**Case Report**
Volume 12:6, 2022

Journal of Civil and Environmental Engineering

ISSN: 2165-784X Open Access

# Optimization Studies on E-waste for the Recovery of Zinc and Aluminium by Electro Deposition

**P Sivakumar*, D Prabhakaran and M Thirumarimurugan**

*Department of Chemical Engineering, Coimbatore Institute of Technology, Tamil Nadu, India*

## Abstract

The world produces 50 million tons of electronic and electrical waste (e-waste) per year, according to a recent UN report, but only 20% is formally recycled. The rest ends up in landfill, or is recycled informally in developing nations. E-waste recycling market in India is predominantly controlled by unorganized sector due to absence of stringent laws and policy framework. Electronics products in the country are reaching their end of life sooner than expected, which has created immense pressure on the government to come up with appropriate laws to promote e-waste recycling and management. Most electronics that are improperly thrown away contain some form of harmful materials such as beryllium, cadmium, mercury and lead. These materials might be trace elements, but when added up in volume, the threat to the environment is significant. However electronic waste also contains fair percentage of precious metals like Cu, Ag, Au, Pt etc. These metals can be recovered from e-waste at cheaper cost than from the usual ores. Several techniques are used to recover precious metals like copper, silver and gold. This paper deals with the collection and segregation of precious metal rich e-waste scrap and leaches zinc and Aluminium effectively by adopting the technique namely Electrodeposition. The composition of Zinc and Aluminium present in the resultant leached product from each technique is analyzed by EDS. A manual comparison of purity, yield percentage, energy consumption will be tabulated and optimization for the three processes will be simulated using Response Surface Methods (RSM) in design-expert software v.11.

**Keywords:** E-waste • Precious metals • Electrodeposition • Optimization • RSM • Design-expert software

## Introduction

E-Waste could be a term wont to cowl things of every kind of electrical and equipment and its components that are discarded by the owner as waste while not the intention of re-use [1]. Metal contamination in the environment is a persisting global issue [2]. The metal reservoirs in the earth have declined due to society's needs and due to uncontrolled mining activities [3]. Therefore, the concept to recover metals from waste streams has emerged [4].

The cost competitive technologies like surface assimilation exploitation agro-wastes and precipitation exploitation an Inverse Fluidized Bed (IFB) reactor were investigated, with special emphasis on the recovery of base metals. Groundnut shell showed smart potential for metal (Cu, Pb and Zn) removal [5]. From artificial neural network modeling, the performance of the Sulfate Reducing Bacteria (SRB) was found to be strongly pH dependent; the removal efficiency of Cu and Zn in the IFB at pH 5.0 was >97%. Electronic waste is a good candidate as secondary metal resource [6]. The recovery of Zinc and Aluminium from computer Printed Circuited Boards (PCBs) using biogenic sulfide precipitation was investigated as well [7]. Using this technology, metals could be recovered at ~0.3 g/g-0.48 g/g PCBs. E-waste could be a in style, informal name for electronic products nearing the end of their useful life [8]. Computers, televisions, VCRs, stereos, copiers, mobile phones and fax machines are common electronic products. Most physics that square measure improperly thrown away contain some kind of harmful materials like atomic number 4, cadmium, mercury and lead. These materials could be trace parts, but when added up in volume, the threat to the environment is significant. However electronic waste also contains fair percentage of precious metals like Cu, Ag, Au, Pd, Rh, Al, Zn etc. These metals can be recovered from E-waste at cheaper cost than from the usual ores. Techniques like Electro deposition is used to recover precious metals like zinc, aluminium copper, silver and gold. E-Waste or Waste Electrical and Equipment (WEEE) is that the term wont to describe previous, end-of-life or discarded appliances exploitation electricity.

