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EXTRACTION OF METALS FROM E-WASTE THROUGH HYDROMETTALLURTGY PROCESS

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Abstract:

E-waste production in great amounts and its problems, which challenges the field of waste And Environment Management, stem from the increase in the production of the electronic Appliances, diversity-seeking consumer, and perishable product. To solve the problem and exact valuable metals by hydrometallurgy, leaching and organic solvent are used. To do this after a specific amount of electrical and electronic waste was crushed, ground, and refined

(Screening), it was sampled. Then, the sample was washed with water to remove out dust. Leached in to the mixture of HCl / HNO_3 (Aqua regia) for 48 hours at a room temperature. After that filter a solution by using wattman filter paper. After separation a filtrate and residue, obtain filtrate part placed in muffle furnace for calcination process. Temperature was maintained 730- 800 degree Celsius. A compact Nano-crystalline (salt powder) has been obtained.

Key words: E-Waste, leaching, filtration, calcination,

1. INRODUCTION

The demand of electrical and electronic equipment (EED) has increased dramatically with the advancement in technology. . The fast development of technology has lead to an increase in a new generation of electronic and electrical waste in the world and has seriously threatened the environment and natural resources. . E-waste like Printed Circuits Boards (PCBs), as the major part of waste, is a considerable source of valuable base metals such as gold, silver and copper. In recent years, a large number of base and valuable metal recycling activities from PCBs waste have focused on pyrometallurgical process. Electronic and electrical

waste is usually processed using modern methods like Pyrometallurgical and Hydrometallurgical. Recovering precious metals from E-waste through hydrometallurgical process is more attractive economically than other methods. In recent decades, a large amount of research has been conducted on recovering metals, using hydrometallurgical methods. In comparison with other pyrometallurgical methods, hydrometallurgical methods are more accurate and predictable. A hydrometallurgical process consists of first a set of operation including acidic or alkaline dissolution (leaching) of solids. The resulting solutions are then exposed to separation and purification methods including deposition, solvent extraction and adsorption in order to isolate and concentrate the intended metals. Eventually, to recover the metals, the solutions are treated using the process of electrolyte recovery, chemical recovery, and crystallization.

1.1. Definitions, classification , and composition of E- waste

There is no standard definitions for E-waste. E-waste embraces various forms of EEE (electrical and electronic equipment) that have no value to their owners. The reported definitions of E-waste in literature are described here.

“Electrical or electronic equipment which is waste …..Including all components, sub-assembles and consumables which are part of the product at the time of discarding.”

E-waste is divided into ten ten categories based on WEEE (Global production of E-waste) is given in Table 1.1 E- Waste is a complex mixture composed of ferrous, nonferrous, plastic and ceramic, material. Composition in electric and electronic equipment is summarized in Table 1.2

Table 1.1 categories of E-waste based on WEEE (Global production of E-waste).

No.	Category	Label
1	Large household appliances	Large HH
2	Small household appliances	Small HH
3	IT and telecommunications equipment	ICT
4	Consumer equipment	CE
5	Lighting equipment	Lighting
6	Electrical and electronic tools (with the exceptions of large-scale stationary industrial tools)	E & E tools
7	Toys, leisure and sport equipment	Toys
8	Medical devices (with the exception of all implanted and infected products)	Medical equipment
9	Monitoring and control instruments	M & C
10	Automatic Dispensers	

Table1.2 Main materials found in electrical and electronic equipment (EEE).

