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Table of Contents

1. Introduction	8
2. Method.....	9
3.1.Document analysis for the case description	9
3.2.Media analysis.....	9
2.2.1. The sample	9
2.2.2. Analysis.....	10
3.3.Semi-structured interviews.....	10
2.3.1. Interviews with stakeholders	10
2.3.2. Interviews with local population.....	11
3.4.Participatory MCDA workshop.....	13
2.4.1. General goal and objectives	13
2.4.2. Applied methodology: participatory MCDA.....	14
2.4.3. Sample.....	15
2.4.4. Procedure: Organization of the session	17
2.4.5. Analysis.....	19
3. Main findings.....	20
3.5.Document review: Case setting	20
3.5.1. Case description	20
3.5.2. Legal and regulatory framework in Spain	27
3.6.Media analysis findings	28
3.6.1. Results from the media qualitative analysis	28
3.6.2. Results from the media quantitative analysis	32
3.7.Interviews findings.....	34
3.7.1. Results from the key stakeholders	34
3.7.2. Results from the local population	42
3.8.Participatory workshop findings	45
3.8.1. Brainstorming.....	47
3.4.2. Selection of criteria	47
3.4.3. Weighting of criteria.....	50
3.4.4. Evaluation of three remediation options	54
3.4.5. Other stakeholders views.....	55
3.4.6. Evaluation of the workshop by participants	57
4. Conclusions	59
4.1.Case study conclusions	59
4.2.Stakeholders workshop conclusions.....	61

4.3. Limitations and future studies	64
5. References.....	65
6. Annexes	68
Annex 1. Chronology of the case.....	68
Annex 2. Invitation letter and leaflet	71
Annex 3. Presentation of the remediation options.....	73
Annex 4. List of criteria presented to workshop participants.....	78
Annex 5. Questionnaire for the weighting of criteria	79
Annex 6. Questionnaire for the evaluation of the remediation options	80
Annex 7. Workshop evaluation questionnaire.....	81

List of Figures

Figure 1. Multi-criteria decision analysis approach	14
Figure 2. Location of Huelva	21
Figure 3. Fertiberia plant facility in Huelva	21
Figure 4. Aerial images of phosphogypsum ponds	22
Figure 5. Aerial photograph of the area of the Tinto river marshes	24
Figure 6. Demonstrations against phosphogypsum ponds	26
Figure 7. Timeline of the main social aspects	27
Figure 8. Spanish Administrative Organisation with regard to the Huelva site	28
Figure 9. Press coverage during de 2005-2017 period.....	34
Figure 10. Workshop session.....	45
Figure 11. Workshop session.....	46
Figure 12. Workshop session.....	46
Figure 13. Distribution of 100 points in terms of importance among the four criteria	50
Figure 14. Importance of criteria by stakeholders' groups	51
Figure 15. Distribution of 100 points among the technical sub-criteria	51
Figure 16. Distribution of 100 points among the environmental sub-criteria	52
Figure 17. Distribution of 100 points among the economic sub-criteria	52
Figure 18. Distribution of 100 points among the social sub-criteria.....	53
Figure 19. Comparative importance of the different sub-criteria.....	53
Figure 20. Sub-criteria according to their importance (average) and agreement (SD)	54
Figure 21. Comparison of the remediation options by criteria.....	55
Figure 22. Assessment of the remediation option by stakeholders' groups (average)	55
Figure 23. Assessment of the remediation options from all involved stakeholders.....	56
Figure 24. Evaluation of the workshop by participants.....	57

List of tables

Table 1. Sample of newspaper articles.....	10
Table 2. List of topics included in the stakeholders interviews.....	10
Table 3.Characteristics of the stakeholders sample.....	11
Table 4. List of topics included in the local population interviews	12
Table 5. Characteristics of the local population sample	13
Table 6. List of people invited to the participatory MCDA workshop.....	16
Table 7. Final sample of the event	17
Table 8. Agenda of the session.....	17
Table 9. List of criteria and sub-criteria.....	18
Table 10. Results from the quantitative analysis	32
Table 11. Assessment of the remediation options.....	54
Table 12. Comparison of the assessment of the remediation options	56

Abstract

The purpose of this document is to report about a stakeholder involvement process applied in a specific long-lasting NORM contamination site in Spain: the phosphogypsum ponds in Huelva, the most important site with NORM residues in Spain. The objective was to assess stakeholders' views about the most relevant criteria to be taken into account when deciding about remediation.

Previously, a case study on the site was carried out by means of a document analysis, media analysis, and interviews with stakeholders and affected population. This first analysis, which is also reported in the present document, allowed the identification of some important socio-technical uncertainties around the management and remediation of the site. It also allowed the identification of relevant stakeholders' groups and possible remediation alternatives.

We decided to apply a participatory MCDA method in a one-day workshop that took place in Huelva on the 6th of March of 2019. 14 representatives of 5 different stakeholders' groups attended the event: industry, environmental NGOs, public authorities (of the local and regional level), researchers, and political parties. We obtained that, from the point of view of the attendees, the most relevant criteria when evaluating a remediation strategy are health and safety, radiological risk, together with air and soil quality. Nevertheless, other aspects were considered also important, which pointed out the need to consider different criteria when taking the decision about remediation. Thus, not only the radiological aspects but also environmental, social and economic issues as well.

We proposed three prototypical remediation alternatives to the workshop participants: in-situ, ex-situ, and a combined one (combination of in-situ and ex-situ options, together with the possible reuse of phosphogypsum as commercial material, to amend saline soils, for CO₂ capture, etc.). The combined option was rated as the best by all stakeholders' groups except for the industry that preferred the in-situ option.

The results of the participatory MCDA pointed out that differences among stakeholders' groups were not as big as it was expected before the event, especially taking into account that there met together people with really opposite views.

During the debate, some controversial issues were raised as critical aspects or important challenges that have been affecting the decision-making on remediation in the Huelva case, such as the existence of different risk perceptions, the perception of lack of a clear legal framework, or the mixture between NORM and other hazardous waste. These issues can be considered as lessons learned and can be taken into account in future similar cases.

The participatory workshop serve as a communication forum and allowed to collect stakeholders' views and concerns, encouraging cooperation and understanding between different interested parties. It was useful to explain different remediation options and involve stakeholders in the assessment of each remediation alternative in a rationally manner. In the view of the authors, participatory MCDA could be a useful tool to involve stakeholders in the management of other NORM sites.

1. Introduction

The objective of TERRITORIES (To Enhance unceRtainties Reduction and stakeholders Involvement TOwards integrated and graded Risk management of humans and wildlife In long-lasting radiological Exposure Situations) is to build a methodological approach to reduce uncertainties to a fit-for-purpose level in support of the decision making process by encompassing stakeholder involvement to assess and manage, in a graded way (effective and absorbed) doses associated to long-lasting exposure situations of both human and wildlife populations. This has to be achieved by: (i) targeting harmonized guidance at the European level, (ii) being unified, i.e. applicable to all types of long-lasting exposure situations, (iii) being made available to those in charge of making decisions, and (iv) considering all relevant sources of uncertainty.

A dedicated work package of the TERRITORIES project (WP3) focuses on stakeholder engagement for a better management of uncertainty in risk assessment and decision-making processes including remediation strategies. The overall research objective of this work package is to analyse the decision-making processes in long-lasting radiological exposure situations, taking into account all components of risk assessment, with two key points: management of uncertainties and stakeholder engagement. As an overall output, this work package will develop guidelines and recommendations on the management of uncertainties in decision-making processes, taking into account stakeholder concerns with regard to radiological (mixed) contamination and NORM contamination.

NORM contamination sites often generate public concern, social controversy and risk amplification. On the one hand, the local population and other key stakeholders may have different risk perceptions on radiological contamination. On the other hand, the stakeholders might differ in their preferences with respect to the remediation of the NORM site. As is often the case, many stakeholders might expect to see all contamination being removed, even when this might not be necessary to maintain adequate and acceptable protection of human health (Booth, 2015). The situation is often more complex than a different risk perception from social actors. A number of socio-ethical issues can play a critical role, as well as issues related to stakeholder engagement, trust and fairness, which justify the need to carry out social studies in the specific contaminated sites.

The first part of this report examines the socio-technical uncertainties around the management and remediation of a specific long-lasting NORM contamination site in Spain, while the second part reports a stakeholder involvement process applied in the same Spanish site to assess their views about the relevant criteria to be taken into account when deciding about remediation.

The phosphogypsum disposal area in Huelva, Spain, was selected for this study because is the most important site with NORM residues in Spain. From several decades, the national and regional authorities have dedicated resources to carry out research and developments projects on the environmental impact assessment, remediation and phosphogypsum reuse options. In addition, some publication recognizes the Huelva site as example of a coherent, evidence-based approach, grounded in sound policy, good science and best practices based in the historical relationship between industry, university researchers, regulatory bodies and regional and national governments (Hilton, Birky, & Johnston, 2010).

The analysis is based on two main tasks:

- Task 3.2.1. **Case study** of the site that includes a document review of the information about the site, a media analysis of a sample of news articles from two newspapers, and around 25 semi-structured interviews with key people and members of the local population.
- Task 3.3.2. **Stakeholder panel** in which we organized a participatory MCDA workshop in Huelva with 14 stakeholders' representatives.

The report is structured in three main parts: a description of the methodology, main findings of the empirical work and final conclusions.

2. Method

The following section describes the methodology used in Task 3.2.1 (Case study) and in Task 3.3.2 (Stakeholder panel).

For the first task, a case study analysis was conducted to gain in-depth insight of the selected site and better understanding of the needs and concerns of stakeholders. The objective was to identify and collect uncertainties related with the management and the remediation that affected people and other stakeholders. The case study entails a case description, a media analysis and semi-structured interviews. Case description collects all important and existing information related to the analysed case. The case description served as a starting point for empirical and qualitative data collection related to social, ethical and communicational aspects of uncertainty management. Based on this, alternative remediation strategies were framed and discussed in the subsequent task, by means of a participatory MCDA workshop. The objective of this second task was to discuss with stakeholders relevant criteria for decision-making about remediation.

The case study was based on the methodology proposed in the document “Methodological document for case studies: Guidelines for researchers” of Milestone 3.1 (Perko & Abelshausen, 2017). Which, at the same time, propose to identify uncertainties taking into account the classification from deliverable (Guillevic, Croüail, Maitre, & Schneider, 2018).

All notes and material collected during the empirical work were treated as confidential. Summaries of notes were exchanged between task members, but not distributed outside the group. For the purpose of reporting, information on findings was generalized and presented in such a way that it was not possible to identify individuals that participated.

2.1. Document analysis for the case description

The objective of the documentary review was to explore and describe the main characteristics of the Huelva site considering socio-economic, technical and regulatory aspects, by means of secondary data. To achieve that, we collected and reviewed the available information mainly focused on the description of the site, and the installation or company from where the NORM contamination originates information about the level of contamination including environmental impacts associated with phosphogypsum storage and disposal (Dueñas, Fernández, Cañete, & Pérez, 2010), protective actions applied, and possible remediation options. In addition, we searched for information about radiation protection regulations that applied and has been developed for NORM situation in Spain; as well as aspects related to how it has been communicated to the population and how the community accepted it.

2.2. Media analysis

The goal of this media analysis was to identify uncertainties reported in mass media (newspapers) related to NORM and other radiological (mixed) contamination in the site. A content and thematic media analysis was implemented to identify and collect the uncertainties reported in the newspapers around the management and remediation process of the phosphogypsum ponds in Huelva (Spain). The media analysis was also useful to identify key stakeholders related to the case study that were invited in the interviews.

2.2.1. The sample

We focused the analysis on the printed media (newspapers). We used the electronic database *My News* for searching news articles appeared in the newspapers. The keywords used to find the articles were “fosfoyesos” and “Fertiberia” (which is the main company producing phosphogypsum there). We only included the articles that specifically dealt with the phosphogypsum ponds in Huelva.

To have a representative sample of news, we selected the most read general information newspapers in the city of Huelva. We selected two newspapers, the most read national-regional newspaper (*El País*) and

the most read local newspaper (*Huelva Información*) in the area. A total sample of 98 articles covering the period 2005-2017 was included in the analysis: 67 from the national-regional newspaper and 31 from the local newspaper (Table 1). We select the period 2005-2017 to capture the evolution of different needs and concerns related to the case study.

Table 1. Sample of newspaper articles

Newspapers	Number of news
El País	67
Huelva Información	31
Total	98

2.2.2. Analysis

A qualitative and quantitative analysis of the articles was carried out to identify and collect the main uncertainties appeared in the sample of news articles from newspapers. For the qualitative analysis, we carried out a thematic analysis of the newspaper articles. For the quantitative analysis, we developed a coding protocol to register the uncertainties in a database. We relied on two coders for all the codifications. Previously, two pilot tests were developed to check the coders' accuracy. The classification of uncertainties for the content analysis was derived from a previous categorization in WP3: Technical uncertainties; Socio-ethical uncertainties and risk perception; Societal uncertainties; Uncertainties related to national policy and the legal and regulatory framework; Uncertainties related to management of NORM waste; and Uncertainties related to communication aspects (Guillevic et al., 2018).

2.3. Semi-structured interviews

2.3.1. Interviews with stakeholders

To collect the views of the key stakeholders on the management of the phosphogypsum waste repository as well as on the remediation process, we conducted semi-structured interviews with a sample of key informants in the city of Huelva.

We developed a protocol to conduct the interviews. This protocol was used as a guide for conducting the interviews and included the different questions to explore the areas related to the management and remediation process of the phosphogypsum ponds (Table 2).

Table 2. List of topics included in the stakeholders interviews

Topic	Questions
Interviewer presentation	Hello, I am A social researcher from Ciemat...
Purpose of the study	We are working in a European project...
Anonymity and duration	The information provided will be kept anonymous. We will carry out an aggregate analysis of discourses without names.
Thanks for the participation	The interview will take about 20 minutes Many thanks for your participation
First introductory questions	Let's start... In your view, what is happening with the phosphogypsum from Fertiberia? Do you think it is the main environmental problem in Huelva? Why? Is it because of NORM?
Role of the interviewee	Which is your role in this issue? When and why did you start your involvement in this? In what way have you been involved in (attending meetings, member of a working group, going to demonstrations, complaining, etc.)

Uncertainties	What kind of uncertainties have you faced during these years? Do you think there are technical uncertainties? Legal? Social?
Actors map	Who have you discussed the issue with? Who has had a prominent role in the issue?
Evaluation of the management	What has been done well and what has been done wrong? By whom have the decisions been taken? (e.g. regarding remediation)
Risk perception	What are the risks of the phosphogypsum for people? And for the environment?
Needs and concerns	In your view, which is the origin of the controversy? What are the worries of the citizens about this issue? What do the citizens need in that sense? What have been done to respond to people concerns and needs? What is your view about how the controversy is being managed?
Trust	Does the population trust Fertiberia for the management of this waste? Do they trust authorities? And NGOs?
Communication	Is the population informed about this topic? How are they informed? Is this information transparent enough?
Engagement	Have the stakeholders been involved somehow? How? Do you think it is adequate?
Finalisation	Do you want to add something else? Would you like to ask me something?
Snowball sampling	Whom do you think we should interview?

Interviewers carried out 15 interviews with authorities, experts and academics, environmental NGOs, industry representatives, and members of the media (Table 3). Three additional stakeholders did not accept an interview but responded by email. The stakeholders were identified from news articles and case reports and invited by email. Snowball technique was also used.

Table 3. Characteristics of the stakeholders' interviews sample

Stakeholder group	Number of informants
Experts and academics	4
Public authorities	5
Environmental NGOs	3
Industry representatives	2
Media	1
Total	15

Interviews were transcribed in order to extract the uncertainties. The average duration of interviews was 45 minutes. Transcriptions were coded with MAXQDA software with the same categories we did in the media analysis. A thematic analysis of the discourses was carried out.

2.3.2. Interviews with local population

To collect the views of the local population on the management of the phosphogypsum ponds as well as on the remediation process, we conducted semi-structured interviews with a sample of residents in the city of Huelva.

We developed a protocol to conduct the interviews. This protocol was used as a guide for conducting the interviews and included the different questions to explore the areas related to management and remediation process of phosphogypsum ponds (Table 4).

Table 4. List of topics included in the local population interviews

Topic	Questions
Interviewer presentation	Hello, I am A social researcher from Ciemat, a Public Research Organization.
Purpose of the study	We are working in a European project on the case of the phosphogypsum ponds here in Huelva. The aim is to collect public views and worries on this topic. Would you be interested in participating by answering some questions?
Anonymity and duration Thank for the participation	The information provided will be kept anonymous. We will carry out an aggregate analysis of discourses without names. The interview will take about 15 minutes Many thanks for your participation
First introductory questions	Let's start... For how long have you been living in Huelva?
Awareness, familiarity and knowledge	When did you hear about the existence of the ponds? And the ponds have been there for many years? What do you know about the phosphogypsum ponds?
Concerns and risk perception	How do you feel about living near the ponds? Have you ever been worried about this issue? What is the general feeling of the neighbors in the area on this issue? In general, what do you think have been the concerns of the people in your neighborhood in relation to phosphogypsum ponds? Is it an issue that worries the population of Huelva? Do you think that phosphogypses are dangerous? Do you think it has had impacts on the health of the local population? Do you think that the risk of phosphogypsum affects all the neighborhoods of Huelva equally? Does this topic generate any other emotion (positive or negative)? Have you ever been afraid of living nearby? What are the positive issues of living near the ponds? And the negative? What benefits does it have for you and for Huelva? What drawbacks does it have?
Knowledge and perception of the remediation	Do you know that there are remediation plans for this area? What do you think about them? Have you heard about the remediation plans of the phosphogypsum pools (cover the ponds, bury the phosphogypses)? Do you think that the remediation of the ponds will be positive or negative for the population of Huelva? Do you know how the decisions about the remediation have been taken? (influential factors and possible options) What things have been done wrong? What things have been done well? Do you know that signatures against the proposed remediation plan have been collected? Do you know why? (because it is perceived as insufficient?)
Trust	What is your opinion about the management of the phosphogypsum waste? Do you think that the population trusts in the management of the authorities? And in the management of Fertiberia? Do you think they have been transparent? Who has played an important role? Have you heard about Mesa de la Ría ¹ ?

¹ "Mesa de la Ría" means "Estuary round table" and it originates in 2002 as an environmental movement to study and debate about the future of the Chemical Industry in Huelva. In 2008, it becomes a political party that presents itself to local elections and wins a councillor.

Engagement and communication	Have you ever received information about the case of phosphogypsum waste? From what channels? Do you feel well informed? How have people's concerns been answered? How has the public been informed? Have you been personally involved in the remediation process? Is the public and social actors considered as interlocutors? Are they adequately involved? Who do you think has played a prominent role? Has there been any protest on the subject? Have you participated?
Uncertainties	What uncertainties are there? What uncertainties have you personally faced?
Demographic data	Gender Age Years living in Huelva
Finalisation	Do you want to add something else? Would you like to ask me something?

