H2020 WORK PROGRAMME

D7.8 – HEALTH AND SAFETY STUDY 1

LEAD BENEFICIARY: ENSO INNOVATION

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15/01/2021	v1	First draft from VERTECH	Methodology and legal review
8/03/2022	v2	Second draft	Update of previous draft and addition of questionnaires
20/4/2022	Final	Submitted version	Final review and submitted version

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LIST OF ABBREVIATIONS AND DEFINITIONS

The following abbreviations and key concepts will be used along this report.

BPR: Biocidal Products Regulation.

BSI: British Standards Institution.

CLP: Classification Labelling, Packaging.

DNEL: Derived No-Effect Levels.

EC: European Commission.

EU: European Union.

EU-OSHA: European Agency for Safety and Health at Work.

H&S: Health and Safety.

ILO: International Labour Organisation.

ISO: International Organization for Standardization.

OEL: Occupational Exposure Limits.

OH&S: Occupational Health and Safety.

PDCA: Plan-Do-Check-Act.

PPP: Plant Protection Products.

REACH: Registration, Evaluation, Authorisation and restriction of Chemicals.

REFIT: Regulatory Fitness.

SDS: Safety Data Sheet.

Hazard: intrinsic property or the ability of something (e.g., work materials, equipment, work methods and practices) with the potential to cause harm, injury, and ill health.

Risk: likelihood that the potential for harm will be attained under the conditions of use and/or exposure, and the possible extent of the harm.

Risk assessment: the process of evaluating the risk to the health and safety of workers while at work, arising from the circumstances of the occurrence of a hazard at the workplace.

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EXECUTIVE SUMMARY

BIORECOVER project aims to apply new sustainable and safe extractive technologies to obtain a wide range of Critical Raw Materials (CRMs) from unexploited secondary and primary sources. The specific sources evaluated are the Bauxite Residue, Mg low-grade ores, PGM low-grade sources and PGM content by-products (i.e., slags, dusts, and press cake). The extracted materials will be manufactured at industrial scale and further used to produce components such as catalysts, brake pads, powder Mg, and oxygen sensors.

Task 7.3 (Health, Safety and Risk assessment), aims to identify working conditions hazards for the new processes developed, in order to remove the avoidable risks for guiding the safety conditions for workplaces and health of the employees working in the selected areas.

As part of this task, a Health and Safety (H&S) assessment will be performed to identify avoidable and non-avoidable risks, setting the corrective measures when required.

This Health and Safety (H&S) study will be addressed following standard procedures in Risk Assessment, aligned with current ISO standards and regulations in Work Health and Safety regulations. Methodology will be adapted to the characteristics of BIORECOVER, and risk assessment will be continuously updated along the project, as BIORECOVER processes are optimized. This study will include equipment, chemical products, emissions, and other aspects that might be detected during the project.

Results of the emission monitoring will be compared with the current regulated values that will be also identified, to prevent health problems for the workers and potential risks due to explosive environment. The outcome from this study will be a H&S evaluation and inputs for the risks' assessment related to H&S issues. The study will be following the proposed methodology by ISO 45001, related to occupational health and safety. The outcome from this study will be a health and safety evaluation and inputs for the assessment of risks in matter of H&S issues related to BIORECOVER technologies.

This first report on Task 7.3.2 sets the framework of BIORECOVER H&S study, setting the methodology and steps that will be followed along the project. Additionally, questionnaires have been developed to collect information from each process and the hazards detected. Those questionnaires can be found under Annex I in this deliverable. This document will be updated through Deliverable 7.9 on M40, with the identified hazards, highlighting avoidable risks, and proposed corrective measures.

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1 FRAMEWORK FOR HEALTH AND SAFETY STUDIES

Concern about ensuring a safe and sustainable work environment for employees has been increasing over the past few decades. Companies have implemented strategies to monitor accidents and incidents, and stablish measures for their prevention and mitigation. According to the International Labour Organisation (ILO), there were more than 2.78 million deaths as a result of occupational accidents or work-related diseases in 2018[1]. Corporations also have the possibility to implement an Occupational Health and Safety (OH&S) management system following dedicated standards, in a voluntary approach, for guiding the safety conditions for workplaces and health of the employees working in these areas[2].

1.1 Occupational Health and Safety (OH&S) EU legislation

With the challenge of enhance and improve the protection of workers in the EU from work-related accidents and diseases, the European Commission (EC) has adopted the general OH&S *Framework Directive* accompanied by further individual directives focusing on specific aspects of health and safety at work[3]. The application of those regulations is not required by law; nevertheless, implementing one of these standards may help organizations to demonstrate compliance with health and safety law[4].

As stablished by Article 153 of the Treaty on the Functioning of the European Union, the EU has the authority to adopt minimum requirements to support and complement the activities of Member States in the field of safety and health at work[5]. Based on this Article, the Council Directive on the introduction of measures to encourage improvements in the safety and health of workers at work (Directive 89/391/EEC) came into force in 1989. Also called OH&S Framework Directive, this text encourages improvements in the safety and health of workers by guaranteeing minimum H&S requirements at work throughout Europe. Thus, the directive contains "*general principles concerning the prevention of occupational risks, the protection of safety and health, the elimination of risk and accident factors, the informing, consultation, balanced participation following national laws and/or practices and training of workers and their representatives, as well as general guidelines for the implementation of the said principles*" (Article 1, Directive 89/391/EEC).

The Framework Directive became a centrepiece of OH&S legislation in the EU[6]. Between 1989 and nowadays, more than 20 daughter directives with more detailed requirements have been adopted, concerning specific hazards at work, specific activities, vulnerable worker, and sectors with higher risks. These further directives and the OH&S framework directives cover together with a broad range of topics and risks, such as workplaces, equipment, signs, personal protective equipment, chemical

[1] Aída Ponce Del Castillo, 'Chapter 5 Occupational Safety and Health in the EU: Back to Basics', 25.
[2] Umut Hulusi İnan, Sait Gül, and Hafize Yılmaz, 'A Multiple Attribute Decision Model to Compare the Firms' Occupational Health and Safety Management Perspectives', *Safety Science*, 91 (2017), 221–31.
[3] Stefan Schulz, 'Health and Safety at Work - Fact Sheets on the European Union - European Parliament', 2019.
[4] HSE, 'ISO 45001 Health and Safety Management Standard', 2020.
[5] European commission, 'Health and Safety at Work - Employment, Social Affairs & Inclusion , 2020.
[6] Laurent Vogel, *The Machinery of Occupational Safety and Health Policy in the European Union History, Institutions, Actors*, 2015.

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agents and chemical safety, physical hazards, biological agents, workload, ergonomic and specific sectors[1]. A list of these OH&S directives is reported in Table 1. The OH&S directives have been transposed in national regulation as minimum protection levels. Member States can maintain or to go further if desired and establish more stringent measures. In this sense, the Commission evaluates the practical implementation of the OH&S legal framework every five years.

Table 1: Overview of the OH&S Directives Sources. Adapted from Del Castillo[1] and UE OSHA[7]. ■ represents the daughter directives (DD*) of the OSH Framework Directive; ■ represents the other individual directives (Others).

