LAYMAN'S REPORT

SUBproducs4LIFE

Innovative circular economy concepts by reusing industrial subproducts and waste

LIFE16 ENV/ES/000481

PROJECT DETAILS

LIFE project reference number: LIFE16 ENV/ES/000481

Project Title: Innovative circular economy concepts by reusing industrial subproducts and waste – SUBproducts4LIFE

Duration: 01/09/17 – 30/06/24

Location: "La Soterraña" mercury mine site in Asturias, Spain

Sector: Industrial

Budget:

- Total project budget: 1,470,296 Euro
- Total eligible project budget: 1,470,296 Euro
- EU financial contribution requested: 882,176 Euro

Coordinator: Universidad de Oviedo

PARTNERS

- **Universidad de Oviedo**

Public Higher Education and Research institution located in Asturias. Recognized by the Spanish Education Ministry as Campus of International Excellence. Within this framework, the University has created two Clusters, representing its commitment to specialization in Biomedicine and Health and Energy, Environment and Climate Change.

- **BIOSFERA Consultoría Medioambiental S.L.**

Specialized consultancy service which came up as a result of the growing demand and interest XXI Century society s for Sustainable Development, Conservation and better management of natural resources. BIOSFERA services aim to provide solutions to the needs of government and private entities such as engineering, consulting, Laboratories, Construction, Power, Mining, etc., which have demands in diverse fields.

- **EDERSA**

Escorias y Derivados belongs to the group Cementos Tudela Veguin, the first company in Spain to manufacture artificial Portland Cement. The company has two manufacturing plants, one situated in Veriña and the other one in Somonte in order to satisfy new needs wich have arisen in the field of construction materials and also to comply with environmental policies, Escorias y Derivados has gone to introduce new materials, slags from blast furnace in the production of cements and derived products such as concretes and mortars, It is highlighting that the aforementioned materials uses to end up in rubbish tips.

- **EDP España**

Global energy leader and one of the main operators on the Iberian Peninsula. The EDP Group is present in Spain in the production, generation, transmission and marketing of electricity, gas and services. The Group has its main business centres in Asturias, Cantabria, Murcia and the Basque Country, where it is a benchmark operator in gas and/or electricity. It is currently the fourth electricity producer and distributor and the second natural gas operator. EDP produces important amounts of fly ash and gypsum as side products, and therefore, is very interested in their valorisation and reutilization.

- **GLOBAL SERVICE**

CUESTIONES ECONÓMICAS S.L. hereinafter GSERVICE started its activity in 2014. GSERVICE took part into several project works, many of them linked to facilities with presence of dangerous pollutants.

- **R&R**

Recuperación y Renovación begins its activity in the field of engineering; its work is mainly linked to industrial and mining activity and focused on the environmental sector. Some of its partners came from the company "TECMIM" that was dedicated to environmental engineering since 1997. Thus, Recuperación y Renovación decided to expand its activity to research in waste recovery from mining activities and steel processes.

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1. INTRODUCTION

SUBproducts4LIFE proposes to demonstrate innovative circular economy concepts by the reuse of industrial subproducts/waste (coal ash and gypsum form coal power plants, and blast furnace slag and steel making slag from steel factories) for the remediation at a real scale of contaminated soils and brownfield areas related to Hg mining (mine, waste dumps and demolition waste of metallurgical plant).

2. BACKGROUND

1. There are relevant industries in Europe such as coal power plants or steel production factories that generate a big amount of industrial subproducts/waste every year with the problem of its storage and very expensive management.

2. A research team of the University of Oviedo, among others, has demonstrated that at a laboratory scale, some of these subproducts can fix heavy metals and other pollutants.

3. On the other hand, there are in Europe a lot of waste dumps produced by metal base mining with a very high content of heavy metals being a problem both for the environment and human health.

4. From previous statements the following new challenge appears: is it possible to use industrial by-products to reduce the pollutant potential of old waste dumps by mixing these subproducts with contaminated waste? After demonstrating it at a laboratory scale, it is necessary to demonstrate it at a real scale.

3. OVERALL GOALS AND SPECIFIC OBJECTIVES

1. Increasing the value chain of 4 sub-products from different industrial processes (coal ash and gypsum from power plants and 2 types of slags from steel production sector), promoting circular economy/recycling synergies and analyzing their life cycles.

2. Promoting industrial symbiosis between active industries with high production levels (power plants and steel production) and contaminated sites (abandoned mines and production plants for metals), by:

a) Demonstrating suitable methodologies for the new use of industrial subproducts (blast furnace slag) as "fixing agents" of heavy metals and closing the life cycle of industrial waste (coal ash, gypsum, and steelmaking slag).

b) Applying these subproducts to demolition and mine waste, water, soil, promoting green economy and resource efficiency concepts.