The local population was contacted from a sample of random calls to the different neighbourhoods of the city of Huelva, obtained from the phone listing of the city. A total of 13 interviews were conducted by interviewers. The characteristics of the sample are shown in Table 5.

Table 5. Characteristics of the local population sample

Characteristics of the sample	
Female (n)	6
Male (n)	7
Age (mean)	66
Area of residence	Huelva

The average duration of interviews was 15 minutes. Interviews were transcribed and coded afterwards with MAXQDA software. As for the interviews with key stakeholders, the coding was done considering the categories obtained in the media analysis. We did a thematic analysis of the information.

2.4. Participatory MCDA workshop

2.4.1. General goal and objectives

The ultimate goal of this participatory workshop was to improve the decision-making on remediation in future NORM contamination cases, by learning from the experience in the case of the phosphogypsum contamination in Huelva, by incorporating stakeholders' multiple values and preferences.

The objective of the workshop was to discuss, in a participative way, the most relevant criteria in NORM remediation decision-making and the main challenges and critical aspects that arise during this process. A secondary objective was to go in depth into some relevant social and communication aspects that seem to play a role in the decision-making process.

Other expected outcomes were:

- To encourage a common reflection among people with very different views
- To assess different prototypical remediation alternatives
- To study the agreement and disagreement points among different stakeholders groups.

2.4.2. Applied methodology: participatory MCDA

We applied a Participatory Multi-Criteria Decision Analysis during a one-day workshop in Huelva. A participatory workshop is a type of session that encourages participants to work together, learn from each other and share information to solve shared problems. It is based on the fact that a good resolution of problems requires the contribution of several experts and stakeholders interested in finding the best solution. Today's environmental problems typically concern a variety of stakeholders with different needs and views about the environment. The remediation alternatives have various impacts, which have to be considered in terms of multiple criteria. Thus, to make well-grounded decisions, there is a great need for methods dealing with a variety of views, values and information (Marttunen, Mustajoki, Dufva, & Karjalainen, 2015).

In recent decades, the use of MCDA in environmental planning has increased rapidly, in a variety of different forms including social MCDA, stakeholder MCDA, analytic-deliberative MCDA and decision conferencing (Antunes, Karadzic, Santos, Beça, & Osann, 2011; Burgess et al., 2007; Huang, Keisler, & Linkov, 2011; Munda, 2006). Experience suggests that well-structured and formalized methods are needed to integrate information from different sources, allowing transparency of the process (Renn, 2006).

Also in contaminated land remediation, different authors have argued for going beyond the prevention of unacceptable risks to human and environmental health as the unique decision criterion, and basing the decision-making in the sustainability framework (Bardos et al., 2011; Murray, Hugo Seymour, Rogut, & Zechowska, 2008). Rosén et al. (2015) have recently proposed a new multi-criteria decision analysis approach to be applied to contaminated land use that incorporates stakeholders' values in the selection and weighting of the criteria for the decision-making (Figure 1). However, the use of MCDA in a participatory way is a challenging task requiring careful design and expertise related to the methodology and process (Sparrevik, Barton, Oen, Sehkar, & Linkov, 2011).

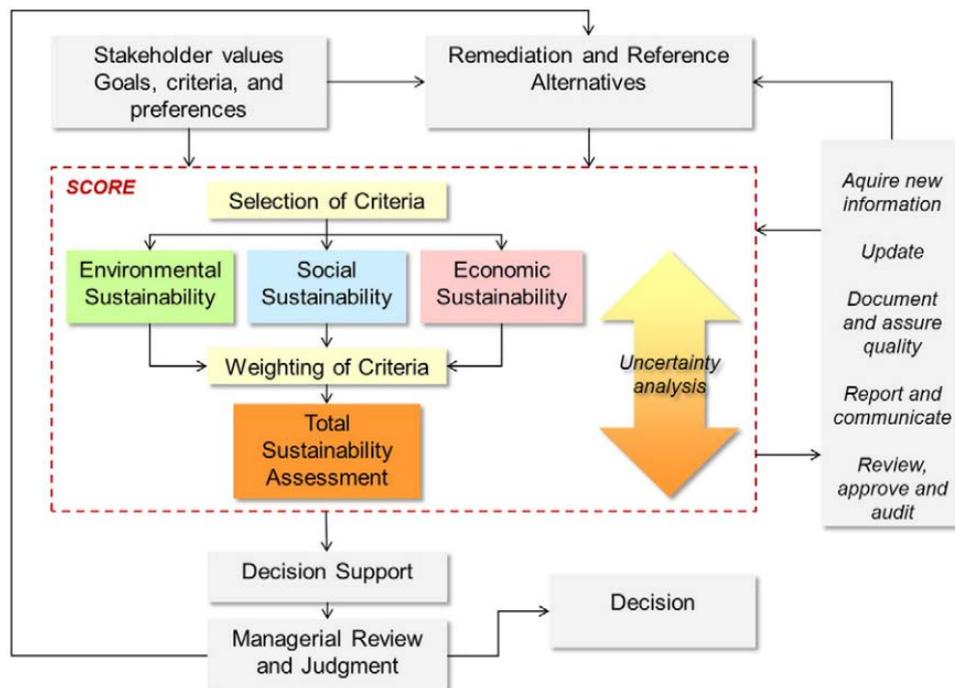


Figure 1. Multi-criteria decision analysis approach (Source: Rosén et al., 2015)

In that sense, participatory Multi-Criteria Decision Analysis method was applied to deal with and incorporate the variety of views, values and information in order to better structure the problem, discuss on the criteria and evaluate different alternatives for remediation. We used a top-down approach, which consisted in developing a list of criteria (derived from a literature review) as a starting point, and presenting it to stakeholders in order to discuss the dimensions with them.

The participatory process was research driven, which implies that the research, even though policy relevant, has no direct link with actual decision-making (Ridder & Pahl-Wostl, 2005). Thus, actors were informed beforehand about the benefits they could expect (Antunes et al., 2011).

The effectiveness of the workshop was evaluated at the end based on the methodology developed by Rowe and Frewer (2000).

In a second-step, relevant participants that were not able to attend the workshop were involved by means of a personal meeting or electronic version of the questionnaires.

2.4.3. The sample

An appropriate balanced group of stakeholders was needed, willing to devote time and attention to the issue. Stakeholders were identified from the previous methodological approach (media analysis and interviews) and supplemented through snowballing. This includes, for example, experts from the research institutes and universities, government representatives, representatives of the involved companies, or environmental organisations. A total of 48 stakeholders' representatives were invited to the event from 10 different stakeholders' groups (Table 6).

Table 6. List of people invited to the participatory MCDA workshop

Stakeholder group	Affiliation
Industry and industry associations	Fertiberia
	VenatorCorp
	AIQBE
	FOE Federación Onubense de Empresarios
Environmental NGOs	Greenpeace
	Ecologistas en Acción
	World Wildlife Fund (WWF)
	Salvia
Research Centres	CIEMAT
	CSIC
	IGME
Universities	Universidad de Huelva
	Universidad de Sevilla
	Universidad de Cantabria
	Universidad de Murcia
Local administration	Huelva City Council
Regional administration	Junta de Andalucía
	Agencia Medio Ambiente y Agua Andalucía
	Diputación de Huelva
National administration	Ministerio Transición Ecológica: Servicio Provincial de Costas
Political parties	EQUO Huelva
	Mesa de la Ría
	PP
	PSOE
	IU
Platforms from the civil society	AAVV Pérez Cubillas
Others	CSN. Consejo de Seguridad Nuclear
	ENRESA. Empresa Nacional de Gestión de Residuos Radiactivos
	EMGRISA. Empresa Gestión Residuos Industriales
	CEDEX
	COAMBA. Colegio de Ambientólogos de Andalucía

We decided not to invite media representatives in order to preserve a climate of greater privacy for the discussion, taking into account that the management of the ponds and the decision-making about remediation have generated important social conflict in Huelva.

An invitation letter and a leaflet were developed to invite the stakeholders to attend the workshop. First invitation was done by email in which we attached the leaflet (Annex 2). After a few days, reminder emails were sent. Phone calls were made to those invited people who did not reply in a period of 7 days. We gave them information regarding workshop aims and the scope of the discussion.

Finally, the event was attended by 14 representatives of 5 different stakeholders' groups (Table 7).

Table 7. Final sample of the workshop

Stakeholder group	N
Industry representatives	1
Public authorities (regional and local)	2
Researchers	7
Environmental NGOs	1
Political parties	3
Total	14

2.4.4. Procedure: Organization of the session

The stakeholder panel discussion was organised in a Hotel meeting room, as a neutral and convenient location, easily accessible by all members.

The session was organized in a format that facilitated the exchange among the participants. A trusting, and participative environment was created, trying to facilitate visual contact and the interventions of all attendees (Jenny, 1994). Therefore, discussion sessions were planned, together with sessions in which the assistants could talk about their experience, and some individual exercises were also planned. The presentation and discussion were led by the responsible task researchers. A neutral and unbiased moderator framed the discussion. The group sessions were audio recorded, after obtaining the approval of the participants. In addition, members of the research team took detailed notes of the discussions.

Table 8. Agenda of the session

Time	Topic
9:30	Welcome and presentation of the workshop
9:40	Presentation of the project
9:50	Presentation of the participants
10:20	First session: Selection of criteria for remediation decision-making
11:15	<i>Coffee break</i>
11:30	Second session: Weighting of criteria
13:30	Lunch
14:30	Third session: Evaluation of remediation options
15:45	Summary and conclusions
16:00	End of workshop

At the beginning of the workshop, participants were welcomed and thanked for their attendance. Then we started with a short presentation of the event: we explained the objectives, showed the agenda of the day (Table 8), and explained the methodology and the expected outcomes. The main rules of the event were also reminded, mainly, the need to respect others' turn to speak and other participants' point of view. This was important considering that the remediation of the phosphogypsum ponds is a quite conflictive issues in Huelva and there were in the room very opposed views.

After that, a brief presentation of the Territories project was carried out, to give some context to the event. Some general data about the project was provided to attendees such as the objectives, the structure in work packages and the main case studies addressed in the Territories library. Work package 3 main objectives and structure was also explained to them.

Then, we opened the floor so that participants could present themselves (name, affiliation and their relation with NORM or the phosphogypsum ponds). At the end of this introduction round, a first brainstorming exercise was carried out: we asked participants to write down the most important criterion that should be taken into account when dealing with remediation. We collected their notes as inputs before the discussion.

Approximately, at half past then, we started with the first exercises of the workshop. It consisted in the selection of the main criteria and sub-criteria to be taken into account to decide about remediation in a NORM site. We provided participants with the following list elaborated from a literature review of studies applying participatory MCDA in different environmental problems (Antunes et al., 2011; Joyce, Goronovski, Tkaczyk, & Björklund, 2017; Langemeyer, Palomo, Baraibar, & Gómez-Baggethun, 2018; Nisbet & Mercer, 2004; Oughton, Forsberg, Bay, Kaiser, & Howard, 2004; Posthumus, Hewett, Morris, & Quinn, 2008; Rosén et al., 2015). A list was provided to participants (Table 9).

Table 9. List of criteria and sub-criteria

Criteria	Sub-criteria	Definition
Technical (performance and feasibility issues)	Radiological risk	Level to which the remediation strategy reduce the radiological risk of the site
	Chemical risk	Level to which the remediation strategy reduce the chemical risk of the site
	Waste	Level to which the remediation strategy removes the waste from the site
	Administrative difficulty	Administrative complexity to implement the remediation strategy
	Technical feasibility	Ease of application, operation and maintenance of the remediation strategy
	Duration	Time required to conduct the remediation strategy
Environmental	Soil	Impacts on soil functions (e.g. in pH, organic content, water retention capacity).
	Ground water	Impacts on ground water quality due to remediation process
	Surface water	Impacts on surface water quality due to remediation process
	Flora and fauna	Impacts on flora and fauna due to remediation process
	Air quality	Pollutant emissions to air (e.g. greenhouse gases, acidifying substances, particulate matter) due to remediation actions
	Non-renewable natural resources	Utilization of non-renewable natural resources to implement the remediation strategy (e.g. fossil fuels, use virgin soil and rock materials for filling, occupation of other areas for waste disposal)
Economic	Non-recyclable waste	Non-recyclable waste production due to remediation actions
	Direct costs	Investments in infrastructures and technology of the remediation strategy (e.g. labour and equipment)
	Employment	Employment creation (short and long term) associated with the implementation of the remediation strategy
	Externalities	Economic benefits or damages associated with the remediation strategy (e.g. sales of scrap materials for reuse, changes in the value of the property, image costs such as the reluctance to buy local products or the drop in tourism)

Social	Land use	Impact of the remediation strategy on the land use (e.g. recreational, houses, industrial)
	Health and security	Effects on health and human safety due to remediation tasks
	Impact on the neighborhood	Negative impacts on the local community (e.g. dust, noise, smell and vibrations) during the remediation works
	Equity/ Justice	Distribution of costs and benefits among different social groups of the community (e.g. negative effects on vulnerable groups)
	Community acceptance	Level of acceptance, trust and local community support in the implementation of the remediation strategy
	Community involvement	Participation and involvement of the local community in the decision-making process about the remediation

Participants were asked, individually, to review the criteria and sub-criteria, the descriptions of each, and to add other relevant issues if they considered necessary (Annex 4). The idea was to think if those aspects were appropriate to decide on the remediation, if they were operative enough, and exhaustive enough.

Then a group discussion was initiated to comment about this. New criteria and sub-criteria proposed by participants were listed and shared in a blackboard (new aspects proposed by participants are included in the results sections but were not added to the list for the next exercises because of time constraints during the event).

After a coffee-break, the second exercise was initiated. It consisted in the weighting of criteria according to their relative importance, specifically participants were individually asked to allocate 100 points in terms of importance, first among the 4 general criteria (technical, environmental, economic and social) and then among the sub-criteria inside each of the four main criteria. Participants were invited to explain the reasons of their distribution (Annex 5). A group discussion was also initiated to comment the importance of the sub-criteria in the Huelva case.

After the lunch break, three general remediation options were presented to participants: in-situ remediation, ex-situ remediation, and combined remediation. A member of the research team briefly explained the main characteristics of each (Annex 6). Participants were asked to assess each remediation options taking into account all sub-criteria provided. They were given three copies (in paper) of the criteria list and had to evaluate each remediation alternative individually. Again, a group discussion was initiated to comment on each remediation option in terms of advantages and drawbacks.

To close the session, the discussion maintained during the day was summarized and the participants were thanked again. Some days after the event, an evaluation questionnaire was distributed among the participants by email. Evaluation is a key element of participatory events, since it allows analyzing and guaranteeing the quality of the exercise. The evaluation questionnaire was based on the framework developed by Gene Rowe and Lynn Frewer (2000) for the evaluation of the effectiveness of the participatory and deliberative processes. The objective of the questionnaire was to know the perception of the participants regarding different issues such as the representativeness, the independence or the learning (Annex 7).

2.4.5. Analysis

After the workshop, the discussion sessions were transcribed. A detailed analysis was conducted on the transcription of the participants' discourse to draw out the key discussion points and issues. The dialogue was analysed to examine:

- New sub-criteria to be considered in the decision-making about remediation.
- Consensus and divergence of different stakeholders groups (industry, researchers, public officials, environmental NGOs).
- Main challenges and critical aspects associated to the decision-making.

The questionnaires administered in the three sessions, as well as the first brainstorming exercise, were processed in Excel and analysed with SPSS software.

3. Main findings

The results are structured in four main parts: case setting (resulting from the document review), media analysis findings, interviews findings, and participatory workshop findings.

3.1. Document review: Case setting

This section includes a description of the most relevant aspects of the legal and regulatory framework in Spain, and a description of the case, which includes the following aspects:

- Geographical situation and main socio-economic aspects.
- Description of the installation.
- Chronological recap of the contamination.
- Physical and radiological characterization.
- Applied protective actions.
- Remediation options.
- Social aspects: interaction with the public, communication and stakeholder engagement.

3.1.1. Case description

Geographical situation and main socio-economic aspects

The phosphogypsum ponds are located in Huelva (autonomous region of Andalusia, at the south-west of Spain) in the Huelva estuary, a few meters from the city of Huelva (Figure 2).

Until 1900, the economy of Huelva was based on agriculture. There was also a strong growth in the mining sector (Marquez Macias & Tornero Tinajer, 2010). In 1964 the Chemical Pole of Huelva started to operate. After this, the city experienced a strong economic growth and became a very attractive area for industrial development.

The Chemical Pole is currently one of the most important industrial complexes in Spain (García-Vázquez, C. and Tejera-Arcenillas, I., 2014). In 2018 the population of Huelva is 144,258 inhabitants. The main economic activities of the municipality in 2017 are commercial sector, tourism, construction, transport; and manufacturing industry (IECA, 2019).

The Huelva estuary, at the confluence of the rivers Tinto and Odiel, has historically been affected by upstream mining activities and industrial discharges from nearby factories, including two phosphoric acid production plants established in 1968. It is one of the most important cases of NORM contamination in Europe.



Figure 2. Location of Huelva (Source: Google Maps)

Description of the installation

The stacks are the result of more than 40 years of phosphogypsum discharges by the companies Fertiberia and Foret (1968-2010). From 1968 Fertiberia and Foret industrial plants in Huelva produced fertilisers using phosphate rock as a raw material for the production of phosphoric acid, various phosphates and fertilisers (Figure 3. Fertiberia plant facility in Huelva). These two factories were together the largest PA producer in the EU, with an overall production capacity of 550 kt P₂O₅. Both plants applied the wet production route through digestion of phosphate rock by sulphuric acid, a process that generates as a co-product large amounts (around 4 tonnes for every tonne of P₂O₅) of phosphogypsum (PG), which are stored in nearby stacks. Along this industrial process, about 90% of the ²²⁶Ra and the ²¹⁰Po and some 15% of the uranium (U) isotopes from the ore are left in the PG (Bolívar et al., 1996).



Figure 3. Fertiberia plant facility in Huelva (Source: huelvahoy.com)

The marshlands used by the local phosphate fertilizer industry for stocking phosphogypsum are located at the south of the city of Huelva, in the estuary of the river Tinto, before its junction with the river Odiel. This is a great area that faces the sea and has marshland vegetation subject to tidal movements of the estuary.

Chronological recap of the contamination

From 1968 until 2010, Fertiberia’s activities in Huelva’s industrial area generated around 2.5 million tonnes of phosphogypsum per year, and 0.5 million tonnes more were produced by Foret. (Annex 1).

All these phosphogypsum were transported from the production plants into the decantation ponds by pumping in a suspension of water, with a maximum suspension of 20% phosphogypsum. Once the phosphogypsum had decanted, the pumped water circulated back to the plant in a closed circuit and is re-used for the process.

