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# Green Synthesis of CUO Nanoparticles from E Waste: An Eco-Friendly Approach

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***ABSTRACT***
*Nanotechnology is an emerging field of science which is related to manipulation of atoms and molecules that has shown great potential in all fields of sciences. Nanotechnology deals with nanoparticles ranging from size 1 to 100 nm in diameter, due to small size and high surface area eventually increases the state of activity. This review focuses on metal nanoparticles and mainly on green synthesis, characterization and application of copper nanoparticles. Green synthesis of copper is economically beneficial and ecofriendly. Copper nanoparticles are used in diverse fields such as biomedicine, pharmaceuticals, bioremediation, molecular biology, bioengineering, genetic engineering, dye degradation, catalysis, cosmetics and textiles. Structural properties and biological effects of copper nanoparticles have promising effectivity in field of life sciences.*
*An environmentally friendly approach to recover copper as nanoparticles from electronic waste (e-waste) has been presented. Selective leaching of copper from powdered old computers waste printed circuit boards and mobile phones was executed. Characterization tests for the produced copper nanoparticles were performed to confirm its structure. It is considered that studied process is highly efficient and environmentally sustainable for preparing copper nanoparticles from WPCBs with the intention of recycling e-waste to gain a higher valued product.*
***Keywords:*** *E-waste, Leaching, Nanoparticles, Printed Circuit Boards, Recycling*

