Keski-Suomen kiertotalousmessut

Kriittiset raaka-aineet tietoon, talteen ja kiertoon

Euroopan unionin osarahoittama

Uudistuva ja osaava Suomi 2021–2027

From Waste to Resource: Recovering Critical Raw Materials in E-Waste Recycling

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Goal of the project

The goal of this project is to develop in Central Finland even globally unique know-how for recovering selected EU-listed critical raw materials (CRMs) from waste materials.

What are Critical Raw Materials (CRMs)

- CRMs are raw materials, economically and strategically important for the European economy but have a high-risk associated with their supply.
- Used in environmental technologies, consumer electronics, health, steel-making, defence, space exploration, and aviation.
- They are not only 'critical' for key industry sectors and future applications, also for sustainable functioning of the European economy.

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EU CRITICAL RAW MATERIALS ACT

EU EXTRACTION

At least 10% of the EU's annual consumpton for extraction

EU PROCESSING

At least 40% of the EU's annual consumption for processing

EU RECYCLING

At least 15% of the EU's annual consumption for recycling

EXTERNAL SOURCES

Not more than 65% of the EU's annual consumption of each strategic raw material at any relevant stage of processing from a single third country

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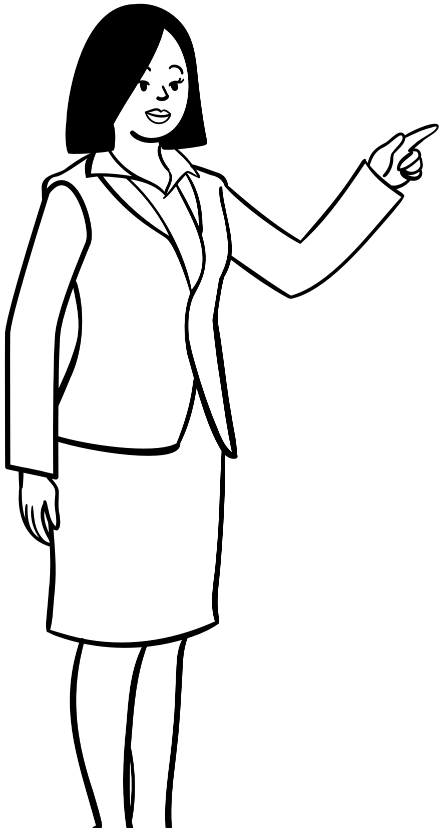

- Introduction
- E-waste collection and flow chart of the work
- Methodology
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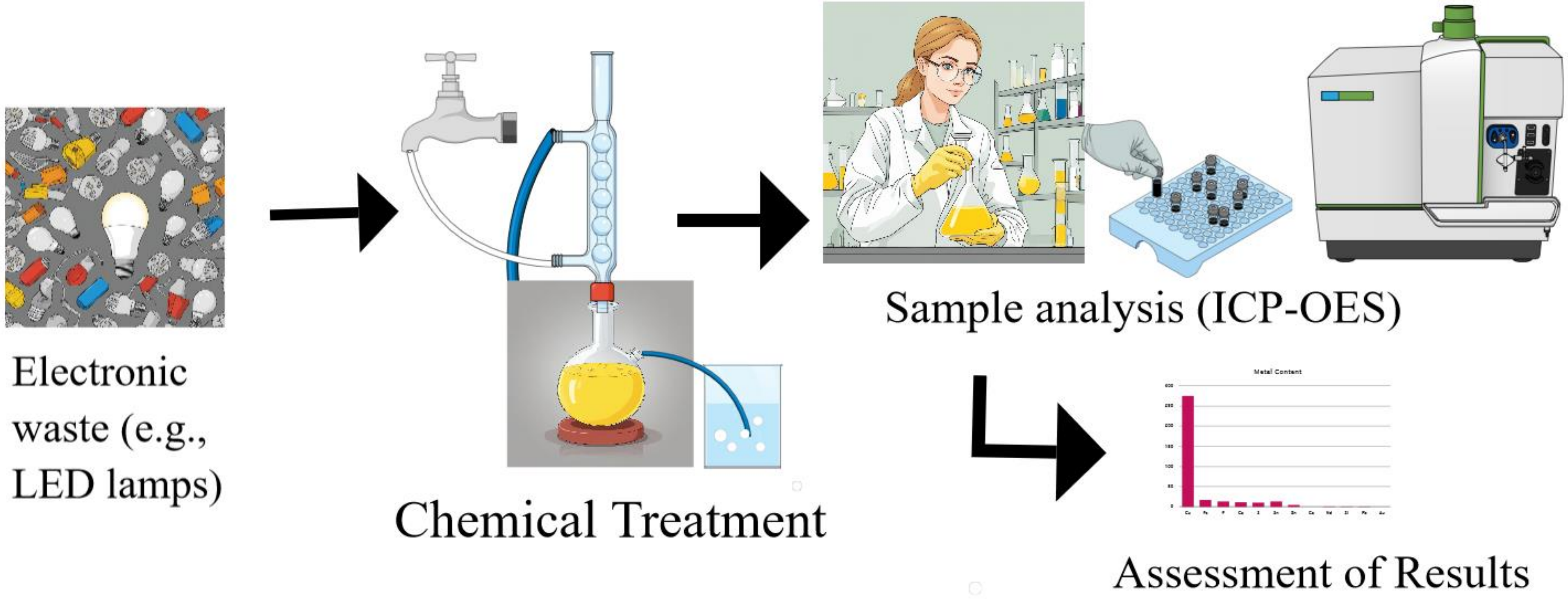
Introduction