This system of recirculation with water was installed in 1997 and represents a notable environmental improvement over the previous transportation process since, up until then, the pumped water which was taken from the estuary - was later dumped back into the same body, carrying a significant fraction of the radioactivity originally present in the phosphogypsum in dissolution and suspension. Moreover, until 1997, the phosphogypsum generated by Foret (approximately 20% of the total amount) was dumped directly into the Odiel River estuary and the phosphogypsum from Fertiberia overflowed from the ponds, into the Tinto River. Nowadays the phosphogypsum piles and ponds in “Las Marismas” cover an area of approximately 850 hectares and it is estimated that the total amount accumulated during the nearly 40 years of operation of this fertiliser factory is 70 million tonnes.

The radiological impact in this area has been continuously monitored since 1988, showing that radionuclide concentrations in the estuary are decreasing since the cessation of discharges to the aquatic environment. Radioactivity in water and surface sediments has returned to background levels except for the River Odiel, where activity in sediments close to the plant still remained in 2002 over one order of magnitude above the natural background levels of the area.

For years, an acid waste stream and 20% of the PG were dumped into the aquatic environment, while the remaining 80% was disposed in stacks over salt marshes of the estuary. Nevertheless, since discharges were forbidden in 1997 by the Andalusian regional government, wastes are stored in the stacks and liquids flow into a closed circulation system. The minor flow of wastes coming from maintenance operations (such as residues from descaling of components, filters or sludge from tanks) is conditioned and disposed in the stacks except for a small fraction, which is directly transferred to an authorized waste collector.

Phosphogypsum ponds cover an area of approximately 850 hectares and it is estimated that the total amount accumulated during more than 40 years (1965-2010) of operation is around 120 million tones. It is worth to mention that he estuary is also affected by upstream mining activities and industrial discharges from nearby factories.

The operating license for the stacks (shown in

Figure 4) was declared null by the National Court in 2007 for failure to comply with the National Shores Act. As a result, both factories will either halt their operations or modify their production process by 2011.



Figure 4. Aerial images of phosphogypsum ponds (Source: El diario.es, 2016; Huelva24.com, 2013)

Physical and radiological characterization

The phosphate rock used in this industrial process is a sedimentary rock that contains natural concentrations of uranium and thorium. In relation to unperturbed typical soils, these concentrations are relatively high for U-238 (1500 Bq/kg), which is usually found in radioactive equilibrium with its decay products, including Ra-226.

In the process of manufacturing phosphoric acid, the rock is ground to the proper grain size and then treated with sulphuric acid. Phosphoric acid and gypsum (phosphogypsum) are produced in the reaction; the greatest part of the radium contained in the phosphate rock usually co-precipitates with gypsum. Most of the uranium and thorium remains with the phosphorus in the phosphoric acid. The redistribution of these natural radionuclides - present in the original rock - to the various products, by-products, solid wastes, and effluents obtained in the industrial process may lead to an exposure of workers and members of the public.

The dry phosphogypsum has a particle density of 2.3 g cm⁻³, an apparent density (including porosity) of 1.5 g cm⁻³ and a solubility in sea water of around 2 g L⁻¹ (May and Sweeney, 1984). Its granulometry has a large proportion of particles of medium and fine size (Bolívar et al., 1996), and its vertical hydraulic conductivity is very variable, oscillating between 10⁻³ and 10⁻⁶ cm s⁻¹. Although more than 95% of the PG is calcium sulphate dihydrate, a significant fraction of phosphoric acid (around 1%), is trapped in its crystalline structure and / or in its pores more mobile, causing its pH to be around to 1.5-2 (Bolívar et al., 1996).

Studies carried out by the University of Huelva shown that the contents in natural radioactivity of the PG are very variable, being the average values and ranges the following: 226Ra (650 Bq kg⁻¹, 400-1100 Bq kg⁻¹), 210Pb (500 Bq kg⁻¹, 300-600 Bq kg⁻¹), 238U (120 Bq kg⁻¹, 30-300 Bq kg⁻¹), 230Th (400 Bq kg⁻¹, 200-700 Bq kg⁻¹), among others (Bolívar et al., 1998; Mas et al., 2006). These concentrations are about 10-40 times higher than the levels found in typical undisturbed soils.

Although during the last years research and attempts have been done for valorisation of the PG, the use of the generated one in the Huelva factories has been until now quite limited and mostly in agriculture as a soil amendment (Abril et al., 2008). Consequently, due to the lack of any market for this compound, the great majority of the generated PG in Huelva has historically been considered as a waste with the following management policy: (a) During the first 30 years of production (until December 1997), 20% of the PG generated was released directly into the Odiel Channel of the Huelva estuary, whereas the remaining 80% was transported from the phosphoric acid production plants in suspension with sea water to a neighbouring marshland area (2 km away from the plants and located in the confluence of the mouths of the Odiel and Tinto rivers), where it was disposed of by means of decantation with the transporting waters draining directly into the estuary; (b) since beginning 1998, all the PG produced in Huelva has been stored in the PG piles following the OSPAR convention. The PG was transported to the disposal area with fresh water, which was reintroduced in the industrial process following a closed cycle, in order to prevent any impact on the estuarine ecosystem.

The legacy site involves a major area formed by four different areas called Zone 1, Zone 2, Zone 3 and Zone 4, as it is shown in Figure 5.



Figure 5. Aerial photograph of the area of the Tinto river marshes. (Source: Guerrero-Márquez et al., 2017)

(1) Settling ponds, dumping area of FY; (2) regulating reservoir, (3) perimeter channel, and (4) pumping station.

Zone 1 is a 450 ha sector and it was the first area submitted to regeneration work. It is calculated that about 12×10^6 tons of PG, including unknown amounts of urban wastes and mining wastes, were released in this sector. The Andalusian Regional Government performed remediation tasks during 1990 in order to minimize both the visual and the environmental impact associated to the different wastes that were released there. To do that, a soil cover of about 30 cm average thickness and a vegetal coverage were added above the naked PG surface. Furthermore, several tenths of soil hills (1.5 m high) were scattered above the soil cover layer in order to allow small tree species to grow.

In Zone 2 (270 ha), the wastes were released until 2010 inside the water recirculation system. In this zone, the gypsum stacks reached 15 m in height above the natural ground, and it continued to grow following a pyramid shape. As the height increases, the sides of the pyramid are covered with a soil layer and a vegetal coverage, in order to minimize the visual impact. Zone 3 (180 ha) is close to Zone 2 and it is only conformed by PG, without any soil coverage. Zone 4 was submitted to a similar remediation process than Zone 1. More detailed, different kinds of industrial and urban wastes were added above the PG: in the first place, a building debris layer was added; thereafter, different kinds of industrial wastes were added and finally, a soil layer like that of zone 1 for different vegetable species can grow on this cover. The total thickness of the coverage (including the three layers: wastes, debris, and soil) is more than 1 m.

Furthermore, one of the sectors contained within the PG stacks was contaminated some years ago by the radioactive ashes produced during the Acerinox Steel factory accident in 1998. An industrial ^{137}Cs radioactive source was accidentally melted with iron wastes in the steel factory. These wastes were treated in a purification plant in the industrial complex of Huelva. The wastes and a certain amount of their ashes were released in Zone 4 and mixed with the PG. Because of the releases, the Spanish National Wastes Enterprise (ENRESA) sealed the sector and remediation works were developed consisting in a cover with a layer of clay to minimize permeability and migration of radioactive Caesium.

Finally, different vegetal species were planted in the sector, and a vigilance program was established. Besides, from Zone 3, it has been possible to observe liquid leakages (filtrations), mostly with a certain flow, into the Tinto River and adjacent marshlands, while from Zone 2, these leakages are clearly minor in number and diffused after overflowing the perimeter channel barrier.

Applied protective actions

A part of the stacks (Zone 1), were restored in 1998 by placing an overlying 30-cm layer of soil and re-vegetation (Cancio et al. 1993). Although studies have shown that the radiological impact to the public due to the stacks is not significant, they remain a source of social concern and receive sustained media coverage. Despite the success of remediation works, and the fact that radon exhalation from restored zones is eight times lower than active PG ponds and gamma dose rates are reduced to almost background levels, public risk perception has not changed.

Remediation options

At present only two remediation options have been handled, the first corresponds to the remediation and immobilization in situ, which is the proposal that the company Fertiberia has made to the authorities for its review. This option consists in conditioning the phosphogypsum material in the ponds through the reconditioning of the material, placing an impervious membrane to send the leaching of material to the surface and ground waters, and finally covering the whole area with material and plant cover. This project has a duration of 30 years and an approximate cost of 70 million euros.

The other alternative has been to remove all the material from the area and store it in landfills of different waste classifications. This proposal is the most successful on the part of the neighbourhood organizations of Huelva and part of the city government and several of the social movements that wish to restore the area in original conditions such as a marsh. An economic study of this option has been carried out, consisting of transferring the 100 million tons to different landfill types according to their classification as waste. This project would have an execution period of 30 years and entailing an economic cost of 1200 million euros.

A third option considered for this workshop has been a combined option considering that part of the material can be used as products for other applications (e.g. construction, agriculture). This option would consider that part of the material with the greatest impact is removed and transferred to disposal, another part is immobilized in situ and another amount is destined to use this material for other applications such as construction materials. In view of the characteristics of PG (more than 95% is $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) and its attractive economic potential, as well as continuously increasing concerns about environmental pollution, nowadays there is great interest in using PG as an alternative raw material for many applications.

Recently a patent has been developed by researchers to use this material to capture of Carbone Dioxide and obtain by-products in the process, which allow the storage area to be left in the initial conditions as a marsh (Cárdenas-Escudero, Morales-Flórez, Pérez-López, Santos, & Esquivias, 2011). https://www.youtube.com/watch?time_continue=11&v=M8iea9Loatc

Social Aspects: interaction with the public, communication and stakeholder engagement

For years the phosphate industry was an engine of economic development, wealth and employment for the city of Huelva. However, it also start being an important source of environmental pollution with significant impacts on health and the environment. For many years, very little information was provided to the local population. Awareness about potential health and environmental problems generated by the industry was very low.

It was in the 2000s when environmental NGOs and other associations started to mobilize against the phosphogypsum ponds (Figure 6). In 2002 it was constituted the citizens' platform Mesa de la Ría, with the aim of studying and discussing the future of the chemical industry in Huelva and recovering the lands of the marshes for citizen uses. In 2007 it took place the first public demonstration and collection of signatures against the phosphogypsum ponds (Figure 6). Social controversy around the remediation started to increase.



Figure 6. Demonstrations against phosphogypsum ponds (Source: Huelvaya.es, 2016)

In 2011, Mesa de la Ría becomes a political party. In 2015, they presented themselves to the local elections at Huelva and got a councillor. The citizens association continues its work with the name Recupera tu Ría.

In 2014 the City Council of Huelva launched the Participation Round Table of the Phosphogypsum, an inter-administrative commission to find the most appropriate solution to remediate the phosphogypsum ponds. This Participatory Round Table was composed to be as much representative as possible including representatives of the national government, the Andalusian regional government and the City Council of Huelva, industry, trade unions, neighbourhood associations, environmental NGOs, etc. It has met in different times: in 30th September 2014, 10th September 2015, 21st July 2016, 19th April 2017 and 12th June 2018. In this last meeting, it was emphasized the need to provide a legal framework to the Participatory Round Table. It was agreed the preparation of a regulation to determine a fixed periodicity in the calls of this organ of participation and its operation dynamics.

In 2015, the Experts Committee of the phosphogypsum was designated by the Participation Round Table of the Phosphogypsum. It is composed of 10 technicians from different disciplines to evaluate the state of the phosphogypsum ponds and to present viable solutions to recover the site.

In 2016 the Head of the Coasts Office of the Government of Spain accepted the remediation plan presented by Fertiberia. In 2017, a public consultation was opened as part of the Environmental Impact Assessment. Administrations such as the City Council of Huelva and the Andalusian regional government, different political parties and associations like "Recupera tu Ría" platform have presented allegations to the project. All the allegations presented should be studied before the final decision expected for the end of this year (Figure 7).

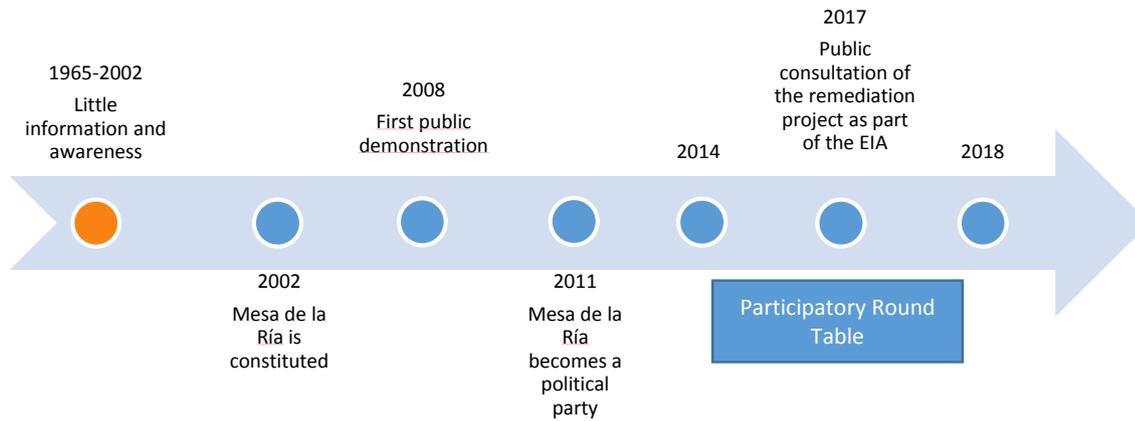


Figure 7. Timeline of the main social aspects

3.1.2. Legal and regulatory framework in Spain

NORM activities and waste are regulated in Spain under Title VII of Royal Decree 783/2001 on health protection against ionizing radiation (BOE, 2001) and Nuclear Safety Council (CSN) Safety Instruction IS-33 of the (CSN), on “radiological criteria for protection against exposure to natural radiation” (BOE, 2012).

Following IS-33, all industries included on a list must register with the regional industry authority and conduct a study on their radiological impact to workers and public. If the results of the study show that the dose criteria (1 mSv/y for workers and 0.3 mSv/y for public) are exceeded, the facility must notify it, and it will remain subject to regulatory control. The level of control imposed varies in terms of risk and plausibility of protection measures, with additional requirements applying if doses to workers are liable to exceed 6 mSv/y.

Complementary to this legislation, Ministerial Order IET/1946/2013 for management of waste generated in activities using materials containing natural radionuclides regulates the control of NORM residues (BOE, 2013). Another document that apply to NORM industries is the Clearance levels in Radiation Protection 122 Part 2 (European Commission, 2000) are used as a screening tool in order to determine which residues need further consideration from the radiation protection standpoint. For residues exceeding those levels, a case-by-case analysis needs to be performed. Conventional disposal routes are approved provided that requirements in IS-33 (including the application of the optimisation principle) are observed and that specified dose limits are met.

An organizational overview over the administrative structures in Spain dealing with the example Huelva NORM sites is shown in Figure 8.

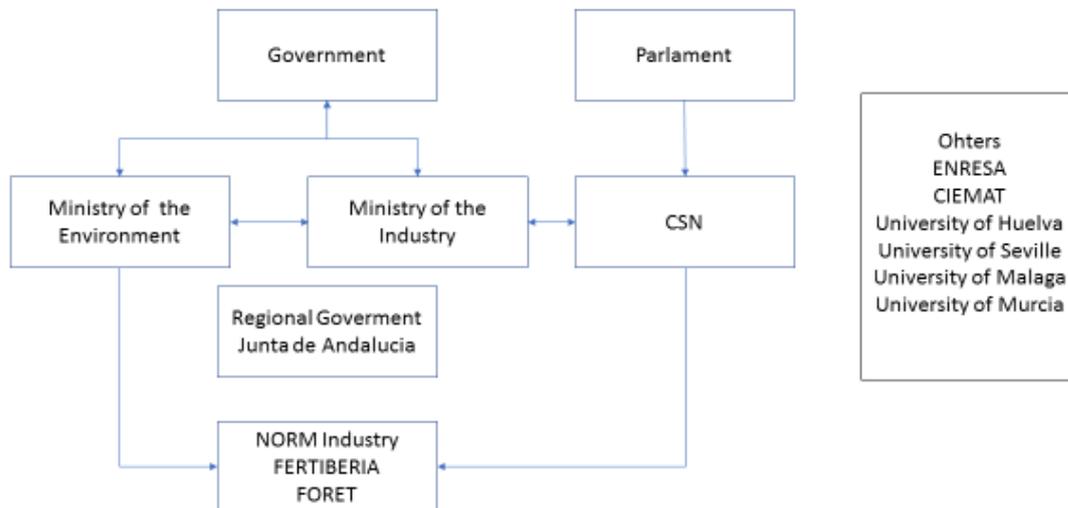


Figure 8. Spanish Administrative Organisation with regard to the Huelva site (Adapted from EC, 2009)

3.2. Media analysis findings

3.2.1. Results from the media qualitative analysis

In this section, we report the qualitative results of the media content analysis. This analysis is aimed at identifying and understanding the set of socio-technical uncertainties around the management and remediation of the phosphogypsum waste repository reported in the newspapers. The results are structured around the various dimensions inductively derived from the analysis.

Uncertainties around the site characterization

The level of radiation in the site is one of the main uncertainties covered in the newspapers. This is especially true during the first years of the media coverage (2007-2010), when the actions and statements by the environmental organizations trigger a discussion on actual radiation levels, types of contaminants, exposure doses, health impacts, etc. The level of radioactivity in the site is said to be more than 100 times higher than the maximum permissible concentration. A news article published in 2007, for instance, informs that Greenpeace asks the government that the phosphogypsum waste repository is declared a radioactive installation, after having found levels of radioactivity in the area between three and 38 times higher than the normal levels. The response from a representative of the regional government is that the technical studies confirm that the radioactive levels in the area are under the authorized limits. In this same article, a representative from the regulatory body (CSN) states that “the phosphogypsum site is an industrial controlled waste. There is no a situation of alarm. This is not a radiological waste repository...”

The controversy affects also the types of contaminants present in the area. News articles refer to the presence of uranium 238, but also polonium, radon, radium, and caesium 137. The uncertainty around the types of contaminants increases with the presence of various wastes: the ones coming from the disposal of the phosphogypsum but also a waste disposal of radioactive ashes generated and disposed after the accident of a scrap processing factory in the area.

Categorization of the NORM waste

Very related to the characterization of the site is the uncertainty around the characterization of the waste. News articles in 2007, but also in 2009 and 2010 refer to the characterization of the phosphogypsum: “is it a waste or a by-product?” In 2010, after an intervention from the European Commission, it is mentioned that the Spanish authorities have always considered the phosphogypsum as

a by-product of the industrial activity instead of a waste. This has delayed, according to the reporter, the implementation of the EU waste legislation.

