

After LIFE Communication Plan

BIOLEACHING OF WEEE WASTES FOR THE RECOVERY OF VALUABLE METALS





Summary

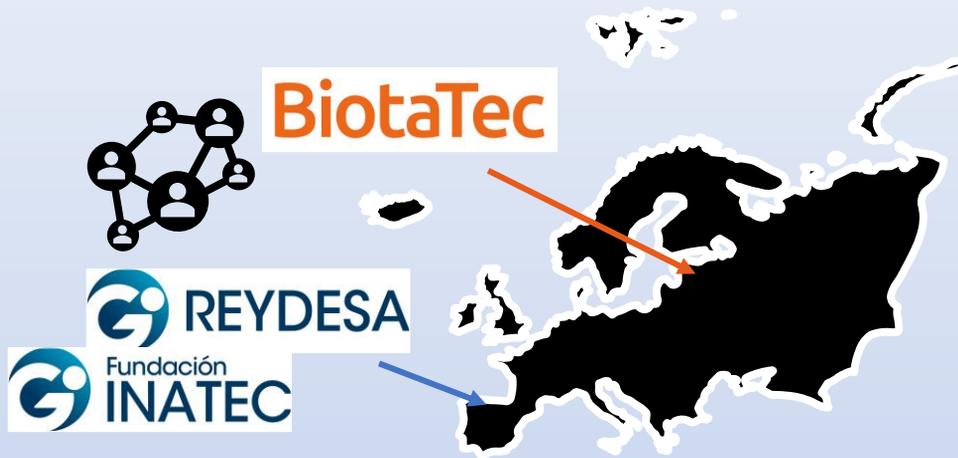
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Abbreviations:

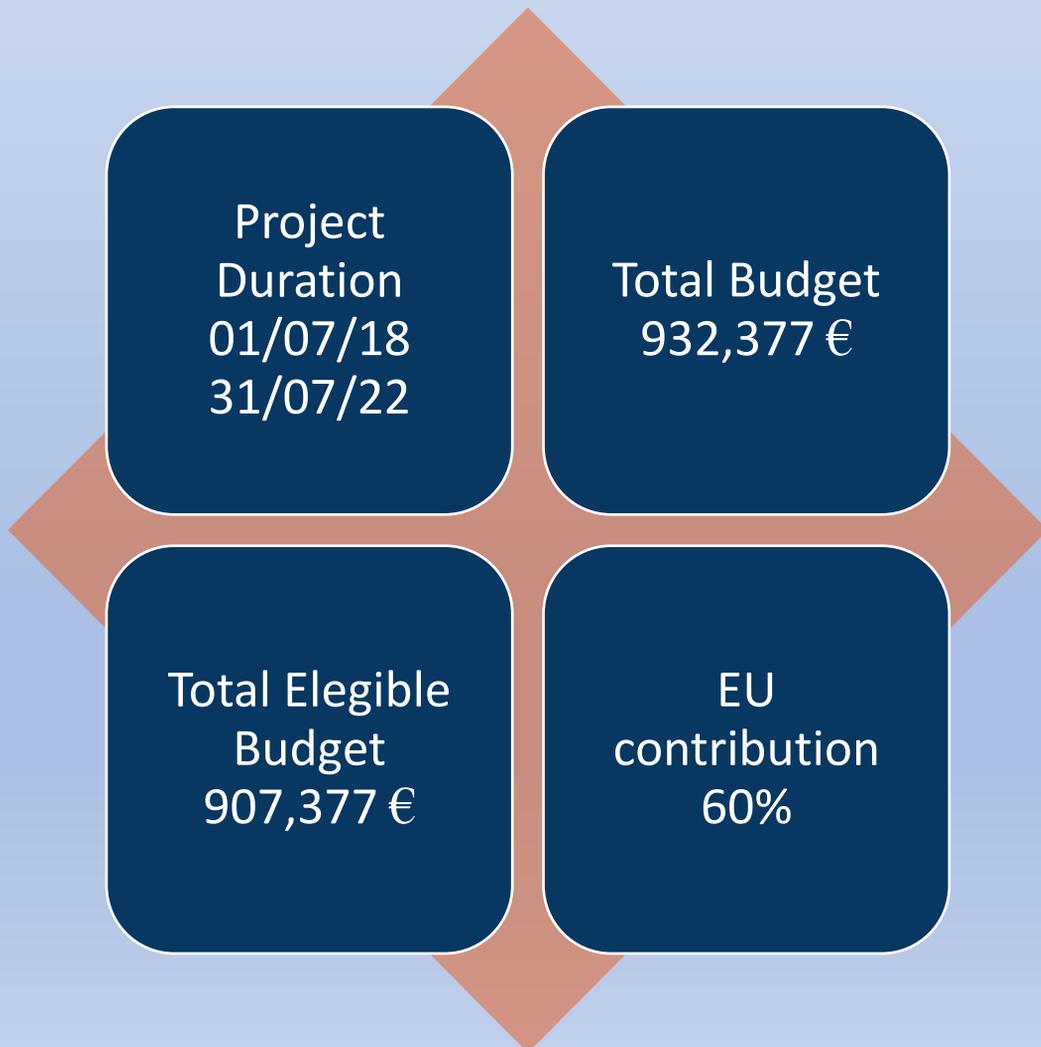
Printed Circuit Board: PCB
Electric and electronic Equipment: EEE
Waste electric and electronic Equipment: WEEE
Non-metallic fraction: NMF
Copper: Cu
Gold: Au
Lithium: Li