- LED lamps are gradually replacing fluorescent and others due to its **longer life, colour variety and energy savings**.
- It contain a chip consisting of a piece of crystal formed from **gallium, indium, aluminium, phosphorus etc**.
- Different gallium compounds **produces different colored light when exposed to an electric current.**
- In our research, essential elements like **gallium, neodymium, and phosphorus, are recovered and they are vital for high-tech and green energy applications**.
- There are **several methods available and here nitric acid (HNO_3), hydrochloric acid (HCl), and aqua regia are investigated**.

Compound	Light Color
Gallium Arsenide (GaAs)	Red
Gallium Nitride (GaN)	Bright Blue
Gallium(III) Phosphide	Green
Aluminum Gallium Indium Phosphide (AlGaInP)	Orange
Gallium Arsenide Phosphide (GaAsP)	Yellow

Flow chart of the work



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Methodology

Fig: Experimental set-up

- Mechanical removal of LEDs

To extract gallium and other critical metals from LED lamps, we began by mechanically removing the LED chips and then crushing them.

The crushed samples were subjected to HCl leaching to solubilize the major elements of interest.

- For comparison, we also treated the samples with nitric acid (HNO_3) and aqua regia.

- Each sample was heated at boiling temperature and continuously stirred for 45 minutes.

Metal concentrations in the leachate were measured using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES).

Oxidation of LEDs

Oxidation of LEDs	Treatment	How oxidation enhances metal dissolution?
To enhance leaching efficiency, we oxidized the crushed LED sample at 1100°C in a muffle furnace.	After oxidation, LED sample were treated with HCl, HNO_3 and aqua regia, later the elemental contents were re-analyzed with ICP-OES.	The oxidation heat treatment to convert the insoluble gallium nitride into a soluble structure of gallium oxide, followed by leaching step using hydrochloric acid.

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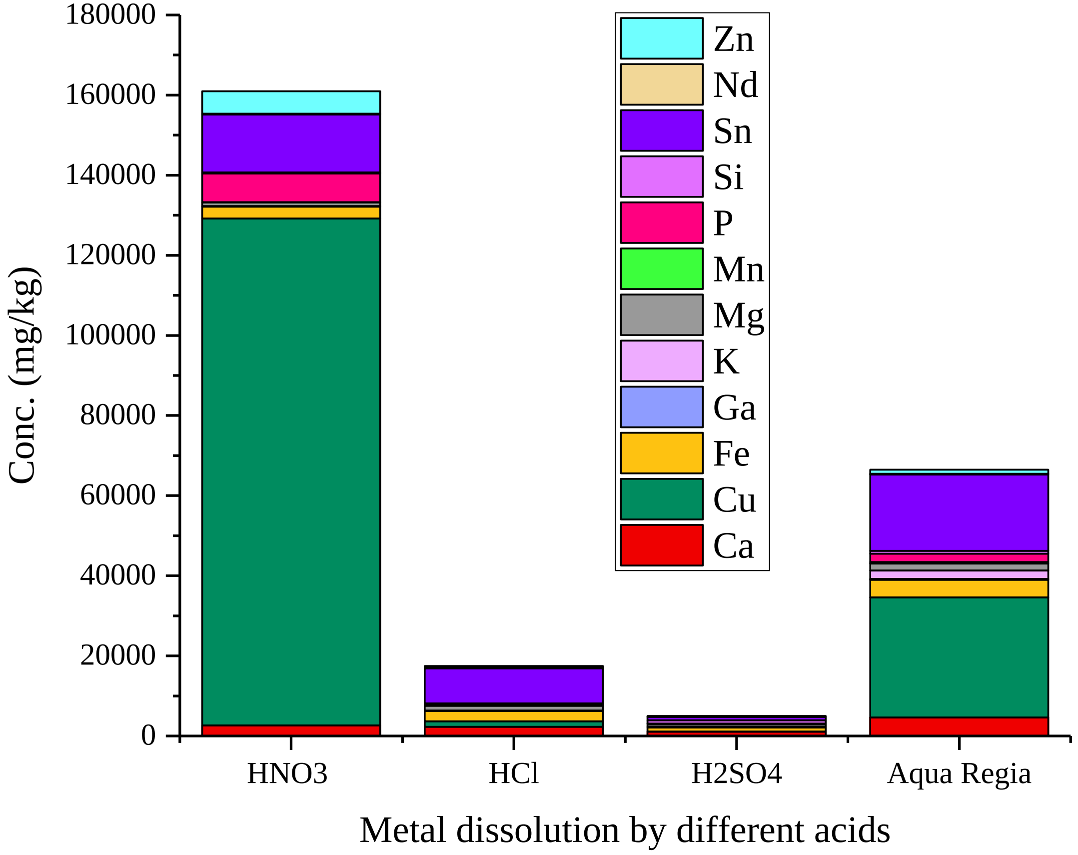
Results

