Low cost E-waste Recycling Technologies

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E-Waste Inventory

- **Globally :**
  - 2014: 41.8 MT
  - 2016: 45.7 MT
  - 2018: 49.8 MT

- **Continent wise: (2014)**
  - Asia: 16MT (3.7Kg/inh);
  - America: 11.7MT (12.2Kg/inh);
  - Europe:11.6MT(15.6Kg/inh);
  - Africa: 1.9MT (1.7Kg/inh)

- **India:**
  - 2014: 1.7MT
  - 2016: 2 Mn MT to reach 5.2 Mn MT by 2020 with 30% CAGR.
  - 2018: 3 MT

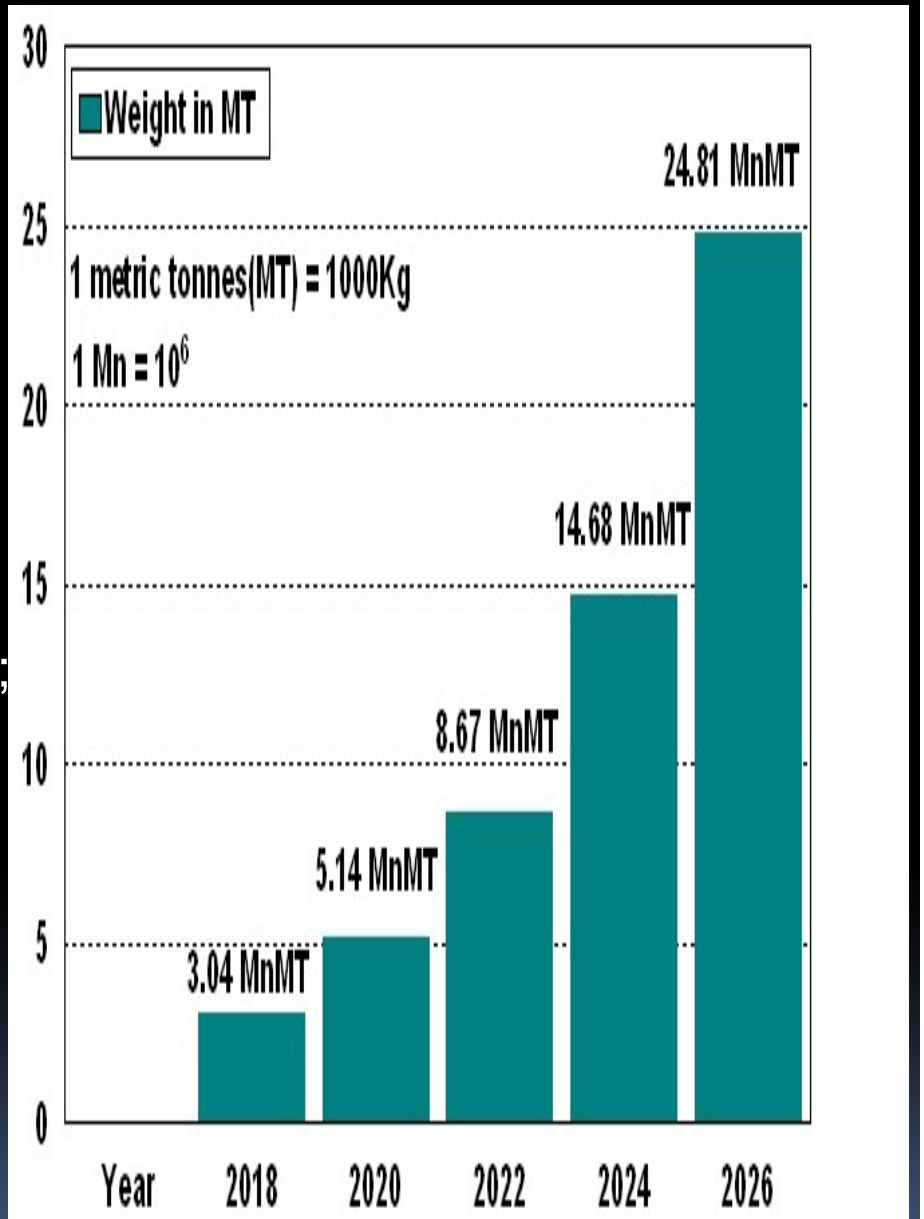


Fig.2: Growth of Ewaste in India

Source: United Nation University, 2014, ASSCHAM 2016

Present Scenario of E-waste Recycling in India

Non-formal sector

- 90-95% e-waste recycling in non-formal sector
- PCBs are treated in primitive methods to remove components & value metals
- Burning cables to recover copper & unwanted materials in open air
- Leaching of heavy metals/ chemicals into landfills and incinerator hazardous
- Recovery yield is poor (~10-20%)- loosing precious metals