Given that the phosphogypsum were considered by the company and the authorities as a by-product, they were sold to agricultural cooperatives in the province as fertilizers. In 2009, an investigation of the Spanish police finds that the fertilizers sold by Fertiberia contain uranium and, therefore, can be contaminating agricultural lands in the region. In this same article, the Department of Environment of the regional government and the company state that the sale of these fertilizers is allowed by the law. Whether these fertilizers are polluting the lands around Doñana (the national park), as argued by the environmental associations, is a significant uncertainty.

Exposure dose to population and workers: Different risk perceptions

The uncertainty around the exposure of the population and the potential health effects of the phosphogypsum waste repository is also very present around the period 2007-2009. Two key issues are the exposure of workers and of the general population to radiation. Environmental organizations state that levels of radiation in the site are above the authorized limits and also that the health of the local population has been significantly compromised by the industry in the area. A demonstration organized by a local nongovernmental organization against the phosphogypsum ponds alerts that “phosphogypsum is cancer”. Although the specific health impacts of the phosphogypsum waste repository are not often discussed, this is presented as an uncertainty in the news articles. An article in 2008, covering the investigation by the Prosecutor General's Office of the phosphogypsum waste repository after a denunciation by a local nongovernmental organization, mentions the presence of carcinogens substances in the area. The industry, on the other hand, as indicated in an article in 2007, neglects the existence of a direct link between the repository and health effects and states that the management of the phosphogypsum wastes has been carried out according to international practices.

The uncertainty is also fed by the fact that scientific studies carried out in the area provide apparently contradictory results. Some studies mentioned in the articles indicate that levels of cancer and other diseases are higher in Huelva than in other cities in Spain, but there are very few studies on the specific effects of the phosphogypsum waste repository. In 2007, a news article mentions one study by the CSIC showing that the average dose for a worker in the site is around 0.5 millisievert per year (half of the authorized level). The study concludes, according to the reporter, that the “impact of the phosphogypsum in the city of Huelva is insignificant”. On the other hand, a study in the area requested by Greenpeace informs in 2009 that the fishermen, the workers and the local population that travel in the area are exposed to a “very important level of radiation”.

In 2014, an article published in El País, in one of its main sections, covers the topic of the phosphogypsum waste repository and refers to a resigned, sceptic and irritated population that is confused about the health impacts of the waste.

This uncertainty is clearly linked to the existence of different risk perceptions of contaminated sites among interested parties. Representatives from the industry state, already in 2008, that there is no radiological risk in the area and that the prior remediation guarantees that there is no risk for the population. Representatives from the environmental and the local organizations state that the phosphogypsum waste repository poses a significant risk for the local population.

Assignment of responsibility for remediation and the cost of remediation: Lack of trust between stakeholders

The responsibility for the remediation of the phosphogypsum wastes is an issue of controversy in the news articles. The responsibility for the remediation is on Fertiberia (the company that during 43 years poured phosphogypsum waste to the ponds located in the marshes of Huelva). The company restored some of the contaminated hectares before 2010 but the willingness and the capability of the company to restore the ponds are put in doubt by some of the actors from the beginning of the process. One of

the first articles about this issue, published in 2005, mentions that “The Administration would in no case allow them to leave Huelva without previously having the degraded areas restored.” In 2008, it is reported that the Administration requests an endorsement from the factory “so that it responds, in case of sudden closure, that it will work on this recovery, with costs to the factory’s budgets and not charged to the public treasury.”

After the decision of the National Court in 2009 confirming the termination of the concession to the company and the obligation of the company to restore the contaminated ponds, the beginning of the remediation generates a significant controversy. The National Court requested the company a guarantee planning to finance the remediation project. Nevertheless, after three years, the remediation has not started, and the media reports the complaints and the lack of trust expressed by the regional government and the local environmental groups. In 2014, the regional government fines Fertiberia with 240.000 euros for not having started the remediation project. In addition, even states that “the payment of the fine does not exempt the company from the recovery of the area”. The company argues that the project, commissioned to a company based in the USA, has suffered from delays. However, this do not stops the local organization “Mesa de la Ría” to organize a demonstration to demand the complete remediation of the ponds. A representative from the Spain’s Department of Environment declares that “the government is on top of the company to verify that it effectively undertakes the complete decontamination of the area”.

A more recent news article published in 2014 refers to the scepticism of the local population around the remediation of the area. The article reflects the view of a citizen living in the area, expressing a clear lack of trust in the process of remediation: “I will never see this done. Nobody is going to solve this”.

Choice and timing of the remediation strategy: Lack of consensus and opposition to the program

From the beginning of the process, there is a lack of consensus among the interested parties on the choice of the remediation plan. This lack of consensus is mainly based on different views on how the remediation should be carried out (mainly, coverage versus removal, being the latter promoted by the environmental groups), a lack of consensus on specific technical criteria, but also on the lack of coordination between parties (delays, motivations, changes in political parties, lack of trust) and a clear opposition from some groups.

The lack of consensus is portrayed in the media from the beginning of the process. Before 2010, the company had carried out remediation works on some of the terrains where the phosphogypsum were deposited. It was a partial remediation and, in the opinion of some environmental groups, insufficient. The ecologists demanded the closure of the company and the immediate removal of the phosphogypsum. Already in 2008, a representative from Greenpeace states that “It is clear that the way in which it has been recovering the old ponds, covering them with a few meters of land and planting vegetation on top, does not work”. For the company, the remediation carried out before 2008 was enough to minimize the risk of contamination in the restored hectares.

In 2009, a group of experts was arranged by the regional government to elaborate a remediation plan for the phosphogypsum ponds based on the best evidence available. A number of technical studies were carried out in 2009 and 2010. In 2010, a pilot remediation project to cover the phosphogypsum wastes started. The local organization “Mesa de la Ría” and Greenpeace question the remediation project as “too easy” and ineffective to remove the risk. Both groups propose the total removal of the waste, a plan that is considered unfeasible and very expensive by the company.

In 2014, a new remediation plan is proposed by the company and endorsed by the new Ministry of Environment. The environmental associations and the regional government oppose the remediation plan and also some local scientists question the remediation plan. On the other hand, the local government creates a participatory table to discuss the remediation of the wastes as well as a group of experts led by the University of Huelva. The plan proposed by the company, commissioned to a North American

company, consists of the covering and revegetation of the waste ponds. The environmental groups insist on the need to remove the waste to a safe area. The regional government considers the project as insufficient and questions why the company has not worked on the remediation after the pilot project in 2010. The group of experts propose an alternative remediation.

In 2017, the remediation plan is still under a process of allegations open by the Ministry of Agriculture and Environment. The regional governments, the local government, various environmental and local associations and private citizens have presented allegations to the remediation plan proposed by the company.

Socio-economic impacts of the remediation and the protection of jobs

A relevant issue generating controversy and uncertainty around the remediation process is the potential socio-economic impact on employment of the closure and remediation of the ponds. This topic is covered in the newspapers from 2008. Representatives from Fertiberia argue that stopping the industrial activity generating the phosphogypsum will produce a significant loss of employment in the area. Representatives from Greenpeace argue that the remediation works could generate jobs in the area.

In 2009, the controversy around the remediation of the area and the loss of jobs has a prominent role in the news articles covering the phosphogypsum waste. Some articles refer to the difficulties of old workers to find a new job in case the industrial activity is stopped due to the need to restore the area. Representatives from the trade unions are interviewed in the articles. This argument is also expressed by representatives from the regional government. The key uncertainty seems to be how to reconcile the remediation of the waste disposal area with the loss of jobs.

A solution to this controversy is presented by the regional government. The spill will be reduced progressively, so workers can be integrated in other sectors and the remediation of the waste will generate new jobs. The president of the regional government states that the new plan “will have very important consequences for the city of Huelva. For instance, the creation of employment in the regeneration works of the ponds...” This message is portrayed in several news articles in 2009.

Need for more dialogue and public participation

In 2010, a delegation from the European Parliament visits the area and states that there is an “apparent lack of communication between the competent national authorities and the municipal and regional authorities”. The delegation also states that “for the good of citizens and not to generate social alarm, the authorities should inform in a “clear and objective way” and to cooperate “urgently” to establish a permanent dialogue to restore the climate of confidence that “regrettably lacks.”

Coordination between administrations

The coordination between administrations in the management of the waste is questioned in some of the news articles. In general, there is some evidence that the various administrations involved have not been adequately coordinated in the process. The 2010 delegation from the European Parliament stated that there is an “apparent lack of communication between the competent national authorities and the municipal and regional authorities”.

In 2011, the Spain’s Ombudsman denounces the “breach of the Law of Coasts that requires collaboration and exchange of information between the competent organisms”. In general, the process has been characterized by the apparently uncoordinated claims by the different administrations (state, regional and local level), the Judiciary system, the European Commission and the Ombudsman.

Between 2014 and 2017, the remediation plan proposed by the company is approved by the Ministry of Environment with some modifications. The regional government, the local government and the provincial uncertainties around the site characterization presented allegations to the plan. The coordination and synergy between administrations seems to be weak.

3.2.2. Results from the media quantitative analysis

In this section, we present the quantitative results obtained in the media content analysis. As we saw in the qualitative analysis, the socio-technical uncertainties are presented in a thematic way based on the examination of a sample of news articles from two newspapers. We show the number of times an uncertainty has appeared in the articles. We structured the quantitative analysis around the various dimensions previously identified in the document “D9.65 – Decision processes /pathways” (Guillevic et al., 2018) as recommended in Perko & Abelshausen (2017).

Most of the newspaper articles studied refer to the technical decisions around the phosphogypsum waste repository and the remediation process (Table 10). We registered 67 mentions to these uncertainties: NORM contamination, remediation and decisions about remediation technology as well as enabling infrastructures. The two subcategories that appeared the most are the “Choice of remediation” (29 times) and the “Time necessary for remediation steps” (25 times). Although both uncertainties are technical in nature, often are linked to broader socio-ethical issues. In a greater distance we can see items related to the “Site characterization”, the “Exposure dose” or the “Types of contamination”.

The second most cited concerns were the socio-ethical decisions and risk perception with a total of 60 mentions. The “different risk perceptions and the lack of consensus among stakeholders” was the most mentioned (32 times), followed by the “impact on the socioeconomic development of the remediation” (15 times), the “Health impacts” (9 times) and the “Protection of vulnerable social groups” (4 times).

Purely societal uncertainties were mentioned a total of 29 times. Both “Lack of trust between stakeholders in the remediation process” and “Groups and individuals opposed to the programme” reached 9 hits each one, followed by “Different demands and concerns among stakeholders” (7 times) and from a greater distance, the “Poor stakeholder involvement” (3 times) and the “Little recognition of the links between environmental, economic and social concerns of the stakeholders”.

Regarding the national policy and the legal and regulatory framework, the topic received 20 mentions, including 9 about the “National policy and regulatory framework in general” and eight regarding the “Lack of synergies among regulators”. The other three remaining all were cited only once.

In the case of the financial decisions, it was cited a total of 20 times, including ten regarding the “Assignment of responsibility” and six about the “Availability of funds”. In a greater distance, we can find the question about “Who will pay?” with a total of three cites, and the “Cost of remediation” with one hit.

The management of NORM waste reached ten hits. The most mentioned item was the “Classification of material” with six times, followed at a distance by the “Uncertainties of management of NORM waste” two times, and a single cite both the “Uncertainties due to lack of clear national approach waste management” and “Waste characterization”.

Finally, the communication reached two hits, both of them related to the “Lack of transparency”.

Table 10. Results from the quantitative analysis

Technical decisions	67
Choice of remediation	29
The time necessary for remediation steps.	25
Site characterization: extent	5
Site characterization	4
Exposure dose	2
Site characterization: level of radiation	1
Types of contamination.	1

Socio-ethical decisions and risk perception	60
Different risk perceptions/lack of consensus	32
Impact on the socioeconomic development	15
Health impact	9
Protection of vulnerable social groups.	4
Societal uncertainties	29
Lack of trust between stakeholders in the remediation process	9
Groups and individuals opposed to the programme	9
Different demands and concerns among stakeholders.	7
Poor stakeholder involvement	3
Little recognition of the links between environmental, economic and social concerns of the stakeholders.	1
National policy and the legal and regulatory framework	20
National policy and regulatory framework	9
Lack of synergies among regulators.	8
Lack of uniform standards.	1
Ineffective	1
Ineffectiveness of the authority	1
Financial decisions	20
Assignment of responsibility	10
Availability of funds	6
Who will pay?	3
Cost of remediation	1
Management of NORM waste	10
Classification of material	6
Uncertainties of management of NORM waste.	2
Uncertainties due to lack of clear national approach to waste management.	1
Waste characterization	1
Communication	2
Lack of transparency	2

Figure 9 summarizes the number of news appeared in the two analysed newspapers during the period from 2005 to 2017. Observing the figure, it is clearly noticeable that there are two main coverage periods that peak the number of news published, one in 2009 and another in 2014. The first peak in 2009 can be related to the resolution about the ban of stacking phosphogypsum in the ponds, planned to be enforced from 31st December 2010. The second peak, in 2014, is related to the remediation of the phosphogypsum ponds, especially about the need that “The Participatory Round Table of Phosphogypsum” starts to discuss remediation strategies, and that these strategies bring a definitive remediation strategy.

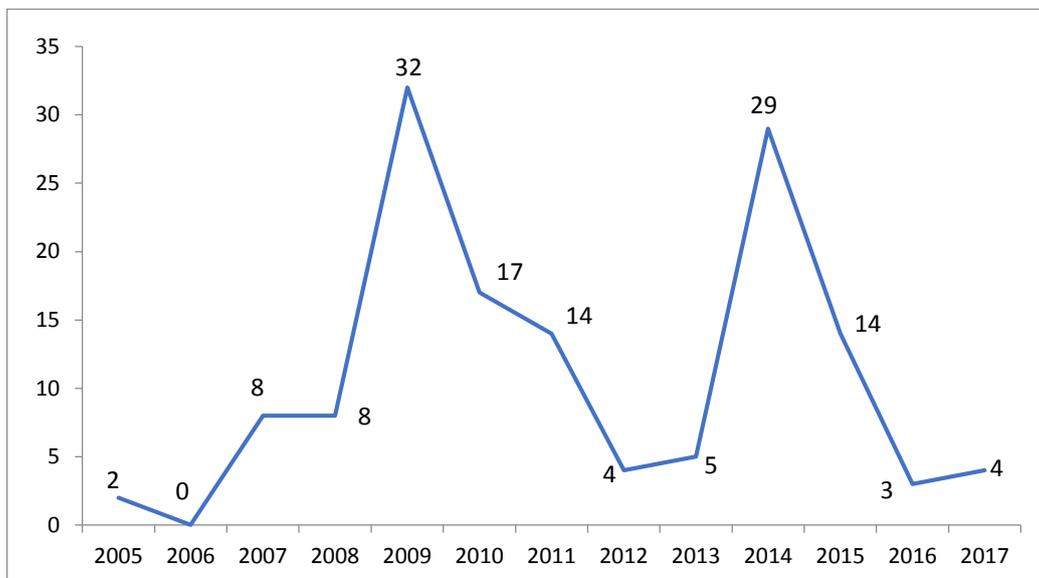


Figure 9. Press coverage during de 2005-2017 period

3.3. Interviews findings

In this section, we report the results of the interviews with key stakeholders and people from the local population. This analysis is aimed at identifying and understanding the set of socio-technical uncertainties around the management and remediation of the phosphogypsum waste repository from the point of view of the involved and affected people.

3.3.1. Results from the key stakeholders

Uncertainties around the site characterization

Some uncertainties related to the level of radiation also come out in the interviews with key people despite a huge amount of studies had been carried out by different experts requested by different entities. One of the interviewees stated:

"There are no ponds in the world as studied as these ones."

Over the years, a couple of scientific committees have been created, composed of experts from different universities and research centres, who have tried to characterize the site. These scientific committees studied the radiological levels of the phosphogypsum waste. Even some representatives of the EU visited the area, checked the studies and elaborated a report. Some of the interviewees declared:

"I do not think there is any scientific uncertainty, the uncertainties are of a social nature."

"A study was commissioned in 1982 and radium concentrations in the phosphogypsum were measured. It was concluded that the radiological risk was therefore minimal and... well, it is a source of radon emission to the environment, but radon is diluted as soon as it leaves... besides, as it is a coastal zone, with the maritime influence, the concentrations tend to be lower".

"The levels of radioactivity are correct."

"The conclusions of the studies are very clear..."

Nevertheless, other interviewees question these studies and show some controversy around the level of radiation of the phosphogypsum waste. While most experts declared that the levels are under the limits, others did not agree:

"We have an impressive contamination due to the radioactive phosphogypsum generated by the Fertiberia plant and the Foret plant, where 7131 tons of radioactive ash contaminated with caesium 137 were added, it was not a small quantity and with radioactivity levels, according to the CSN, which exceeded 3500 times what is allowed by legislation."

"Even the area where the phosphogypsum were covered with a layer of soil for a later revegetation had levels up to 9 times higher with respect to the gamma radiation; but the soil samples indicated that, in comparison with other soils of Huelva, there were large amounts of radium 226 that has alpha particles and that in its disintegration generates radon 222."

Some disagreement regarding the procedure for radium measurement come out. Some experts accused the environmentalist of taking irregular samples (too close to the ground) to obtain higher values of radium. On the contrary, other interviewees clearly stated that the main contamination of Huelva comes from the abandoned mining activity in the Huelva province, but not from the phosphogypsum.

Categorization of the NORM waste

Some controversy appeared around the classification of phosphogypsum waste by some interviewees. It seems that a late regulatory implementation is the cause of this uncertainty. Because they were first considered as by-products and then as industrial wastes. Anyway, phosphogypsum are not classified as radioactive waste. Some debate around the reuse of the phosphogypsum come out. Some interviewees clearly defend the possibility of recycling them as an argument in favour of its classification as by-product:

"In the book that I have recommended to you, that one by the IAEA, a lot of possible uses of phosphogypsum are established. They are being used as a road base because they are very impermeable and make the road more durable."

The use of phosphogypsum as an agricultural fertilizer is also mentioned by some interviewees. Others mentioned that they should be considered a radioactive waste because of the radioactivity levels:

"With regard to the phosphogypsum, what happened is that the CSN said that they were going to monitor it and that the levels were in accordance with the regulations ... there was a huge discussion about it, but because of it is NORM they could not do anything..."

National policy and regulatory framework

The interviews with the key actors also showed that some uncertainties are due to a late national policy and regulatory framework for the management of this waste. The first authorization to dump waste is from the 60s and did not consider the environmental impact of the discharges. It was only a permission to use the land and they accumulated the waste in open circuit. One of the interviewees stated:

"It is an authorization obtained from The Coasts Department for occupation of the maritime-terrestrial public domain... it was an occupancy license, let's say, like the one that could be gave to a beach bar, right? Then they had a permit to occupy the marsh and they extended until the 1,200 hectares they are occupying now."

