



Determination of Some Heavy and Precious Metals from Printed Circuit Board (PCB) from a Television Set by Atomic Absorption Spectrophotometer

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Aim: This research work aimed to determine the concentrations of some heavy and precious metals from printed circuit board (PCB) of a television set using Atomic Absorption Spectrophotometer (AAS) in order to identify elements with higher concentration as target source of raw materials for metal recovery.

Study Design: Grab sampling technique was applied in this study. The study area was a refuse dump site at computer village Ogbunabali, Port Harcourt.

Place and Duration of Study: This study was carried out at computer village Ogbunabali, Port Harcourt, Rivers State, Nigeria between 2020 and 2021.

Methodology: The metal fractions attached to the PCB were subjected to mechanical separation, placed inside a 75ml Kjeldahl flask and thereafter digested with a 20ml nitric acid (HNO₃). The prepared sample was filtered, then made up to 100ml using distilled water and analysed using AAS (Shimadzu model AA6300).

Results: The results showed the presence of some heavy metals such as: (Fe, 0.0644mg/l, Pb, 0.0732mg/l, Cu, 0.0627mg/l, Ni, 0.1076mg/l and Cd, 0.0001mg/l) in higher concentrations (apart from Cd) than the precious metals (Au, 0.0297mg/l, Pd, 0.0042mg/l, Ag, 0.0316mg/l and Li, 0.0019mg/l). This confirmed that the PCB which is an electronic waste was largely made up of heavy and precious metals.

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Conclusion: Metals can be determined effectively from electronic waste using HNO_3 and AAS. It is therefore, recommended that proper recycling methods should be put in place in order to reduce the pollution caused by these electronic wastes.

Keywords: Electronic waste (e-waste); printed circuit board; metal recovery; AAS; HNO_3 .

1. INTRODUCTION

In the world today, there is an exponential increase in the consumer demand for modern electrical and electronic equipment (EEE), as a result of the latest technological development in their manufacturing and designing. This high demands as well as change in consumer tastes have unwittingly shortened the useful life of these electrical and electronic devices. Thus, these out-of-date devices are continually being discarded into the environment, where they infiltrate into soil and groundwater aquifer, causing environmental pollution. The discarded devices have contributed in no small measure to the global generation of huge quantities of waste electrical and electronic equipment (WEEE) [1] that needs to be properly managed.

[2] viewed electronic wastes (popularly called e-wastes) as dangerous since they contain hazardous materials such as minerals, energy and chemicals used for their manufacturing. Their hazardous natures also depend on their condition and density [3]. E-waste comprises of all the components, sub-assemblies and consumables, which are part of the product at the time of discarding [4]. It contains a mixture of ferrous, non ferrous, plastic and ceramic materials [4] and more than 1000 different substances which are classified as hazardous when discarded [5]. E-waste also contain precious metals (PMs) such as gold (Au), silver (Ag), palladium (Pd), platinum (Pt), rhodium (Rd), iridium (Ir), etc and heavy metals such as lead (Pb), nickel (Ni), zinc (Zn), iron (Fe), copper (Cu), mercury (Hg), cadmium (Cd), etc. [6] noted that precious metals are widely used in the manufacture of electronic appliances due to their high chemical stability and good conducting properties. E-wastes are categorized as discarded computers, television, call phones, refrigerators, copiers, fax machines, electrical lamps and batteries.

The generation of e-waste globally is increasing exponentially [7] and is expected to skyrocket far beyond human imagination, in the near future [8,2]. At present, 20 to 25 million tons of e-waste are being generated globally in a year with

Europe, United States of America and Australia taking the lead [4]. In the developing countries, there is a substantial increase in e-waste generation. This is as a result of the forecasted economic growth [9]. A study carried out by [10] showed that an average of 5 million secondhand computers weighing 60,000 tonnes entered Nigeria through Lagos port, out of which nearly 30,000 tonnes were non-functional or irreparable.

The composition of e-waste differs chemically and physically from domestic and industrial wastes. Chemically, it consists of metals, metalloids, halogenated compounds and radioactive elements [5]. Physically, we have printed circuit boards (PCBs), cathode ray tubes (CRTs), epoxy resins, rubber and so on [11]. PCBs are commonly found in consumer electronics such as televisions, mobile phones, laptops and computers [4]. PCBs are essential parts of almost all electrical and electronic equipment, and they constitute about 3% of the total electronic scraps by weight [12]. PCB contains noble metals, rare metals; platinum group metals (PGMs), resin and glass [13]. [14] and [4] discovered that PCBs are 40% metals, 30% plastics and 30% ceramics. [9] investigated the composition of spent PCBs from mobile phones and personal computers and discovered that PCBs from mobile phones had higher (34.5%) copper contents while personal computer (20%).