Individual directives	Topic	DD*	Others
Workplaces, equipment, signs, personal protective equipment			
Directive 89/654/EEC	Workplace requirements	■	
Directive 2009/104/EC	Work equipment	■	
Directive 89/656/EEC	Personal Protective Equipment	■	
Directive 92/58/EEC	Safety and/or health signs at work	■	
Directive 1999/92/EC	Risks from explosive atmospheres (ATEX)	■	
Directive 2014/34/EU	Equipment and protective systems (ATEX)		■
Exposure to chemical agents and chemical safety			
Directive 91/322/CEE	Indicative limit values		■
Directive 98/24/EC	Risks related to chemical agents at work	■	
Directive 2000/39/EC	Indicative Occupational Exposure Limit values (1)		■
Directive 2004/37/EC	Exposure to carcinogens or mutagens at work	■	
Directive 2006/15/EC	Indicative Occupational Exposure Limit values (2)		■
Directive 2009/161/EU	Indicative Occupational Exposure Limit values (3)		■
Directive 2009/148/EC	Exposure to asbestos at work		■
Directive 2017/164/EU	Indicative Occupational Exposure Limit values (4)		■
Directive 2019/1831	Indicative Occupational Exposure Limit values (5)		■
Exposure to physical hazards			
Directive 2002/44/EC	Vibration	■	
Directive 2003/10/EC	Noise	■	
Directive 2006/25/EC	Artificial optical radiation	■	
Directive 2013/35/EU	Electromagnetic fields	■	
Directive 2013/59/Euratom	Ionizing radiation		■
Exposure to biological agents			
Directive 2000/54/EC	Biological agents at work	■	
Provisions on workload, ergonomic and psychosocial risks			
Directive 90/270/EEC	Display screen equipment	■	

[7] EU-OSHA, 'European Directives on Safety and Health at Work', 2020.

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Directive 90/269/EEC	Manual handling of loads		
Sector specific and worker related provisions			
Directive 91/383/EEC	Fixed duration or temporary employment relationship		
Directive 92/29/EEC	Medical treatment onboard vessels		
Directive 92/57/EEC	Temporary or mobile construction sites		
Directive 92/85/EEC	Pregnant and breastfeeding workers		
Directive 92/91/EEC	Mineral-extracting industries through drilling		
Directive 92/104/EEC	Mineral-extracting industries		
Directive 93/103/EC	Work onboard fishing vessels		
Directive 94/33/EEC	Young people at work		
Directive 2010/32/EU	Prevention from sharp injuries in the hospital and healthcare sector		

1.2 International Standards

As defined by the International Organization for Standardization (ISO), the formal definition of a standard is: a document, established by consensus and approved by a recognized body that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context. In general, its adoption is on a voluntary basis and it can be developed by national, regional, and international standards developing organizations and by businesses or other organizations for their internal use.

European standards are published to meet specific European needs such as those around the internal European market to enhance the competitive position of Europe, whilst maintaining strong connections with international standardization organizations[7].

In the field of occupational health and safety, standards are an important element in prevention activity for safe and healthy workplaces. As a basic classification to approach the standardization landscape here, two possible categories of standards can be considered: i) standards for products and services; ii) standards for management systems.

1.2.1 Standards for products and services

Concerning the first category, standards set out technical requirements for products and services. They define some specific requirements, specifications, guidelines, or characteristics for a determined item (e.g., a material, a product, a procedure, a process or a service) in order to make such an item meet certain well-defined objectives. In OH&S, standardization has delivered good results in fields including the following: terms and definitions, measurements, and planning of measurement, testing and sampling procedures, statistical methods and data exchange, safety signals and warning signs, as well as a selection of equipment. For instance, some standards define measurement methods for emissions such as noise, vibration, radiation, and harmful substances. Usually, these standards correspond to the highest level of safety and health that can reasonably be expected from a product.

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1.2.2 Standards for management system

In the second category, standards set out minimum requirements for non-technical areas such as harmonization of OH&S management system. In recent years, various management systems have been introduced within companies. Since then, systems have been standardized and became certifiable for some of them. Well-known examples include OHSAS 18001, the ISO 9000 series of standards for a quality management system and ISO 14000 for an environmental management system. From 2018, an international standard has been defined for occupation health and safety management system: ISO 45001.

Several references have recognized that implementing a safety management system is the most efficient way to allocate resources for safety, since it not only improves working conditions but also positively influences employees' attitudes and behaviours with regards to safety, consequently improving the safety environment. This approach brings the government together with industry and associations to encourage employers to build effective H&S management systems[8].

1.2.3 OHSAS 18001

In 1999, the OSHAS 18001 appears as a unifying model. Developed by the British Standards Institution (BSI), OHSAS 18001 is an instrument for handling occupational risk in the work environment (British Standards Institution., 1999). In 2007, the standard has been reviewed to be harmonized with the ILO-OSH 2001 standard established by the ILO.

OHSAS 18001:2007 has been the dominant OH&S Management System in industry and it has been implemented by many firms of a variety of sizes and sectors. It aimed to promote a systematic and structured management understanding to provide safety of workers' health sustainability[8]. This standard helps the organization to implement a sound OH&S management system allowing it to reduce risks to personnel and establish the right safe

ty measures in place. Based on the Plan-Do-Check-Act (PDCA) cycle, OHSAS 18001:2007 also looks at the best ways to improve and maintain OH&S system, while performing in line with the company's policy.

1.2.4 ISO 45001

Since March 2018, a new international standard about OH&S management system, ISO 45001:2018, has been published. It was based on earlier international standards in this area, such as OHSAS 18001:2007, the International Labour Organization's ILO-OSH Guidelines, various national standards and the ILO's international labour standards and conventions[9].

This standard provides a framework for all organizations to manage risks and opportunities to help prevent work-related injury and ill health to workers. It is applicable for all organizations, regardless

[8] Beatriz Fernández-Muñiz, José Montes-Peón, and Camilo Vázquez-Ordás, 'Occupational Risk Management under the OHSAS 18001 Standard: Analysis of Perceptions and Attitudes of Certified Firms', *Journal of Cleaner Production*, 24 (2012), 36–47 <https://doi.org/10.1016/j.jclepro.2011.11.008>.
[9] ILO (2018) Safety and health at work

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of size, industry, or nature of business. The norm adopts a risk-based approach that ensures it is effective and undergoes continual improvement to meet an organization's ever-changing context.

1.3 Other legislation

1.3.1 Regulation (EC) No 1907/2006 or REACH

REACH (Registration, Evaluation, Authorisation, and restriction of Chemicals) stands stipulates those substances imported or manufactured in quantities above one tonne per annum (per manufacturer/importer) shall be registered. Also, it controls the registration and obligations to communicate hazards and risks along the supply chain, places risk management duties on all the actors in the supply chain, who often are employers in terms of producers or downstream users of a chemical substance[10].

REACH entered into force on 1 June 2007, and nowadays is the main European regulation controlling the risks involved in the use of chemical products. REACH tends to improve the protection of human health and the environment by establishing a harmonized standard for all products on the EU market.

In REACH, when certain conditions are met, the suppliers should compile and supply a Safety Data Sheet (SDS). This SDS must specify national Occupational Exposure Limits (OELs) and biological limit values determined following OH&S directives. However, if the quantity exceeds ten tonnes, a chemical safety assessment shall be performed to demonstrate safe use of the chemical by determining Derived No-Effect Levels (DNELs). Therefore, in the same SDS section, for the same substance, both types of value can be mentioned, even if the calculation methods are totally different.

Moreover, other legislations covering chemical hazard identification and classification are:

- Plant Protection Products Regulation (PPPs - 1107/2009/EC);
- Classification, Labelling, Packaging Regulation (CLP - 1272/2008/EC);
- Biocidal Products Regulation (BPR - 528/2012/EU).