## Case Presentation

E-waste use consists of 3 main steps: Assortment, pre process and finish process . Each step is essential for the recovery of metals. E-waste assortment is expedited by applicable government policies,

***Address for Correspondence:** *P Sivakumar, Department of Chemical Engineering, Coimbatore Institute of Technology, Tamil Nadu, India, Tel: 9750609418; E-mail: chemsiva13@gmail.com*



**Received:** 19 August, 2019, Manuscript No. jcde-19-1369; **Editor assigned:** 23 August, 2019, PreQC No. P-1369; **Reviewed:** 06 September, 2019, QC No. Q-1369; **Revised:** 22 August, 2022, QI No. Q-1369; Manuscript No. R-1369; **Published:** 19 September, 2022, DOI: 10.37421/2165-784X. 2022.12.455

effective advertisement for public awareness, and by installing separate collection facilities at public places. End of life electronic components are sorted at the collection facility where useable components are returned to the consumer supply chain.

Pre process of e-waste is one in all the foremost necessary steps within the use chain. (Coombs C) The expired equipment's are manually dismantled at collection facilities and individual components are tested and isolated from e-waste. During the early stage, housing, wiring boards and drives, and other components are separated. Mechanical processing is an integrated part of this stage where e-waste scrap is shredded into pieces using hammer mills Metals and non-metals are separated during this stage using techniques similar to that employed in the extraction, e.g., screening, magnetic, eddy current and density separation techniques.

The final stage within the use chain of e-waste is that the finish process, where the non-metal and metal fractions of e-waste are further processed. There are variety of studies on the use and utilization of the non-metals fractions from e-waste, for example from wasted PCBs that contain >70% of non-metallic fractions. In general, the non-metallic fractions of PCBs square measure chiefly composed of thermosetting resins and glass fibers. Thermoset resins can't be re-melted thanks to their chain structure.

Electro deposition is a deposition of a substance on an electrode by the action of electricity in an electro chemical reactor. Electro chemical reactor consists of anode, cathode separated by iron permeable membrane. Complete recovery of metal will be at the cathode. Re-generation of chlorine will be at the anode. Completed recovery of copper, gold, silver, lead and palladium from the leachate solution is possible by electro deposition method about eight hours, with high current efficiency (Figure 1).

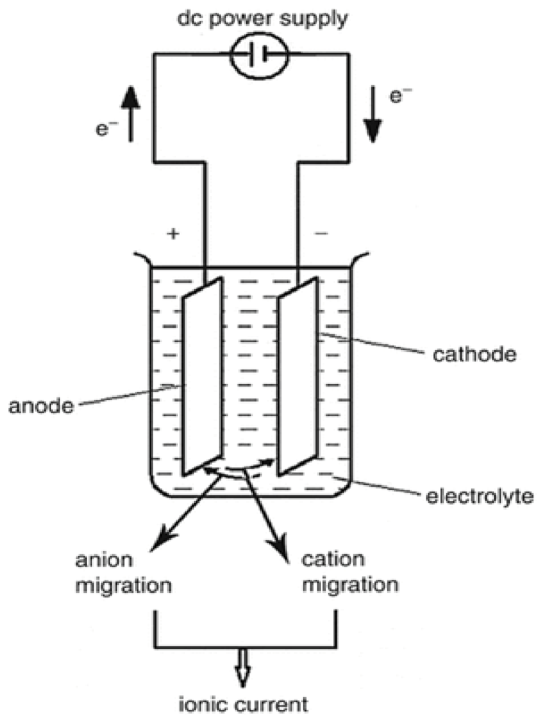



**Figure 1.** Schematic representation of electro winning process.

### Design expert software

Design-expert is a piece of statistical software installed to design and interpret multi-factor experiments. In metallurgical processing, the software is used to design an experiment to see how certain parameters varies with the processing conditions. The software offers a wide range of designs, including factorials, fractional factors and composite designs. It can handle both process variables and mixture variables. It offers a system generated D-optimal designs for cases where standard designs are not applicable, or where we wish to argument an existing design. This software is not suitable for designing and analysing repeated measures designs of the kind that are often used in the human sciences. In this study, we utilized the latest version of Design-Expert software i.e., version.11.1.2.