In 2003, the regional authorities (Junta de Andalucía) requested the site operator (Fertiberia) to dump in close circuit. Fertiberia asked new permissions to General Directorate of Coasts, to stack in height. However, Fertiberia could not obtain the licenses. Through an inspection, they realize that they are accumulating in height and a sanctioning file was opened for breach of the conditions of the concession and an expiration file for breach of the conditions of the concession:

"The origin of the whole problem is in the concession that does not respect the limits."

In 2007, The Supreme Court asked to finish the industrial activity and do the remediation of the site. Fertiberia closed the part of the factory producing those phosphogypsum. One of the interviewees explained the following:

“There was a judicial procedure between the General Directorate of Coasts and Fertiberia, because Coasts wanted one of the zones to return to the maritime-terrestrial public domain, and Fertiberia said no. Well, that finally ended in the Supreme Court, if I'm not wrong, and it was declared that yes, the General Directorate of Coasts was right, that it had to be returned and also demanded the closure of the phosphogypsum deposit in the area, in any area”

In December 2010 the waste disposal ended. Then, the remediation started to be studied. The first remediation project was rejected, and a second one was elaborated. At the time of the interviews, the project is in the environmental impact evaluation phase. If the General Directorate of Coasts give the approval, the project will go to the regional government (Junta de Andalucía), and then to the local one. One actor stated:

“The problem has become politicised, it has stopped being a technical issue to become a judicial issue and the solution that will be given to this issue will be a judicial solution, that is, the projects are being presented and the judge is the one who is requesting modifications or new studies.”

Additionally, the lack of uniform standards for managing NORM waste also came out in the interviews. Some interviewees clearly pointed that in Spain the issue of NORM waste management is not developed at all and it is not really assigned to ENRESA, which is the public company for the management of radioactive waste. One of the actors declared:

“Many laws related to waste management have been violated by almost all the political parties that exist today.”

Some interviewees talked about the permissions needed to start the remediation and expressed some doubts about possible corruption or mala praxis related with economic interests:

“All the problems associated with the ponds of phosphogypsum is the excuse for other factors much more important. It is a struggle simply for power: the area in which these phosphogypsum are located is an estuary that, if the industrial complex is closed, the value of these lands would be immense from the architectural point of view and from the tourist point of view.”

Impacts on public health

In these interviews with the key people also appeared the uncertainty regarding the radiation doses to the population, and the concern of the population for this issue is recognized:

“There is a very important concern with the subject of phosphogypsum.”

Public concern is explained by interviewees because the phosphogypsum ponds are very close to the residence areas and because of the worry normally associated to radiation risks. As reported by some interviewees, people perceive that this waste has an important health risk associated and they have in mind that phosphogypsum waste produces cancer. In fact, some of the experts interviewed explained that some of the studies carried out were clearly launched to respond to the social demand and not because of a real scientific need.

Some of the interviewees stated that there is no risk associated to the phosphogypsum ponds while others clearly raised their worry:

“It has the risk of any industrial installation, everything generates a risk, but all the studies we have say that it is an acceptable risk, which is not... from the radiological point of view, it is not a risk that can affect the local population.”

“From the point of view of public opinion yes, perhaps it is more serious. From the scientific point of view I doubt it...”

“The universities, CIEMAT, the Nuclear Safety Council have spent thirty years saying that it is not dangerous.”

“Even accepting that there were leaks, what value can these leaks have? Taking into account that the oldest phosphogypsum is almost 50 years old, there is no radiation anymore ... then there is no danger at all.”

“Phosphogypsum have natural radioactivity but on average it has less than 1msv so that it does not affect the population.”

“The studies concluded that there was no risk to the population unless new houses are built in the surface (the average radio concentration was about 600 bq / m²) or unless the phosphogypsum are used as building material. That's what could not be done.”

“I made a public statement that phosphogypsum could not be the same as cancer because the radiation that reaches Huelva is zero, so if the radiation that arrives is zero, there will be cancer from other things but not from the phosphogypsum.”

“In recent years environmental awareness has increased, people have noticed the environmental damage and collateral damage in health, such as a higher incidence of some types of cancer.”

“Another study concludes that there is radon gas, which is carcinogenic.”

“Huelva is a much polluted town within Spain and is the place with the highest rate of different types of cancer in Spain.”

In that sense, some actors explained that there are many studies demonstrating that the NORM contamination is below the accepted levels and do not have any risk for health. They declare that, in fact, the main contamination of the rivers come from the mining activity not from the phosphogypsum waste. Besides, it seems there are many other industries generating important pollution in the zone but, as they do not generate radiation, people perceive it as less dangerous, despite there are many other relevant pollutants in addition to NORM (e.g. arsenic). Nevertheless, it seems the inhabitants do not understand or agree with this:

“The pollution that reaches the estuary through the Tinto and Odiel rivers comes from abandoned mining. In fact, in a rainy week, 99 out of 100 of the pollution comes from these abandoned mining areas.”

“Phosphogypsum have clearly harmed the environment, but people is not aware that the main pollution problem in the estuary of the “Ria de Huelva” do not come from the ponds but rather the mining pollution that has been abandoned in Huelva province.”

Some of the interviewees pointed out that the environmental NGOs have created important alarm among the population, despite the low exposure doses and the low risks:

“What role have they played? They have sensitized the population. Now, the population is very sensitive. There are demonstrations with the slogan: phosphogypsum equal to cancer. That what people have in mind. They have created a lot of alarm. Some years before, people did not know about the topic...”

It is interesting to note that even some interviewees explained that it was thanks to the creation of these ponds that malaria was eradicated in the city many years ago.

Regarding environmental risk, also different perceptions coexist. On one hand, some of the key people interviewed recognize the value of the marsh and highlight the environmental impact of NORM pollution there:

“This is an area of marshland, the marsh has its environmental value, its ecological value, 50 years ago nobody was aware of that value, but today there are European directives for the protection of wetlands, at the end it has been recognized the value it has”.

On the other hand, some interviewees stated that NORM contained in the phosphogypsum are not the main environmental pollutant in Huelva and they affirm categorically that metal discharge is more important. Interestingly, one of the experts explain that the main environmental problem is not any kind of pollution but the geological stability of the estuary:

“It must be taken into account that one of the zones is 40 meters high. This is generating a huge underground pressure. Let's say that, for every square centimetre of marsh, every square centimetre supports a kilo of phosphogypsum. That is unstable and can cause a structural collapse.”

Lack of trust

Lack of trust is also a recurrent issue. Distrust in the industry, in the national administration and political parties is mentioned but also in some experts from universities who had led some of the studies on the risks. Some of the interviewees perceive that the industry has paid some of those studies so that they are not really independent. Some even accuse the local administration and the unions of complicity with the industry. Others accuse the media of being speaker of the denunciations of environmental groups. The fact that the decisions of the participation committee (Participatory Round Table) are not binding also generates great distrust as it is illustrated by the following quote:

“Citizens think that whatever the industry wants will be done. They think that the experts will not be able to change anything, because in the end it is the administrations that authorize, and the interests of the industry prevail. The participation round table and the expert committee do not have a legal entity. That is a problem and makes its conclusions not binding.”

Lack of trust is related with three different aspects: a poor management of the waste, delay in the remediation, and assumption of responsibility for the remediation (and costs).

In terms of the waste management, some actors declare that from the 60s and until 1998 there has been a bad management of the waste by Fertiberia with no intervention from the public authorities. This has generated an important distrust in the administrations and the industry among the local population. In contrast, they trust environmental NGOs because they uncovered the issue and tried to increase awareness about the risks among the population.

In terms of time, it is reported that decision related to the remediation is taking too much time, which seems to generate distrust among the population and the local actors:

“What has been done wrong is that this issue has been left too long, that is, for 40 years the waste has been pouring out and no one have taken any action.”

In terms of the assumption of responsibility, while the industry declare their assumption of responsibility, other actors perceived this is not real:

“All costs are assumed by Fertiberia. Since it was sentenced in 2010 until now, there have been 8 years in the remediation project, other studies and the safe maintenance of the ponds in the conditions that it is... unable to start up the remediation project. 45 million euros have been already spent. And the project will be around another 70 million. And of course all will be paid by Fertiberia.”

“...when it's time to restore, Fertiberia says ‘no, there has been an embezzlement, the factory has closed’. It declares bankruptcy and therefore... the State has to assume it. To avoid that the State put a bail”.

Choice and timing of the remediation strategy: Lack of consensus and opposition to the program

The main controversy regarding the remediation plan has to do with the lack of agreement among those who want the waste to be covered (in-situ) versus those who ask for a removal (ex-situ). Experts point out that there is no study suggesting that the removal could be an option (the risks of removing and transporting are too high, there are no available storage places and costs would be really high).

"The population wants the waste out of there. From my point of view, it is not possible. Imagine moving 120 million tons of this residue. First, where are you going to deposit it? Many environmental platforms propose to use old mines for the deposit of these phosphogypsum, but it is taking the problem from one site and transfer it to another. The removal of all that waste and transportation to another site will cause more pollution problems because phosphogypsum will be risen to the atmosphere. Well, I do not see it possible. There is a high amount of waste..."

"The project presented aims to completely eliminate the possibility that a contaminant may emerge from outside, with a seal and a vegetal regeneration of the area so that it remains safety within, from the salt marsh. And it is also planned to make a control and follow-up on the post closure of all possible pollutants that could emerge in surface waters, in groundwater, radioactivity, finally... All... The project has an estimated duration of about 10 years. Right now, there is no technical uncertainty about remediation, because the most advanced technologies in the world will be used by the company. They have already closed 70 ponds such as ours or larger ones all over the world, in Australia, Asia, Europe ... everywhere"

"You can also find other reports, such as the report made by ERGMASA, which is a public company of environmental management of Andalusia, on the removal of phosphogypsum that come up with numbers that... are crazy. That has not been done anywhere in the world... What is done in other places in the world is a good remediation so that the environmental impact is practically zero".

"We would not accept anything that does not suppose a return to its natural condition. The area has to return to its natural marsh condition."

Diverse arguments are given by some actors as reasons against the remediation plan carried out by Ardaman and Associates Inc. (Fertiberia proposal).

- The first argument against this plan has to do with the zones of the ponds that the plan covers (only Zones 2 and 3). Some actors request the inclusion of Zone 4 in the plan. In fact, some people perceive that the first restoration made in Zone 1 is not enough and should be restored again.

"We fight in order to change the remediation plan of those Zones 2 and 3 and also in order to include Zone 1 and 4 in the remediation model because the current remediation does not work."

- The second issue is related to the treatment of the black phosphogypsum, which are more radioactive than the others. Some actors against the plan perceive this is not well addressed in the proposed remediation plan.
- A third argument raised by some of the interviewees is the need of classifying the ponds as a radioactive installation, in order to better providing specific treatments and the most demanding safety measures.
- A fourth argument is the singularity of the ponds in terms of the seismic activity and structural stability, which is perceived as not contemplated in the remediation plan proposed:

"There are stacks of up to 35 meters in a unique sedimentary substructure such as salt marshes, in addition to medium-high seismic activity. This singularity is not contemplated in the remediation project proposed by Fertiberia."

Others think that the last project for the environmental remediation is good enough:

"I have not read it in detail but I think the project now...The first project presented by the company was made by an engineering company here in Huelva and was relatively bad, but the last one applies the technology that is applied in any industrial waste landfill..."

One interesting argument that appeared is the possibility to re-use the waste in the future, in favour of a remediation in place (in-situ).

Finally, it is worth to mention that some of the interviewees summarize the controversy around the remediation as a fight between different interests as it is illustrated in the following quote:

"It is the typical dispute: Fertiberia is presenting a study that they consider appropriate and the State tells them yes, but then the ecologists appear and say no, we want to add 20 more things and Fertiberia says no, and the ecologist take Fertiberia to the Court... This is a dispute that mix political and other issues, not just a science issue."

Socio-economic impacts of the remediation and the protection of jobs

Different socio-economic impacts of the management and remediation are also mentioned. A first one is the economic growth that has occurred in the region due to industrial development from the 60's. It has to be taken into account that Huelva was an economically depressed area due to the closure of mining industries with heavy losses of jobs. Linked to this, the closure of the phosphoric acid factory in 2010 had a significant impact on jobs.

"Since 2010, phosphogypsum and phosphoric acid are no longer produced. The plants were closed. That means 200 people unemployed."

A second issue are the effects on tourism. As explained by some of the interviewees, those groups opposed to the remediation program are doing an information campaign that harms the tourism in the area.

"The groups against de remediation are distributing leaflets in the hotels, to all people, even the foreigners, telling them that there is radioactivity, that the water they bath in is very bad, scaring people. These people will not want to come back. They are doing a huge damage to Huelva, sometimes an irreparable damage, which will take many years to repair."

Need for more dialogue and public participation

In the interviews with key stakeholders, some actors explained that before 2002 very little information about the phosphogypsum was available to the public. In 2002 a local NGO called "Mesa de la Ría" was constituted and awareness of the local population started to increase. Fertiberia held a press conference to present the project of remediation and experts did some talks, anyway some voices recognize a lack of adequate risk communication to the public:

"There was not a communication campaign to reassure the population with scientific data."

Regarding public involvement, it was not until 2014 that a Participatory Round Table was launched by the City Council to engage all the stakeholders in the remediation plan. This Participatory Round Table was constituted by different voices against and in favour of the remediation project presented by Fertiberia (political parties, authorities, industry, experts, and local associations). It has met some times until its creation, and the industry left it after one of the meetings because of dialogue problems. Some interviewees express their disagreement with the fact that any decision taken by the Participatory Round Table is not binding so that it is more an Informative Assembly.

In 2017, as part of the Environmental Impact Assessment of the remediation project, a public consultation was launched receiving around 1.350 statements.

Financial aspects

Regarding the financial decisions, one of the most cited uncertainty is related to the economic cost of the remediation. Some respondents say the site would not be remediated due to the high costs it will have, apart from the decision finally taken between the stakeholders.

"They will not take it away because that will cost millions of euros."

"They have to agree if they do one thing or the other, but let's see who puts the millions."

Some respondents think the problem is not only economic but also political. They think that even with the changes occurred in the local government the situation is the same.

"Is a political and economic problem, we used to have different political parties but it's the same thing."

Other respondents also cite the judicial sentences that obliged the company to give a solution to the case.

"There were some Court rulings that obliged the company to give a solution to that."

Other aspects

Some interviewees from the stakeholders groups pointed out other relevant issues such as irreconcilable interests for the land use. It is mentioned as one of the main causes of the controversy regarding the remediation project. While the building sector is interested in using the land for tourism uses, the industry sector is interested in the industrial use.

"In fact, one of the groups that has always positioned itself more against the industry has been the college of architects; the director of the college of architects was one of the most active ..."

"There is a kind of confrontation between the housing market and the industry."

"The political party 'Mesa de la Ría' was created by the architects of Huelva when it was the construction boom and logically it was created a bit from the speculative point of view... they wanted to remove all factories from here and create recreational areas and buildings."

Other relevant issue in this case study is a poor coordination between administrations at the local, regional and national level. In the interviews with key stakeholders many of them refer to a complex system of competencies among the different levels (General Directorate of Coasts at the national level, the regional Government of Andalucía, the Huelva City Council) and argue that here has not been a good coordination among them. One of the interviewees points out that it coincided with a period of transfer of competences from the national government to the regions and, in the end, nobody assumed the responsibility for the management.

"Possibly, it is also a problem of lack of coordination between administrations. When the Junta de Andalucía approved this project around 1995 or 1997, in Madrid, it governed the PP and PSOE governed in Junta de Andalucía. PP and PSOE at that time did not get along... surely this have affected. If politicians had acted, if they had said, let's do it as soon as possible, for sure this would be settled and there would not have been so much controversy."

"There is important lack of harmony among the administrations. The central administration has authorized the closure project without taking into account the other administrations that have competences, the autonomic, and the local. The central administration has chosen to impose its own criteria. An inter-administrative commission should have been created."

Another important issue is that nowadays the decision about the remediation is in the National High Court. In 2000, Fertiberia was denounced for stacking higher than allowed in the initial license. In 2010 the license was removed and they were forced to stop the phosphoric plants.

The role of ENRESA and CSN is also questioned in the interviews with the key people. For some, they should have had a more important role in the issue taking into account that there is radioactive contamination.

3.3.2. Results from the local population

Level of radiation and classification of waste

In the interviews with the local population, the issue of the level of radiation is not mentioned and no data about the classification of waste appeared. People seem to understand contamination in a categorical way: contaminated or not contaminated, but the scale of measurement or the specific type of contaminants are not known.

Some respondents from the city of Huelva speak about the size of the ponds and about the possible radioactivity of the phosphogypsum. Some interviewees also highlight the importance of having studies that define if the phosphogypsum is dangerous and what type of remediation should be done in this case.

"It's awesome big, sometimes with the binoculars I see the trucks there."

"Some say they are radioactive and others say they aren't."

Risk perception of health and environment impacts

Differences in health risk perception appeared among the local population. Some of the interviewees felt worried about the presence of the phosphogypsum waste in the city and its radioactivity. Many of these interviewees consider that it is a generalized concern among the population of Huelva and that the phosphogypsum ponds affect especially to the population that lives close to there.

"I'm very worried because it's so close to the city."

"It is a generalized concern in Huelva for years."

"Due to the information that I have saying that the ponds are radioactive, I neither really enjoy living here, nor working here."

Many of the interviewees believe the phosphogypsum waste repository has a negative effect on the people's health. These interviewees consider that the highest rate of cancer and other serious diseases in Huelva are related to the phosphogypsum ponds.

"The rate of cancer in Huelva is exaggerated."

In contrast, other respondents say that they do not feel worried about it and they think it is not dangerous to live near the phosphogypsum ponds. Some of them argue that they are used to live close to many factories that pollute while others think they have other important aspects of their life to worry about.

"I haven't had any problem because there is the waste repository there, we have other kinds of factories, so we are used to it..."

"I have other kinds of problems to worry about."

In that sense, some respondents think the phosphogypsum do not have any harmful effects. Some of them cited people who never worked there or in other factories in the zone, but still developed cancer or respondents explaining their personal experiences working all their life in the factory and having a very good health at an old age.

"I really do not think they are dangerous because otherwise we would all be dead already or with another kind of diseases."

"I've been working with the phosphogypsum for 47 years and I do not take a pill at all."

Many of the respondents from the local population think the phosphogypsum is dangerous and polluting for the environment. Some of them are very worried about the contamination of the sea and the river and about the consequences that this issue could have on the human health through the fish and the water that they consume. The damage to fauna and the poor air quality in Huelva are also mentioned.

"It produces a way for the waste to get to the river and then goes to the sea and as a consequence of that this zone is very contaminated."

"With the storms of these days, there are experts who say that this accumulated phosphogypsum can seep into the estuary and contaminate the entire estuary, fish, and such."

