is seen that a majority of the consumer 55.56% seek to repair and use or repair and sell the electronic products.

- It is to be noted that a very large number of 29.76% kept the electronic goods in custody leading to obsolescence while 14.58% disposed the products on an as-is basis.
- The analysis pointed to the fact 56.83% of the respondents were aware about e-waste.
- A significantly large number of respondents 87% were not aware about the e-waste policy which includes 71% who said a categorical "No".
- The surveys of 6.93% respondents were able to sell the products to a recycler. However, a significantly higher number 54% sold it to an Electric / Electronic shop.
- 63% of the respondents said that they were aware about the harmful effects of e-waste.
- 48% of the respondents were aware about the take back program of Electronic products by the producer. While 52% were either ignorant or not aware.
- However, a higher 55% of respondents were aware about the take back program from a dealer / sales point which shows that dealers had this as a sales or marketing point to boost up the sales.
- This data is in consonance with the study and leads us to the question of higher support for popularising the buyback scheme both by sellers and producers. Further, this shows that the EPR has to be extended in right spirit.

- While Govt. Of India has taken extensive steps to popularise awareness about e-waste, still 70.52% respondents felt that there is a need to bring more awareness about e-waste.
- Only 4.99% of respondents were part of RWA's which is segregating e-waste.
- There is this need for bringing awareness about e-waste segregation to Municipal bodies, workers, elected representatives and RWA's to maximize collection of e-waste in a safe manner.
- While talking about awareness, 78.69% felt that the Government should make more efforts on educating the workers segregation and recycling of e-waste.
- It is significant to note that 77.80% of the respondents felt that use of Electronic products affects their health.
- It was a surprise to note that 64.74% of respondents were aware that Electronic products contain hazardous substances.
- On the specific question of knowledge of health users created by e-waste a guarded response was there as 57.88% felt that awareness about health users needs to be highlighters.

7.5 Analysis of survey done for dismantlers

- During the survey and questionnaire addressed it was seen that the work force of dismantlers primarily consisted of Male workers who accounted for 89.6% of the dismantlers work force. Female workers were less and few and largely in the upper age group. Female workers comprised 10.6% of the dismantlers.
- Another discerning feature was the religious dispersion of the dismantlers. Around 80% belonged to Muslim community and rest were Hindus.

- Of the dismantlers so engaged in the e-waste recycling industry the study revealed that:
 - a. Only 2% were graduates who were primarily doing the liasing work.
 - b. Majority of dismantlers (89%) were not educated, school dropouts and had not passed class 10th .
 - c. 8.8% dismantlers had passed class 10th .
 - d. There was a general feeling amongst the dismantlers that jobs were not forthcoming after passing class 10th and they had to perform these jobs to earn their livelihood.
 - e. While dismantling of electronic products was done as a measure of job security it was strange to see that only 28.7% dismantlers got work for the full year.
 - f. While 52.5 worked between 3-6 months.
 - g. 19.1% worked for only 3 months in a year.

The study was not conclusive as to whether dismantlers in (b) and (c) category did work on any other job.

On the safety front

- The results of this question was expected lines with 97.9% of dismantler not using gloves.
- Even the 2.1% who were using gloves were using them intermittantly.
- There is a need to utilize safe and secure methods for recycling dismantling, physical dismantling and seperation of electronic products.
- Dismantlers sitting on hard desk, motherboard, server parts was a common sight.

- During the visit hardly anybody was seen working with a shoe through 12.8% said that they wear shoes while working.
- 87.2% wear shoes while dismantling.
- Masks were a strict no-no and 100% of these surveyed said that they never wear masks.
- In case of excessive dust they cover their faces with a cloth or a towel, which we found was more contaminated.
- The results of health status was no less surprising as 82.8% did not carry out periodical health checks.
- While working many of them used lead batteries, acids, asbestos material, hazardous substances and other electronic materials yet they were not subjected to any health checkup.
- 26.5% of the workers said that their entire family worked on e-waste.
- The survey revealed that
- 47.9% suffered from skin diseases
- 24.5% had respiratory symptoms and
- 26.6% contacted other diseases
- While a majority of 59.6% were never admitted to hospital, yet a higher percentage (40.4%) were admitted.
- No direct correlation between dismantling related admission and/ or otherwise was established as it was not part of the study but a correlation with lack of safety measures points to a dismal picture.
- Majority of people (58.5%) dismantled between 10-50 boards a day.
- Few (1.1%) were dismantling 100 or more boards.