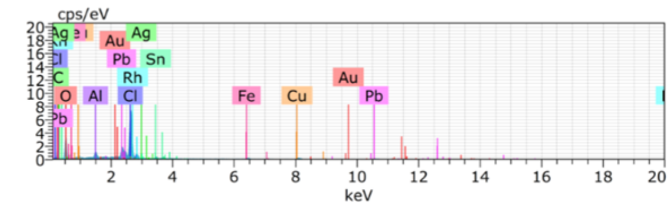
### Data analysis

Process variables can be split into Continuous and Categorical. Here, continuous and categorical variables are coined as Numeric and Categorical variables. Numerical variables can be varied freely over a wide range whereas Categoric variables are subjected to few distinct values.

## Results and Discussion

### Graph from EDS

Energy-Dispersive X-ray Spectrographic analysis (EDS, EDX, EDXS or XEDS), generally known as energy dispersive X-ray analysis (EDXA) or Energy Dispersive X-Ray Microanalysis (EDXMA), is an analytical technique used for the basic analysis or chemical characterization of a sample. It depends on an interaction of some supply of X-ray excitation and a sample. Its characterization capabilities are due in massive half to the {elemental the basic} principle that every element contains a distinctive atomic structure permitting a novel set of peaks on its magnetic force emission spectrum (which is that the main principle of spectroscopy). To stimulate the emission of characteristic X-rays from a specimen, a high-energy beam of charged particles like electrons or protons or a beam of X-rays, is targeted into the sample being studied. At rest, AN atom at intervals the sample contains state (or unexcited) negatrons in separate energy levels or electron shells absolute to the nucleus (Figure 2).




Objects 4426 Date:3/5/2019 3:01:00 PM HV:20.0kV Puls th.:3.45kcps

| El | AN | Series | unn. C [wt.%] | norm. C [wt.%] | Atom. C [at.%] | Error (1 Sigma) [wt.%] |
|---|---|---|---|---|---|---|
| O | 8 | K-series | 25.93 | 31.69 | 40.40 | 3.73 |
| C | 6 | K-series | 22.06 | 26.96 | 45.79 | 3.41 |
| Cl | 17 | K-series | 11.38 | 13.91 | 8.00 | 0.42 |
| Rh | 45 | L-series | 9.75 | 11.92 | 2.36 | 0.36 |
| Pb | 82 | L-series | 7.24 | 8.84 | 0.87 | 0.38 |
| Cu | 29 | K-series | 1.96 | 2.39 | 0.77 | 0.11 |
| Sn | 50 | L-series | 1.31 | 1.60 | 0.27 | 0.08 |
| Al | 13 | K-series | 1.22 | 1.49 | 1.13 | 0.09 |
| Fe | 26 | K-series | 0.88 | 1.08 | 0.39 | 0.07 |
| Au | 79 | L-series | 0.09 | 0.11 | 0.01 | 0.05 |
| Ag | 47 | L-series | 0.00 | 0.00 | 0.00 | 0.00 |
| | | Total: | 81.82 | 100.00 | 100.00 | |

**Figure 2.** EDS analysis of the sample.

## Contour plots from design-expert software

The incident beam might excite an negatron in AN inner shell, ejecting it from the shell whereas making an negatron hole wherever the negatron was. An electron from an outer, higher-energy shell then fills the hole, and the difference in energy between the higher-energy shell and the lower energy shell may be released in the form of an X-ray. The number and energy of the X-rays emitted from a specimen are often measured by an energy-dispersive prism spectroscope. As the energies of the X-rays are characteristic of the distinction in energy between the 2 shells and of the atomic structure of the emitting component, EDS permits the elemental composition of the specimen to be measured (Figures 3-6 and Table 1).