1.3.2 European Community Strategies

The fundamentals of European H&S legislation put in place by the Framework directive and the individual OH&S directives are supported by multiannual community strategies. Different strategies have been adopted since 1978. These strategies are formally endorsed by the European Commission after consultation and they are voluntarily implemented by the Member States and stakeholders as social partners and other EU institutions and bodies. The most recent one is the EU Strategic Framework on Health and Safety at work 2014 – 2020, which was adopted in 2015.

As the strategic framework expires in 2020, the Council and Commission is working for the renewal of the strategy. The new strategy needs to be more ambitious in calling for clear actions. In this sense,

[10] European Commission, 'Ex-Post Evaluation of the European Union Occupatinal Safety and Health Directives (REFIT Evaluation)', 2017.

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their executive committee published in October 2019, the ETUC position on a new EU strategy on Occupational Safety and Health for 2021 – 2027 [11].

1.3.3 Guidance documents

Some organizations claimed a need to simplify legislation where appropriate, to make it easier for Small and Medium-size Enterprises (SMEs) to implement H&S assessment[1]. Therefore, to avoid the bureaucratic burden of H&S measures for a company, numerous bodies have published a series of European guidelines. There are different types of guidelines; the most prominent are practical guidelines from the European Commission setting out best practices for the prevention of risks. Other guidelines are also available such as Council Recommendations, European Commission Communications, EU Social partner's agreements, and others. On its website, the EU-OSHA lists per topic the guidelines available related to OH&S[7].

In addition to the guidelines, other non-binding documents are made available to employers at international and European levels such as harmonized standards.

[11] ETUC, *ETUC Position on a New EU Strategy on Occupational Safety and Health*, 2019.

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2 HEALTH AND SAFETY METHODOLOGY

As it has been mentioned in the section before, the Health and Safety (H&S) regulations and standards report a set of steps to follow for H&S evaluation. This procedure is based on the PDCA (Plan-Do-Check-Act) approach that is an inherent part of the systematic method to determine workable solutions, assessing the results, and implementing ones that have been shown to work. The PDCA approach is based on the following steps (Figure 1):

1. **Plan:** identify and assess OH&S risks and opportunities, establish OH&S objectives and processes needed to obtain results in line with OH&S policy.
2. **Do:** implement the processes, as planned.
3. **Check:** monitor, measure and report results considering OH&S policies and objectives.
4. **Act:** act to continually improve OH&S performance so that it achieved the expected results.

Figure 1: Plan-Do-Check-Act (PDCA) methodology (ISO 45001).

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For the development of a H&S analysis, it's necessary to perform the operational risk assessment. It is also one of the key elements of ISO 45001 based on voluntary agreement. The risk assessment is the process to evaluate the H&S risks of workers while at work, arising from the circumstances of the occurrence of hazard at the workplace. It is the basis for successful management as well as the key to reducing work-related accidents and occupational diseases. Implement a risk assessment can improve workplace safety and health and business performance[12].

To prepare the risk assessment, another prior step is necessary: to define the scope of the risk assessment. The scope includes any system, activities, physical or analytical boundaries of the study. Indeed, because OH&S risk assessment is concerned with hazards in which H&S can be harmed, clearly defining the activities or tasks of interest is an important first step in any OH&S risk assessment.

The system boundaries set out the equipment, work tasks, worker or locations of the workplace that are going to be included in the risk assessment. This can also be referred to as 'boundaries of applicability'. The scope can cover all activities and locations or only some and it can also change in time.

In the common way of carrying out a risk assessment, 4 questions should always be borne in mind when approaching a risk assessment (Figure 2). Companies should implement a step-by-step risk assessment to ensure H&S of employees[7].

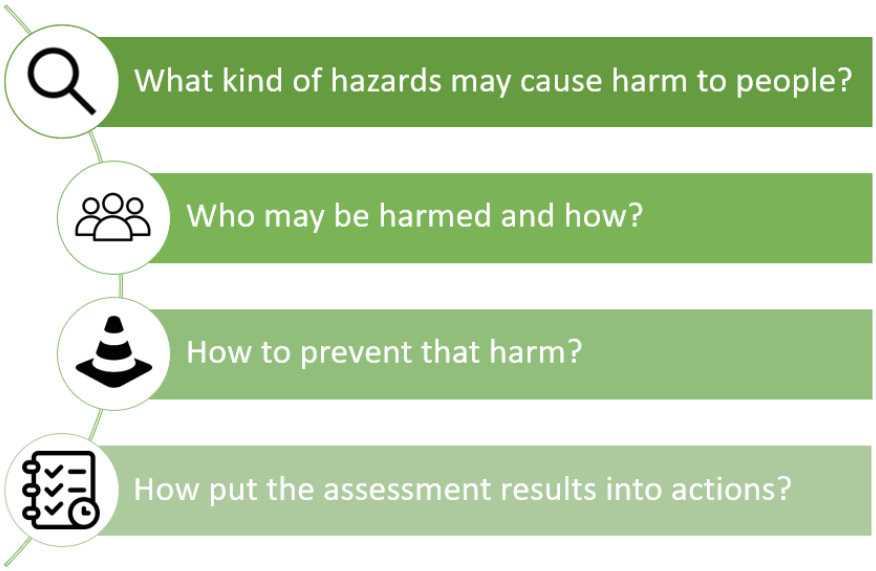

Figure 2: Risk assessment approach in H&S.

[12] European commission (2020) Health and safety at work - Employment, Social Affairs & Inclusion - European commission.

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3 BIORECOVER HEALTH & SAFETY STUDY

The objective of this task is to identify the working condition hazards linked to the new processes developed in the project, setting a methodology to evaluate the risks raised and the measures to remove avoidable risks and set corrective measures for those non-avoidable.

This study will include the equipment used, chemical products, emissions from the different process, biological hazards linked to the use of cultures and any other aspects detected along the project. While additional hazards might exist due to conventional work in laboratory or field, this task will focus on the working conditions, equipment and reagents linked to the raw matters used (mine tailings, bauxite residues, etc. and the biorecover processes; Characterisation and conditioning of raw matters, pre-treatment, bioleaching, and post-treatment.

Based on the methodology previously described, Occupational Health and Safety of BIORECOVER will be carried out following five stages:

I. Information Collection (process conditions, reagents involved, workers exposed…)
II. Hazard Identification, linked to the information collected
III. Risk Assessment
IV. Action Planning for Risk elimination or reduction
V. Risk Assessment Documentation

This assessment will be updated continuously during the project, in order to detect new hazards linked to the optimisation and scale up of the processes, avoiding new risks for workers involved in the project.

3.1 Methodology

3.1.1 Information Collection

Hazard identification requires the previous collection of information related to the existing risks on the different worksites of the partners involved in BIORECOVER. In order to ensure an exhaustive collection of information and the adequate risk identification, thus collaboration of all consortium is essential to address properly the hazard evaluation of each process.

Questionaries have been developed specifically for each partner (Figure 4), according to the tasks developed in each work package. Each partner will provide data related with the chemicals, and operational conditions of each stage, as well as a preliminary identification of hazards related to each task. This step will allow collecting information on the environment, geographical area, tasks, population and/or known past experiences with a sector-specific approach. The information collected will be analysed to perform the risk assessment. All questionnaires developed are attached in Annex I of the present deliverable and have been sent to the corresponding partners.