Project LIFE BIOTAWEE



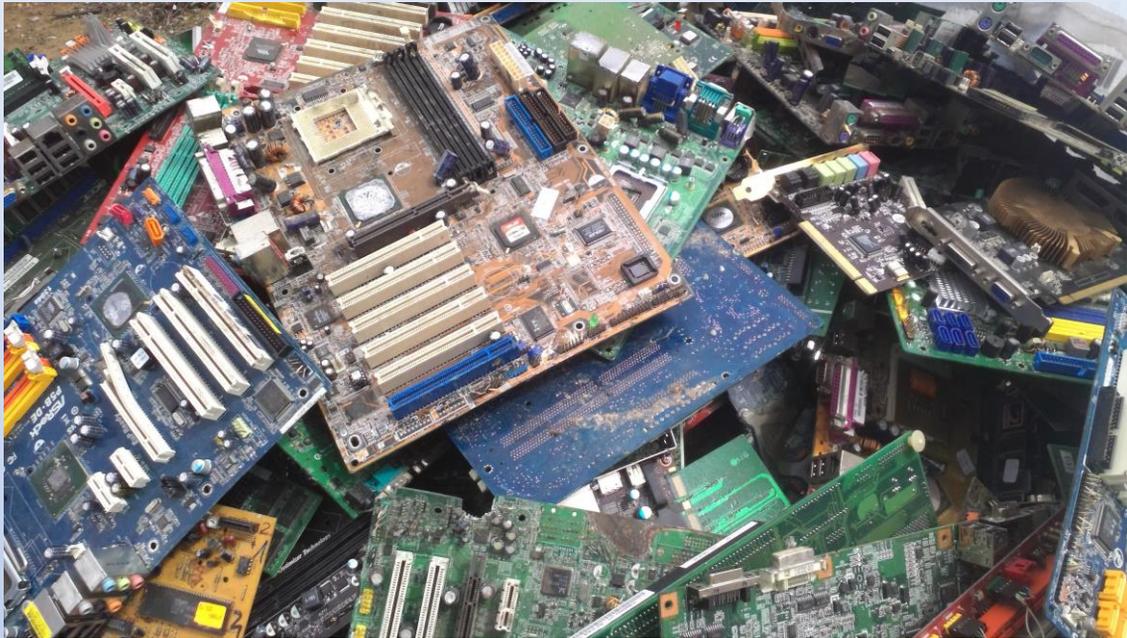
LIFE BIOTAWEE is a project co-financed by the European Commission through the LIFE Programme.