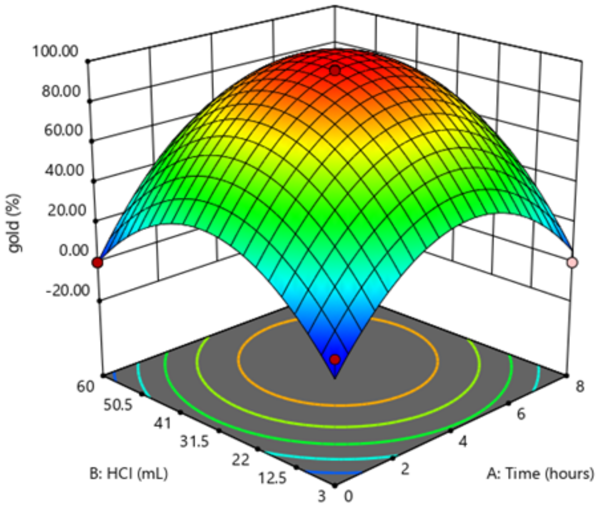



**Figure 3.** Yield % of gold for hydrometallurgy.

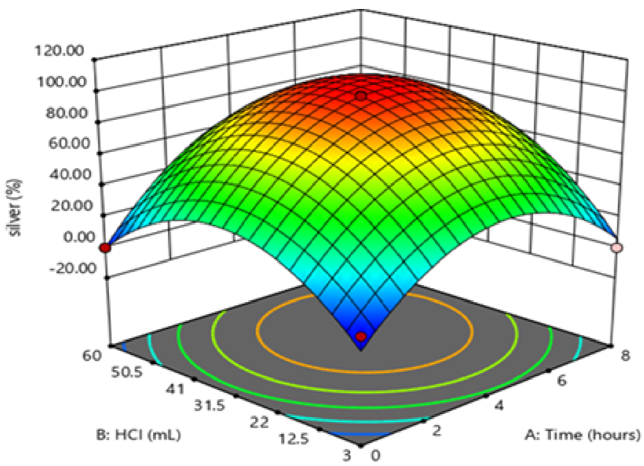



**Figure 4.** Yield % of silver for hydrometallurgy.

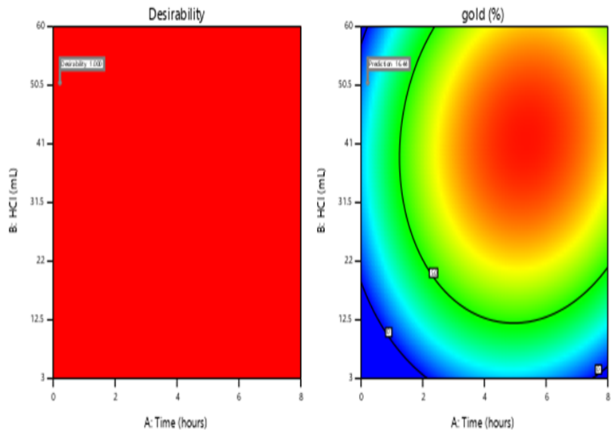



**Figure 5.** Desirability plots for gold.

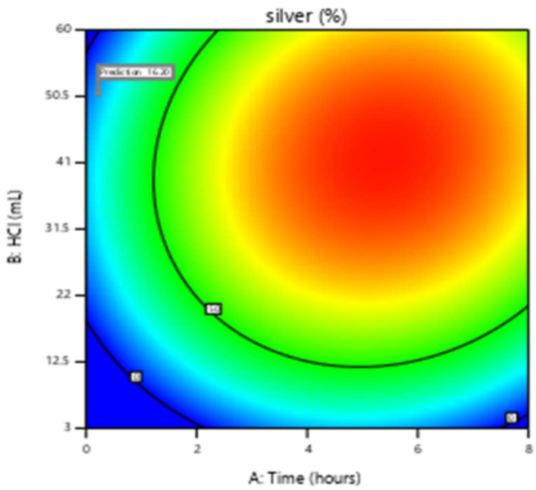



**Figure 6.** Desirability plots for silver.

**Table 1.** Solution table for hydrometallurgy.

| Number | Time (Hours) | HCl (mL) | HNO3 (mL) | Amount of feed (grams) | Yield % of gold | Yield % of silver | Desira-bility | Result |
|---|---|---|---|---|---|---|---|---|
| 1 | 4.08 | 50.564 | 17.302 | 17.726 | 79.519 | 82.656 | 1 | Selected |
| 2 | 4 | 3 | 1 | 10 | 15.506 | 14.668 | 1 | |
| 3 | 4 | 31.5 | 1 | 20 | 8.269 | 6.727 | 1 | |
| 4 | 4 | 31.5 | 10.5 | 10 | 95.152 | 97.269 | 1 | |
| 5 | 8 | 60 | 10.5 | 10 | 47.662 | 50.589 | 1 | |
| 6 | 4 | 60 | 1 | 10 | 7.042 | 6.755 | 1 | |
| 7 | 0 | 3 | 10.5 | 10 | 8.967 | 8.637 | 1 | |
| 8 | 4 | 60 | 20 | 10 | 78.739 | 79.485 | 1 | |
| 9 | 0 | 60 | 10.5 | 10 | 0.169 | 0.139 | 1 | |
| 10 | 4 | 31.5 | 1 | 0 | 0.856 | 1.208 | 1 | |

## Conclusion

It is concluded that the collection and segregation of precious metal rich e-waste scrap and leaches zinc and Aluminium effectively by adopting the technique namely Electrodeposition. The composition of Zinc and Aluminium present in the resultant leached product from each technique is analyzed by EDS. A manual comparison of purity, yield percentage, energy consumption will be tabulated and optimization for the three processes will be simulated using response surface methods.