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	TREATMENT FOR PLGO WASTE			
	Technology	*Stages*	*Comments*	*Hazards identification*
T3.1. Treatment: Identification and selection of the indigenous microbial populations from the raw materials	Cyanide producing bacteria test to be used as biocatalyst for PGM mobilization	Bacteria isolation	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		Enrichment media use	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		Exposition to increasing metal concentration	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		Physiological characterization	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		Genetical characterization	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		Indicate if there are more...		
T3.2 Screening based on microorganism activity	Evaluation of PGM mobilization at lab-scale	Grow and adaptation experiments	LB + tryptone, yeast extracts, sodium chloride, glycine, pH=7.2	*Indicate operational risks...*
		Incubation	30ºC, rotary shaker 150 rpm	*Indicate operational risks...*
		Bacterial density measurement by OD	600nm	*Indicate operational risks...*
		Ion-selective electrode, titration against standard	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		Mobilization experiments	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		PGM solubility analysis by AAS/ICP-AES	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		Microorganisms culture	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		pH measurement	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		redox potential measurement	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		TOC analysis	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		Cell counting	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		Microscopic inspection	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		Indicate if there are more...		
	Washed residue analysis	Wasing	Deionized water	*Indicate operational risks...*
		PGM cuantification by ICP-OES	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		SEM	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		XRF	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		MLA	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		Indicate if there are more...		
T3.3 Optimization of selected microorganism	Optimization of operational conditions by DoE, RSM, and neutral network	pH measurement	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		temperature measurement	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		residence time measurement	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		Particle size measurement	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		Solid concentration measurement	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		Stirring	*Use of more chemicals, operatinal conditions (pH, T°...)*	*Indicate operational risks...*
		Indicate if there are more...	*Use of more chemicals, operatinal conditions (pH, T°...)*	

Figure 3. Questionnaire example for H&S data collection.

Additionally, an initial review of activities and risks was already carried out by BIORECOVER consortium under WP10, in order to ensure compliance with the relevant national legislation at the beginning of the project. These fist risk analysis, reported in *D.10.1. EPQ Requirement No 3,* and have been taken into consideration under this action

3.1.2 Hazard Identification

Hazard identification will be carried out from the analysis of the information reported by each partner through the questionaries. Hazards reported by each partner will be reviewed, as well as operational conditions, chemicals, and other data included, in order to identify additional hazards related to each stage. This identification will also rely on observation, meetings with partners and review of specific H&S documentation. Some expected hazards are listed below:

- Work practices and layout of premises.
- Use of electricity.
- Use of work equipment, such as tools and machines.
- Hazardous substances such as chemicals, dust, fumes.
- Physical agents, such as noise, vibration, radiation.
- Biological agents, such as molds, bacteria, viruses.
- Environmental factors, such as inadequate light, temperature, humidity, or ventilation.

Finally, this hazard identification will be periodically updated with BIORECOVER consortium in order to ensure new hazards are identified

3.1.3 Assessing risks arise from hazards

Once hazards have been identified, as well as who they affect, it is necessary to prioritize risks. An adequate OH&S risk assessment involves at least 2 variables:

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- The consequences of the harm related to an identified risk.
- The likelihood, of a harm to happed

In order to take into account these variables related to the different hazards identified, a matrix can be de developed that combines quantified values related to the consequences and the likehood of each hazard.

To assess the risks, it is necessary to consider the possible extent of harm from an identified risk as a range of outcomes such as the one detailed in Table 2, on a scale from 1 to 5.

Table 2: Range of possible extent of harm from an identified risk.

Descriptor	Level	Definition
Insignificant	**1**	No injury
Minor	**2**	Injury/ ill health requiring first aid
Moderate	**3**	Injury/ill health requiring medical attention
Major	**4**	Injury/ill health requiring hospital admission
Severe	**5**	Fatality

A similar approach is used to address the probability of a harm to happened (likehood). At this point, ENSO also developed a classification from 1-5, based on the different probability of a harm to occurring (Table 3).

Table 3: Range of likelihood of the possible harm occurring.

Descriptor	Level	Definition
Rare	**1**	May occur somewhere, sometime ("once in a life time / once in a hundred years")
Unlikely	**2**	May occur somewhere within the Department over an extended period of time
Possible	**3**	May occur several times across the Department or a region over a period of time
Likely	**4**	May be anticipated multiple times over a period of time. May occur once every few repetitions of the activity or event
Almost Certain	**5**	Prone to occur regularly. It is anticipated for each repetition of the activity of event

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According to these ranges, assessed in collaboration with the partners involved in the process where the harm was identified, a Risk matrix is developed to assign a risk level, based on the combination of Likehood and Consequence. According to the score of these two variables, a risk will be classified from Low to Extreme. This classification will lead to the adoption of different measures and under a different timeframe (Table 4).

Table 4. Risk classification based on the Risk Assessment Matrix

Score	Descriptor	Definition
16-25	Extreme	Notify **Workplace Manager and/or Management OHS Nominee** immediately. Corrective actions should be taken immediately. Cease associated activity.
11-15	High	Notify **Workplace Manager and/or Management OHS Nominee** immediately. Corrective actions should be taken within 48 hours of notification.
5-10	Medium	Notify **Nominated employee, HSR / HSC**. Nominated employee, OHS Representative / HSC is to follow up that corrective action is taken within 7 days.
1-4	Low	Notify **Nominated employee, HSR / HSC**. Nominated employee, HSR / HSC is to follow up that corrective action is taken within a reasonable time.

Table 5: Risk matrix to assess the likelihood and consequence of risks over the project technologies.

			Consecuence				
			Insignificant 1	Minor 2	Moderate 3	Major 4	Severe 5
Likehood	Rare	1	LOW	LOW	LOW	LOW	MEDIUM
	Unlikely	2	LOW	LOW	MEDIUM	MEDIUM	MEDIUM
	Possible	3	LOW	MEDIUM	MEDIUM	HIGH	HIGH
	Likely	4	LOW	MEDIUM	HIGH	EXTREME	EXTREME
	Almost Certain	5	MEDIUM	HIGH	EXTREME	EXTREME	EXTREME

Regarding the risk scoring, two types of risks are considered: inherent/intrinsic risk and residual risk. The inherent/intrinsic risk is the level of risk that an activity/hazard category would pose if no

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controls or other mitigating factors were in place. The residual risk is the level of risk associated with an activity after proposed/additional controls have been implemented to further eliminate or reduce the risk. Risk Assessment matrix will be updated with the updated hazards detected along the project.

3.1.4 Planning actions to eliminate or reduce risks

Once all the risks are assessed, next stage is to address these risks by implementing actions that allows its reduction or elimination.

On this Planning Phase, the organization needs to identify if there are any existing controls and whether they are adequate for the identified hazard. There is also a decision to take on the necessity to act to reduce or eliminate the risk or no. If action is needed, it is necessary to answer the following questions: What should be done? What steps should be taken? Who will do them, and when?

Within this phase, the ISO 45001 standard requires organizations to establish a hierarchy of controls. This term means the priority in the selection and implementation of controls related to OH&S hazards. Several groups of controls can be established. The hierarchy is introduced to encourage the organization to implement controls that will eliminate or decrease the risk of a hazard in the most satisfying way. Therefore, if new or improved controls are required, their selection should be determined by the principle of the hierarchy of controls (Figure 4), which defines the order of considering the controls. An organization may choose to implement one or a combination of several kinds of control if necessary.