- Significantly higher number of dismantlers (26.6%) were dismantling between 50-100 boards.
- While 58.5% admitted to using acids 41.5% did not use acids in the processes involved.
- 51.1% of dismantlers said that they sold different waste material as scrap and did not throw the waste, as it was a resource.
- 38.4% threw the wastes on the roadside after dismantling.
- The visit to the areas it was seen that waste material was thrown on waste land, drains and garbage bins.
- 41.5% of dismantlers said they got hurt while dismantling the waste which correlates well with the admission to the hospital.
- Children of 30.9% of the dismantlers also worked in the units.
- 92.50% of the respondents sold the Waste Scrap to different dealers.
- A majority of 56.4% felt that dismantling work was not safe.

7.6 Analysis of survey done for Recyclers

- Only 44% of recyclers had environmental clearance from SPCB, and other state agencies.
- 90% of the recyclers had a S.S.I registration which was a positive sign.
- 68% of the recyclers said they had basic equipments and facilities while 28% said that they had informal facility only.
- Only 16.7% of the recyclers had collection centres while rest depended on work through producers, auctions etc.

- While 84% admitted to following minimum wages they were ignorant about gender equity and other personal policies
- 64% of recyclers said they used good manufacturing practices while 36% had either no idea or did not use (GMPs).
- 28% said that the layout of then plant supported GMP's 72% were
- 88% of the employees of recyclers were uneducated.
- Awareness about safe recycling polices was low though 48% claimed that they encourage awareness programme for safe environment recycling.
- Recycling of noble metals is done manually by all 100% recyclers which is a cause of concern.
- 96% of the recycler did not have DG sets
- Transportation of e-waste was done on case to case basis. The field visits showed that most of the e-waste was brought in open containers.
- 92% of the recycler expressed difficulties in filling the forms of CPCB/SPCB. Thus compliance was affected.
- 72% were not aware about this. While 20% said a categorical "No" only 8% recyclers had a tie up with producers as part of EPR.
- Most of them had linkages with recognized refurbishes, dealers etc. either partly or fully.

7.7 Analysis of survey of Bulk Consumers

- A very high 72% of the bulk consumers were not registered with SPCB. Infact they were not aware that they had to be regulated.

- It was also heartening to know that 92.3% of the bulk consumer used products from a wide mix of companies i.e. 3 and above. It reflects on efficiency and better scientific use of products based on merit.
- There was however clarity amongst institutional buyers as to what characterising e-waste.
- Only 16% of bulk consumers were disposing e-waste as part of Municipal waste. A significantly high percentage (72%) of bulk consumer was auctioning the discarded products.
- 92% of the bulk consumers were selling the Electrical / Electronics waste to the collection point.
- While 70% of the bulk consumer were aware about take back program they were not utilizing it as most of there were auctioning the discarded products.
- 96% of the bulk consumers were auctioning the e-waste after technical and financial appraisal of the recycler which is a big positive.
- Efficiency got a big thumb up while choosing recyclers while cost effectiveness and location factors were also kept in view while finalising technical parameters.

7.8 Analysis for survey of producers

- 90% producers had taken authorization from SPCB's. This is in strong contrast to recyclers and Bulk consumers where many of them had not taken authorization from SPCBs.
- The producer felt that Government bodies were very lax in giving approvals and authorisation with 50% citing time delay as the major factor. 40% producers felt that

there was lack of understanding amongst Govt. functionaries about the processes.

- 80% of the producers said that they had a policy on taking back end of life / discarded products.
- 50% of the producers discarded defective products as they felt that it affects their brand. However 20% repaired them and then sold them and 30% reused the components.
- 80% of producers did not have a policy to take back end of life/discarded products.
- There was mixed response to this question as 50% used the services of e-waste recycler groups and the rest did not. There is thus a need to reference EPR policies within the producers' domain.
- There seems to be no system of check on material given to recycler as 70% felt that it saved the responsibility of the recyclers. 20% producers however did a random check to know the recycling process.
- Again 100% producers said that they maintain a record of documentary evidence of products recycled / dismantlers.
- While 100% said that they had a drop box location of there are neither available on their sites or on products.
- None of the producers had their collection centre. However 70% of the producers encouraged users to drop their discarded / end of life electronic products to distributors and 30% advised them to send to dismantlers.
- While 30% of producer did not provide any training on e-waste to their employees 70% producers did educate

their either through a training program or on the job training.

- 90% producers did not distinction between recyclers and dismantlers.
- 100% of producers showed compliance on RoHS in their facilities which was a positive sign.
- 50% of producers laid emphasis on hygiene alongwith safety as part of their product cycle.
- The major impediments cited by the producer for implementation of EPR was lack of chain (60%). They also cited fund limitation (10%) and poor knowledge of consumer (30%) as stumbling blocks.
- The producers felt that Government needs to put in more efforts to popularise the E-waste Management and Handling Rules 2012 (Amdnded in 2018). 60% felt that this awareness needs to be sealed up.
- 40% felt that the rules need to be made more simpler and people be integrated into the awareness programme.
- While 100% of producers demand a direct linkage with their dealers and recyclers. There is no documentary evidence provided by them. 100% producers had direct linkage with their dealers and middlemen.