## References


1. Anindya, Alicia. "Minor Elements Distribution During the Smelting of Weee with Copper Scrap." PhD Diss., RMIT University 2012.
2. He, Wenzhi, Guangming Li, Xingfa Ma, and Hua Wang, et al. "WEEE Recovery Strategies and the WEEE Treatment Status in China." *J Hazard Mater* 136 (2006): 502-512.
3. Kusch, Sigrid, and Colin D. Hills. "The Link between E-Waste and GDP New Insights from Data from the Pan-European Region." *Resources* 6 (2017): 15.
4. Behnamfard, Ali, Mohammad Mehdi Salarirad, and Francesco Veglio. "Process Development for Recovery of Copper and Precious Metals from Waste Printed Circuit Boards with Emphasize on Palladium and Gold Leaching and Precipitation." *Waste Manag* 33 (2013): 2354-2363.
5. Robinson, Brett H. "E-waste: An Assessment of Global Production and Environmental Impacts." *Sci Total Environ* 408 (2009): 183-191.
6. Xakalashe, Buhle S, Randburg Mintek, K Seongjun, and J Cui, et al. "An Overview of Recycling of Electronic Waste Part 2." *Chem Technol* (2012): 23-26.
7. Busselle, Lincoln D, Ted A Moore, John M Shoemaker, and Ronald E Allred, et al. "Separation Processes and Economic Evaluation of Tertiary Recycling of Electronic Scrap." *Proc 1999 IEEE Int Sympo Electron Environ* (1999): 192-197.
8. Borthakur, Anwesha, and Pardeep Singh. "Electronic waste in India: Problems and policies." *Int J Environ Sci* 3 (2012): 353-362.


**How to cite this article:** Sivakumar, P, D Prabhakaran and M Thirumarimurugan. "Optimization Studies on E-waste for the Recovery of Zinc and Aluminium by Electro Deposition." *J Mater Sci Eng* 12 (2022): 455.