Initially, after hydrochloric acid (HCl) treatment without oxidation, the concentrations of

- ❑ gallium (Ga) 76 mg/kg,
- ❑ neodymium (Nd) 152 mg/kg, and
- ❑ phosphorus (P) 64 mg/kg were found.

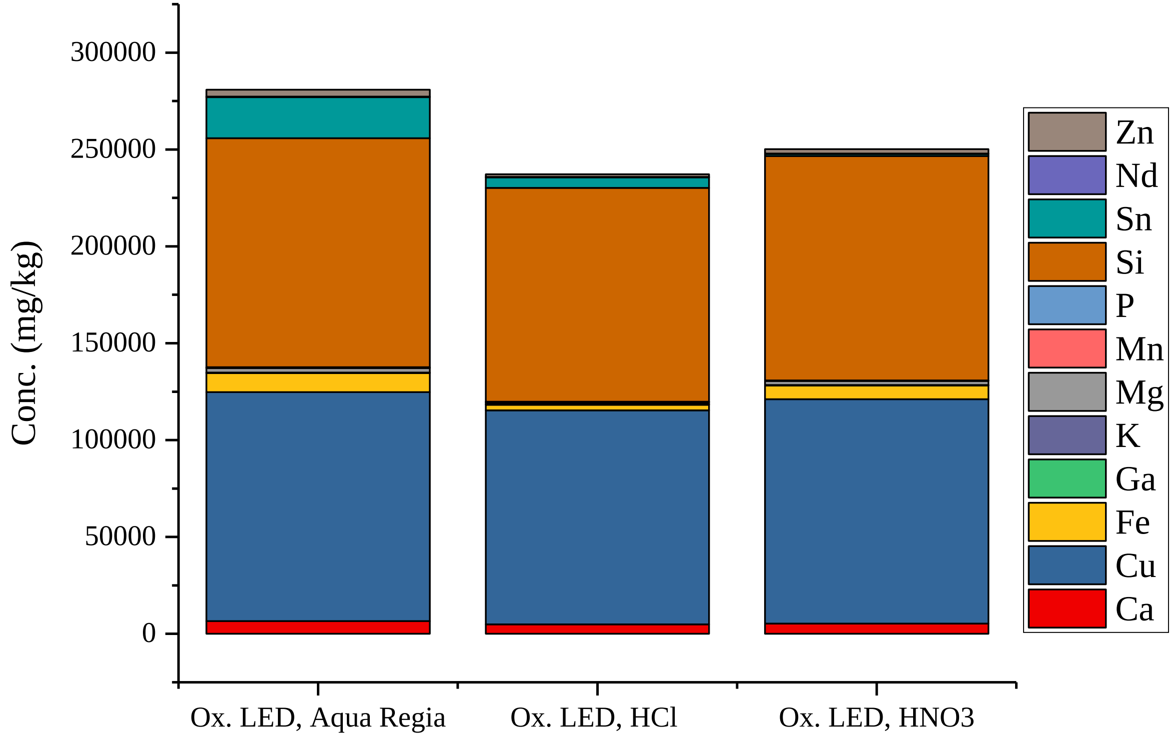


Results after oxidation of LEDs

The results demonstrate that the concentrations of various metals significantly increased following the oxidation of LED samples.

After post-oxidation, concentrations rose to 188 mg/kg for Ga, 164 mg/kg for Nd, and 79 mg/kg for P.

The higher concentrations of Ga, Nd, and P observed after HCl treatment highlight the potential of this method for pilot-scale operations



Conclusion

- Our study highlights the potential for using chemical treatments to enhance the recycling of CRMs.
- By evaluating different acids for metal dissolution, we gathered valuable insights into the recycling capabilities of LED lamps and these findings underscore the feasibility of targeted recycling processes for other e-waste.
- This research lays the groundwork for developing specialized recycling strategies and encourages further exploration into optimizing these methods for improved resource recovery.

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