Although, it is on record that researchers from countries like India, Japan, Korea, Australia, Turkey and Norway have extracted, recovered and even recycled wastes and precious, base and heavy metals from electrical and electronic equipment in their countries, according to their legislation, employing mechanical processing, hydrometallurgical [15], pyrometallurgical [16], electrometallurgical routes and biometallurgy [17], there is no report on the determination and recovery of potentially toxic elements from e-wastes obtained from electronic or computer villages in Nigeria using Atomic Absorption Spectroscopy (AAS). For this reason, the PCB from a discarded television set was chosen to be studied. Therefore, this study is aimed at determining heavy and precious metals from

PCB of a television set by the use of AAS. The study will be beneficial economically and environmentally. The determined metals will help to provide a new source of cheap and easily available metals which might be relevant for use in our industries.

2. MATERIALS AND METHODS

2.1 Materials

The materials and equipment used include 5g of sample, 20ml HNO₃, 75ml Kjeldahl flask, 100ml volumetric flask, whatman No. 42 filter paper, AAS, analytical weighing balance, pipette, distilled water.

2.2 Methods

2.2.1 Sample collection

The PCB part attached to the Sony television waste were separated and collected at a refuse dump at computer village Port Harcourt, Rivers State, Nigeria and transported to Jach Petro-Analytical Laboratory Limited, Rumuokwursi, Port Harcourt for sample preparation and analysis.

2.2.2 Sample preparation

The e-waste was subjected to mechanical separation were the plastic parts and hazardous parts were separated and disposed safely without creating any harm to the environment. After the separation, 5g of the sample was weighed and placed in a 75ml kjeldahl flask. Twenty ml [20ml] of HNO₃ was measured using a pipette and poured into the flask containing the weighed sample. These were allowed to stay for 48hours, in order for the sample to properly digest all of its oxidizable metals into the solvent (HNO₃). The contents of the flask were digested until the brown fumes of nitrous oxide ceased to

appear. The prepared samples were filtered using Whatman No.42 filter paper into a 100ml volumetric flask. Distilled water was used to make up the solution to 100ml.

2.2.3 Sample Analysis

The concentrations of Fe, Pd, Cu, Ni, Cd, Au, Pb, Ag and Li were analyzed using AAS [Shimadzu model AA6300]. The instrument was calibrated based on the individual metals. 1.000g of Ni and Cu metals each were dissolved in 200ml of concentrated HNO₃ and diluted to 1L in a volumetric flask with deionized water. 1.000g of Ag metal was dissolved in 20ml of HCl and 2 drops of concentrated HNO₃ (aqua regia) and diluted with deionized water. Also 1.000g of Li metal was dissolved in 25ml HNO₃ and diluted to 1L in a volumetric flask with deionized water. Aqua regia (HCl = HNO₃) was used to dissolve Au and Pb. A mixture of H₂SO₄ and H₂O₂ was used for the dissolution of Fe and Cd while NaCl was used to leach Pb.

The data were analyzed in triplicate and the mean concentration values were recorded.

3. RESULTS AND DISCUSSION

The concentrations of each of the metals analysed in mg/l, mg/kg and weight percent are shown in Table 1.

The results indicate that the PCB of a television set contains higher amount of Ni (0.1076mg/l), followed by Pb (0.0732mg/l) as compared to other heavy metals analysed. Among the heavy metals analysed, Cd (0.0001mg/l) was the least metal found in a television PCB. Amongst the precious metals analysed, Ag (0.0316mg/l) had the highest concentration while Li (0.0019mg/l) recorded the least concentration. Although, the values of the concentrations in weight % of the heavy metals differ significantly from those

Table 1. Concentration of metals from PCB of a television

S/N	Metals	Concentration (mg/l)	PPM (mg/kg)	Weight percent (wt %)
1	Fe	0.0644	1.288	0.0001288
2	Pb	0.0732	1.464	0.0001464
3	Cu	0.0627	1.254	0.0001254
4	Ni	0.1076	2.152	0.0002152
5	Cd	0.0001	0.002	0.0000002
6	Au	0.0297	0.594	0.0000594
7	Pd	0.0042	0.084	0.0000084
8	Ag	0.0316	0.632	0.0000632
9	Li	0.0019	0.038	0.0000038

recorded by (7): Fe (20.4712%), Pb (6.2988%), Cu (6.9287%), Ni (0.8503%), the weight percent values of only Ni matched with the weight percent values recorded for rare earth and valuable metals by (7): Au (0.0016%), Pd (0.0003%), Ag (0.0189%), Ni (0.0002%) and Cd (0.0094%). The high concentrations of heavy metals such as Pb and Cu as shown in Table 1. could be attributed to their use for soldering or preventing oxidation and conductive properties respectively. Also, the weight % value obtained in this study fall within the values obtained by Isildar et al., [2] for PCBs: Au and Pd (1-100ppm), Fe and Ni (100-10,000ppm) and Cu (>10,000ppm).

4. CONCLUSION

Heavy and valuable metals are found in printed circuit board of a television set. Among the heavy metals analysed, Ni recorded the highest concentration while Ag had the highest concentration among the precious metals. Determination of these metals from television PCB using HNO_3 as a solvent and AAS showed favourable presence for the metals. Therefore, AAS is another promising analytical technique for the determination of metals from electronic waste.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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