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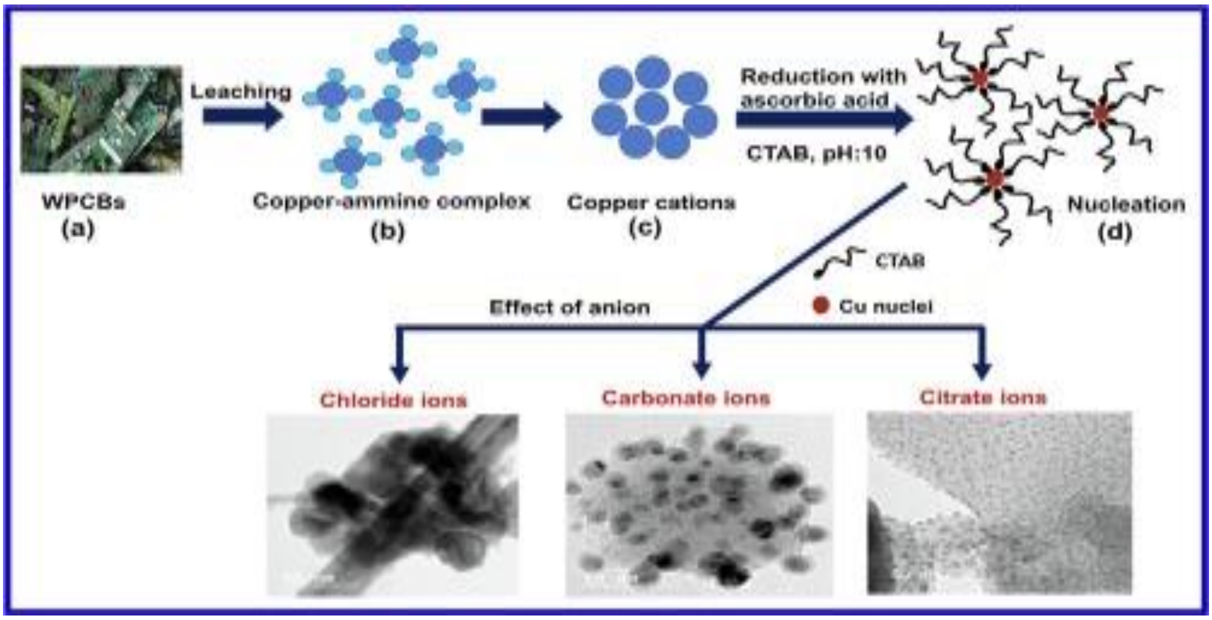
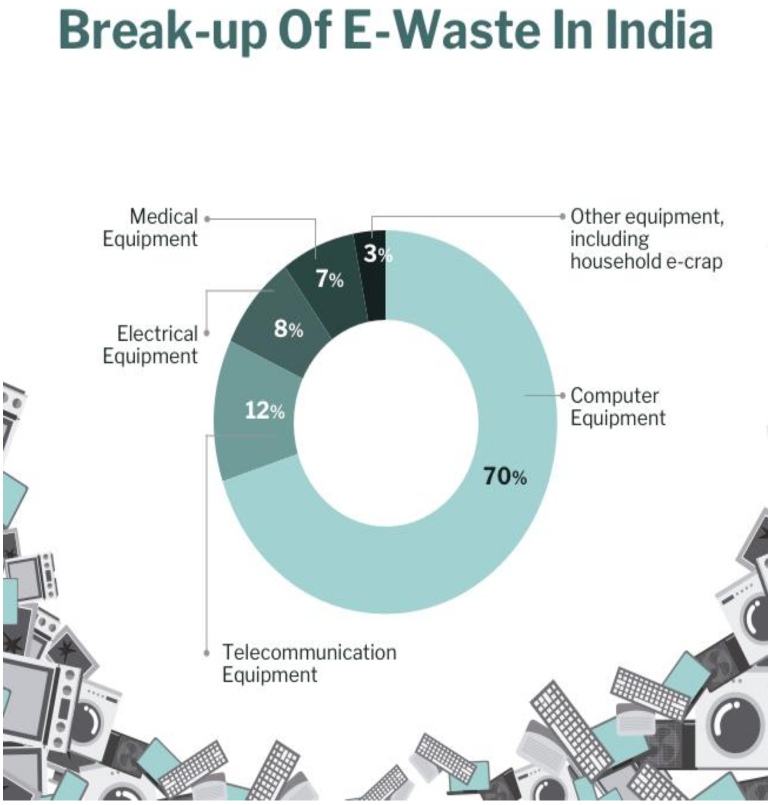
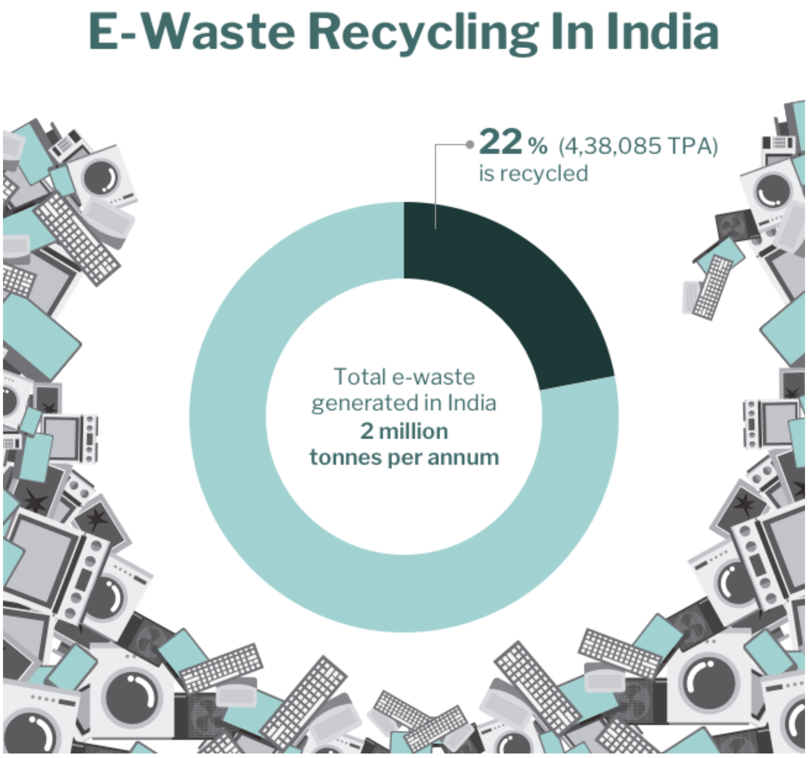