Project LIFE BIOTAWEE

Collection, treatment and recycling of WEEE is essential to improve the environmental management, contribute to a circular economy and enhance resource efficiency. In this way, the recycling of WEEE offers substantial opportunities in terms of making secondary raw materials available on the market.



Recovery of valuable metals from the NMF of PCBs from WEEE by the application of an innovative 2-step bioleaching technology

- Increasing recovery degree of PCB of WEEE contributing also to reduce European dependence of some high-valued metals with very low EU supply (mainly Au but also Cu and Ag).
- Promoting the use of biotechnology in the recycling processes of PCB of WEEE, contributing to make recycling sector a “bio-based industry”.
- Reducing the processing cost, CO₂ and waste generation respect to hydrometallurgical process.
- Evaluate the technological and economic possibilities in widening the usage of the innovative technology on other complex wastes in order to reduce the processing cost (e.g. ELV or batteries).
- Ensuring the efficient communication and dissemination of LIFE BIOTAWEE project activities and results to the general public and relevant stakeholders at European level.

29

Cu

63.54

79

Au

196.97

47

Ag

107.87



Project LIFE BIOTAWEE

PCBs can be found in any piece of EEE: nearly all electronic items, including computers, calculators and remote-control units, contain large circuit boards; an increasing number of white goods, as washing machines contains circuit boards for example in electronic timers. PCBs contain metals, polymers, ceramics and are manufactured by sophisticated technologies.

The main metals in PCBs are copper used as an electric current conductor (paths on laminate and parts of electric connectors and electronic elements), and tin used in solder for connections between elements and tracks on the board. The precious metals are also found in PCBs, mostly in electronic ones. The silver is mainly used in solder and contacts, whereas gold is in electronic components and is a protective later on contacts. Also, palladium is being used in contacts and multilayer ceramic capacitors.

The following table shows the metal content in the NMF of PCB after the mechanical treatment:

| % metals | Cu % | Ag g/t | Au g/t | Ni % | Pb % | Sn % | Zn % | Al % | Fe % | Cr % |
|------------|------|--------|--------|------|------|------|------|------|------|------|
| NMF of PCB | 7.93 | 81 | 42 | 0.06 | 0.27 | 0.50 | 0.39 | 7.24 | 0.37 | 0.05 |

Bioleaching or biomining is the technique of extracting metals from ores and other solid materials typically using micro-organisms (bacteria, archae, fungi or plants).

Uses direct metabolism or byproducts of microbial processes to solubilize a metal sulfidic ore or waste into an aqueous solution, and it is used at commercial scale for the extraction of base and precious metals.

Anaerobic (ARGCON5) is in process of being patented by BIOTATEC

Aerobic (At. ferroxidans) Cu extraction from the NMF of PCBs demonstrated

Aerobic (Ch. violaceum) Au extraction from the NMF of PCBs demonstrated



Achievements

Technical results achieved

- ✓ The aerobic process performed in 50L pilot plant with *At. ferroxidans*, showed a **recovery of 86 - 95% Cu and 1-4% Ag**. Other metals contained in the waste in very low quantity have been also extracted with a recovery, around 76-88.5 % Al, 98% Zn or 53- 55% Ni.
- ✓ Cyanogenic bioleaching with *Chromobacterium violaceum* culture in aerobic bioleaching was performed in 20L reactor obtaining a **gold extraction of 45 %**
- ✓ **Reduce 38 % the processing cost** of 2 aerobic step bioleachings compared to hydrometallurgical process.

Environmental impact of the project

- ✓ Avoid the incineration of almost 300 Tn/ year of PCB only from the REYDESA's process.
- ✓ Reduce the volume of unused fractions of PCB. From 1 Tn, 10 % is NMF (impurities) of PCB but there is also another NMF, the suction dust from the mechanical treatment which may be the 30 % of PCB.
- ✓ Reduction in hazardous effluents waste generation of 3.88 Tn/Tn PCB respect a complete hydrometallurgical process.
- ✓ LIFE BIOTAWEE process can reduce 42 % CO₂ eq. compared with the hydrometallurgical process
- ✓ Replicability: LIFE- BIOTAWEE process may treat the filter dust obtained from the mechanical treatment of other WEEE in REYDESA and in other companies of the recycling sector
- ✓ Promoting the use of biotechnology in the recycling process, contributing to make the recycling sector a "bio-based industry".
- ✓ Recovery per Tn of PCBs: 182 Kg Cu, 0.24 Kg Ag and 0,021 Kg Au