7.9 Analysis of Hypothesis Tested

Tabulated format of hypothesis tested using SPSS.

Sn no		Chi-square value	Chosen significant level	Result
01	Between dismantlers and safety issues.	.004	$\alpha = 0.05$	There was a significant

				association between dismantlers and safety issues. ($X^2(1) = 8.456$, $p < 0.004$).
02	Between association dismantlers and their health checkups.	.043	$\alpha = 0.05$	There was a significant association between association dismantlers and their health checkups. ($X^2(1) = 4.088$, $p < 0.043$).
03	Between consumer and awareness about harmful effects of e-waste.	.052	$\alpha = 0.05$	There was a significant association between consumer and awareness about harmful effects of e-waste. ($X^2(1) = 5.897$, $p < .052$).
04	Between consumer and their knowledge about buy back scheme	.008	$\alpha = 0.05$	There was a significant association between consumer and their knowledge about buy back scheme ($X^2(1) = 9.570$, $p < .008$).
05	Between consumer and awareness about e-waste.	.050	$\alpha = 0.05$	There was a significant association

				between consumer and awareness about e-waste. $(X^2(1) = 5.973, p < .050)$.
06	Between bulk consumer and their regulator	.018	$\alpha = 0.05$	There was a significant association between bulk consumer and their regulator $(X^2(1) = 5.590, p < .018)$. This shows that a significant number of bulk consumers are registered with SPCB which is a positive trend and its need to be encouraged
07	Between recycler and compliance with necessary regulatory procedures	.001	$\alpha = 0.05$	There was a significant association between recycler and compliance with necessary regulatory procedures $(X^2(1) = 11.979, p < 0.01)$.
08	Between Recyclers & transport of e-waste	.022	$\alpha = 0.05$	There was a significant association between Recyclers & transport of e-

				waste ($\chi^2(1) = 7.639, p < .022$).
09	Between producers and dismantlers/recyclers	-*	$\alpha = 0.05$	The hypothesis remained inconclusive through SPSS.

*Data is constant

7.9.1 Decision and Conclusions for Hypothesis -1

Since the p-value is (0.052) around the chosen significance level $\alpha = 0.05$, the null hypothesis, can be rejected and it can be concluded that there is an association between consumer and awareness about harmful effects of e-waste.

Based on the results, it can be stated that:

There was a significant association between consumer and awareness about harmful effects of e-waste.

- ($\chi^2(1) = 5.897, p < .052$).

Physical survey points to the fact that 60% of the consumers were aware about e-waste.

7.9.2 Decision and Conclusions for hypothesis - 2

Since the p-value (0.050) equal to the chosen significance level $\alpha = 0.05$, the null hypothesis, can be rejected and it can be concluded that there is an association between consumer and awareness about e-waste.

Based on the results, it can be stated that:

There was a significant association between consumer and awareness about e-waste.

- ($\chi^2(1) = 5.973, p < .050$).

It was surprising to see that significant no. of consumer were aware about e-waste.

Data shows that while they were aware about e-waste, they were not aware about e-waste policy.

7.9.3 Decision and Conclusions -3

Since the p-value(0.0081) is less than the chosen significance level $\alpha = 0.05$, the null hypothesis, can be rejected and it can be concluded that there is an association between consumer and their knowledge about buy back scheme

Based on the results, it can be stated that:

There was a significant association between consumer and their knowledge about buy back scheme

- ($\chi^2(1) = 9.570, p < .008$).

Significantly large no of consumer (around 40%) were aware about the buyback scheme.

7.9.4 Decision and Conclusions for hypothesis - 4

Since the p-value (0.004) is less than the chosen significance level $\alpha = 0.05$, the null hypothesis, can be rejected & it can be concluded that there is an association between dismantlers and safety issues.

Based on the results, it can stated that :

There was a significant association between dismantlers and safety issues.

- ($\chi^2(1) = 8.456, p < 0.004$).

This is in conformity with the physical survey wherein about 56.38% of dismantlers did not feel safe

7.9.5 Decision and Conclusions for hypothesis -5

Since the p-value(0.043) is less than the chosen significance level $\alpha = 0.05$, the null hypothesis can be rejected and it can be concluded that there is an association Dismantlers and their health checkups.

Based on the results, it can be stated that:

There was a significant association between association Dismantlers and their health checkups.

- ($\chi^2(1) = 4.088, p < 0.043$).

The results are corroborated by the fact that dismantlers suffer from a number of diseases which has come out in the questionnaire.

7.9.6 Decision and Conclusions for hyposthesis -6

Since the p-value is less than the chosen significance level $\alpha = 0.05$, the null hypothesis can be rejected & it can be concluded that,

there is an association between recycler and compliance with necessary regulatory procedures .