3. Achieving a better soil management and land re-use:

a) In active industries, reusing different types of subproducts.

b) In already built-up areas in former mines and facilities.

Coal-burning power plant

Electricity=Product

Abandoned mercury mine area

Ashes= by-product

- Economical value

-Reduced impact

Ash waste dump

Ashes= Waste

- Expensive management

- Environmental impact

4. MAIN PROJECT ACTIVITIES

There are three pilot areas:

- **Pilot case 1**: Metallurgical process waste (reduction of water contamination).
- **Pilot case 2**: Demolition debris (reduction of water contamination and Hg emission).
- **Pilot case 3**: Mine water and leachates produced in pilot areas 1 and 2.

These are the Pilot areas:

Pilot Area 1: treatment of metallurgical process waste

The treatment consisted in covering the contaminated waste with ash and slag.

The objectives pursued were the following:

- To valorize the use of by-products for the remediation of contaminated tailing dumps.
- To reduce the contamination of the leachate produced in the landfill.
- To test phytoremediation techniques.

The actions taken were the following:

Treatment of the waste from metallurgical process tailings dump.

- Clearance and refurbishment of the area and geometric modelling.
- Covering the demolition debris with two layers of ash and slag.
- Installation of a drainage system.
- Application of phytoremediation techniques.

Pilot Area 2: treatment of demolition debris from structures and buildings of metallurgical plant

The treatment consisted in covering the highly contaminated debris with ash and slag.

The objectives pursued were the following:

- To valorize the use of by-products for the remediation of contaminated waste.
- To reduce the contamination of the leachate produced in the area.
- To develop a guide of good practices to work with high Hg and As contamination.

The actions taken were the following:

Treatment of high contaminated debris from the demolition of the metallurgical plant.

- Construction of a treatment cell or pool and floor impermeabilization.
- Filling the treatment cell with demolition debris.
- Covering the demolition debris with two layers of ash and slag (key action).
- Installation of a drainage system.

Pilot Area 3: treatment of mine water and leachates from pilot areas 1 and 2

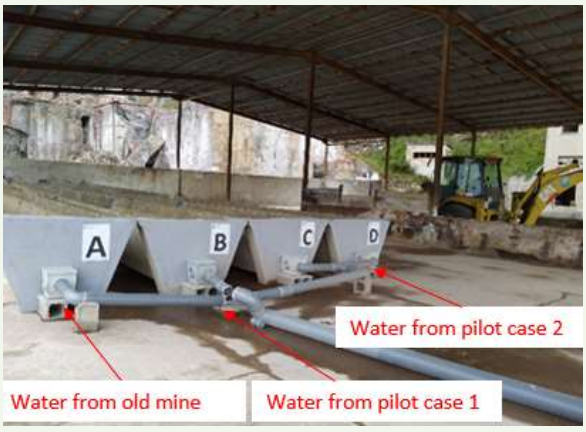
The treatment consisted in cleaning the water by passing it through a filter with a mix ash/slag. Reduction of PTEs in the water prevents their dispersion into the environment.

The objectives pursued were the following:

- Full-scale system: 4 channels filled with a mix of ash and slag as filtering material.
- The analysis of the system efficiency and capacity under real conditions.
- Analysis of the replicability of the method in other sites.

The actions taken were the following:

- Construction of the filtering channels and filling them with ashes/slags.
- Installation of pipe system to conduct contaminated water to filtering channels.
- Effectiveness control system (water sampling at the entrance and exit).



5. MAIN SUBproducts4LIFE PROJECT RESULTS

The main successes achieved in the project are the following:

- Development Health and Safety protocols to work under extreme conditions.
- Demonstration at a full-scale of the use of ash/slag to avoid Hg emissions and water contamination as a competitive technique.
- Relevant results about the use of ash/slag to clean diminish the contamination in water and leachates.
- Development of phytoremediation techniques – replication of I+Darts.
- Wide diffusion and dissemination: open-access papers with the results in prestigious journals accessible to anyone (open-access), press, radio and TV.
- Several companies and institutions able to develop projects in contaminated areas.
- Promotion of the global rehabilitation of La Soterraña and El Terronal.

In relation to pilot cases 1 and 2, there are some advantages of the SUBproducts4LIFE solution:

- It is a solution easy to implement.
- Hg emissions to the atmosphere are reduced/eliminated.
- Ashes do not allow the infiltration and contamination of the rainwater.
- Contamination of the rainwater is reduced/eliminated.
- It is independent of the type of pollutant and flow rate, and it remains over time.

