E-waste valorization by recovering valuable metals with microorganisms

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A biotechnological process

For electronic waste managers and related companies,

that allows to recover metals from obsolete electronic devices with greater value than the price obtained for the waste,

not as the conventional processes that need to be centralized with large volumes, high energy consumption and environmental impact.
THE PROBLEM

- United States: 11%
- Canada: 2%
- Mexico: 1%
- Chile: 36%
- Argentina: 4%
- Peru: 11%
- Brazil: 1%
- Ecuador: 2%
- DRC: 6%
- Zambia: 1%
- Indonesia: 4%
- Russia: 0.8%
- Mongolia: 5%
- China: 2%
- Pakistan: 3%
- Iran: 0.9%
- Kázakhstan: 0.6%
- Poland: 1%
- Papua New Guinea: 1%
- Philippines: 2%
- Fiji: 1%
- Australia: 3%
- 30% plastic
- 30% refractory
- 40% metals

3-5% annual
THE SOLUTION

- 10-20% Cu
- 0.3-5% Cu
- T=1200 ºC
- R ↑
- T=30ºC
- No R
E-waste valorisation by recovering valuable metals with microorganisms

Mobile phone composition

E-waste valorisation by recovering valuable metals with microorganisms

Mobile phone composition
E-waste valorisation by recovering valuable metals with microorganisms

Bioleaching

- Iron oxidation by microorganisms
- Cementation of bioleached Cu
- Solubilisation of Cu from PCB
- Fe²⁺ + O₂ + H²O → Fe³⁺ + H₂O
- Cu²⁺ + H²O → Cu⁰ + H⁺
E-waste valorisation by recovering valuable metals with microorganisms

Investigation of electronic waste bioleaching

Flask  Lab scale  Pilot plant
Bioleaching process

1 step

**Biological reaction**

$$4 \text{Fe}^{2+} + 4 \text{H}^+ + \text{O}_2 \xrightarrow{\text{Ac. ferrooxidans}} 4 \text{Fe}^{3+} + 2 \text{H}_2\text{O}$$

2 steps

**Chemical reaction**

$$\text{Cu} + 2 \text{Fe}^{3+} \rightarrow \text{Cu}^{2+} + 2 \text{Fe}^{2+}$$
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Toxicity tests

![Graph showing oxygen saturation over time for Abiotic and Day 0 conditions, with Day 5 showing a slight decrease.](image)

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Toxicity assays by microrespirometries

Nickel

% Relative loss of activity vs. time (h)

0 20 40 60 80 100

0 4 8 12 16 20 24 28 32 36 40 44 48

0.0005M 0.05M 0.1M 0.3M 1M 1.5M

Materials and methods

Results and discussion

Conclusions and Future work
Toxicity assays by microrespirometries

Aluminium
Toxicity assays by microrespirometries

Copper

![Graph showing toxicity assays by microrespirometries for Copper](image-url)
Toxicity assays by microrespirometries

Metal’s comparison

![Graph showing metal's comparison over time](image-url)
Toxicity assays by microrespirometries

Metal’s comparison

![Graph showing metal's comparison](image-url)
1 Biological regeneration
2 Biomass separation
3 E-waste bioleaching
4 Metal recovery
Copper recovery in batch and column reactors

![Graph showing copper recovery over time in batch and column reactors.](image-url)
Bioleaching of electronic waste

• **Bioleaching** process to recover copper from the electronic scrap is **effective**, verifying the proof of concept.

• **Column reactor** improve the metal extraction efficiency.

• **Automatic** and **continuous** operation makes possible to recover **85%** in less than **6 hours**.

• **Ni, Al** and **Cu** affect biological activity, depending on the concentration as well as the time contact.
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