Based on the results, it can be stated that:

There was a significant association between recycler and compliance with necessary regulatory procedures ($\chi^2(1) = 11.979, p < 0.01$).

Thus while the recyclers comply with the statutory requirements of E-Waste management tools they are not comfortable with filing this form periodically.

7.9.7 Decision and Conclusions for hyposthesis -7

Since the p-value (0.022) is less than the chosen significance level $\alpha = 0.05$, the null hypothesis can be rejected & it can be concluded that there is an association between Recyclers & transport of e-waste.

Based on the results, it can be stated that:

There was a significant association between Recyclers & transport of e-waste ($\chi^2(1) = 7.639, p < .022$).

This is corroborated by the field unit in which no of recyclers are disposing waste in containers, bag etc.

7.9.8 Decision and Conclusions for hypothesis -8

Since the p-value (0.018) is around the chosen significance level $\alpha = 0.05$, the null hypothesis, can be rejected and it can be concluded

that there is an association between bulk consumer and their registration with SPCB

Based on the results, it can be stated that:

There was a significant association between bulk consumer and their regulator ($\chi^2(1) = 5.590, p < .018$).

This shows that a significant number of bulk consumers are registered with SPCB which is a positive trend and its need to be encouraged.

7.10 Challenges faced in e-waste implementation

7.10.1 A number of challenges to a successful implementation of EPR are there in India especially in the short run considering the various social/economic and environmental factors attached with it. The basic idea behind EPR is simple; producers that design products and place them on the market should have a responsibility for the end-of-life treatment of those products. This study notes that the EPR policy approach has been developed in response to problems faced by advanced countries and based on these countries' conditions and capacity; it is a comprehensive approach aimed at meeting a number of objectives simultaneously. It also observes that the developing countries typically takes this comprehensive interpretation as given which makes its implementation in developing countries a challenging task.

7.10.2 Although EPR systems may vary from country to country, a few basics apply consistently. Based on industrialized economies' experiences, some prerequisites for effective EPR systems are to have clear objectives and a corresponding set of policies to deliver them; involve and develop clear roles for each key stakeholder; include an incentive mechanism for compliance and penalties for noncompliance. Currently, the e- waste management system is mostly manual and low tech and the 'take back' by producers is

limited to few IT equipment and few formal collection centres in India. There is lack of effort from producers that results in limited implementation of EPR.

7.10.3 The e-waste issue becomes more difficult to handle due to a lack of comprehensive data. The real comparable data available on e-waste is the biggest challenge as, it gives magnitude to the issue on a national level, so policy makers are aware of the issue in order to take action. Though there is considerable knowledge about the negative environmental and health impacts through primitive recycling methods in informal sector, better information about the quantitative and qualitative dimensions associated with the e-waste problem makes it more understandable and useful in order to better inform policy making at the private and public levels.

7.10.4 Competition of formal sector with informal sector: The policies are uniformly defined for the formal and informal sector. But both the sectors compete for resources due to different mode of operation. The informal sector has low operating costs and it can therefore offer households relatively higher cash payments for end of life items (***Sinha et al., 2005***). Research in Delhi has found that informal recyclers with cheaper operating costs will pay double formal recyclers' prices for hard disks and mobile phones, and three times the amount for computer processors (***Chaturvedi et al, 2013***). Even the illegal imports of e-waste found a way in the informal sector (***IT's Underbelly, 2010***).

Unlike regulated formal recycling businesses, informal ones generally require comparatively little initial capital to set up. In

addition, they do not invest in pollution control or in labour protection, and owners can always avoid paying taxes since they are not registered businesses. The formal sector having large infrastructure and high operational cost finds difficulty in competing with the informal sector. The implication of this is that market instruments are typically needed in order to re-route e-waste into more organized collection schemes and make formal collection systems competitive.

The rules fail to integrate the informal sector in the collection, segregation and dismantling of E-waste. There is no mention of rehabilitation of unorganized players which handle 90% of the E-waste.

It is difficult to formalise the informal sector in the short run and therefore the need lies in how to involve them in the value chain in the long term since efficient management of informal sector can help in two ways, one is to help the organized sector in scientifically disposing E-waste by creating a safe supply chain and second is to sustain their livelihood by adopting safe method of handling E-waste. The both the sectors formal and informal can coexist together if the experience and skills of the huge workforce involved in the informal sector can be utilised along with the environmental friendly recycling technologies.

7.10.5 Trans-boundary movement of E-waste: The rules are oblivious to the fact how the electronic waste will be imported into the country. But the rules have no provisions to control the illegal imports. Though the trans-boundary movement of hazardous waste is banned under the Basel Convention, dealers have found ways to get consignments of electronic scrap into the country as they are not properly classified. It has been found from the past studies that, most electronic scrap which comes into the country is classified as plastic scrap or mixed waste. This is a serious issue which needs

urgent attention since India is a signatory of Basel Convention and is required to enforce strict checking measures to stop entry of illegal E-waste from other countries.