Lack of trust

Some participants assured they do not trust in the management of the situation that authorities and political parties are doing of the problem. A great number of interviewees feel that the authorities are not working to solve the problem. They consider that it is necessary that the politicians reach agreements and they have the willingness to solve this situation.

"Politicians say many words but at the end they do nothing at all."

Some respondents trust in the environmental associations because they think that these kind of organizations really fight for a better environment.

"I trust more in the associations that fight for a better environment, more than in the authorities."

The majority of respondents think that authorities are not managing it properly. The long time the problem is lasting or the dumping of contaminant products from other industries are some of the reasons given by the interviewees.

"They are not managing it well because already with the years that have passed they should have made some decision."

"It has allowed that Acerinox dumped polluting products."

Other respondents are not sure if the factory is still open or when the factory stopped to dumping phosphogypsum in the marshland.

"Now it seems that there is no heavy machinery, I do not know."

"They have not thrown it for more than 20 years, they are using it for the land."

Remediation alternatives

In the interviews with the local population, some respondents express their lack of awareness about which remediation process will be applied and do not know what they want to do as expressed in the following quote:

"I do not know what they want to do."

Most interviewees consider the best solution would be to remove the phosphogypsum to another place (ex-situ). However, they recognize that the repository is so big that it is impossible to remove all the phosphogypsum from there.

"I would like that this could be transported to another site."

"I am not sure how they could remove the phosphogypsum from there and take them elsewhere. It has a larger size than Barcelona, where will they take it?"

Some respondents explain that some remediation works have already been done and the remediation plan will consist to cover the phosphogypsum ponds.

"They were covering the ponds some years ago. You could see trucks. They covered it and replant."

"Fertiberia want to cover it."

In the case of the time necessary for the remediation, some interviewees think the time to remediate the site would be so big that they do not believe it is even possible.

"They would need a lot of trucks 24 hours a day to take them away."

"The removal will take years and years."

Some interviewees highlight they have been hearing about the remediation for many years. They also mention that the remediation process is very slow.

"There is a project to remove them, but when I do not know."

"Everything goes very slowly."

The respondents think that if everybody involved in the remediation process works hard it can be possible to remove all the phosphogypsum there.

"If they all work together, I think they can remove it."

Public opposition

Also in the interviews with the local population, discussion about public opposition to the phosphogypsum waste repository came out. Respondents explained different actions taken by the inhabitants of the region. One of the most commented actions were the demonstrations that took place in Huelva. They also speak about the collection of signatures or social networks activity.

"They have made demonstrations in front of the Sub-delegation of the Government, in front of the Junta de Andalucía, etc."

"I have not participated in many demonstrations but I signed against the phosphogypsum disposal."

Socio-economic impacts

The interviews with the local population show different opinions on the impacts regarding the socioeconomic development due to Fertiberia operations. Some of them say Fertiberia and other companies in the Huelva's chemical pole have created wealth and transformed the city from a rural to an industrial area.

"When they started to build the factories, Huelva was a village and now it is one of the most important poles in Europe."

In contrast, some respondents do not agree with the idea that these industries created wealthy to the region. They think that both Fertiberia and other industries contaminated the region while enriching themselves and this wealth never reverted to the city.

"Fertiberia has taken the added value of all production and wealth and left all the pollution there."

"They insist that they have given a lot of workplaces, yes, but they have contaminated."

Some of the interviewees stated that the population is not happy with the pollution that industries have left in Huelva, including phosphogypsum waste repository. However, they accept it because many people in Huelva have worked there and they have lived off the industry.

"The population is not very happy with the issue of the phosphogypsum but Fertiberia employed a lot of people."

Communication and involvement

Regarding communication aspects, in the interviews with the local population we collected different opinions showing how the respondents get informed about this topic. Some of them get informed by the general press like the newspapers and television. Others argued that the information they get comes from the social networks and associations.

"I get informed by the newspapers."

"The media tend to inform if there is something, but through social networks among citizens we inform more."

Other respondents even affirm they informed themselves searching actively for information.

"I feel informed, but because I look for the information."

Other respondents say the media informs about the case but there is some censorship of the information given. Some of them consider the authorities and the industry try to cover up the dangers of the phosphogypsum repository.

"The press talks about it, but it's silenced and covered-up."

"I don't feel very well informed by the authorities, rather they cover it up."

"On television, they report what happens, but you cannot talk about everything because there is censorship about the case."

Some interviewees highlight the role of the Mesa de la Ría in the problem of phosphogypsum ponds and the concern that this association express for the pollution issues. However, other interviewees are a bit more pessimists and say that neither the demonstrations nor the environmental associations like Mesa de la Ría cannot achieve anything.

"Neither with Mesa de la Ría nor without it, nothing is solved; I think they do not do much."

"There have been demonstrations, but they are not worth anything."

3.4. Participatory workshop findings

In this section, we report the results of the participatory workshop that took place the 6th of March in Huelva (Spain). It was attended by 14 representatives from universities, research centres, industry, environmental organizations, and local and regional authorities (Figure 10, Figure 11, Figure 12).



Figure 10. Workshop session (Source: CIEMAT)

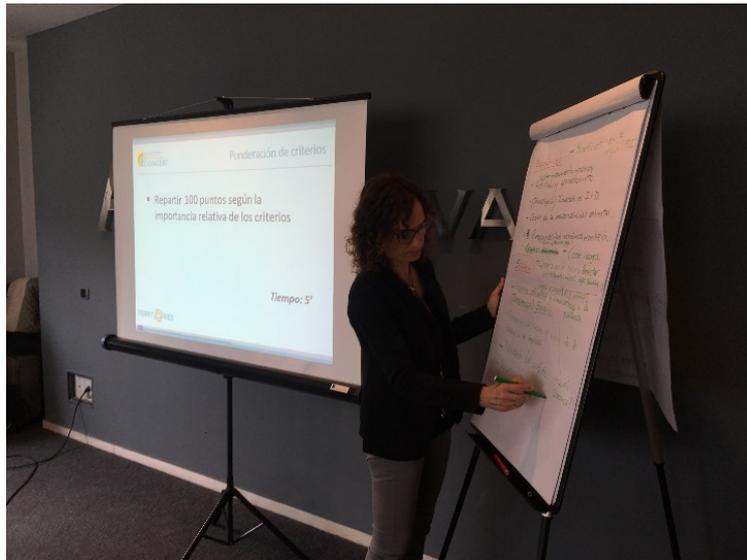


Figure 11. Workshop session (Source: CIEMAT)



Figure 12. Workshop session (Source: CIEMAT)

This analysis is aimed at identifying, defining and weighting different technical, environmental, economic and social criteria and sub-criteria that, taking the views of attendees, should be considered when making a decision on the remediation strategy of a NORM site. Particular emphasis was placed on social criteria, trying to go in depth into the relevant aspects being considered by the local community, such as acceptance of the remediation option, confidence, and the information, communication and engagement strategies. Different prototypical remediation options were assessed taking into account the considered criteria. It is expected that the findings can contribute to the improvement of future decision-making processes of contaminated NORM sites.

The results are structured in six subsections: at first an identification of the most important criteria done by the workshop attendees, at second the debate on some proposed criteria, then the weighting of those criteria, and the evaluation of the remediation options taking those criteria into account. Finally, we present the results from the evaluation of the workshop made by the attendees and, the last section includes the views of some other relevant stakeholders that did not attend the meeting and were involved in a second stage.

3.4.1. Brainstorming

After participants' introduction, a first brainstorming about the most important criterion in decision-making on NORM remediation, clearly pointed out that the risk for health and the environment is the main criterion to take into account when deciding about the remediation strategy: 7 out of 14 participants mentioned these aspects as the most important ones. The following extracts illustrate it:

"Application of the principle of radiological protection optimization (ALARA), that is, to reduce the doses to the population as low as possible considering social and economic factors."

"Caution, prior knowledge of the area and the environment and security guarantee for the population."

"Preserve the health of people and ecosystems."

"Direct impact on public health: How much? How?"

"Eliminate all contact or negative impact to the environment to avoid the possible effects to the people's health."

"Risk for people and the environment."

"Guarantee health and environmental quality."

The second most mentioned criterion had to do with the characterization and management of the waste, 3 out of 14 mentioned these aspects as illustrated by the following quotes:

"Do not mix NORM waste with others that are not and not add several NORM residues in an uncontrolled manner."

"Characterization of the totality of the waste by zones."

"Recovery of radionuclides and recycling of material, within the concept of the circular economy. The sale of obtained products finances the recycling."

Other mentioned criteria were the need for transparent technical studies and acceptance of the society.

3.4.2. Selection of criteria

After the warming-up session, participants read and discussed the list of criteria we presented to them (Annex 4). As a first reaction, the proposed criteria and sub-criteria were considered good but many of the participants proposed to add other issues.

Technical criteria

Regarding the technical criteria, a first insight was that it was a difficult and somehow mixed category. Some of them proposed to split it and change the name. As it contained two different issues (different type of risks and other aspects related to the viability of the strategy), some participants proposed to rename as follows: "risk assessment criteria" and "viability criteria". Others proposed to join the risk aspects with the environmental criteria because, in their view, some aspects were very much related (e.g. radiological risks and risks for the environment).

Participants identified other potential aspects to be considered such as:

- Geological risk (geo-tectonic stability) which means how the remediation strategy can affect the geological conditions of the site (the geological balance or stability of the ponds).
- Risk of disaster, which means any type of accident during the implementation of the remediation process (for instance, a tsunami or a severe weather phenomenon) as part of the risk assessment category.
- Waste mixture which means effects of chemical and radiological mixture

One participant propose to change the name of the criterion "administrative difficulties" to "legal framework" to include also the difficulties associated to absence of an effective and consolidated

regulation that allows taking imminent actions on these sites (in his view, there is no common framework that regulates NORM sites in Spain).

Another participant proposed to change the category “waste” for “waste management” in order to consider not only the disposal of waste but also the possible recovery and recycling. A discussion about the advantages and disadvantages of local repositories versus centralized repositories for NORM waste came out.

For the “time” criterion it was pointed out the need to include not only the execution time of the remediation strategy but also the monitoring period, which could include a re-evaluation of the remediation itself taking into account the best available techniques over the years (periodic review of the strategy).

Environmental criteria

Regarding the environmental criteria, it was proposed to add some specific aspects relevant to the idiosyncrasies of the Huelva site:

- Impact on coastal waters, including the sea and the marshes.
- Fluvial modification, which includes the effects of remediation on the bed and the river channel.
- Alteration of protected natural spaces (for instance, possible loss of the World Heritage rating of the zone).

In addition, participants proposed to add some details in the definition of the criteria. Regarding the soil and air quality criteria, they proposed to highlight specifically the effects of radionuclides as part of the impact of the remediation strategy. In the flora and fauna criterion, one participant proposed to consider the bioaccumulation and bio-amplification of heavy metal contamination and radioactive elements as well.

Economic criteria

Regarding the economic aspects, three new issues were proposed to add:

- Cost related to the elimination of non-recyclable waste.
- Health costs, which means those expenses associated to the health impacts of the local population, such as expenses of sick leaves.
- Costs of environmental responsibility, which means those costs associated with the damages that may occur during the implementation of the strategy.

Besides, participants proposed to split the benefits associated to the commercial viability of waste (that was part of externalities) into a separate criterion because of its importance. In the externalities criterion description, “loss of investors” was proposed to be added as well.

Expenses associated to the monitoring, control and maintenance of the remediation strategy were also pointed out both in the direct costs and job criteria descriptions, in order to consider not only the implementation period but also a longer period after.

Interesting discussions about the responsibility of the remediation costs and the need of a repository for NORM waste appeared during the session. Regarding responsibility issues, participants were divided in those thinking that the industry should pay the full costs (arguing “the polluter pays” or “everything ends up being paid with public money”) and those who thought that is not so simple:

“Possibly when these discharges began to occur they were not regulated in any way, then the responsibility cannot be only for the industry. In the end, society as a whole says, so that these companies continue to generate economic wealth, we are going to take care of this...”

Regarding the repository, one of the participants stated that the main cost of the remediation is the waste storage/disposal and pointed out that there is no NORM repository in Spain:

“In relation to NORM waste, there is no repository where these waste can be stored. El Cabril is not for that.”

He pointed out the need to recycle those wastes closing the life cycle:

“The valuation or recovery of the waste is very positive. However, what is never taken into account is the economic cost generated by the waste that I have left after my re-use. It is very good to calculate the benefits that I will get, but I should include the cost of managing the waste I will generate, in order to close the economic life cycle.”

Other participants argued that the costs of the waste recovery or disposal should be charged on the final price of the product when it is taken out in the market.

Social criteria

Finally, regarding the social criteria, different relevant topics were raised despite not being real decision-making criteria. The need of information to the population was clearly pointed out as a very important issue. Some of the participants felt there has been lack of transparency regarding the phosphogypsum. An interesting debate about the hidden interests of industry, the regulator body and public administration, and the dilemma between information and security appeared:

“I do not think there is anyone in the Administration who has any interest in hiding anything and less related to the health of the inhabitants, rather the opposite.”

“In relation to the information that is given on radiological waste, I would rather talk about the fact that sometimes there is a clash between giving the information and the security consideration in what you are saying.”

“People have the right to know that there is a NORM site here and people have the right to know if there is an area that is considered a radioactive facility. You have the right above the security I understand.”

In that sense, some participants talked about “social contamination” of the affected population, in the sense that there seem to be some pressure to the population by the industry lobby and the local media that try to modify the perception of the reality of what is happening in this city and in a very clear operation of image clean-up.

Regarding public communication, the need to adapt the language to the population was highlighted (not using scientific slang). It was also linked to the need to educate the population regarding the risks, and the need to take into account the different risk perceptions. Education and communication is fundamental for public participation. In that sense, some participants demanded a communication responsible body and they propose that medical doctors could be a trusted source of information in that sense.

Other participants stated that sometimes there is a need to prohibit those activities that pose a risk, beyond the opinion of society or its risk perception. Bans have to be complemented with education on risks.

Another relevant topic raised in the discussion is de politicisation of the conflict in the sense that the conflict have become an issue of the political agenda. This is causing an unnecessary prolongation in the decision-making.

Other criteria

Other issues were highlighted, mainly related to the legal framework and the regulatory body. The need of a body for NORM management and control came out and some doubts were raised regarding the role of CSN in that sense:

"I believe that the volume of NORM's problems is incomparable with the usual scope for which the Council is created. The Council was created in the 80s and the problem of NORM by volume, by affected population, by economic and social implications of all kinds, exceeds the structure that the Council has".

Besides, regarding the regulator it was clearly mentioned that the main problem have been that the social conflict appeared before the regulation for NORM:

"When the famous title 7 of the EU Directive came out and started to be implemented, there was a lot of awareness by some stakeholders, and the regulator body had not taken any steps yet. The regulator has been behind the situation: that's the reason!"

Regarding the legal framework, one participant stated that it should be taken into account that the NORM industries are not radioactivity facilities because they do not produce radioactive materials, only their wastes are radioactive. This is the reason why the radioactive materials law is not applicable for NORM industries. In a similar sense, another participant stated that the main problem of NORM sites in Spain is a legal one:

"The European Waste Management Directive also highlights the need to revalue the waste. The problem is legal. We talk about radionuclides, but there are other things too. There are concentrations of arsenic, cadmium, lead, etc. that add complexity to the issue. Either the legislators change or there is nothing to do. Only appeal to the precautionary principle and apply Article 45 and 16 of the Constitution. But, at the moment, from my point of view, there is a blockage of the technical norm that prevents action."

3.4.3. Weighting of criteria

In the second session of the workshop, participants were asked to weight the list of criteria and sub-criteria according to their relative importance. Only the proposed criteria were considered (not the new ones) because a qualitative analysis of the discourse of the first session would have been necessary before the session (Annex 5). It was an individual exercise.

When we asked to distribute 100 points among the main four criteria, in average, environmental issues were weighted as the most important ones (31 points out of 100 were given in average to this criterion). Social aspects were given 27 points in average while 26 points were given to technical (including viability issues). Finally, economic aspects were considered as the least important with an average of 16 points (Figure 13).

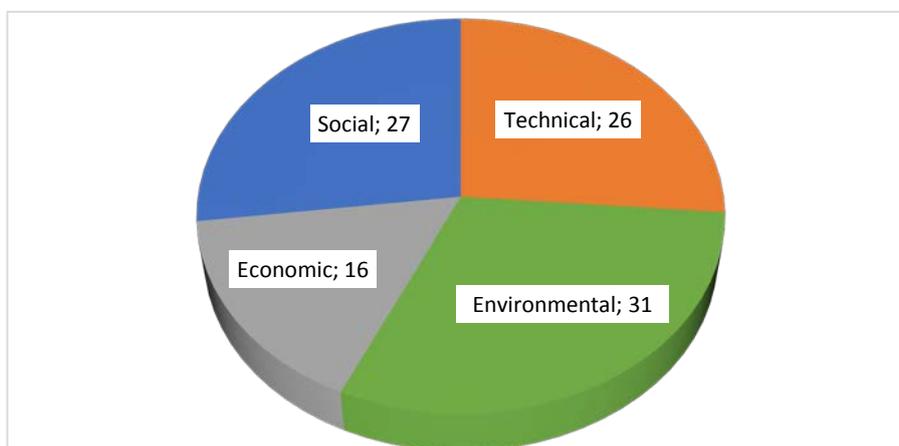


Figure 13. Distribution of 100 points in terms of importance among the four criteria

If we consider potential differences among the different type of stakeholders involved (Figure 14), technical criteria was more important for scientists from universities and research centres (30%) and public authorities (28%), but less important for environmental NGOs (22%) and the industry (20%). Researchers, NGOs and authorities allocated around 30% of the importance to environmental aspects, but the industry allocated less (20%). On the contrary, the industry allocated 30% to economic criteria while researchers (18%), NGOs (14%), and public authorities (10%) allocated less. NGOs and public authorities allocated 33% of the importance points to social aspects, the industry allocated 30% and researchers allocated only 19%.