Formal sector

- 5-10% e-waste is recycled in formal sector
- Segregating, disassembling to recover: structural metal parts, cables, Printed Circuit Board (PCB), glass components etc.
- Limited PCB treatment or Exported them for further process to recover precious metals

Structural parts

Precious Metals

Plastics

Hazardous waste

Potential Materials Recovered from E-waste

Recovered Items	Recycling Option	Used
1. **Small & large structural metal parts, heat sinks, Ferrous metal** 2. **Ferrite & ceramic components Non ferrous metal scrap mainly Cu & Al** 3. **Glass components**	Dismantling, Segregation, Smelting Available with local smelters	Recovered materials can be sold at market price
4. **Precious metal scrap, PCBs with IC Chips, electronic components and connectors**	Exported/ High end imported Technology Required Indigenous technology developed: Smelting + Hydro-metallurgy + Electro-chemical Process	High value extracted Precious metals can be sold
5. **Small & large structural plastic parts, flame retardants plastic** 6. **Cables and wires**	low value/ dealt in informal sector Indigenous Technology Developed	Value added master batch made high value extracted metals
7. **Hazardous wastes like CFC, Mercury (Hg) Switches, CRT, and capacitor**	Indigenous Technology Developed	Extracted metals to be sold to market
8. **Hazardous wastes like batteries specially Lithium ion**	High end imported Technology Required Indigenous technology developed:	High value extracted Precious metals can be sold

Technology Developed for Extraction of Metals

- Processing technology successfully developed for recycling and reuse of electronic waste
  - Pulverization, physical separation, chemical leaching etc.
  - Pilot Plant level demonstration done to recover precious metal from 1 Metric Tonnes of e-waste with a recovery rate of 95%.
  - Commercialization

NML, Jamshedpur

- Printed circuit boards processing technology was successfully developed & demonstrated
  - Depopulation, pyrolysis, calciner, chemical leaching etc.

CMET, Hyderabad & E-parisara, Bangalore

Dismantling and Segregation

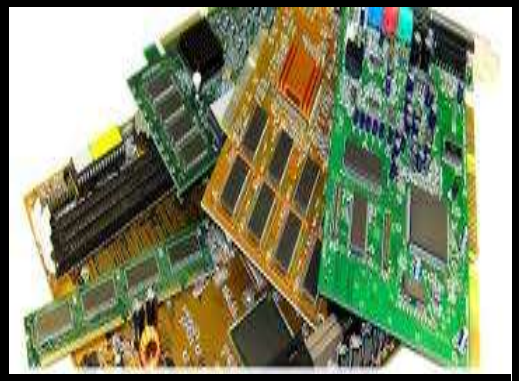
Initial Process

Electronic Products

Segregated Components

Printed Circuit Boards

PCB Recycling



Populated PCB

Pulverized PCB

Physical Separation (Magnetic, Gravity, Electrical)

Metal Rich Powder

Cu, Au Ag Pd metals fractions

Chemical Leaching

Cu, Au Ag, Pd

NML, Jamshedpur- process

PCB Recycling

Populated PCB

Depopulator

Depopulated PCB

Pyrolysis

- Oil
- Gas
- Solid

Calcinations & Smelting

Materials

Chemical Leaching & Electrolysis

Metal Recovery

CMET, Hyderabad & E-Parisara, B'lr- process

Process Flow Chart

Precious metals

Printed circuit boards

Depopulation (10kg/hour)

Anode mud processing (5kg/batch)

Environmental sound PCB Recycling Technology: 100Kg capacity

❖Prototype systems developed

❖Demonstration plant established

❖Flue gases are treated in a secondary burner and the dioxin and furnas contents within admissible emission limit of CPCB

Shredding (20kg/hour)

Electro-refining (5kg Cu/day)

Calcination (100kg/day)

Refining of copper (150kg/day)

Smelting (150kg/day)

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ISSUED TO:

M/S. CENTRE FOR MATERIALS FOR ELECTRONICS TECHNOLOGY (C-MET)
(Scientific Society, Ministry of Electronics and Information Technology (Melty), Govt of India).
IDA Phase-III,Cherlapally, HCL (PO),
Hyderabad-500051
Telangana State
INDIA.