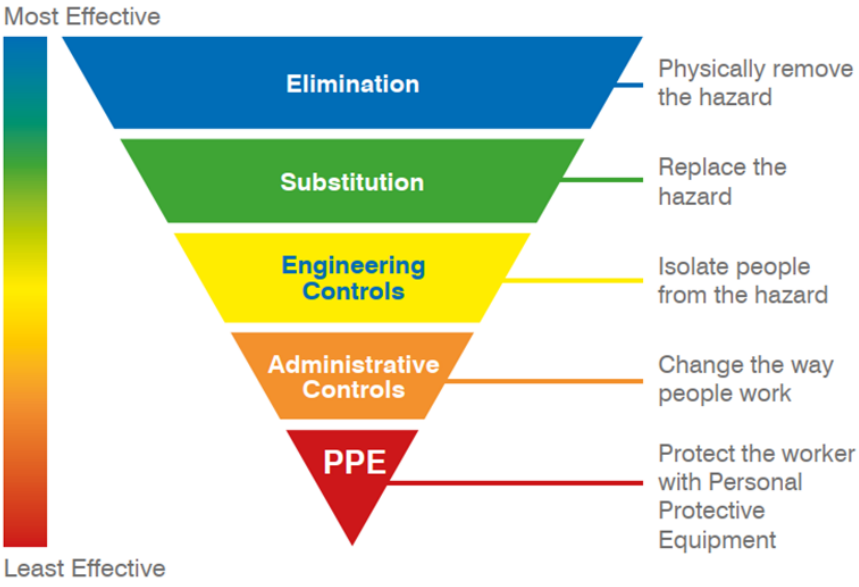

Figure 4: Hierarchy of controls according to the ISO 45001[4].

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Taking excessive steps to eliminate a very small risk, while only applying personal protective equipment controls to a much greater hazard, is not only a poor utilization of resources but will also not reduce the overall hazard level of a company. It is why the next step, consisting to set up an action plan with appropriate measures is important. As stated in the European Commission's OH&S practical guideline, the action plan should include preventive measures, protection measures and mitigations measures.

Preventive measures

It is much better for workers and employers to act before something bad happens, to anticipate the risk and prevent it. Therefore, prevention is a key concept and the main objective of OSH. Preventive measures aim to reduce the likelihood of occurrence of a work accident or an occupational disease.

Protection measures

Protection measures can be of two types: collectives and individuals. In general, protection measures should be primarily collective. Individual measures are alternatives if collective solutions are not feasible, effective or relevant.

Collective measures are designed to enclose or isolate the risk using physical barriers, organizational or administrative measures to diminish the exposure duration (job rotation, the timing of the job, safety signs).

Individual measures include any adequate Personnel Protective Equipment (PPE) designed to protect the worker.

Mitigation measures

Preventive and protection measures need to be complemented with mitigation measures. By preparing to emergencies, this type of measure aims to reduce the severity of any damage to facilities as well as harm to an employee and/or public. For instance, emergency plans, evacuation plans, warning systems (alarms, flashing lights), a test of emergency procedures, exercises and drills, fire-extinguishing system or return-to-work-plan can be part of mitigation solutions.

3.1.5 Documenting risk assessment

The OH&S Framework Directive requires the employer to own an assessment of the risks to safety and health at work. In this sense, the results of the risk assessment should be written down and keep a written record for reference[7]. There are no specific requirements as to the content of the written record[13]. For BIORECOVER project, ENSO proposes to include in the final document the following information:

[13] European Commission, *Health and Safety at Work Is Everybody's Business. Practical Guide for Employers*, *European Commissioner for Employment*, 2016.

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- Name and function of the person(s) carrying out the examination.
- Hazards and risks identified.
- Groups of workers facing risks.
- Necessary protection measures, who will be responsible for them and how to monitor the progress.
- Information about the involvement of workers and their representatives in the risk assessment process.
- Actions implemented to reduce or eliminate de risks previously detected.

3.2 Preliminary Results obtained

Based on the information recovered in Deliverable 10.1 and the questionnaires received from BIORECOVER consortium, a first identification of Hazards and a tentative hazard classification has been carried out. Additional hazards are expected to be identified within the next months, under the periodic H&S review of the project.

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Table 6. BIORECOVER Risk Assessment

Partner	Technology	Hazard	Description	Conseq.	Likehood	Risk		Corrective measures adopted
CETIM	Optimization of operational conditions to maximize the dissolution of REE (WP4)	**Infections and allergic reactions due to spore release of A. niger**	*A niger is a fungi classified as Risk Level 2. It produces spores and it may cause infections and allergic reactions. It may also produce toxins with negrotoxic effect (Ochratoxin A).*	Moderate	Unlikely	**6**	**MEDIUM**	Use of PPE for management of A. niger. Tests are carried out at a Microbiology Clase 2 laboratory where only workers with specific training to operate with bacteria, fungal cultures, etc. are allowed
	Optimization of operational conditions to maximize the dissolution of REE and Mg (WP3)	**Risk of burns on Autoclave and heating blankets**	*Heating blankets can reach high temperatures if not installed and operated properly. Autoclave and heating blankets. Autoclaving step uses temperatures up to 121 ºC*	Minor	Rare	**2**	**LOW**	Workers operating all equipment are trained on risks linked to its operation.
	Optimization of operational conditions to maximize the dissolution of REE and Mg (WP3)	**Spillage and exposure to bauxite residue and A. niger /spores**	*Spillage and exposure danger when sampling REE and Mg tests*	Moderate	Unlikely	**6**	**MEDIUM**	Internal H&S protocols involves the use of safety glasses, gloves and other PPE in order to protect workers from accidental spillage.
	Optimization of operational conditions to maximize the dissolution of REE (WP3)	**Handling of bauxite**	*Hazard linked to the handling of bauxite. If inhaled it may cause irritation after constant exposition to the powder. It may cause burns in skin and eyes to the presence of caustic ingredients.*	Moderate	Unlikely	**6**	**MEDIUM**	As part of the internal H&S protocols, workers will wear proper face mask, safety glasses when working with bauxite residues
UCPH	Identification y selection of indigenous microbial populations	**Exposure to microorganisms**	*Exposure to microorganisms in Class 1 Microbiology laboratories.*	Moderate	Unlikely	**6**	**MEDIUM**	Internal H&S procedures and specific training for working in Class 1 microbiology facilities
TR	REE and PGM recovery with polymeric microcapsules	**Exposure to organic chemicals**	*Cyanex 272 (Lewatit TP 272) and D2EHPA (Lewatit VP OC 1026) have been carried out at batch, 30ºC and 24 h, using a synthetic solution at pH 1. Also acids are used in the re-extraction of Y*	Moderate	Unlikely	**6**	**MEDIUM**	Adoption of H&S protective measures to work with organic chemicals, based on internal TR protocols and the HSDS from the reagents involved.

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			and Sc. Regular hazards related to the exposure to organic, acid and alkaline chemicals are detected					Use of gloves, face mask, laboratory fume hoods and other PPE when required.
	Continuous extraction tests in columns	**Accidental spillage**	*Extraction tests are operated in continuous using microcapsules and a synthetic solution with pH. Eventual break might cause spillage of these chemicals and irritation or skin and eyes*	Minor	Rare	**2**	**LOW**	
ALGAENERGY	Extraction of metals from synthetic bioleachate	**Exposure to bioleachate containing metals**	*Exposure to solutions with metals and chemical reagents*	Moderate	Unlikely	**6**	**MEDIUM**	Measures to minimize risks related to exposure to harmful compounds. Personal protective equipment, selection of metal salts to decrease H&S risks for workers, adequate ventilation of laboratory
JM	Handling of Pt salts (WP1,4 and 6)	**Exposure to Pt salts**	*Risks associated to Pt salts*	Moderate	Unlikely	**6**	**MEDIUM**	best handling policies for sensitizing Pt salts have been determined and all solutions > 10 ppm Pt are handled in a glovebox to minimize exposure. Large quantities of PGM containing material and all CRM materials are also handled in a glovebox, fume hood, or dust cabinet
	Use of H2 in High pressure vessels (WP6)	**Explosion Risk**	*Risk of explosion due to the use of pressure vessels and flammable chemicals*	Major	Unlikely	**8**	**MEDIUM**	Personnel will be trained in the operation of high-pressure vessels prior to its operation
	Validation of metals recovered (WP6)	**Handling of corrosive and flammable chemicals**	*Risk related to the handling of corrosive and flammable chemicals*	Moderate	Unlikely	**6**	**MEDIUM**	JM has established an internal Health and Safety policy with specific provisions for offices and labs. Employees are trained in use of hazardous chemicals and trained by experienced personnel. Risk assessments and COSHH assessments are conducted prior to all experiments. Best practices and updated policies are shared across JMTC (Johnson Matthey Technology Centre).