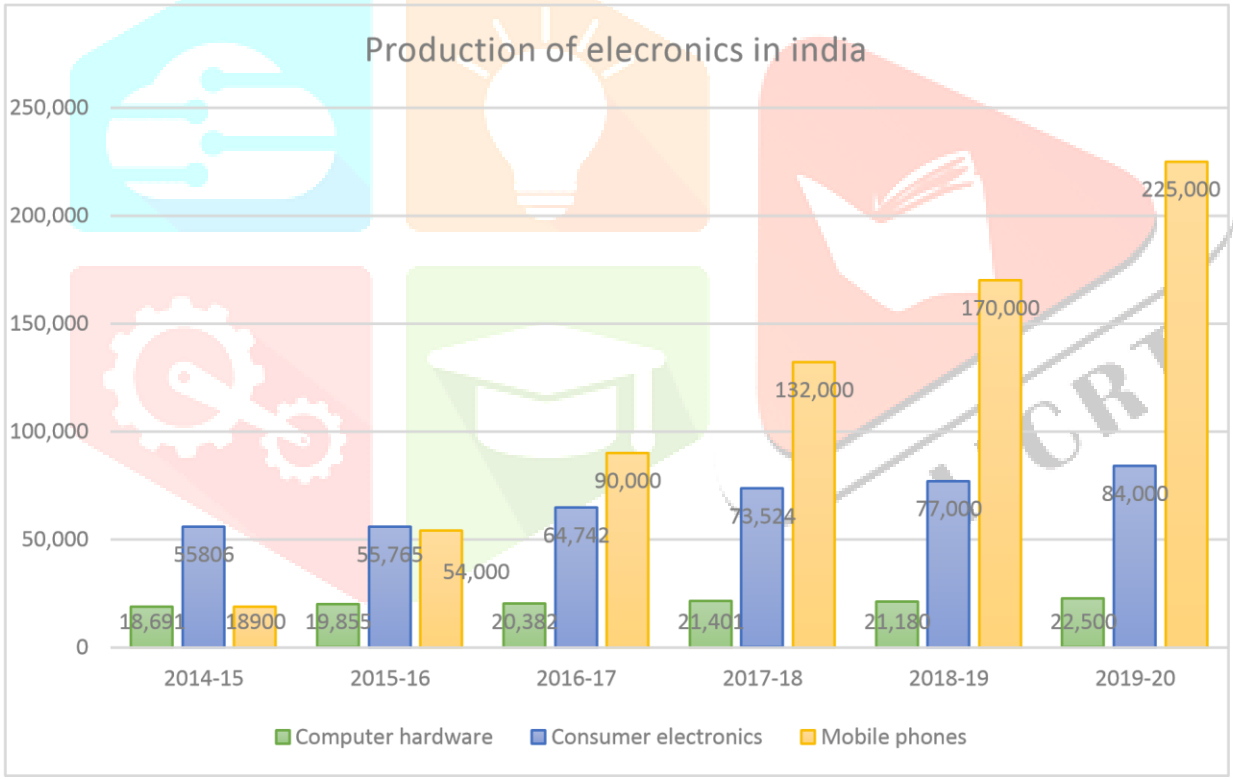
No.	Material	Percentage
1	Ferrous	38
2	Non-ferrous	28
3	Plastics	19
4	Glass	4
5	Wood	1
6	Other	10

Printed circuit boards (PCBs) are found in electrical and electronics appliances (televisions, computers, mobile phones and laptops). Generally, PCBs are composed of 40% metals, 30% plastics and 30% ceramics [6]. PCBs are coated with base metals (BMs) (tin, silver or copper) to make them conductive.

1.2. E-waste generation

Actual data on generation or import of e-waste is a hard task to do. Several studies have been conducted by various agencies to find out the inventory of e-waste in the country. India's share in global hardware electronics production is about 3 per cent. The production of mobile handset and Liquid Crystal Display (LCD) and Light Emitting Diode (LED) products in the country has gone up rapidly, and over the last few years, the demand of these electronic product is increasingly being met by domestic production. Production of cellular mobile phones in terms of volume reached 225 million (22.5 crore) units in 2017-18as compared to production of 60 million (6 crore) units in 2014-15. As same data of consumer electronics and computer are showed in Graph1.1.

Graph.1.1



1.3. How much E-waste does India generate per year?

It's difficult to find actual data of E-waste generation in India. Moreover, data from different sources presents a high degree of variance.