Report Number : VLL/VLS/18-19/10658/01
Issued Date : 2018-12-10
Your Ref : HD/PUR/SP-32/GASAN/84/2018-19/5-12-2018
And Date : 2018-12-05

SAMPLE PARTICULARS : SOURCE EMISSION MONITORING AT INCINERETOR STACK

Sample Registration Date	: 2018-12-08	Sampling Date	: 2018-12-08
Analysis Starting Date	: 2018-12-10	Analysis Completion Date	: 2018-12-10
Test Required	: Oxygen, Carbon Monoxide, Carbon dioxide, Sulphur Dioxide and Oxides of Nitrogen;		
SAMPLE COLLECTED BY VIMTYA LABS LTD		LAB REF.:EC	

TEST REPORT

Sl. No.	PARAMETERS	UOM	METHOD OF TESTING	RESULTS	Limits
1	Diameter of stack	m	-	0.5	-
2	Flue gas temperature	°C	-	58	-
3	Velocity	m/sec	-	6.5	-
4	Volumetric flow rate	Nm^3/Sec	-	1.128	-
5	Volumetric flow rate	Nm^3/Sec	-	4061.52	-
6	Oxygen	%	Flue Gas Analyzer	8.4	-
7	Carbon Monoxide	mg/Nm^3	Flue Gas Analyzer	3.7	100
8	Carbon Dioxide	%	Flue Gas Analyzer	7.32	-
9	Sulphur Dioxide	mg/Nm^3	Flue Gas Analyzer	BDL	200
10	Oxides of Nitrogen	mg/Nm^3	Flue Gas Analyzer	55.35	400

Instruments used: For HF and HCl – Ion selective Electrode analyzer;
All the Values are represented at 11% O_2

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Group Leader-Environment

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Lab Report

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Hyderabad-500051
Telangana State. INDIA.

Report Number : VLL/VLS//18/010658/02
Issue Date : 2018-12-21
Your Ref : HD/PUR/SP-32/GASAN/84/2018-19/5-12-2018
and Date : 2018-12-05

Sample Particulars: SOURCE EMISSION MONITORING FOR INCINERATOR STACK

Sample Registration Date: 2018-12-08
Analysis starting date : 2018-12-10
Sampling Date : 2018-12-08
Analysis Completion date: 2018-12-21
Quantity received: XAD Module, Filter Paper and Methanol/$MeCl_2$ Line Washing:
Samples collected at E-WASTE CALICINATION / INCINERATION:
Test Required: PCDD and PCDF:
SAMPLE COLLECTED BY VIMTA LABS LTD
LAB REF.: EC;

TEST RESULTS

Sl. No.	PARAMETERS	UOM	RESULTS
1	Height	m	6.0
2	Diameter of stack	m	0.5
3	Load	Kg/hr	100
3	Flue gas temperature	°C	58
4	Velocity	m/sec	6.5
5	Volumetric flow rate	Nm^3/hr	4061.52
6	Oxygen as O_2	%	8.4
Dioxin and Furans			
6	2,3,7,8-TCDF	ng/Nm^3, TEQ	0.00233
7	1,2,3,7,8-PeCDF	ng/Nm^3, TEQ	0.00171
8	2,3,4,7,8-PeCDF	ng/Nm^3, TEQ	0.00181
9	1,2,3,4,7,8-HxCDF	ng/Nm^3, TEQ	0.00171
10	1,2,3,6,7,8-HxCDF	ng/Nm^3, TEQ	0.00220
11	2,3,4,6,7,8-HxCDF	ng/Nm^3, TEQ	0.00181
12	1,2,3,7,8,9-HxCDF	ng/Nm^3, TEQ	0.00164
13	1,2,3,4,6,7,8-HpCDF	ng/Nm^3, TEQ	0.00175
14	1,2,3,4,7,8,9-HpCDF	ng/Nm^3, TEQ	0.00216
15	OCDF	ng/Nm^3, TEQ	0.00202
16	2,3,7,8-TCDD	ng/Nm^3, TEQ	0.00217
17	1,2,3,7,8-PeCDD	ng/Nm^3, TEQ	0.00237
18	1,2,3,4,7,8-HxCDD	ng/Nm^3, TEQ	0.00234
19	1,2,3,6,7,8-HxCDD	ng/Nm^3, TEQ	0.00215
20	1,2,3,7,8,9-HxCDD	ng/Nm^3, TEQ	0.00189
21	1,2,3,4,6,7,8-HpCDD	ng/Nm^3, TEQ	0.00191
22	OCDD	ng/Nm^3, TEQ	0.00172
Total Furans & Dioxins		ng/Nm^3, TEQ Corrected to 11% O_2Concentration	0.03369
Limit		ng TEQ/Nm^3	0.1