Waste is mainly classified in two categories 1. Hazardous and 2. Non-hazardous material. E-Waste is composed of plastics, ferrous and non-ferrous material, wood, glass and ceramics, rubber, printed circuit board and other items. In non-ferrous material, different type of metals like Aluminium, Copper and precious metals such as such as gold, silver, palladium and platinum. PCB contains plastics (30%), metals (40%) and ceramics (30%). There are 60 metals which are used to make printed circuit board, LCD, cathode ray tube and displays. Lead, arsenic, mercury, cadmium is present in e-waste which is hazardous to human health and the environment.

E-waste is a result of increased production and demand for Electrical and Electronic Appliances (EEA). The discarded EEA contains heavy metals it must be carefully disposed of in order to prevent any environmental harm. Researchers and pollution control boards in the relevant nations are taking notice of rapid increase in e-waste in order to properly dispose of and recycle the garbage. It is important to safely handle and sustainably remove all of the metals from old electrical and electronic products. Different methods were suggested by various researchers for preparation of ultra- fine copper powders from waste circuit boards. These methods included chemical reduction, cementation, electrochemical process and electro kinetic process. The common and important constituents in PCBs are ceramics, metals and polymeric parts about 30% mass of wasted circuit boards included wide array of important metals such as copper, gold and silver and unsafe materials like tin, lead and brominated fire inhibitors. Copper is the essential metal in electronic appliances. It has highest content in WPCBs that ranges from10 to 30 masses % among the metallic elements. If these boards are disposed inappropriately, noxious materials would cause harsh environmental problems and countless high-valued metals would be lost. Recycling of waste PCBs increased extraordinary considerations for waste handling as well as for recovery of valuable materials. Presently many technologies are suggested for recovering copper from WPCBs. Most important part of mobile for recovery of metals is printed circuit board and it contributes 20- 30% of total mobile weight.

E-waste is related to discarded electronic devices and gadgets such as discarded computer monitors, mobile phones, chargers, compact discs, headphones, televisions, air conditioners, fridges and lot more. Life span of electronic devices is getting short day by day due to technological advancement ultimately increase the volume of e-waste. It also increases the health hazards and environmental pollution in many ways.




**SOURCE: SWACHA INDIA**

Mismanagement of e-waste has both environmental and human effect. Liquid and atmospheric emissions from e-waste makes its way into water bodies, soil and air. This has an adverse effect on crops, drinking water consumed by humans and animals. Prolonged exposure to pollutants released from e- waste can cause damage to kidneys,blood system, skin disorders, respiratory diseases, lung cancer.

In this work for the first time a simple, non-expensive, environmentally friendly process for the recovery of pure copper as nanoparticles from leachant solutions of WPCBs of computers and mobile phones using Parthenium weed is presented. Parthenium weed belongs to Asteraceae family, a weed of global significance, a weed which occupies railway tracks, cultivated fields and road sides. The potentiality of parthenium weed is analysed after the Phyto chemical analysis of the plant extract. Green synthesis approaches are eco-friendly and cost-effective because they do not require high temperatures, pressures, energy, and toxic chemicals. Ascorbic acid is used as a reductant and also as a stabilizing agent for copper nanoparticles. Copper was first leached from WPCBs powder using aqua regia solution (a solution of concentrated HNO3 and Hcl in the ratio of 1:3). In characterization of printed circuit board, it was found that copper has highest concentration among the entire element present. Recovery of copper especially from smart phone due to its increasing volume makes it worth due to its unique properties.