Also, in relation with Pilot Area 2, there has been a successful restoration of the area. The Principality of Asturias has authorized the following:

- The use of fly ashes instead of 0.5 m of natural clay (valorization of a subproduct, less environmental impact/footprint, reduction of a natural resource, safety money)
- The use of selected plants from phytoremediation techniques

If we compare the solution implemented with other solutions, there are the results:

- Removing or encapsulation of demolition debris:

  - More expensive.
  - Higher carbon footprint.
  - Worse ESG score.

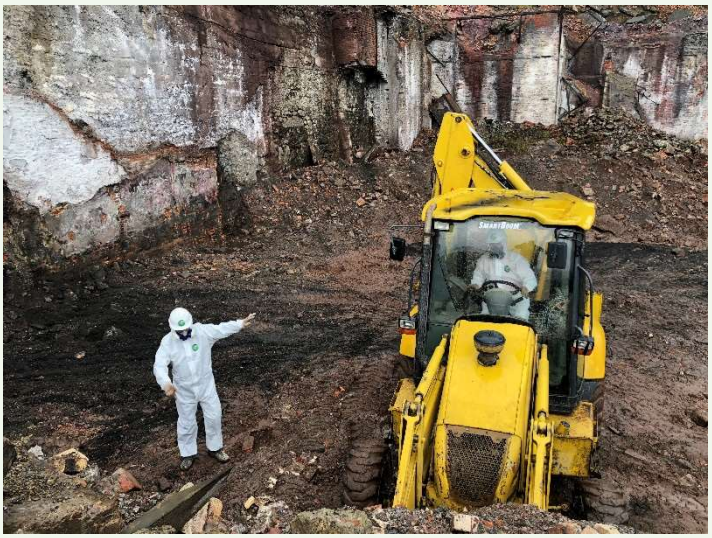
- Covering the demolition debris (La Soterraña):

  - Cheaper solution.
  - Lower carbon footprint.
  - Better ESG score.

In relation with occupational risks and health and safety, we reached the following results:

- Demolition debris behaves as an emission focus.
- There were very high concentration of gaseous HG (several times the limits allowed).
- Emission and diffusion models were developed to analyse the problem.
- Health and safety protocol was supposed to work under these conditions.

Hg-gas concentration on the rubble C_{10} (ng/m³)	Scenario	Hg-gas concentration ranges C_{10} (ng/m³)	Temperature ranges ⚜ (ºC)
≤ 10,000	Green	5000 – 7500	0ºC - 5ºC
		7500 – 10,000	5ºC - 10ºC
10,000 - 20,000	Orange	10,000 – 15,000	10ºC - 15ºC
		15,000 – 20,000	15ºC - 20ºC
≥ 20,000	Red	20,000 – 40,000	20ºC - 25ºC
		40,000 – 60,000	25ºC - 30ºC

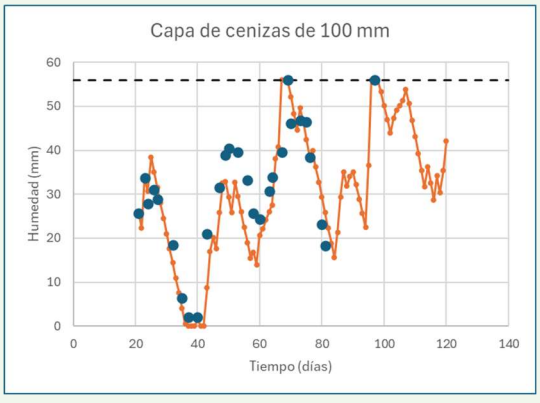


In other actions, an efficiency analysis of the proposed reuse of subproducts and decontamination methodologies/technologies applied in the 3 pilot areas was done, which involved:

A research about water-barrier effect of ashes to complete the analysis:

- Monitoring of raining, temperature and solar radiation was carried out.
- Determination of the ash and slag humidity.