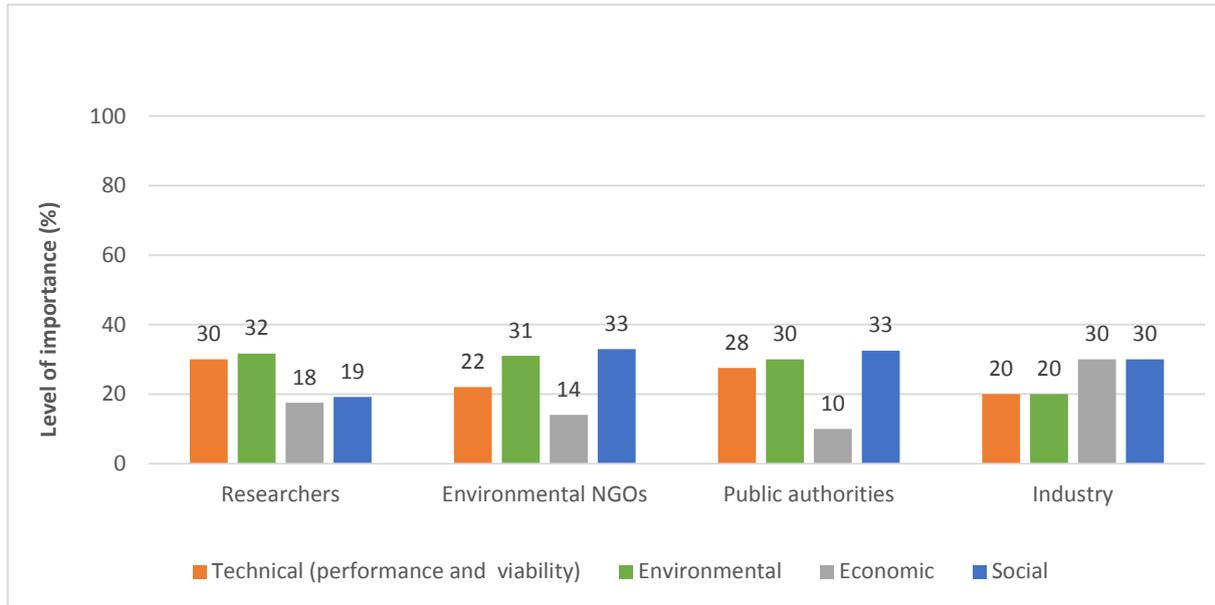


Figure 14. Importance of criteria by stakeholders' groups

Then we asked participants to distribute 100 points inside each criteria (among the sub-criteria of each category).

If we focus on the technical aspects (Figure 15), the radiological risk was weighted as the most important one (24% of the resources in average) directly followed by administrative difficulty and chemical risk (around 18% both). The duration in time of the remediation strategy was considered the least important issue (9%).

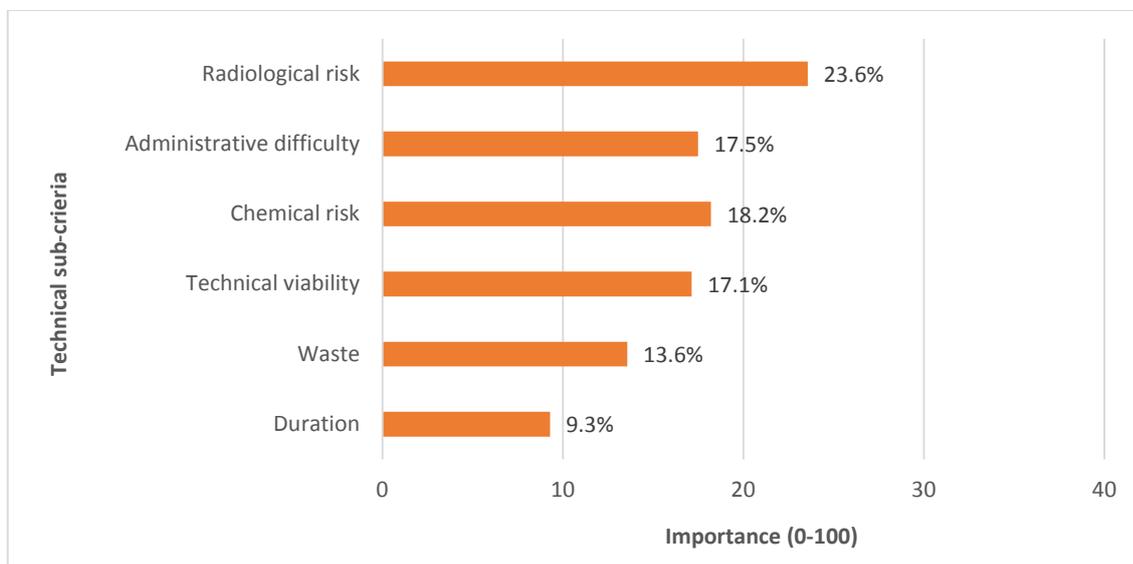


Figure 15. Distribution of 100 points among the technical sub-criteria

Regarding environmental aspects (Figure 16), air quality (around 19%) and soil (around 18%) were considered the most relevant aspects for the decision-making about the remediation option. Non-renewable natural resources and non-recyclable waste were considered the least important ones in this category (9% and 7% in average).

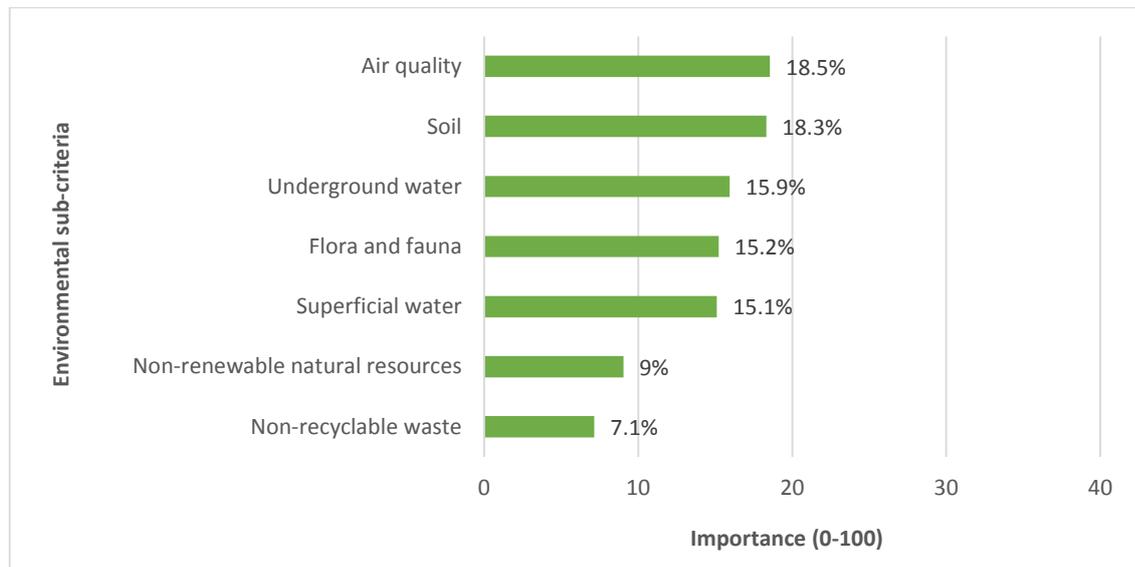


Figure 16. Distribution of 100 points among the environmental sub-criteria

Focusing on the economic issues (Figure 17), direct costs of the remediation is considered the most important sub-criterion with 36% of the resources in average. Nevertheless, externalities and employment are considered quite important as well (around 34% and 30% respectively).

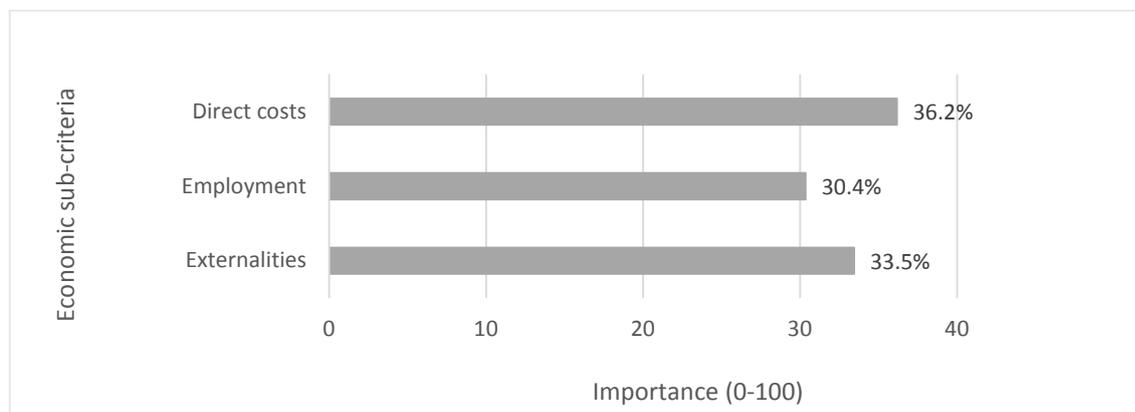


Figure 17. Distribution of 100 points among the economic sub-criteria

Finally, regarding the social aspects (Figure 18), health and safety stands out as the most important issue receiving 31 out of 100 of the resources in average. The second criterion is acceptance of the community, obtaining 18% of the resources. The other four criteria (impact in the neighbourhood, community involvement, equity, and land use) are considered equally important with weights ranging from 11 to 14 points.

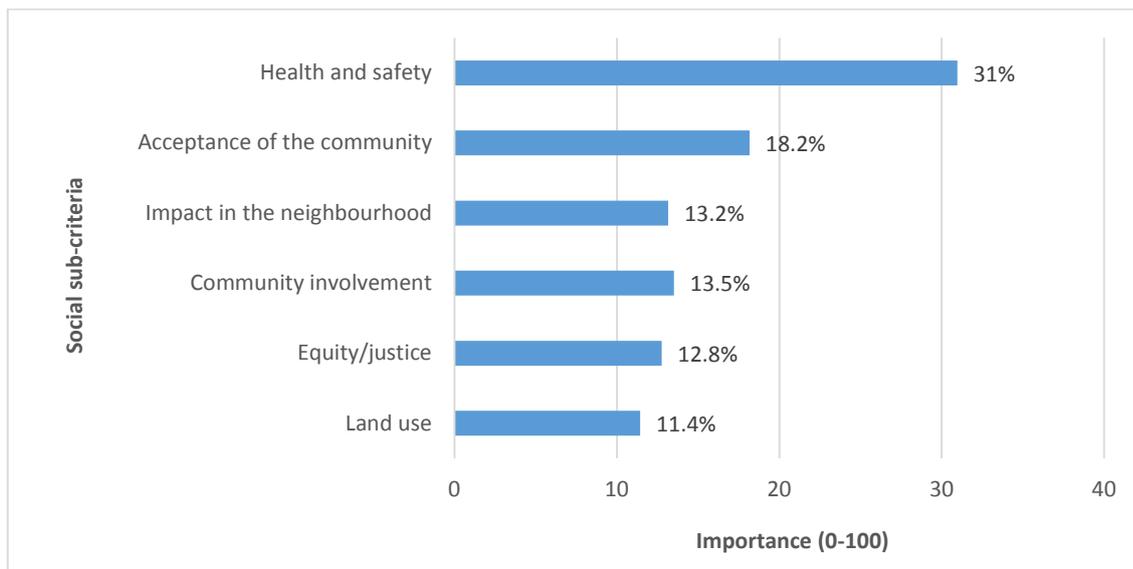


Figure 18. Distribution of 100 points among the social sub-criteria

To study the importance of the different sub-criteria altogether we weighted them, in order to avoid the effect of different number of sub-criteria in the four different main criteria. As it is shown in Figure 19, health and safety is considered as the most important sub-criteria with 19 out of 70 points. Radiological risk, the impact on the soil and the impact on air quality are rated equally important, with weights between 13 and 14 points. Non-recyclable waste, non-renewable resources, duration and land use are considered the least important aspects (receiving between 5% and 7% of the resources in average).

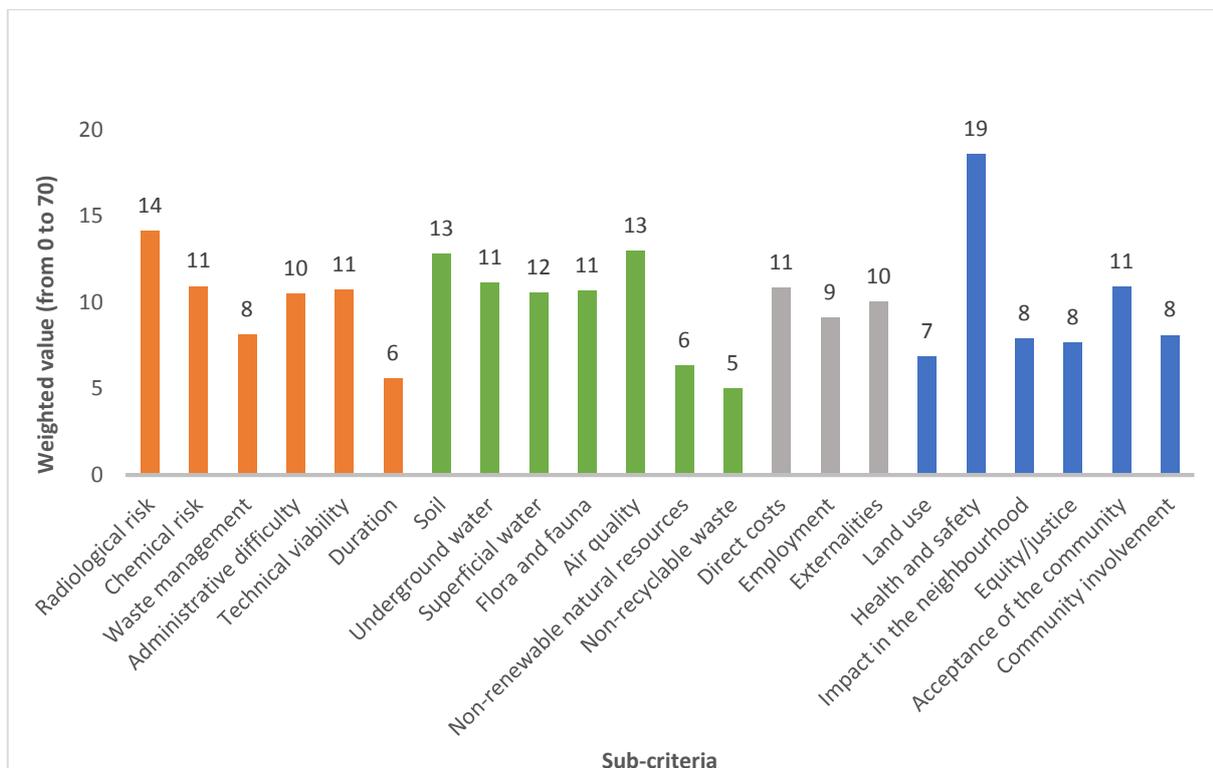


Figure 19. Comparative importance of the different sub-criteria

If we consider the standard deviation of the responses to study stakeholders' agreement in the assessment of the different sub-criteria (Figure 20), we found that in general impact in the neighbourhood (SD 4.19) is the criterion with major agreement among the stakeholders that attended the workshop, followed by Non-recyclable waste (SD 5.08), Duration (SD 5.14), and Underground water (SD 5.17). On the opposite side, we found Externalities, Administrative difficulty, and Health and Safety (SD 5.17).

issues with a standard deviation above 15. It is interesting that there is less agreement in those aspects that are considered as more important in average (health and safety and radiological risk).

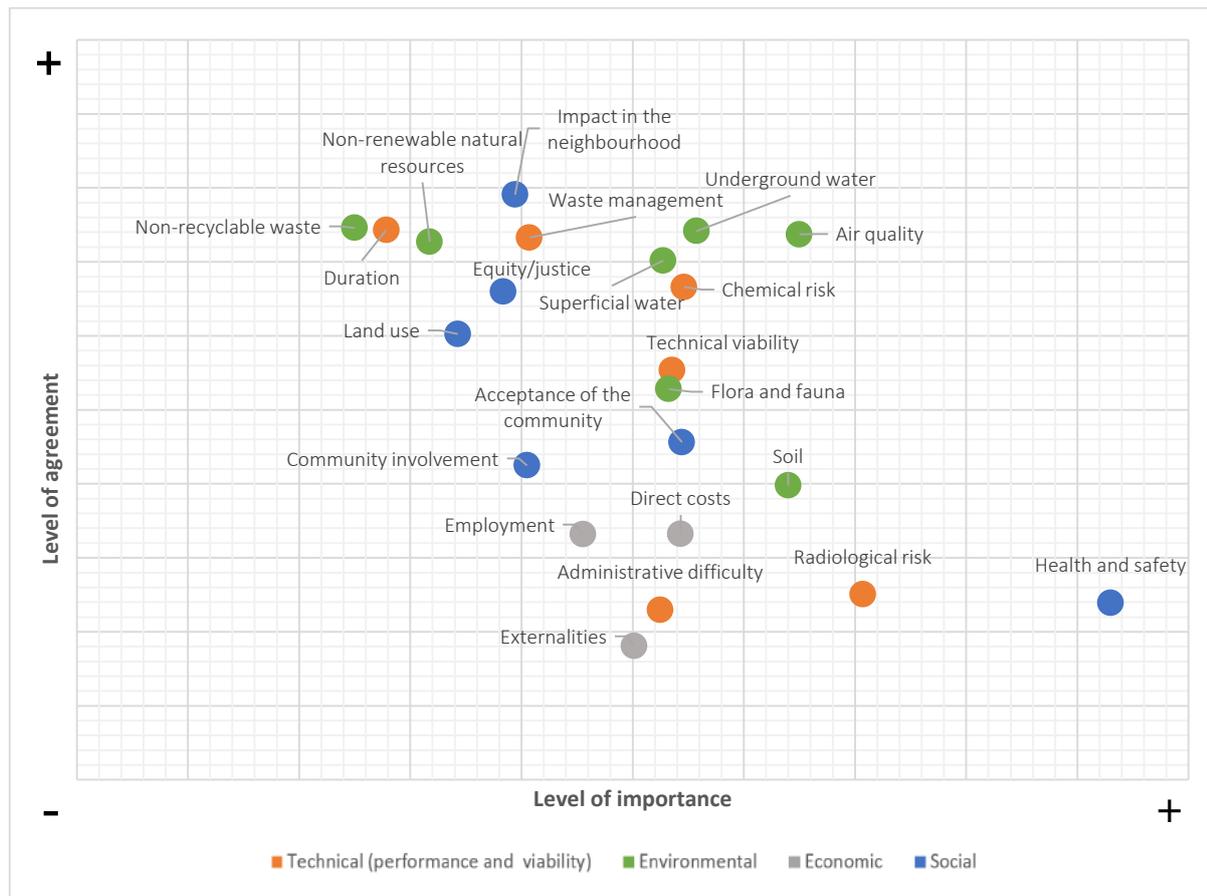


Figure 20. Sub-criteria according to their importance (average) and agreement (SD)

3.4.4. Evaluation of three remediation options

In the last session of the workshop, participants were asked to rate the proposed remediation options taking into account the list of criteria, in a scale that ranged from 1 to 10. In general, combined remediation option was rated as the best one with an average of 6.7 points (Annex 6). In-situ remediation option obtained, in average, 5.8 points; while ex-situ remediation option was rated as the worst with 5.4 out of 10 points (Table 11).