7.10.6 Recycling economics: Deposits of precious metals in e-waste are 40-50 times richer than ores extracted from traditional mines (Harvey, 2013). It is also cheaper and less carbon intensive to extract precious metals from e-scrap. Abundance of electronic waste in India and diktat by government stating that the onus of safe disposal of gadgets will be on producers and bulk consumers has attracted a lot of investment into start-ups doing e-waste recycling. Organized sector has grown from 3 per cent to 10 per cent approximately in last six years in India and there are 148 registered dismantlers/recycling units in India to handle e-waste.

The organized e-waste recycling industry is at its inflection point in India and is expected to grow at a brisk pace. End to end and responsible recycling of e-waste in the organized sector is the need of the hour. Growth of organized e-waste recycling industry will actually allow India to manage e-waste effectively and efficiently and will also help to conserve natural resources. It will also help India save a lot of foreign exchange by cutting down gold and silver imports.

7.10.7 The lack of awareness has been observed in most of the cases like electronic items are stored unattended because of lack of knowledge about their management. Such electronic junks keep lying in houses, offices, warehouses etc. Generally, these wastes are mixed with household wastes, which are finally disposed of at landfills. This necessitates implementation of appropriate management measures including stringent regulations. In India, the people are still to realize the associations between the cause of generation of e-waste and its effects including detrimental health and environmental effects. Presently, the responsibility of spreading

the awareness has been put on the producers of electrical and electronic equipment. But the intervention by the state local bodies/government is very much needed on this front. Awareness regarding the hazards of e-waste is also low because of structural deficiency in implementation of policies, poor literacy and poverty of an important major stake holder i.e. informal sector.

7.11 Issues arising in e -waste management

There are several issues that are required to be addressed for sustainable management of e-waste in India in the current scenario. Following are the some of the major issues that need attention while handling e-waste:

7.11.1 Functioning of EPR: One of the most serious challenges to the functioning of EPR systems in developing economies is the difficulty of identifying the producer due to several reasons

- If a producer goes bankrupt there is no entity that will bear its extended responsibilities over existing products.
- Small shops assemble products and there are several non-brand products built from imported parts.
- Due to low labour costs and a huge second-hand market, repair businesses are popular in India. During the repairs several modifications, such as the replacement of original parts, or the use of imitation brand logos, can be made to the original product, making producer responsibility for the product more complicated.
- For imported goods, usually the importer handle the responsibilities of the producers and evade the EPR system.

EPR system has several subcomponents addressing different issues, it requires physical infrastructure and complying behaviour,

and adequate institutions and capacity to enforce regulations at all levels, including the municipal level.

7.11.2 Issues of the Informal sector in e-waste management

- Backyard smelting using crude processes results in fugitive emissions leads to pollution problems and slag containing heavy metals creating health problems.
- No proper infrastructure like sophisticated machinery or protective equipment is used for extraction of components from electronic and electrical items.
- Working in poorly ventilated closed areas without masks results in exposure to dangerous and slow poisoning chemicals.
- Children and women are routinely involved in the informal system.
- Most e-waste recycling in this sector involves small enterprises that are numerous, widespread, and difficult to regulate.
- Above all, the establishments engaged in informal sector are untaxed and do not generate revenue.

7.11.3 Issues of the formal sector in e-waste management

- Most of the e-waste is not directed to formal recyclers and is rather diverted to informal sectors. So formal recyclers have to depend on informal recyclers/refurbishes for supply of - waste.
- Informal sector pays more for e-waste which results in inflow of a much larger fraction of waste and therefore they extract more profit out of the business. Also it has been found that

Informal sector is not ready to sell the waste to formal sector at less rate.

- Recycling technologies adopted in formal sector are capital intensive and need sizeable amount of investment. So the cost of operations may not necessarily be recovered by the sale of recovered materials.

7.11.4 Collection mechanism and the role of SMEs: The concept works very well in developed countries where a number of organisations come together to implement take back of e-waste financed by producers. But, India being a vast country, setting up a collection mechanism is a huge challenge. If any of the brands try individually to reach out to all parts of the country, it will not be economically sustainable.

Also the biggest challenge in India is the' socio-economic structure where one person's waste is another persons' resource and, therefore, already in place are chains where people are paid for their waste by local disposers (*kabadiwallas*). People do not part with their waste for free and that is the challenge that government, producers and collectors need to address. The e-waste rules, 2011 are open ended in terms of establishing a nation-wide streamlined collection mechanism.

