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Investigation into the Recovery of Valuable Metals from Waste Mobile Phone Printed Circuit Boards (PCBs): An Australian Case Study

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Abstract
Electrical and electronic equipment including mobile phone devices have developed rapidly and their useful lifespans reduced as a result of the changes in equipment features and designs. This creates a large waste stream and lately became a critical environmental issue. Printed circuit board (PCB) is one of the main components of the waste electrical and electronic equipment. PCB typically contains various metals including valuable (copper, gold, silver, platinum) and toxic heavy metals (mercury, lead, arsenic). Recycling of end of life mobile devices has the potential to solve many problems including resource depletion, environmental pollution, and landfill disposal. This article investigates the feasibility of the recovery of valuable metals from waste mobile phone PCBs through a city based induction smelting plant in the city of Sydney, Australia. Mobile phones from different companies, models, and year of manufacture collected and average weight percentages of materials content for each type of phone have been reported. A laboratory size smelter then utilized to recover precious metals out of waste mobile PCBs. It concluded that local electronic waste recycling in Australia is theoretically viable and prevent the ethical and legal issues raised from exporting these wastes.

Keywords
Printed circuit boards (PCBs); Mobile phone; Precious metals; Recycling

Introduction:
The use of electronic and electric equipment has risen dramatically over the two decades with the advancements in technology, material science, and manufacturing processes [1-5]. The global production of electronic waste is about 20-50 million tons per year [6,7] although more recent studies suggest that this figure could be on the low side as there is no standard practice for reporting waste electronic and electric equipment (WEEE) [8]. Mobile phones are sLgnLficant contributors to the production of electronic waste (e-waste), with global sales passing one billion marks in 2009 [9]. According to statistics released by Australian Mobile Telecommunication Association (AMTA), Australians upgrade or exchange their mobile phones every eighteen months, meaning there are approximately 16 million unused mobile phones stashed away at home or in the oٹce [10]. The average working life of a mobile phone is seven years but worldwide the average consumer changes their mobile every eleven months

Material and Methods
The recovery of valuable metals from selected waste printed circuit boards (PCBs) is quite dLٹcult as the waste mobile PCBs are diverse and complex in terms of type, size, shape, components and composition and with time, the composition has been continuously changed. Besides; presence of numerous metallic elements leads to complex recovery process and the recovery process becomes more complicated when the elements are available in minute concentration. In this work, mobile phones from different companies, models, and year of manufacture were used. They were collected randomly to simulate the real situation.

Result
Essential to any recycling scheme is the collection of materials to be processed. For this project, a small-scale collection route with twenty phones was carried out. Collection on a larger scale proved to be more difficult as the benefits of e-waste recycling are yet unknown to the general public besides having access to an applicable system providing easy ways for donating unwanted items is not in place in most of the countries including Australia

Disassembly
The manual disassembly process is an idealized situation as any potential recycling plant use automatic processes. He labour cost of manual disassembly heavily outweighs any economic value gain from the recycling process. On average, it takes about ten to fifteen minutes to disassemble one phone. A form of automatic disassembly was not investigated in this study but a quality disassembly system is critical for any recycling plant. The twenty phones selected for disassembly in this study were of different ages, types, and manufacturers hence, the material content varied quite noticeably.

Conclusion
A feasibility study conducted to assess the possibility of recycling precious metals out of waste mobile phones' PCBs through a city based induction smelting plant for the city of Sydney. Twenty phones tested in this study varied in age, type, and manufacturer. The process used manual disassembly of printed circuit boards in consideration of the different composition ratios in different fractions. In this study, the PCBs cut into pieces up to 5 cm2 and placed into the smelter with copper of a known purity. He melting temperature set to be

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1200°C. The comparison between different mobile PCBs time periods presented an indication of the material content of different mobile's PCBs.

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