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4 CONCLUSIONS

Considering the legislative context mentioned in this deliverable and the different requirements on the Framework Directives on Occupational Safety and Health, ENSO has defined in this deliverable the methodology to address the Health and Safety (H&S) study of the different processes developed in BIORECOVER.

As in other assessments carried out in the project (LCA, LCC), H&S will take into account the evolution of the different processes within the different WP, performing a continuous update of the H&S study to reflect the progress in the project (reagents used, microbial cultures, working conditions, etc.). Thus, a continuous flow of information with the consortium will be required.

A set of questionnaires, annexed to this deliverable, have been developed to collect the information required for risk evaluation. Hazard Identification will be addressed based on this information provided from all partners, assessing the different risks that might arise from the identified hazards. A score-based risk matrix will be built based on the likehood and consequences of every identified risk, stablishing a risk level, from low to extreme.

Next step after Risk Assessment will be the development of actions to reduce or eliminate the risks, developing a set of measures, based in the Hierarchy of controls indicated in ISO 45001. This task will be also carried out in collaboration with the partners responsible for each process.

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ANNEX I: QUESTIONNAIRES FOR HAZARD IDENTIFICATION

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This section gathers all questionnaires developed and sent to the consortium to collect data regarding the processes developed and the hazards initially identified by them.

1. **Pre-treatment questionnaire for BR treated by UC.**

	PRE-TREATMENT FOR BR WASTE			
	Technology	***Stages***	***Comments***	***Hazards identification***
T2.1. Pre-treatment: Identification and selection of indigenous microbial populations	BR specifically indigenous bacteria isolation (With potential ability to remove Fe, Al, Ca or Ti)	*Indicate if there are stages…*	Oxalate, 20-30ºC	*Indicate operational risks…*
			Use of more chemicals, operational conditions (pH, Tº…)	
T2.2 Screening based on microorganism activity	Diverse phylogenetic microorganisms' activity: High metal resistance and growth rate, alkaliphilic and able to use cheap substrate	Use of Horikoshi medium	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Centrifugation	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		ICP-MS use	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		XRF use	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Microscopic observation	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Indicate if there are more…		
T2.3 Optimisation of selected microorganisms and parameters	Confirming the biological activity	XRF	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Indicate if there are more…		

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2. Pre-treatment questionnaire for MgW treated by UC.

	PRE-TREATMENT FOR MgW WASTE			
	Technology	***Stages***	***Comments***	***Hazards identification***
T2.1. Pre-treatment: Identification and selection of indigenous microbial populations	MgW specifically indigenous bacteria isolation (With potential ability to remove silicon, Fe or $CaCO_3$)	Incubation medium	NaCl 0,85%, 20-30ºC	*Indicate operational risks…*
		Evaluation of dissolution potential	$CaCO_3$ and $MgCO_3$ solutions, 20-30ºC	*Indicate operational risks…*
		Indicate if there are more…	*Use of more chemicals, operational conditions (pH, Tº…)*	
T2.2 Screening based on microorganism activity	Diverse phylogenetic microorganisms' activity: Decalcification potential, and growth rate, and able to use cheap substrate	Use of minimal media	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		ICP-MS use	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Microscopic observation	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Indicate if there are more…		
T2.3 Optimisation of selected microorganisms and parameters	Confirming the biological activity	XRF	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Indicate if there are more…		

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3. Pre-treatment questionnaire for PCBP treated by UC.

	PRE-TREATMENT FOR PCBP WASTE			
	Technology	***Stages***	***Comments***	***Hazards identification***
T2.2 Screening based on microorganism activity	Diverse phylogenetic microorganisms' activity: Able to grow at alkaline pH (8, 8.5), resistant to Cu, Ni, Zn and Fe presence, and able to remove Cu, Ni, and Co	Slurry preparation	Deionized water	*Indicate operational risks…*
		Heat	45ºC, airing	*Indicate operational risks…*
		ICP-MS analysis	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		pH and redox potential	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Washing and sieving	water	*Indicate operational risks…*
		Indicate if there are more…		
T2.3 Optimisation of selected microorganisms and parameters	Definition of the strains and conditions	Definition of strains to be used	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Definition of growing and leaching conditions	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Ability to increase the target metal mobilization test	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		HPLC	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		XRF	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Indicate if there are more…		

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4. Pre-treatment questionnaire for BR treated by UCPH.

	PRE-TREATMENT FOR BR WASTE			
	Technology	***Stages***	***Comments***	***Hazards identification***
T2.1. Pre-treatment: Identification and selection of indigenous microbial populations	Characterization of total microbial communities: High throughput sequencing (HTS)	*Indicate if there are stages…*	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
	Characterization of total microbial communities: Biochemical assays	Carbon sources use	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		pH	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Metal resistance	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Biofilm formation	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Growth rate	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Metabolite's consumption and production	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		HPLC	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Indicate if there are more…	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
	Identification of microbial consortia with potential synergetic effect of IC removal	Strains combination	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Enrichment and dilution series	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Micro sampling and cultures	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Indicate if there are more…	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
	Phylogenetical identification	Ribosomal subunit sequencing	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Preserving	Horikoshi medium (glycerol-alkaline medium, -80ºC)	*Indicate operational risks…*
		Indicate if there are more…		

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T2.2 Screening based on microorganism activity	Diverse phylogenetic microorganisms' activity: High metal resistance and growth rate, alkaliphilic and able to use cheap substrate	Use of Horikoshi medium	*Use of chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Centrifugation	*Use of chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		ICP-MS use	*Use of chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		XRF use	*Use of chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Microscopic observation	*Use of chemicals, operational conditions (pH, Tº...)*	*Use of chemicals, operational conditions (pH, Tº...)*
		Indicate if there are more...		
T2.3 Optimisation of selected microorganisms and parameters	Genomic characterization of each isolate and consortia selected	Illumina MiSeq use	*Use of chemicals, operational conditions (pH, Tº...)*	*Use of chemicals, operational conditions (pH, Tº...)*
		Immobilization/ mobilization	*Use of chemicals, operational conditions (pH, Tº...)*	*Use of chemicals, operational conditions (pH, Tº...)*
		Transcriptomes analysis	*Use of chemicals, operational conditions (pH, Tº...)*	*Use of chemicals, operational conditions (pH, Tº...)*
		Indicate if there are more...		

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5. Pre-treatment questionnaire for MgW treated by UCPH.