7.11.5 E. Stakeholders: There are too many stakeholders involved in e-waste management and the e-waste, 2011 do cover almost all stakeholders with their assigned specific roles. However, with limited human, financial and technical capacity of SPCSs and CPCS,

it will remain a challenge to monitor so many players and ensure the compliance of the rules in the country.

7.11.6 Recycling of e-waste needs to be popularized more to create awareness among the general public and small businesses so that the people dispose of their electronic waste responsibly to prevent uncontrolled and dangerous scrapping of e-waste for a cleaner India, The rules do not mention specific technologies or processes to be used for recycling, Under the requirement of environmentally sound management, specific technology options can be spelt out in the E-waste rules as specified under the Biomedical Waste Rules.

7.11.7 G. Capacity Building: There is a need to build up the capacity or developing the standard curriculum for e-waste academy. There is need to develop platform to for sharing knowledge, interaction with the experts, and develop collaborative partnerships.

Above findings and analysis shows that there exists an urgent need for a detailed assessment of the current and future scenario including quantification, characteristics, existing disposal practices, environmental impacts etc. Institutional infrastructures, including e-waste collection, transportation, treatment, storage, recovery and disposal, need to be established, at national and/grass root levels for the environmentally sound management of e-wastes.

7.12 After reviewing the various policy initiatives by Government of India through both primary and secondary and prevailing scenario on e-waste management in India, it is concluded that in spite of the existence of the rules i.e. E-waste rules, 2011, (as amended in 2016, 2018) for more than seven years, the challenge of efficient E-waste management and reporting continues to persist. More than 90% of this waste is still handled through the unorganized sector,

leading to irreversible damages to the people engaged in dismantling electronic devices by getting exposed to lead, mercury, cadmium, flame retardants and other dangerous toxins. While the fact cannot be ignored that the informal sector gives jobs to thousands of people and also supports the formal agencies in waste management, at the same time it is lacking skills and technologies in managing the hazardous materials contained in e-waste.

Adding to these woes is the challenge of ensuring adherence to the E-waste rules by organizations stemming from lack of awareness and lack of stringent penalties on the defaulters in the formal sector. While there is a critical need for consumers to consciously follow take back policies; manufacturers need to ensure 'extended producers' responsibility' by suitably collaborating with peers and incentivising consumers to return the electronic equipment at end of its life. Producers can also see it as business opportunity by targeting environmentally conscious bulk consumers like banks, educational institutions and IT companies with attractive buy-back agreements thereby enabling responsible E-waste management. It is essential that the government strictly enforces the E-waste rules and develop a mechanism to strengthen the process of penalizing defaulters. While some dedicated NGOs are spreading awareness and sensitising manufacturers and consumer; innovative models are required for new age entrepreneurs to come forward to establish recycling facilities built on latest techniques available. Recycling can be made into a business opportunity to create circular economy of e-waste by bringing the informal sector into the value chain supported by the fact that the India is a labour intensive country. Sustainability of e-waste management systems can be ensured by improving the effectiveness of collection and recycling systems put together.

E-waste management in India today presents a highly complex problem with involvement of myriad of actors along the value chain. While stakeholder engagement and enhanced awareness generation remains critical to the success of the waste management system, the platform for sharing good practices which can be adopted and replicated across the country will trigger change in the current practices to manage e- waste. There is no unique or ideal model for e-waste management in developing countries, each of which is characterized by its own specific environmental, social, technological, economic and cultural conditions. A proper coordination between Government, producers, users, and recycling sector (formal as well as informal) can bring about a remarkable change in the present scenario of e-waste in India and move towards an environmentally sustainable practice of handling of e-waste in future.

Chapter 8

RECOMMENDATIONS AND CONCLUSION

8.1 Recommendations

The successful implementation of a smart e-waste management system for developing countries like India seems unlikely under the conditions surrounding current e-waste recycling mechanism in India coupled with the insufficient institutional and administrative capacity for enforcement. The main focus of the study is the mismatch between the specific challenges and conditions on the one hand and the comprehensive EPR policy approach that India is trying to implement on the other hand. Based on these parameters some of the recommendations that could steer India's e-waste market towards greener and fairer outcomes are as under:

8.1.1 To fill up the gap between formal and informal sector.

The environmental and socio-economic factors in which the formal and informal sectors handle e-waste are quite different. Effectiveness of the present regulation on informal recyclers is very weak. Policies should clearly differentiate between the two sectors. The formal recyclers are recognized by and registered with the Central and State Pollution Control Board. The Informal Sector Recyclers do not hold a legal entity. Currently the EPR policies indirectly aim at regulating the formal sector because the informal sector is largely unregulated. In the policy it is assumed that it will

be able to regulate the informal e-waste sector through e- waste rules, 2011 which allow only registered companies with updated and safe technologies to recycle e-waste and where getting registered means having a large area and technology.