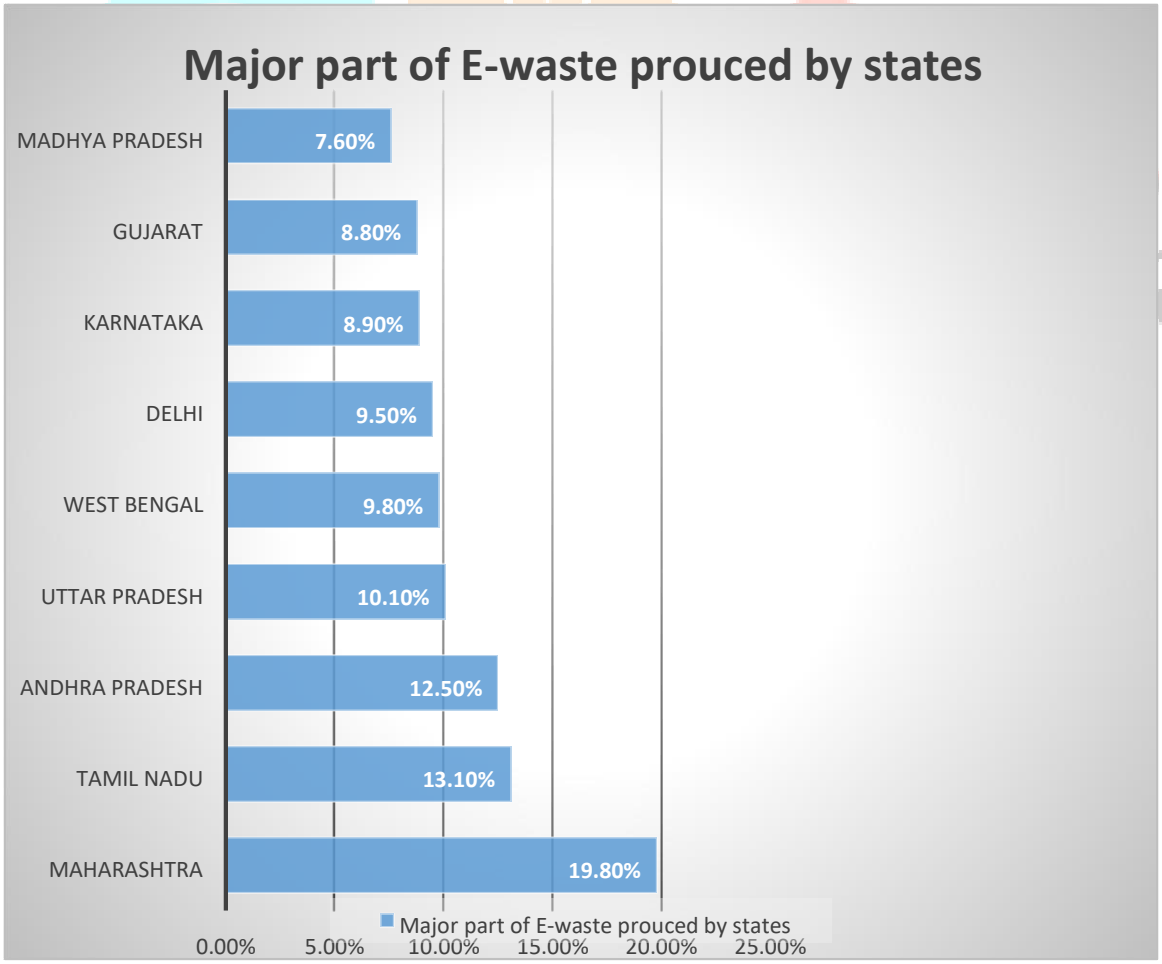
Provided data here is supplemented conjecture data provided by global and national government agencies.

Table 1.3:- Year-wise data of E-waste generation in India

Year	E-waste generation (million metric tons)
2015	1.97
2016	2.22
2017	2.53
2018	2.86
2019	3.23

1.4. Statistics of E-waste generates in states of India.

Sixty-five cities in India generate more than 60% of the total E-waste generated in India. Ten states generate 70% of the total E-waste generated in India. Maharashtra ranks first followed by Tamilnadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh, and Punjab in the list of E-waste generating states in India.



1.5. Different techniques to Treat E-waste:-

During pre-processing metal fraction separated from E-waste. Once this operation is carried out there are various routes for E-waste processing. The following section will explain in more detail about various routes.