| S. No | Name of the metal | Concentration in % |
|---|---|---|
| 1. | Copper (Cu) | 37.1 |
| 2. | Aluminum (Al) | 3.2 |
| 3. | Lead (Pb) | 1.3 |
| 4. | Zinc (Zn) | 0.9 |
| 5. | Nickel (Ni) | 0.4 |
| 6. | Gold (Au) | 0.07 |
| 7. | Silver (ag) | 0.27 |
| 8. | Iron (Fe) | 4.2 |
| 9. | Tin (Sn) | 2.5 |
| 10. | Palladium (Pd) | 0.03 |

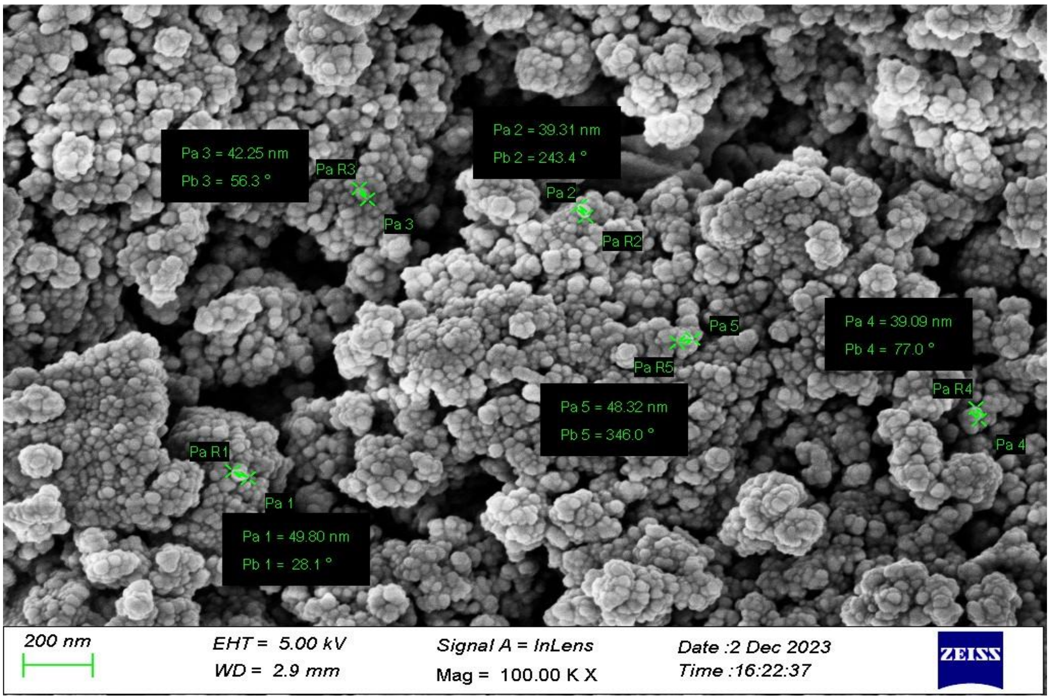
**Table 1: Metal concentrations obtained from PCB through leaching process**

Physical treatment is usually given to liberate metals during the process to reduce chemical and metallurgical process. The first step of physical treatment includes manual dismantling in which hammer and chisel are used to remove top mounted materials. copper is found between resin layers. The size of the particles is reduced to increase the leaching efficiency. Copper nanoparticles are synthesized by reducing the freshly prepared metallic salt solution. About 1gram of metallic salt obtained from PCB leaching are taken in 100ml volumetric flask and dissolved with distilled water. The metallic salt solution was mixed plant extract and stored under dark conditions. The reaction mixture was prepared in ratio of 9:1 (V/V) of freshly prepared metallic salt solution and plant extract, respectively, the initial colour of the solution was observed. Based on the yield of copper oxide nanoparticles and the spectrophotometer absorption results, 0.1M concentration of metal solution and Parthenium hysterophorus as a biological reducing agent was selected for further studies.