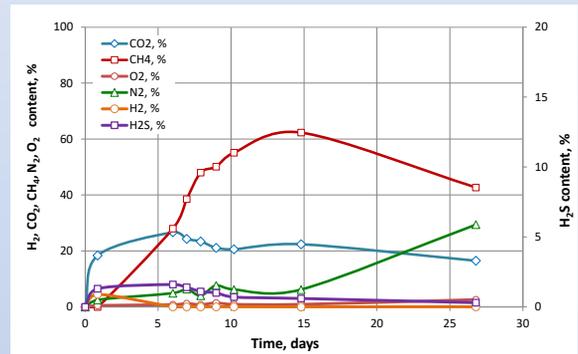
Achievements (Replicability)

SUCTION DUST RECOVERED FROM THE MECHANICAL TREATMENT OF PCB

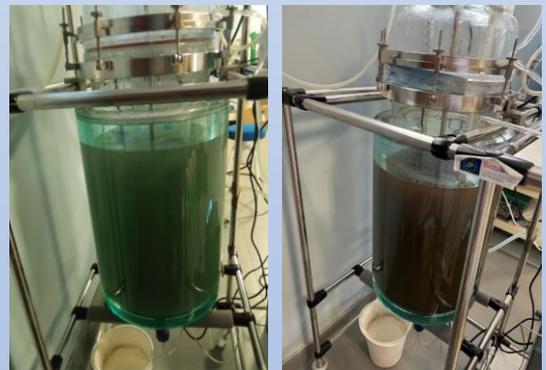
Two test where performed: at 20 L (anaerobic + aerobic) and at 50L (aerobic).

| Sample | Cu % | Ag g/t | Au g/t | Ni % | Pb % | Sn % | Zn % | Al % | Fe % | Cr % |
|---------------------|------|--------|--------|------|------|------|------|------|------|------|
| Filter dust zig-zag | 8.18 | 498 | 390 | 0.40 | 1.57 | 2.62 | 1.09 | 5.18 | 3.77 | 0.08 |

Test at 20 L, an innovative more efficient 2-step bioleaching technology, has been performed in laboratory and bench scale, evaluating the methane formation and also the release of metals in the solution. Its application to other type of waste, zigzag dust, has showed better results than the ones obtained for non-metallic fraction of PCB, indicating that its application could be successful for other type of waste.



Tests at 50L have been performed for the recovery of metals from the non-metallic fraction of mechanically treated PCB using aerobic conditions required by microorganisms "*Acidithiobacillus ferrooxidans*".



The extraction yield obtained for Cu reach the 98%, and 69% for Al. Other metals are also recovered, taking into account that its content in the initial waste is lower than 1%, that is the case of Zn 64%, Ni 51% or Sn 7%.

SUCTION DUST RECOVERED FROM THE MECHANICAL TREATMENT OF WEEE

| Sample | Cu % | Ag g/t | Au g/t | Ni % | Pb % | Sn % | Zn % | Al % | Fe % | Cr % |
|--------|-------|--------|--------|------|------|------|------|------|-------|------|
| Type 1 | 18.6 | 145 | 13 | 0.12 | 2.18 | 0.55 | 1.67 | 6.22 | 4.18 | 0.16 |
| Type 2 | 23.14 | 15 | 0 | 0.16 | 0.14 | 0.08 | 0.78 | 4.06 | 27.46 | 0.07 |



This waste has metallic contents that tend to be between 10 and 30%, mainly Cu, and in some cases Fe, corresponding the rest of the material to non-metallic fractions of low granulometry. Some particular filters are considered dangerous wastes due to their Pb content (> 0.3%); being difficult to treat, due to their fine granulometry and content of organic matter (20-30%) and inert (35%).