1. Hydrometallurgical processes
2. Pyro metallurgical processes
3. Bio-metallurgical processes

2. LITRETURE REVIEW

- In 2007 David studied the process of recovering metals from amorphous solid waste by leaching which is the most important step in the hydrometallurgical process used to extract metals from ore. Amorphous material samples are formed from used industrial catalyst based on Cu, Ni, Al2o3, and physically characterized by Atomic absorption spectroscopy (AAS) and is chemically analyzed to determine the metal content. Then carry out leaching research in sulfuric acid and hydrogen peroxide and ammonia without gas injection to determine which of these will be the best way to deal this type of waste. The result shows that addition of hydrogen peroxide improves metal leaching by 0.2% which is not make distinct difference.
- In 2012 Abhishek Tripathi, Manoj Kumar, Archana Agrawal studied the process of leaching gold from waste PCBs with Ammonium Thiosulfate. In this method the cutting granules of 0.5-3.0 mm PCBs were used for leaching in 500 ml glass beaker in open atmosphere. The effect of various parameters like ammonium thiosulphate concentration, PH, copper sulfate concentration, pulp density was studied. After completion of reaction the maximum leaching of gold in the PH range 10-10.5 may be attributed to the higher stability of ammonium thiosulphate. At end process the maximum leaching was 78.8% gold at all optimized condition.
- In 2015 Flavia P.C Silvas, Monica M. Jimenez Correa studied the process of printed circuit board recycling: physical processing and copper extraction by selective leaching for material recovery and sustainability of electrical and electronic industry. Which is describe a new hydrometallurgical route (leaching process) to recycle printed circuit boards (PCBs) and recover copper. Methodology include PCBs characterization and a combined route of physical and hydrometallurgical processing. Chemical analysis by ICP-OES were

performed .On leaching process were used two stages. First one is sulfuric media and second is oxidant media. The result showed that the PCBs composition was 74.6 wt. % of non-magnetic material and 25.4 wt. % of magnetic one. At the last recovery factor. Was 32 kg of cu in 100 kg of PCBs.

- In 2017 Mohammad Aali Dehchenari, Rahim Aali studied the Hydrometallurgical process of extracting gold from electrical and electronic waste. The process was in six stages includes grinding, leaching in aqua regia, leaching in nitric acid, filtration, extracting gold, washing and purifying. Measurement of extracted precious metals were carried out by ICPOES. The result of this study indicates the purity rate of the final gold recovery yielded

  82.3%.

3. EXPERIMANTEL SECTION

3.1 RAW MATERIAL

This research has contains 10 PCBs (mobile phones) circuits. Collected from various scrap shops and mobile shops & Aqua regia solution.

Figure 3.1 collected PCBs.

3.2 METAL CONTENT IN PCBs.

SR.NO	METALS	PERCENTAGE (%)
1	Cu	49.0%
2	Zn	21.8%
3	Ni	6.5%
4	Al	5.5%
5	Pb	1.9%
6	Fe	11.6%
7	Sn	1.7%
8	Cr	0.5%
9	Au	0.1%
10	Ag	1.5%

- Methodology include PCBs characterization and a combined route of physical and hydrometallurgical processing. On leaching process aqua regia solution was used.

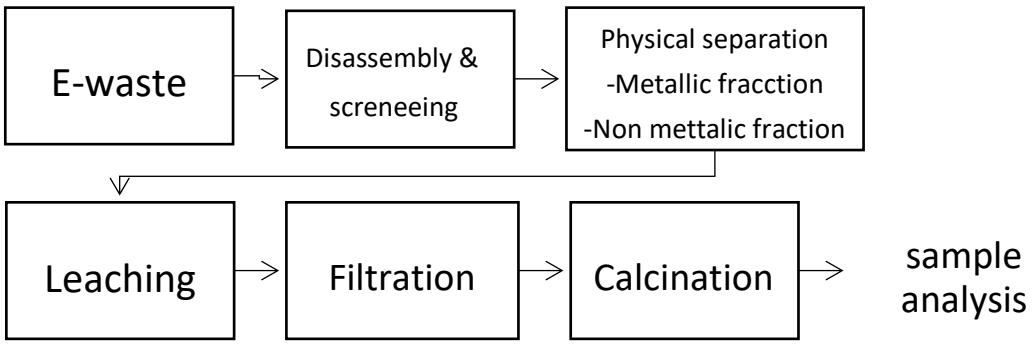
3.3 PHYSICAL PROCESS

In a physical process involves a combination of cutter, knife and hammer. At firstly a PCBs were crushed in a general mixture but that wasn't effective so crushing was continued with initially equipment. Within a 2 to 3 hours we get a small granules of PCBs.