Method of Testing: As per USEPA Method- 23A & 8290
Instrument used: Auto Spec premier (HRGC/HRMS)
Minimum Detectable Limit – 0.01pg
All the values are corrected to 11% O_2 as per CPCB guidelines.

Dr.SubbaReddy Mallampati
Group Leader-Environment

Metal Extraction from PCB Recycling:
Demonstration Plant

C-MET Hyderabad

Status:
ToT ready up till black copper & also precious metal

End user:
Copper smelters, E- waste recyclers

Capacity: 30 TPA

100Kg PCB (3.5MT e-waste) /batch

EPPL Bangalore

Capacity: 300 TPA

1000Kg PCB (35MT e-waste) /day

Metal Extraction from PCB Recycling:
Demonstration Plant
C-MET Hyderabad

E-Waste Demo Plant at C-MET

Electro-Refining unit
(5kg/day Deposition rate)

Anode Mud
Leaching Unit

Metal Extraction from PCB Recycling:
Demonstration Plant

EPPL Bangalore

Indigenously designed and fabricated low cost furnace for smelting of PCBs.

Ingots of Black copper

Metal Extraction from PCB Recycling:
Demonstration Plant
EPPL Bangalore

Scaled up Electrolysis of Anode Copper to 99.9 % pure copper, collection of precious metals rich anode slime

Ingots of fire refined copper

Typical Potential Materials from e-waste:
Demonstration Plant

E-waste mixture (Desktop, laptop, refrigerator, TV, Washing machine etc.) 35MT

a.	Ferrous (iron & steel) :	13.80 MT (39%)
b.	Non ferrous (Cu, Al, Pb, Sn etc) :	10.20 MT (29%)
c.	Plastics:	8.00 MT (23%)
d.	Glass:	2.00 MT (06%)
e.	PCB:	1.00 MT (03%)

a., b. and d. to be sold to smelter based on their market value
c. and e. would be processed

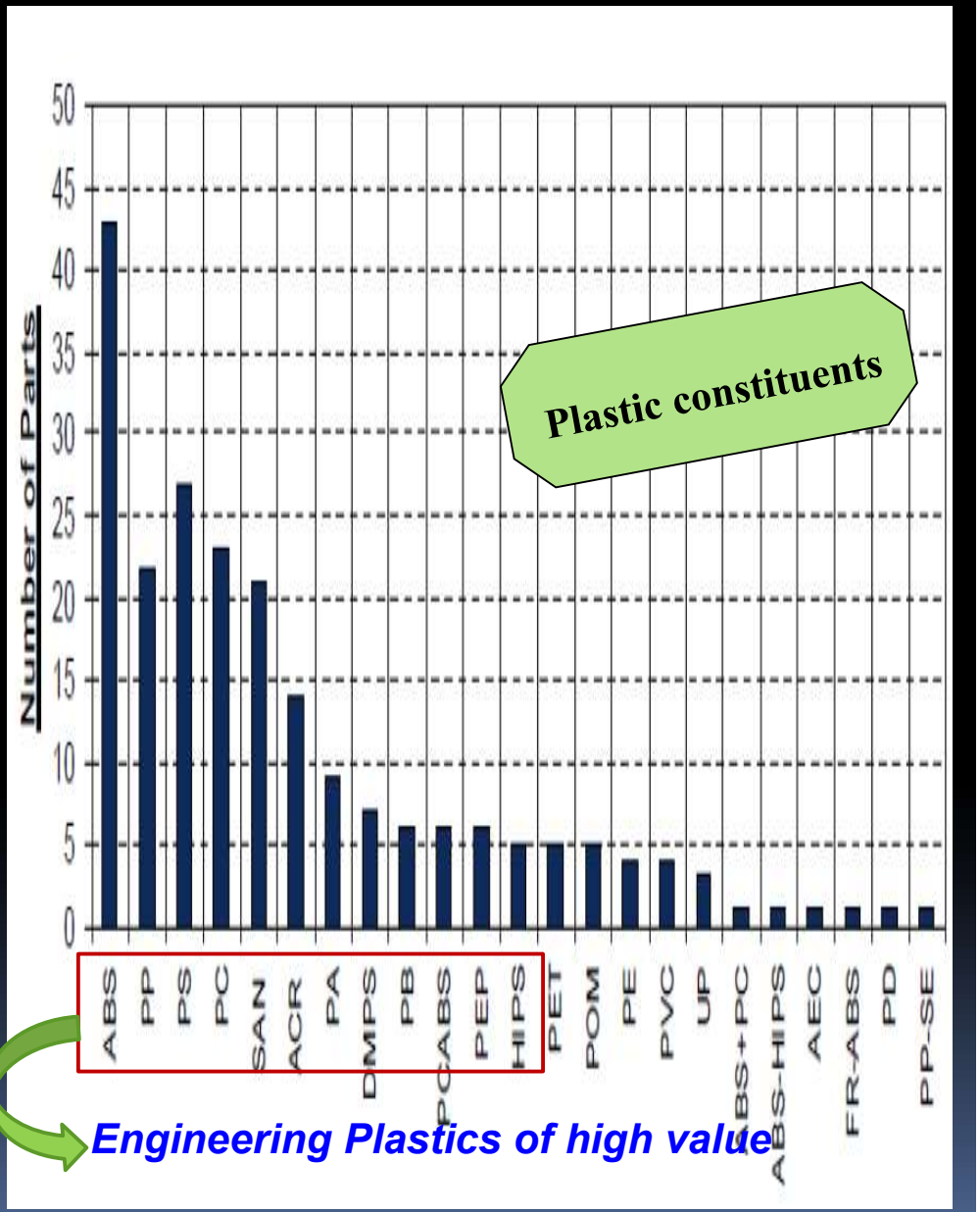
**** Li-ion battery mixture (of mobile, laptop, tubular batteries etc. 10MT***