8.1.2 Many e-waste workers in informal sector have developed their practices over many years operating in a relative regulatory vacuum. They are highly skilled at manual dismantling, with far-reaching networks enabling e-waste collection from small, peripheral sources, and detailed knowledge of electronic appliances and the value of components. For the formal sector or local authorities to duplicate such activities would demand huge expense and unfeasibly efficient management systems.

8.1.3 India's e-waste recycling sector should capitalize on the strengths of this huge workforce and see it as part of the solution, rather than an obstacle, to more inclusive green economies. The developing countries like India are labour intensive countries and hence informal organizations must be strengthened to save cost of new technologies in the capital intensive recycling sector. Big institutions in India can successfully operate high- technology recycling plants, but often cannot access sufficient e-waste to be economically feasible. Informal collectors can help bridge this gap, and should be valued rather than excluded. For dismantling, low-cost manual workers may be critical for the economic feasibility of the whole e-waste value recovery model in emerging economies like India. However, the inequalities that exist in the informal e-waste economy need to be understood, including the difference in income levels between poverty driven, survivalist labourers and more autonomous owners of rapidly growing small enterprises.

8.1.4 India should think of a green and inclusive e-waste economy while promoting livelihoods of workers involved in informal sector. The solution should come in the form of models where existing informal collection and dismantling markets are supported by, and integrated with, formal recycling companies using clean technologies for metal recovery and toxic compound. The current policy frameworks have limitations, particularly gaps in appropriate guidance and support to the informal sector.

8.1.5 The role of municipalities in a state should be increased to reintegrate and reorganize the city's vast informal workforce. Innovations for inclusivity in India's informal e-waste markets need to be explored further.

8.1.6 The informal SMEs should be encouraged to play a significant role in terms of employment which needs to be maintained by facilitating improvement of the technology, making their processes more efficient and integrating their activity with the mainstream activity of recycling and recovery.

8.1.7 Such type of policy interventions is needed that incentivize informal actors so as to divert materials into clean (formal) recycling channels and reduces the occupational hazards.

8.1.8 The economics of hybrid formal-informal models need to work all the way along the chain, so new formal recyclers can survive along with mature informal markets. India's changing regulatory context is encouraging many new formal recycling companies. But the ultimate success of policy implementation will largely depend on reconciling the informal and formal economies. Much still needs to be explored in India's existing e-waste models to understand how informal markets can be integral to greening economies by way of nationwide programs.

8.1.9 To set up a e-waste portal providing the comprehensive information about e- waste at all India level

There is an urgent need to set up such a platform where all types of information regarding e-waste policies and measures taken by various states in India should be available. Though SPCB maintain the information of e-waste of their respective states, but there are many issues which can be brought up at a single platform so that it becomes easy for the stakeholders to access the information at one go. At present there are numerous scattered efforts done by the Government/NGOs/Institutions which if brought at a single place may help others involved in the e-waste value chain.

An exclusive portal on e-waste may be the answer to this problem. Presently the e- waste is generally sub - headed under the solid waste at many places. The portal may have all types of information on e-waste like

- Provide the state wise complete details of the registered dismantlers/collectors/ recyclers of the e-waste giving the links to respective SPCBs. Besides it should also provide the information about the informal organizations so that formal as well as informal sector can have an access to each other.
- A streamlined and robust system for collection and take back may be established on the portal to help the stakeholders.
- The portal may be used to fill up the Form 2/3 online as required under the E- waste rules, 2011, which will remove the need to submit the returns on e- waste manually. This will not only ease out the work of CPCB but also help in getting the comprehensive data on e-waste easily.

- The good practices across the country in the management of e-waste may be shared on the site like partnership of Chintan, NGO with safai sena to improve collection, e-parihara recycling unit in Bangalore,' PPP model of Pimpri Chinwad at Pune etc.so that it may have an outreach in other parts of the country also. This may specially prove to be very helpful in guiding and showing the path to other stakeholders at different locations in the country in improving the ways of e-waste management.
 - The links to all those sites which are involved directly or indirectly in the handling of the e-waste like Taxies Link! Chintan! MAITI WEEErecycie etc. may be available on the website.
 - The general concept and the harms of the e-waste to health and environment may be kept in the form of FAQs (Frequently Asked Questions) which are easy to understand by the consumer.
 - Do's and Don'ts of e-waste should be clearly spelled out to raise awareness. The information is the key to the achievement of many successful objectives. On the same lines, the benefits of e- governance can be reaped into efficient implementation of e-waste management.
1. To increase the awareness in consumers about e-waste via popular media like Television, Radio, Print media, Social Media, SMS and Internet advertisements

8.1.10 Lack of awareness among various stakeholders including consumers about the ill effects of the end-of-life products (e-waste) is the major concern in our country. This is one area which really needs lot of attention as it has been emphasized in almost every literature review. The consumer in general, are not aware of the

fact that e-waste is also a type of waste which needs proper disposal. E-wastes should never be disposed with garbage and other household wastes otherwise it finds way in landfills with other type of solid wastes.