**Characterization of copper nanoparticles**

SEM is a surface imaging method, fully capable of resolving different particle sizes, size distributions, nanomaterial shapes, and the surface morphology of the synthesized particles at the micro and nanoscales. Using SEM, we can probe the morphology of particles and derive a histogram from the images by either by measuring and counting the particles manually, or by using specific software. The combination of SEM with energy-dispersive X-ray spectroscopy (EDX) can be used to examine silver powder morphology and also conduct chemical composition analysis. The limitation of SEM is that it is not able to resolve the internal structure, but it can provide valuable information regarding the purity and the degree of particle aggregation. The modern high-resolution SEM is able to identify the morphology of nanoparticles below the level of 10 nm.

The obtained copper nanoparticle was analysed with scanning electron microscope (SEM). The morphological characterization of green synthesized CuO NPs was carried out using SEM. The SEM images revealed that CuO NPs had spherical shape particles. There is some agglomeration and aggregate due to their high surface free energy and sample preparation but individual nanoparticles can also be detected. The SEM image of different magnifications are shown in figures. The size of the particles was calculated by SEM analysis was found to be in the range of 30-40 nm with an average particle diameter of 35 nm as displayed in size distribution histogram. The nano material was found consistent in shape indicating a crystalline structure. The homogenous nucleation process due to reduction of $Cu^2$ to Cu0 was responsible for the formation of CuO NPs structure. **[N. Rauf, 2020**].