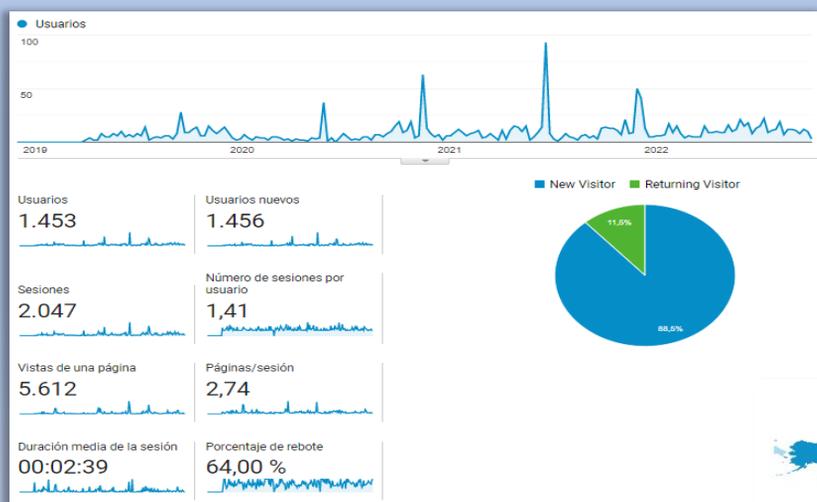


Achievements

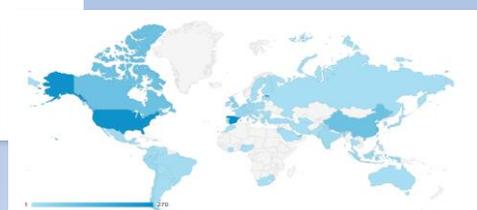
Dissemination activities during the project

- ✓ **Two webinars have been organized**; at Estonian level was organized in December 2021 by BIOTATEC a webinar regarding electronic waste management, in July 2022 a webinar has been organized by REYDESA in collaboration with ACLIMA (Basque environmental cluster), with the participation of INATEC.
- ✓ BIOTATEC attended online the 10th **International Symposium on Biomining** (Biomining '21).
- ✓ In this period **two press releases have been performed in which BIOTAWEE project has been mentioned**, one called "Electronic waste can become the Nokia of Estonia" and the one published in the Otua group website, regarding the Kick of meeting of the project. Additionally, ACLIMA has also release a note about the webinar organized by REYDESA in July 2022, in which a link to the youtube video of the webinar is available.
- ✓ The rest of **news of the project have been released in the BIOTAWEE project website** section, including also more information about the webinars organised.
- ✓ In the academic field the technical publications have covered **master thesis** as well as **bachelor thesis** in the University of Tartu.
- ✓ In this period **three publications in technical journals have been prepared**, one submitted to Letters in Applied Microbiology in June 2022 by BIOTATEC, other published in June 2022 in the journal *Industria Quimica* by REYDESA-INATEC, and the last one that is already on elaboration by BIOTATEC.
- ✓ A **European patent is under development by BIOTATEC** whose examination is already in progress entitled "*Method for decomposition of organic matter of graptolite argillite by microbial consortium*".

WEBPAGE:



| | | |
|-----|--|----------------------|
| 1. | | Spain |
| 2. | | United States |
| 3. | | Estonia |
| 4. | | Canada |
| 5. | | China |
| 6. | | United Arab Emirates |
| 7. | | United Kingdom |
| 8. | | (not set) |
| 9. | | Netherlands |
| 10. | | Germany |





Exploitation Plan

REYDESA and BIOTATEC had signed a commercialisation agreement on May 27th, 2022 for the use of the Know-How and the pilot plant developed in LIFE BIOTAWEE Project.

During the term of this agreement:

- REYDESA will be entitled to use the Know-How and the Pilot Plant in Spain
- BIOTATEC will be entitled to exploit or grant licenses to third parties to use the Know-How anywhere out of Spain and also to use the Know-How on its own behalf with no restrictions.



This commercialisation agreement will have a term of 3 years from the date it was entered into.



Project Continuation

BiotaTec is developing further strategies for valorisation of e-waste with grant from Estonian Government and EU as well as raising additional capital.