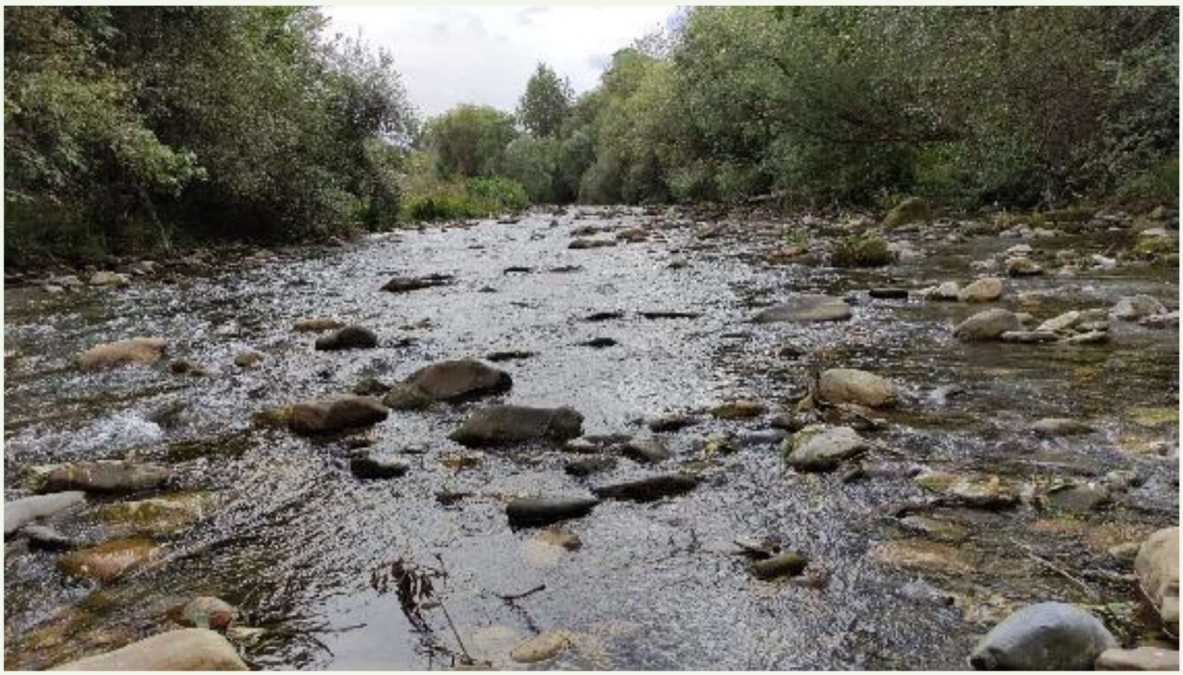
- The mechanism of raining/evapotranspiration which explains the ashes behavior has been explained which allows to extent the implementation of the results.
- With rainy weather in Asturias, a layer of 50 cm of ashes reduces the infiltration of 90% of water.



In relation with secondary impacts, this was the environmental impact assessment of the project SUBproducts4LIFE:

During the project development, the ecological status of three streams in the Muñón valley and the river Lena was characterized according to biological (benthic invertebrates, phytobenthos, macrophytes and fish), physicochemical (pH and conductivity) and hydromorphological (riverside forest and heterogeneity of the river habitat) quality indicators.

It is important to mention thar the project SUBproducts4LIFE does not have a negative effect on the river life. The positive effect is no clear due to limited scope of the project.



In relation with replication, these are the results of the phytoremediation techniques:

- Replicability of a previous LIFE project LIFE I+DARTS.
- Selected birches, previously raised in greenhouse, were planted in situ.
- To add slags and ashes to the soil improve the growth of the plants.
- To add slags and ashes to the soil improve the phytoremediation capacity.
- Slags and ashes become promising as amendments for As and Hg immobilization.

6. DISSEMINATION

In relation with the dissemination of the project:

During the development of the works, these have been the actions taken:

- News in regional newspapers.
- Broadcasting in radio and TV.
- Meetings and visits of neighbors.

After getting results:

- Scientific paper publication.
- LIFE Centre installation.
- Networking.
- Workshop.

7. TRANSFERENCE AND FUTURE

At this moment, as a result of the project, there is a team formed by companies and public organizations with a very high grade of specialization which are able to participate in activities of remediation of sites highly contaminated with mercury, arsenic and other PTEs in any part of Europe, including:

- Collaboration/advising/consulting.
- Monitorization and risk analysis.
- Engineering, planning and works execution.
- Supplying by-products (ashes and slags).

To sum up, it is important to mention that the project has experienced a delay of 4 years and to expose some of the problems that occurred throughout the project. It is a lesson to learn :

Problems for getting permissions and authorization ⟶ delays (2 years).

COVID-19 Pandemic ⟶ the project is stopped just when permits were obtained.

Geopolitical (war in Ukraine) ⟶ complex market, prices increased continuously .

Severe drought ⟶ does not allow study the proposed solution in pilot case 3.

Very hard work conditions due to Hg emissions ⟶ very low performance.

Some problems with the administrations ⟶ difficult the replicability.