Figure 3.2 small granules of PCBs.

3.4 HYDROMETTALLURGICAL PROCESS

In to the screening part samples of 148 gms screened over 2 times and it remains with mostly metallic part 120 gms. Then leaching part quartering sample of 120 gms were used.



Leaching:

A broken PCBs granules weighed 120 gm put in to a 1000ml beaker and as a leaching agent aqua regia solution were used. To make this solution concentrated HNO_3 and HCL was use in ratio of 1:3. And to dissolve a metallic fraction from granules an aqua regia solution was used in arbitrarily solid: liquid ratio was taken 1:4. And solution kept under room temperature for 48 hours. After completion the process solution was filtrate out.

REACTIONS:

$$2Au + 11HCl + 3HNO_3 \rightarrow 2H[AUCl_4] + 3NOCl + 6H_2O$$

Figure 3.3 Dumped granules in sol.

FILTRATION:

After 48 hours of leaching solution was filtered using watt-man filter paper it took 30-45 minutes to do it. Then after separating residue part was placed in own to dry it. Temperature was 90 degree Celsius. After drying weigh of residue was 50 gm. And filtrate part was 71 gm. Further a filtrate part was send for thermal process to evaporate water molecules in which temperature was maintain 100-120 degree Celsius. It took 3-4 hours to completion then obtain part was 71 gm placed in own to complete dry it.

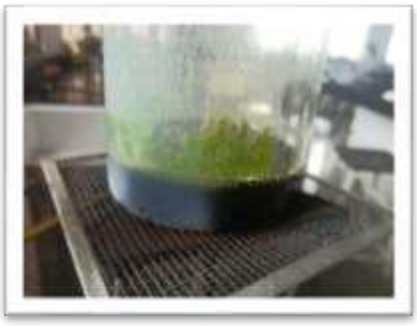


Figure 3.4 Filtrate Placed on Burner.

CALCINATION PROCESS:

After taking out from the own sample is in solid small particle form collected in sample bottle and the further process is in muffle furnace and for that silica crucible has been used. For 5-6 hours sample kept in to a muffle furnace and temperature maintained in between 730-800 Celsius. And then after completing the process as shown in the image we got our metallic salt in powder form.

Figure 3.5 Calcination Process.

3.6 Obtained salt powder

4. Result and Discussion

4.1 Chemical Characterization of Sample:

The MP-AES (Microwave Plasma Atomic Absorption Spectroscopy) is a High sensitivity atomic emission spectrometer that is the perfect alternative to the to the traditional flame Atomic Absorption Spectroscopy (AAS) technique.

The loss during the milling route (combination of knife and hammer) was less than 6 wt.%, a worth 4 times less than the one obtained by Each of cited used one PCB type worked with PCB from obsolete cellular phones and with PCBs from computers only used hammer mills and crushed at grid and Loss during the comminuted process may occur due fine and light particles like optical. .

Nonetheless, studies showed that PCBs comminution using hammer mill is efficient at industrial scales for comparative purposes, the share in magnetic and nonmagnetic material was calculated and therefore the mass loss was ignored. Comparing the results obtained within the magnetic separation for PCB from printers with those found within the literature for PCBs from computers and cell phones.

MP-AES Image of the metals concentration in that analysis shows that mainly contained copper and some traces of iron. Hydrometallurgical flow route resulted from study showing that cu can be selectively recovered from PCBs as copper with some other compound composition. These PCBs can be hydrometallurgical reprocessed and can be used as potential secondary resource for cu production.