The aim is to further develop and improve the bioextraction technology of various metals from different types of e-waste.

Additionally, it will be explored the possible ways to increase the overall value of e-waste leaching process through biosynthesis of metallic nanoparticles.

The Budget for this action: 3,320,820.00€





Project Replication

Over the next three years, REYDESA and INATEC will participate in a basic research project to study the extraction of lithium contained in the black mass generated in the mechanical treatments of lithium-ion batteries at the end of their useful life.

The project brings together a total of 31 initiatives structured around three axes; **decarbonization, connectivity and mobility** as a service. In the field of decarbonisation, initiatives related to hydrogen, carbon-neutral fuels, batteries or the reduction of the weight of materials, among others, are included. Regarding the second axis -connectivity- different initiatives related to digitization, cybersecurity, the development of electronic vehicle platforms or connectivity will be addressed. Likewise, in terms of the axis of mobility as a service, new technologies will be developed that allow vehicles to be equipped with of innovative features.

The Group is made up of fifty companies that cover all areas of the future industrial ecosystem, technology companies, clean energy, circular economy, artificial intelligence, cybersecurity, services, vehicle manufacturing, components and batteries. Likewise, there are universities and technology centers, promoting public-private collaboration.

The Budget for this action: 900,249.27 €



Environmental Objectives:

- Contribute with this project to exceed the objectives proposed in the new draft of the European Commission (COM(2020) 798/3), of the Battery Regulation where it is established that, by 2025, all recycling processes must reach certain rates of recovery of 35% Li, having to reach 70% by 2030.
- Reduce the environmental impacts derived from metal recovery through traditional methods, which have a high impact and obtain a very limited recovery percentage of Li.
- Decoupling between economic growth and the generation of environmental impacts, by increasing the recovery percentage of Li.
- Contribution to the transition towards a Li consumption model. more circular and with a higher added value

The project has been submitted (and accepted) to the call of "Strategic Project for the Recovery and Economic Transformation (PERTE) of the Electric and Connected Vehicle" of the Ministry of Industry of the Government of Spain.



Future communication actions

- Maintenance of the LIFE BIOTAWEE project website: The LIFE BIOTAWEE website is the central communication tool which disseminate the project information in three languages and will be maintained online during five years.
- Printing communication materials (Layman): ensuring the dissemination of the LIFE BIOTAWEE achievements.
- Collaboration between partners: The collaboration and the networking activities will be open between Reydesa and Biotatec in order to maintain a dynamic dialogue.
- Promotion of the continuation activities: BiotaTec will continue to seek industrial partners to implement our WEEE recycling technologies in industrially-mature form.
- Promotion of the replication activities: through the presence in sectoral associations, among which the following stand out:
 - Aclima, Basque Country environmental cluster.
 - Spanish Federation of Recovery.
 - Euric, continental recovery association.
 - A.Spire: continental public-private association for the efficiency of the use of resources and energy.
 - Bureau of International Recycling, international federation of recovery companies.
- Disseminate the projects/future actions related continuation/replication carried out through each corporate websites

| Actions | Responsible | Estimated cost (€) |
|--|------------------|--------------------|
| Maintenance of the LIFE BIOTAWEE project website | REYDESA | 2,500,00 |
| Printing communication materials (Layman) | REYDESA | 1,000,00 |
| Collaboration between partners | REYDESA/BIOTATEC | 2,000.00 |
| Promotion of the continuation activities | BIOTATEC | 1,800,00 |
| Promotion of the replication activities | REYDESA | 1,500,00 |
| Disseminate through each corporate websites | REYDESA/BIOTATEC | 1,000,00 |

After LIFE Communication Plan

BIOLEACHING OF WEEE WASTES FOR THE RECOVERY OF VALUABLE METALS

The background of the entire page is a dense, top-down view of a large pile of electronic waste (WEEE). It includes numerous green and brown printed circuit boards (PCBs), various electronic components like capacitors and resistors, and other fragments of electronic devices.

¿Do you want to know
more about the Project?

Visit our website:

www.biotawee.com