a.	Aluminum:	1.50 MT (15%)
b.	Copper :	1.00 MT (10%)
c.	Cobalt:	1.80 MT (8%)
d.	Lithium:	0.18 MT (2%)
e.	Plastic:	0.90 MT (9%)
f.	Carbon:	2.00 MT (20%)
g.	Electrolyte:	1.90 MT (19%)
h.	Steel, Nickel, others:	0.72 MT (7%)

a., b. c. d. e and h would be recovered

Technology developed for E-waste Plastics

- 7 categories of plastics (ABS, HIPS, PC, PP, PVC, nylons, Epoxy, phenolic, Polyesters etc.) Segregated in 3 Types:
  - Homogenous type ***Type 1:*** (76%): housing, mouse etc.. Processing technology developed to convert these plastic to Master batch for value added product, gained virgin properties, Process patented. TOT in progress
  - Heterogenous type: ***Type 2 (***20.5%): connectors, catridge, etc., & ***Type 3 (***3.5%): Thermoset plastics containing BFR, fillers & heavy metals



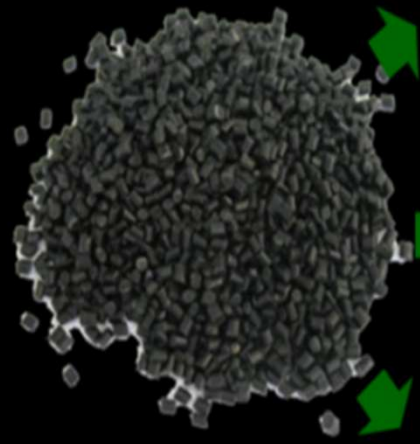
CIPET, Bhubaneswar

Technology developed for E-waste Plastics

CIPET, Bhubaneswar

Collection, segregation/ identification of plastics

Grinding, washing mechanical recycling



Blending with additives & fillers for properties optimization

Other Materials Processed : *Demonstration Plant*

- All types of wires/ connectors
- CFL / Fluorescent Tube
- Rare earth materials from Phosphors (Yttrium, Europium etc.)
- Rare earth materials from Neodymium (Nd) from Hard disc

Way forward

- Create infrastructure: Eco-park with public and private funding
- Provide affordable technologies, adequate tools machineries, handholding and training to informal sector: To make them formal
- Creating awareness to all stakeholders to channelize the materials to created infrastructures and formal sector
- Next step should be benchmarking the created facility and auditing the standard