	PRE-TREATMENT FOR MgW WASTE			
	Technology	***Stages***	***Comments***	***Hazards identification***
T2.1. Pre-treatment: Identification and selection of indigenous microbial populations	Characterization of total microbial communities: High throughput sequencing (HTS)	*Indicate if there are stages…*	Use of chemicals, operational conditions (pH, Tº…)	*Indicate operational risks…*
	Characterization of total microbial communities: Biochemical assays	Carbon sources use	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		pH	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Metal resistance	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Biofilm formation	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Growth rate	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Metabolites consumption and production	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		HPLC	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Indicate if there are more…	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
	Identification of microbial consortia with potential synergetic effect of IC removal	Strains combination	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Enrichment and dilution series	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Microsampling and cultures	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Co-cultivation of microorganisms with $CaCO_3$ biomineralization capacity	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Indicate if there are more…	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*

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	Phylogenetical identification	Ribosomal subunit sequencing	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Preserving	(Luria-Bertani Broth) 15% glycerol, -80ºC	*Indicate operational risks…*
		Indicate if there are more…		
T2.2 Screening based on microorganism activity	Diverse phylogenetic microorganisms' activity: Decalcification potential, and growth rate, and able to use cheap substrate	Use of minimal media	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		ICP-MS use	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Microscopic observation	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Indicate if there are more…		
T2.3 Optimisation of selected microorganisms and parameters	Genomic characterization of each isolate and consortia selected	Illumina MiSeq use	*Use of chemicals, operational conditions (pH, Tº…)*	*Use of chemicals, operational conditions (pH, Tº…)*
		Immobilization/ mobilization	*Use of chemicals, operational conditions (pH, Tº…)*	*Use of chemicals, operational conditions (pH, Tº…)*
		Transcriptomes analysis	*Use of chemicals, operational conditions (pH, Tº…)*	*Use of chemicals, operational conditions (pH, Tº…)*
		Indicate if there are more…		

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6. Pre-treatment questionnaire for PLGO treated by UWITS.

	PRE-TREATMENT FOR PLGO WASTE			
	Technology	***Stages***	***Comments***	***Hazards identification***
T2.1. Pre-treatment: Identification and selection of indigenous microbial populations	PLGO specifically indigenous bacteria isolation (With potential ability to remove Cu, Ni or Co)	pH adjustment of 9K medium	Sulphuric acid	*Indicate operational risks…*
		Culture enrichment	Ferrous sulphate/sulphur	*Indicate operational risks…*
		Incubation	Rotary shaker	*Indicate operational risks…*
		Storing	Sterile glycerol (20%), 20ºC	*Indicate operational risks…*
		Light and scanning microscopy	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Indicate if there are more…		
T2.2 Screening based on microorganism activity	Isolated species activity to remove Cu, Ni, and Co	Mesophilic microorganisms use	35ºC, stirred tank reactor	*Indicate operational risks…*
		Thermophilic microorganisms use	65ºC, stirred tank reactor	*Indicate operational risks…*
		Crushed low grade ore preparation	Deionized water	*Indicate operational risks…*
		AAS/ICP-AES technique	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		pH control and redox probe	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		TOC analysis	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Washing and sieving	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Filtration	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		ICP-OES use	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		SEM use	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		XRF use	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		MLA use	*Use of chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Indicate if there are more…		

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T2.3 Optimisation of selected microorganisms and parameters	Optimizing microorganisms to maximize mobilization	pH measurement	*Use of chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Redox potential measurement	*Use of chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Solids concentration measurement	*Use of chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Temperature measurement	*Use of chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Particle size measurement	*Use of chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		

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7. Treatment questionnaire for BR treated by CETIM.

	TREATMENT FOR BR WASTE			
	Technology	***Stages***	***Comments***	***Hazards identification***
T3.2 Screening based on microorganism activity	Screening	Initial screening of the BR	Enrichment of microbia	*Indicate operational risks…*
		Screening of BR with amended species	Enrichment of microbia	*Indicate operational risks…*
		Optimization	Density, temperature, pH,	*Indicate operational risks…*
		Large scale screening	ICP-MS	*Indicate operational risks…*
		Most promising consortia	DNA extraction, SSU, rRNA gene, HTS	*Indicate operational risks…*
		Indicate if there are more…	*Use of more chemicals, operational conditions (pH, T°…)*	
T3.3 Optimization of selected microorganism	Optimization of operational conditions to maximize the dissolution of REE	pH measurement	*Use of more chemicals, operational conditions (pH, T°…)*	*Indicate operational risks…*
		temperature measurement	*Use of more chemicals, operational conditions (pH, T°…)*	*Indicate operational risks…*
		redox potential measurement	*Use of more chemicals, operational conditions (pH, T°…)*	*Indicate operational risks…*
		stirring	*Use of more chemicals, operational conditions (pH, T°…)*	*Indicate operational risks…*
		biocatalyst dosage	*Use of more chemicals, operational conditions (pH, T°…)*	*Indicate operational risks…*
		residence time measurement	*Use of more chemicals, operational conditions (pH, T°…)*	*Indicate operational risks…*
		Pulp and density measurement	*Use of more chemicals, operational conditions (pH, T°…)*	*Indicate operational risks…*
		ICP-MS	*Use of more chemicals, operational conditions (pH, T°…)*	*Indicate operational risks…*
		XRF	*Use of more chemicals, operational conditions (pH, T°…)*	*Indicate operational risks…*
		SEM	*Use of more chemicals, operational conditions (pH, T°…)*	*Indicate operational risks…*
		Indicate if there are more…	*Use of more chemicals, operational conditions (pH, T°…)*	

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8. Treatment questionnaire for MgW treated by CETIM.

	TREATMENT FOR MgW WASTE			
	Technology	*Stages*	*Comments*	*Hazards identification*
T3.3 Optimization of selected microorganism	Optimization of operational conditions to maximize the dissolution of Mg	pH measurement	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		temperature measurement	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		redox potential measurement	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		stirring	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		biocatalyst dosage	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		residence time measurement	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Particle size measurement	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Solid concentration measurement	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		ICP-MS	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		XRF	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		SEM	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...	*Use of more chemicals, operational conditions (pH, Tº...)*	

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9. Treatment questionnaire for PCBP treated by CETIM.

	TREATMENT FOR PCBP WASTE			
	Technology	*Stages*	*Comments*	*Hazards identification*
T3.3 Optimization of selected microorganism	Optimization of operational conditions to maximize the dissolution of PGM	Particle size measurement	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		temperature measurement	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		redox potential measurement	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		stirring	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		biocatalyst dosage	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		residence time measurement	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Particle size measurement	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Solid concentration measurement	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		ICP-MS	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		XRF	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		SEM	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...	*Use of more chemicals, operational conditions (pH, Tº...)*	

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10. Treatment questionnaire for BR treated by LNU.

	TREATMENT FOR BR WASTE			
	Technology	*Stages*	*Comments*	*Hazards identification*
T3.1. Treatment: Identification and selection of the indigenous microbial populations from the raw materials	Selection of microbial communities best suited for mobilization of REE-Sc	*Indicate if there are stages…*	*Use of more chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*

11. Treatment questionnaire for MgW treated by LNU.

	TREATMENT FOR MgW WASTE			
	Technology	*Stages*	*Comments*	*Hazards identification*
T3.1. Treatment: Identification and selection of the indigenous microbial populations from the raw materials	Selection of microbial communities best suited for mobilization of Mg	*Indicate if there are stages…*	*Use of more chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
T3.2 Screening based on microorganism activity	Screening and selection of microorganisms	Screening	*Use of more chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Acid leaching test	Biologically produced acids, pH, density, temperature, particle size…	*Indicate operational risks…*
		AAS use	*Use of more chemicals, operational conditions (pH, Tº…)*	*Indicate operational risks…*
		Indicate if there are more…		

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12. Treatment questionnaire for PCBP treated by LNU.