As in figure 4.1 shows a spectra of metals we got by Hydrometallurgy process copper is highest yielded because of a PCBs contains most of metallic part is copper and different solution are being used for extraction of metals But in small scale a preferable and also a for better result Hydrometallurgy process can be used.

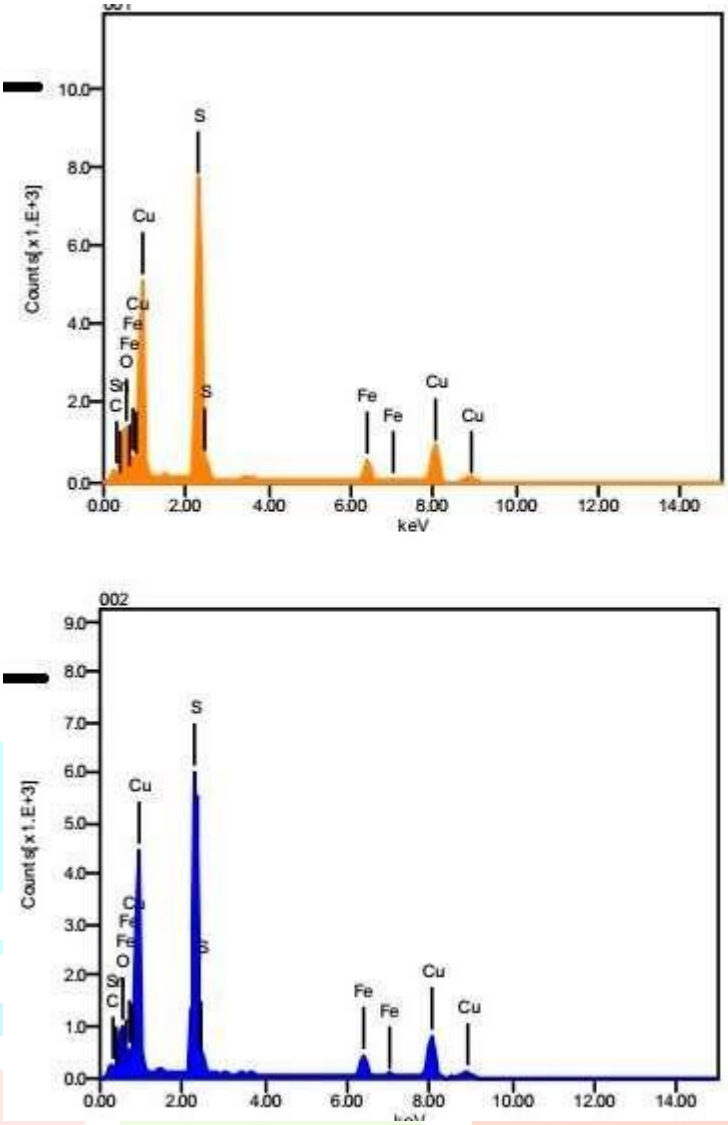


Figure 4.1 MP-AES spectra of metals

Analysis MP-AES was done on 3 gm obtained sample result shows that 95% copper is being recovered from PCBS.

5. CONCLUSION

Concerning the physical processing, it can be concluded that 74.6 wt.% in mass correspond to non-magnetic (NMA) material and 25.4 wt.% to magnetic (MA). Printed circuit boards (PCBs) from printers are composed by: 44 wt.% metals, 28.5 wt.% polymers and 27.5 wt.% ceramics. Also, the chemical analysis showed that PCBs metal composition is: 0.3 wt.% Ag; 3.7 wt.% Al; 0.004 wt.% Au; 32.5 wt.% Cu; 1.4 wt.% Fe; 0.3 wt.% Ni; 0.9 wt.% Sn; 0.6 wt.% Zn, and 4.1 wt.% corresponds to the sum of other metals. On the leaching the extraction percentage of Cu was 100 wt.%, of Zn 60 wt.% and of Al 10 wt.%. At the end of the hydrometallurgical processing was obtained 100% of copper extraction and the recovery factor was 98.46%, which corresponds to a 32 gm of Cu in 100 gm of PCB.

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