8.1.11 Presently, the responsibility of spreading the awareness has been put on the producers of electrical and electronic equipment as per the rules. But the intervention by the state local bodies/government is very much needed on this front. Some of the initiatives in spreading the awareness may be:

8.1.12 Include the study on e-waste into curriculum of the school/college education at the appropriate level so that the children become aware about this waste stream. The awareness about 3Rs i.e. Reduce! Reuse! Recycle must be stressed upon in the school college studies. The young generation which is obsessed with the use of new gadgets as soon as they come in the market should know about the harms of e-waste and should be encouraged for reducing the waste, reusing the equipment till the time it's possible and then handle it further for proper disposal. The students' awareness in environmental issues will positively affect student attitudes.

8.1.13 The mass media like Television, Radio Channels, print media, social media and Internet should be widely used for spreading the awareness by means of advertisements on the similar lines of save water save trees! Save energy etc. so that the consumer gets at least aware of this waste-stream. Even the SMS is a quick way to attract the attention of the consumers towards the proper way of disposal of e-waste. The consumer shall be made aware channelizing the e- waste into nearest collection centres instead of disposing the e-waste with municipal waste and their

contribution in reduce/reuse and recycling. Better information and education channels that influence public behaviour are key factors by way of which consumers may understand the environmental and human impacts of unregulated e-waste recycling.

8.1.14 The bulk consumers of let equipment like public institutions and other large institutions and businesses should specifically be addressed to dispose of their e-waste using the collection and recycling infrastructure set up under the EPR system. Rather, it may be mandated for the bulk consumers of e-products to systematically dispose of their obsolete products.

8.1.15 The consumers may be made aware that e-waste is not a daily waste and needs proper disposal less frequently, may be once/twice in a year which may not be difficult to follow. Better information and education channels that influence public behaviour are key so that consumers must understand the environmental risks associated with the unregulated e-waste recycling.

8.1.16 To increase the reuse of e-waste with the help of Government / NGOs initiatives

Waste prevention is perhaps more preferred to any other waste management option including recycling. Donating electronics for reuse extends the lives of valuable products and keeps them out of the waste management system for a longer time. Reuse, in addition to being an environmentally preferable alternative, also benefits society. The consumers should be encouraged for donating used electronics in schools, non-profit organizations, and lower-income families. Reuse of still-functional devices can meet the needs of communities or individuals who would not otherwise acquire them. Reuse can provide individual and societal benefit in developing countries like India. From a policy perspective, reuse of

electronic devices makes the most efficient use of scarce materials, reduces the amount of transportation required to put a device back on the market, provides jobs and opportunity for individuals, and reduces supply for environmentally degrading informal recycling in developing countries.

8.1.17 To strengthen the implementation of EPR practices

The implementation of EPR should be strengthened as mere mention of EPR approach is not sufficient enough. Appropriate institutional system with monitoring and regulatory capacity is required to regularly review the progress of EPR implementation. Though the CPCB/SPCBs are the administrative body for conducting assessment of e-waste generation and processing and also compilation of data on e-waste but the sufficient human, financial and technical capacity is a must to have an overall control over the so many players. The schemes should be evolved by the government to incentivize the mechanism for compliance and penalties for non-compliance of EPR.

8.1.18 For achieving the objectives using EPR, Government should review the specific national situation regarding e-waste say extracting lessons from experiences in implementing EPR systems in other .developing countries, consulting with various e-waste stakeholder groups that would be affected by an EPR system, including informal waste collectors and recyclers, brand owners, importers, distributors, retailers, and municipal authorities responsible for waste management. Simultaneously national infrastructure for e-waste management, related policies already existing and new ones needed, and the capacity to implement EPR-based policies should be thoroughly evaluated.

8.1.19 To start the practice of rewarding the good recyclers

The government may start the scheme of certification with a reward for good recyclers which may prove to be instrumental in identifying the good recyclers for both formal as well as informal sector. This may encourage the recyclers to have appropriate technology, produce recycled material of a defined minimum quality, and operate under established health and environmental standards. In fact, the informal sector can also be incorporated into such a system by developing the capacity of some of the informal recycle schemes already operating, upgrading their technical know-how as well as upgrading their infrastructure.

The recommendations suggested above may help the government to some extent to formulate clear objectives, standards and draft policies that would be more suitable for the country, as well as on the components of such a system, such as stakeholder responsibilities, collection schemes, performance standards, targets, etc. for sustainable management of e-waste in the country.

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LIST OF ANNEXURES