Pa 3 = 42.25 nm
Pb 3 = 56.3 °
Pa 2 = 39.31 nm
Pb 2 = 243.4 °
Pa 4 = 39.09 nm
Pb 4 = 77.0 °
Pa 5 = 48.32 nm
Pb 5 = 346.0 °
Pa 1 = 49.80 nm
Pb 1 = 28.1 °
200 nm
EHT = 5.00 kV
WD = 2.9 mm
Signal A = InLens
Mag = 100.00 K X
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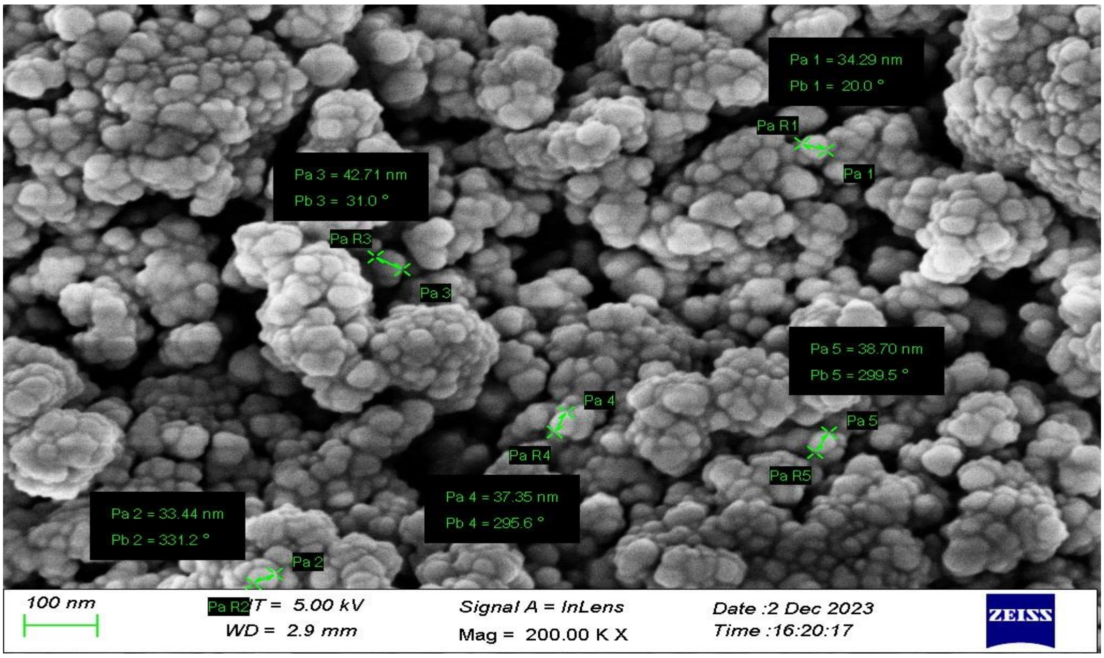
Pa 1 = 34.29 nm
Pb 1 = 20.0 °
Pa 3 = 42.71 nm
Pb 3 = 31.0 °
Pa 5 = 38.70 nm
Pb 5 = 299.5 °
Pa 2 = 33.44 nm
Pb 2 = 331.2 °
Pa 4 = 37.35 nm
Pb 4 = 295.6 °
100 nm
EHT = 5.00 kV
WD = 2.9 mm
Signal A = InLens
Mag = 200.00 K X
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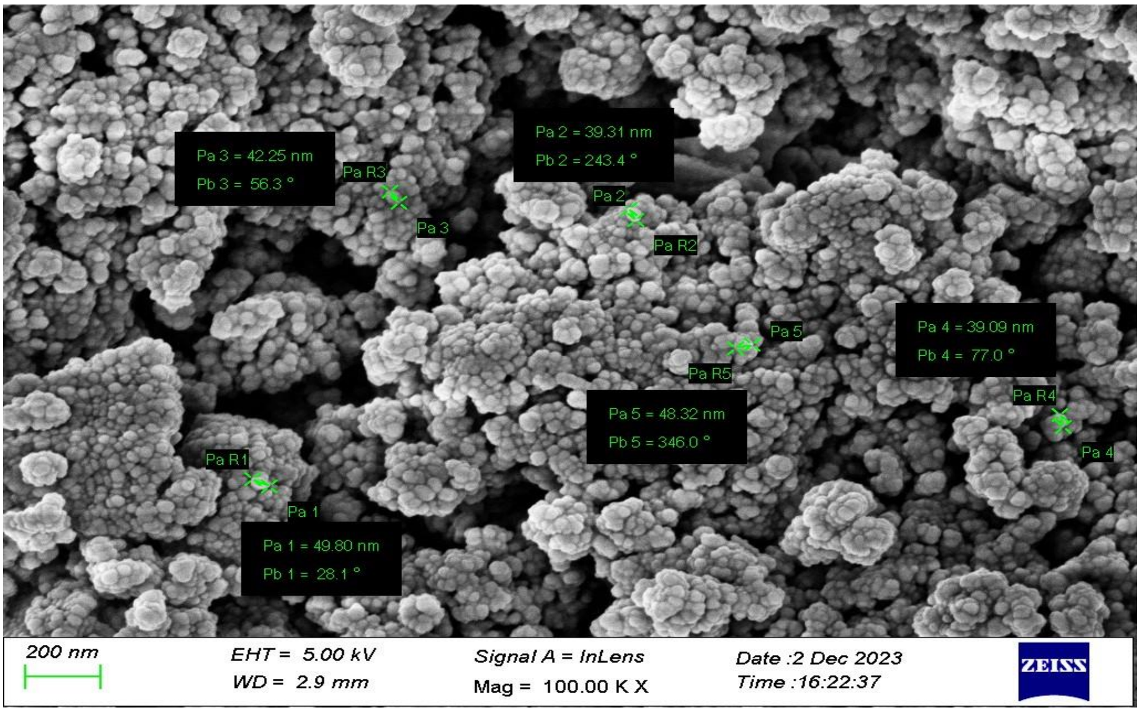


**Figure: Scanning electron microscope images of CuONPs synthesized from PCB**

This review comprehensively addressed synthesis, characterization, and applications of copper nanoparticles. Finally, if we succeed in all these studies, it would help the researchers of the nanoscience and nanotechnology and environmental community to develop safer, biocompatible agents containing copper nanoparticles. Finally, the great concern is that the developing nanotechnology-based methods should be better than available technologies and it should overcome the limitations of existing treatment techniques. It has to provide a safe, reliable and viable treatment of pollutants with high accuracy in an eco-friendly manner.

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