	TREATMENT FOR PCBP WASTE			
	Technology	***Stages***	***Comments***	***Hazards identification***
T3.2 Screening based on microorganism activity	Screening based on microorganism activity	Growth of candidate spices	*Use of chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Lab-scale bioleaching trials	*Use of chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Density measurement	*Use of chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		pH measurement	*Use of chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Particle size measurement	*Use of chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Large-scale initial screening	*Use of chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		ICP-MS	*Use of chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		

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13.Treatment questionnaire for PLGO treated by UWITS.

	TREATMENT FOR PLGO WASTE			
	Technology	*Stages*	*Comments*	*Hazards identification*
T3.1. Treatment: Identification and selection of the indigenous microbial populations from the raw materials	Cyanide producing bacteria test to be used as biocatalyst for PGM mobilization	Bacteria isolation	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Enrichment media use	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Exposition to increasing metal concentration	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Physiological characterization	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Genetical characterization	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		
T3.2 Screening based on microorganism activity	Evaluation of PGM mobilization at lab-scale	Grow and adaptation experiments	LB + tryptone, yeast extracts, sodium chloride, glycine, pH=7.2	*Indicate operational risks...*
		Incubation	30ºC, rotary shaker 150 rpm	*Indicate operational risks...*
		Bacterial density measurement by OD	600nm	*Indicate operational risks...*
		Ion-selective electrode, titration against standard $AgNO_3$	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Mobilization experiments	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		PGM solubility analysis by AAS/ICP-AES	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Microorganisms culture	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		pH measurement	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		redox potential measurement	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		TOC analysis	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Cell counting	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*

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		Microscopic inspection	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		
	Washed residue analysis	Washing	Deionized water	*Indicate operational risks...*
		PGM quantification by ICP-OES	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		SEM	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		XRF	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		MLA	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		
T3.3 Optimization of selected microorganism	Optimization of operational conditions by DoE, RSM, and neutral network	pH measurement	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		temperature measurement	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		residence time measurement	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Particle size measurement	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Solid concentration measurement	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Stirring	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...	*Use of more chemicals, operational conditions (pH, Tº...)*	

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14. Post-treatment: CRM recovery (ALGAENERGY)

	POST-TREATMENT FOR REE FROM BR WASTE			
	Technology	*Stages*	*Comments*	*Hazards identification*
T4.2. R&D of microalgal biosorption	T4.2.1: Chlorella vulgaris cultivation and biosorbent preparation	Cultivation of selected strains in photobioreactors	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Condition`s control for cultivation	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Concentrate by centrifugation	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		CRM uptake by biosorption	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		CRM uptake by bioaccumulation	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		
	T4.2.2: Microalgal adsorption/desorption test with synthetic bioleachate	Microalgae suspension in bioleachate under stirring	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Microalgae suspension in bioleachate under appropriate illumination conditions	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Immobilized biomass removal	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		CRM characterization by ICP-MS	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		
	T4.2.3: Optimization of selected biosorbents		*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		

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15. Post-treatment: CRM recovery (CETIM)

	POST-TREATMENT FOR REE FROM BR WASTE			
	Technology	*Stages*	*Comments*	*Hazards identification*
T4.2. R&D of microalgal biosorption	T4.2.1: Microalgae cultivation and biosorbent preparation	Cultivation of selected strains in photobioreactors	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Condition`s control for cultivation	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Concentrate by centrifugation	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		CRM uptake by biosorption	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		CRM uptake by bioaccumulation	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		
	T4.2.2: Microalgal adsorption/desorption test with synthetic bioleachate	Microalgae suspension in bioleachate under stirring	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Microalgae suspension in bioleachate under appropriate illumination conditions	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Immobilized biomass removal	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		CRM characterization by ICP-MS	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		
	T4.2.3: Optimization of selected biosorbents		*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		
T4.4. R&D of extracellular biosynthesis of Mg nanoparticles using fungal cell-free filtrates	T4.4.1: Fungi selection, cultivation and biosorbent preparation	Screen of Mg biorecover activity on potential isolates	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		
	T4.4.2: Fungal-based biorecovery using synthetic solutions	Ability of the cell-free filtrate to immobilization Mg selectively tests	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		SEM	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*

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		EDS	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		FTIR	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		ICP-MS	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		
	T4.4.3 Optimization of fungal-based of Mg and PGM recovery	Optimization of selected organisms to maximize the metals recovery	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		SEM	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		EDS	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		FTIR	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		ICP-MS	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		TGA	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		

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16. Post-treatment: CRM recovery (JM)

	POST-TREATMENT FOR REE FROM BR WASTE			
	Technology	***Stages***	***Comments***	***Hazards identification***
T4.5. R&D of protein-based of Mg and PGM recovery	T4.5.1: Production and screening of known proteins and protein domains with metal-binding properties	Metal-binding conation	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		High-throughput colorimetric assay for Mg	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		
	T4.5.2: Design, engineering, production, screening of candidate proteins	New binding domains and scaffolds design	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		DNA synthesis and cloning	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		ICP-MS	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		
	T4.5.3: Optimization of protein production and of binding process	Optimization of the Mg and Pt binding process by denaturation	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Optimization of the Mg and Pt binding process by the use of chelators	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		

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17. Post-treatment: CRM recovery (TR)

	POST-TREATMENT FOR REE FROM BR WASTE			
	Technology	***Stages***	***Comments***	***Hazards identification***
T4.1. R&D of polymeric microcapsules for REE and PGM recovery	R&D for the microcapsules production process	Construction of monomer	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Extractants tests	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Toluene addition	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Ratio construction monomer/extractant	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Ratio of continuous phase	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Stirring	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Temperature adjustment	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		SEM for morphological evaluation	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Malvern Mastersizer for particle size distribution	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Microwave digestion	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		ICP	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		
	Microcapsules extraction/stripping tests with synthetic leachate	Microcapsules submerging	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Temperature adjustment	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Stirring	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Vacuum filtration	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Chemical characterization	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*

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		Physical characterization	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Stripping performance	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Microcapsule production tests in continuous	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		
	R&D of REE adsorption with microcapsules using bioleachates	Microcapsules tests for metal recovery	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Suspended solids removal	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Neutralization to remove Fe	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Evaluation of quantity and purity of final products	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		

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18. Post-treatment: CRM recovery (UC)

	POST-TREATMENT FOR REE FROM BR WASTE			
	Technology	***Stages***	***Comments***	***Hazards identification***
T4.3. R&D of REE and PGM by biosorption/active bacterial cell uptake	T4.3.1: Identification and selection of cells with ligands for the target metals	Siderophore activity screening tests on isolates	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Chrome Azurol Sulfonate (CAS) assay	*NaCl 87%, 22-30ºC, CAS agar medium...*	*Indicate operational risks...*
		Indicate if there are more...		
	T4.3.2: Screening of ligands selectivity with synthetic leachates	Siderophore capacity to biosorb metals	*20-30ºC, low rich culture use*	*Indicate operational risks...*
		ICP-MS	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		
	T4.3.3: Characterization and optimization of REE and PGM recovery by active cell uptake with real bioleachates	Incubation of strains in pregnant leachates	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Operational conditions monitoring	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Controls without cells	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Efficiency of metal recovery analysis	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Batch plantonik cells immobilization	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Partially purified siderophores immobilization	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		ICP-MS	*Use of more chemicals, operational conditions (pH, Tº...)*	*Indicate operational risks...*
		Indicate if there are more...		

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