Table 11. Assessment of the remediation options

Remediation option	Average
Combined	6.7
In-situ	5.8
Ex-situ	5.4

In-situ remediation option is considered the best in terms of technical aspects, but the worst in terms of environmental and social aspects. Ex-situ remediation option is considered good in terms of social sustainability but worst in the technical and economic aspects. Combined remediation option is perceived the best in terms of economic and environmental sustainability (Figure 21).

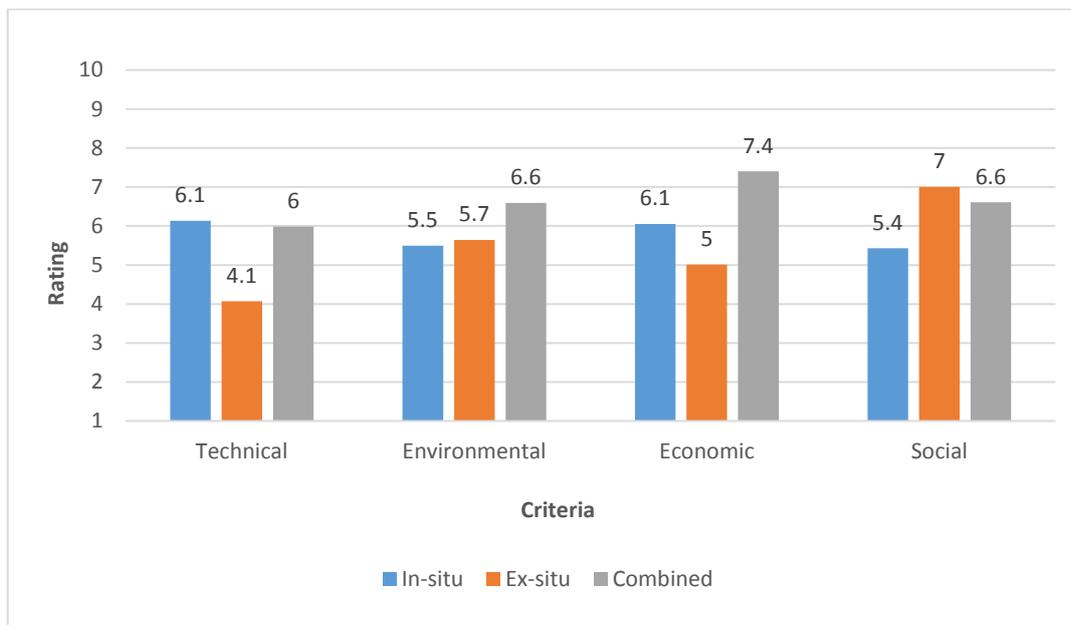


Figure 21. Comparison of the remediation options by criteria

By stakeholders' groups (Figure 22), industry prefers in-situ option; public authorities prefer the combined alternative. Environmental NGOs prefer also the combined one, but they rate ex-situ as a good option too. Finally, scientist from universities and research centres, in average, prefer the combined remediation but they also rate the in-situ alternative as a good option.

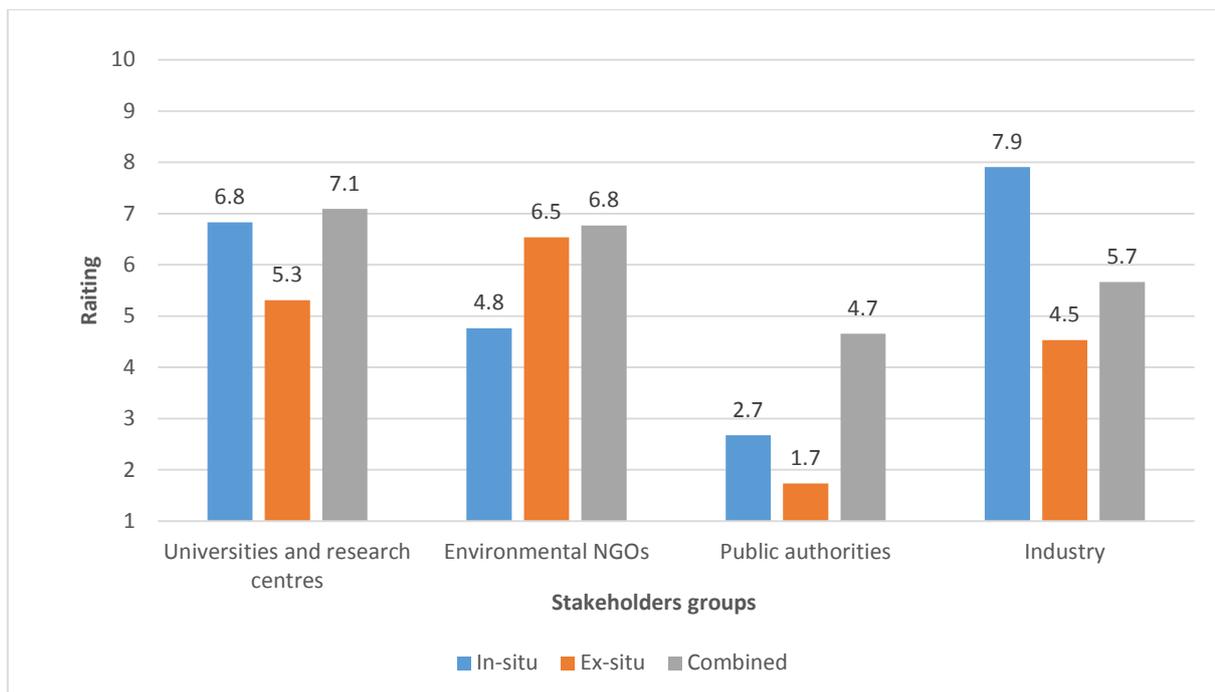


Figure 22. Assessment of the remediation option by stakeholders' groups (average)

3.4.5. Other stakeholders views

As a second-stage involvement strategy, the questionnaires developed to assess the criteria, sub-criteria and remediation alternatives were sent by email to other relevant stakeholders in order to obtain a wider assessment from all the relevant stakeholders'. We obtained four answers by email after the event. It was the case of an industry representative, the National Radioactive Waste Management Company (ENRESA), the Spanish Nuclear Safety Council (CSN) and one representative from Huelva University.

We analysed again the data of the last session (Evaluation of three remediation options) in order to include this new data. Despite the four stakeholders' representatives were not present in the workshop discussions, the views of the regulator and the national waste management company were of special interest because of their role. As shown in Table 12, including the new responses obtained after the workshop session, in-situ option is somehow better valued than before (because new stakeholders valued it better in terms of technical and social aspects, Figure 23). Ex-situ and combined options were valued very similarly.

Table 12. Comparison of remediation options by workshop participants vs all involved stakeholders

Criteria Remediation option	Technical		Environmental		Economic		Social		Average	
	N=14	N=18	N=14	N=18	N=14	N=18	N=14	N=18	N=14	N=18
In-situ	6.1	6.4	5.5	6.0	6.1	6.2	5.4	6.0	5.8	6.1
Ex-situ	4.1	4.4	5.7	5.7	5.0	5.1	7.0	6.9	5.4	5.5
Combined	6.0	5.9	7.0	6.6	7.4	7.3	6.6	6.7	6.7	6.6

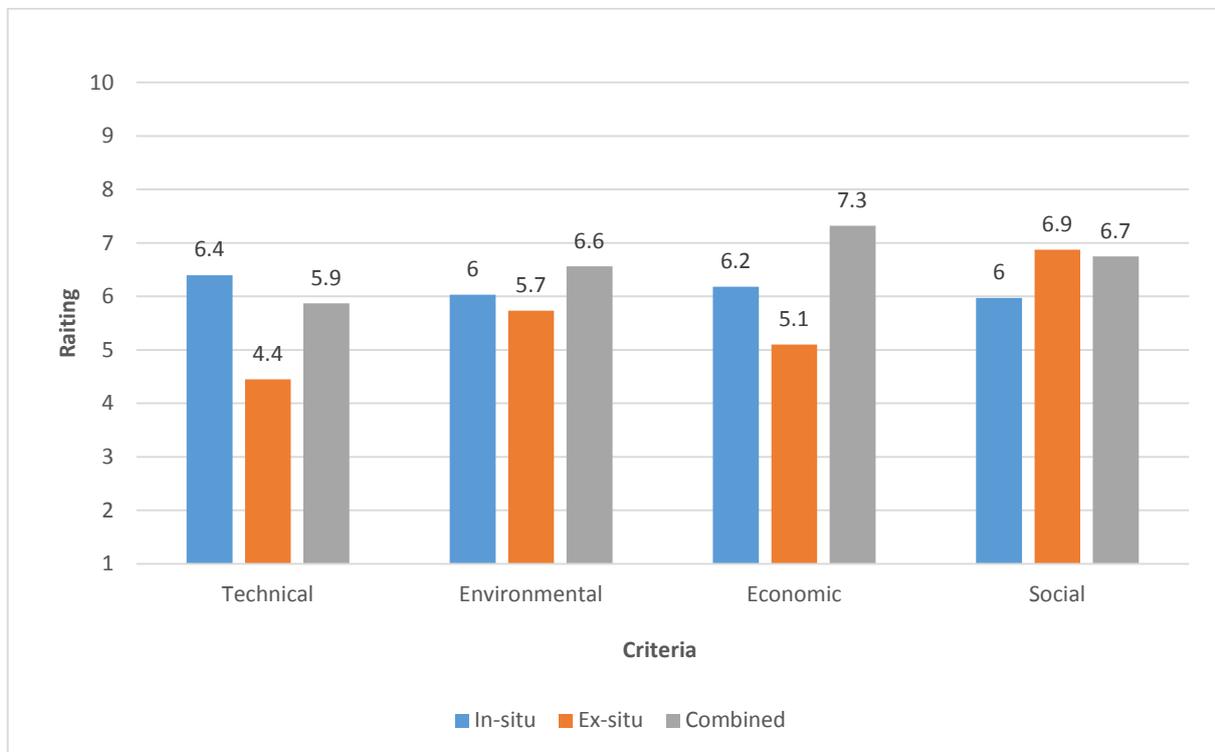


Figure 23. Assessment of the remediation options from all involved stakeholders

Following with this second stage involvement strategy, we maintained a meeting with representatives from CSN and ENRESA. In that meeting, we commented some preliminary results from the workshop with them in order to obtain their views. They did not know participatory MCDA methodology. However, they found it interesting for the specific case, and to be applied in other situations.

Below are some of their comments:

- Regarding the possibility of re-using phosphogypsum waste, they think that cement industry will not be willing to buy it.
- The transposition of the European Directive is still pending in Spain, but the existing regulatory framework is sufficient to regulate this waste.
- Need to involve more stakeholders in order to get a wider view.
- A lot of money has been spent on the characterization of the ponds.

Their roles in the issue were clarified: CSN is in charge of the application of the regulatory framework. Thus, when a remediation is decided they have to establish if it is in accordance with the legislation. They are not decision-makers. In fact, they do not know who is in charge of the final decision. Regarding ENRESA, they actually have no role in the issue.

From the view of CSN representatives, Multiple Criteria Decision Analysis tools (MCDA) are useful for evaluating and selecting between alternative remediation options. It is expected that Spanish decision-makers should not, in principle, use MCDA recommendations as the sole basis for their decision, but can reconsider once again the preferences of the stakeholders. In their opinion, it is difficult to apply this option in the case of Huelva, it is a complex tool that requires adequate training and communication among all interested parties in order to ensure its comprehension and acceptance.

3.4.6. Evaluation of the workshop by participants

We asked participants to rate their participation in the workshop by means of an online questionnaire we distribute a few days after the event (Annex 7). 10 out of 14 of the attendees answered the questionnaire. In average, the event obtained a mean score of 4.07 in a 5-point scale (Figure 24). The best-rated aspects were: neutrality of the moderators, the possibility to express opinions, and enough time of the event, with means of 4.5 points. On the other side, learning (3.4), new ideas (3.5) and representativeness (3.6) were rated as the worst aspects.

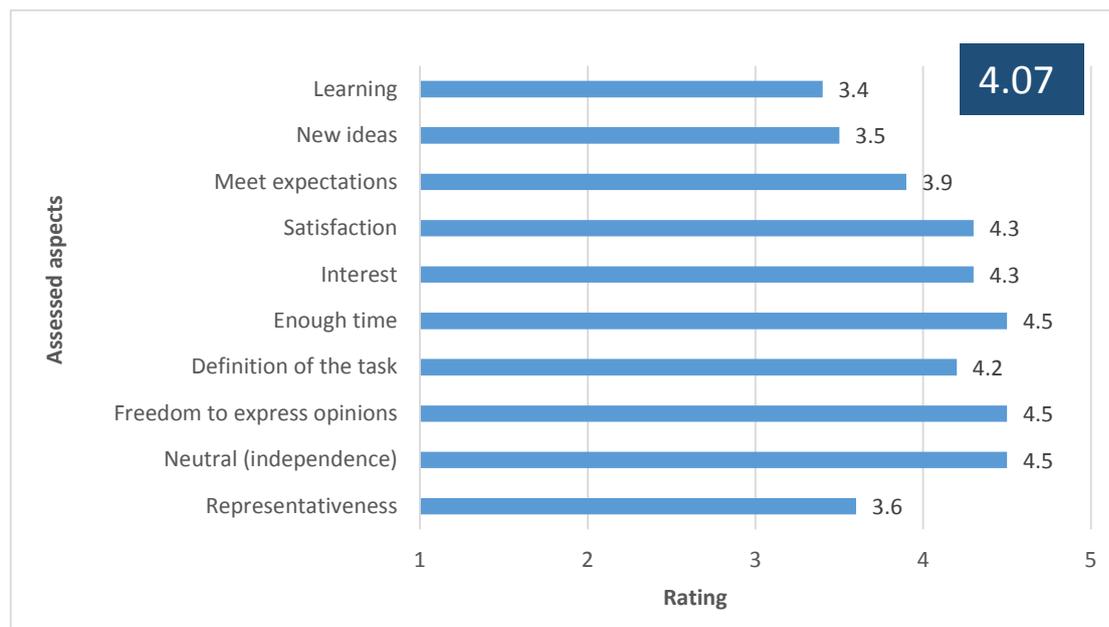


Figure 24. Evaluation of the workshop by participants

When we asked participants what they liked most about the event, participants stand out the following aspects:

- The wide variety of participants
- The possibility to meet people committed in the recovery of NORM sites
- The multidisciplinary orientation of the topic
- The methodology
- The kindness and professionalism of the moderators
- The large number of different views from which some issues were addressed
- Freedom when expressing my opinion
- Very effective organization

Participants were asked to highlight what do they like less about the workshop, the following issues arise:

- Limited presence of women
- The excessive polarization of some participants
- The assistance of few specialized researchers
- Time was a bit scarce
- Sometime the discussion deviated from the central issue
- Limited attendance of industry representatives

Finally, we asked participants what they would have done differently:

- To invite less representatives from the ecologist groups
- To insist more for the presence of industry and policy-makers
- Prolong the workshop time
- To organize a more technical event
- Insist on the participation of policy makers
- Try to avoid some heated discussions
- Try to limit the discussions that were not focus on the topic.
- Put some specific examples of areas affected by NORM and how they are being managed. This would help a lot when analysing the risks.
- To specify a common language on some of the basic concepts treated (hazards, risks, risk assessment...) since being such a disparate group we could not have the same interpretation of them

4. Conclusions

In the first part of the present report, different social, ethical and communication aspects related to uncertainty management and the associated environmental remediation process of the phosphogypsum waste repository in Huelva (Spain) have been examined. More in-depth understanding about the needs and concerns of stakeholders and people living in the area have been gained. In the second part of the report some of the main criteria to be considered when taking the decision of remediation have been identified based on the experience of attendees in the Huelva's workshop and thus, promoting the direct involvement of stakeholders. The following sections provide some main conclusions organized in two sections: conclusions from the case study and conclusions from the participatory MCDA workshop.

4.1. Case study conclusions

A first documentary analysis was carried out to describe the case, the chronology of the contamination and remediation actions, the legal aspects affecting this NORM waste repository, and some first ideas about the existing social controversy. Then, empirical work was carried out to identify and understand some of the uncertainties that have played a role in the waste management and the environmental remediation decision-making process. This work consisted in: i) a content and thematic analysis of the two most read national and local level newspapers from 2005 to 2017; ii) semi-structured interviews with a sample of key informants (N=15); iii) semi-structured interviews with members of the local population (N=13).

From the press news messages and from the discourses of main actors and some members of the local population in Huelva, ten main uncertainties have been identified:

1. Among the key actors, we found very different discourses regarding the site characterization of the ponds, specifically about the **level of radiation** and the type of contaminants present in the repository. There is not clear agreement around the level of radiation coming from the phosphogypsum ponds: while some actors state that the levels are below the standards others think they are clearly above, despite many studies to characterize the site have been carried out during the last years. A critical issue of the controversy is the black phosphogypsum coming from Acerinox industry, which contain cesium 137.
2. In terms of the management of the NORM waste, the **changes in the classification of material** have clearly contributed to the controversy. First, phosphogypsum were considered as by-product but later they were reclassified as industrial waste. This was due to delay in the implementation of the EU waste legislation. During the period in which phosphogypsum was considered a by-product they were sold as fertilizers. Some key actors claim that this has contributed to expand the contaminated area. Other voices request that they should be classified as radioactive waste in order to be managed in a proper way.
3. Another important uncertainty is the Spanish **legal and regulatory framework**. Specifically, some key actors argued that NORM waste management legal framework is insufficient, arrives late and it is not enough developed in Spain, contributing to a poor management that increased the controversy.
4. **Exposure doses to population and workers** are still important uncertainties among some key actors and some representatives of the local population. They claim there are not enough studies on the specific health effects of the phosphogypsum waste repository. This uncertainty is clearly linked to the existence of different risk perceptions among interested parties. This uncertainty generates important concern among members of the NGOs and local population.

5. The **assignment of responsibility for remediation and the cost of remediation** is another issue of controversy. Some actors perceived that the site operator is not assuming its responsibility, while Fertiberia explains that the costs are not a problem for them and that the delays in the remediation are due to denounces received to the remediation plans they have proposed. Local population seem to be somehow skeptical regarding the remediation. In part, they attribute part of the responsibility to the public administration.
6. A very clear social uncertainty is the existing **lack of trust between stakeholders**. Distrust is widely extended among different stakeholders and also among the local population, and it is linked to the perception of a bad management of the waste during many years, to the delay in the environmental remediation of the site, a poor assumption of responsibility from the industry but also from the administration. Some interviewees from the local population express a higher level of trust in the environmental groups.
7. From the beginning of the process, there is a **lack of consensus among the interested parties on the choice of the remediation plan**. Very opposed views coexist regarding the best and feasible remediation strategy. Those against the proposal give different arguments: it is insufficient to deal with the contamination, does not include some of the areas occupied by the waste, that it not consider the particularity of the ponds in terms of structural stability. The local population is less aware about the specific remediation strategy proposed but it seems they are more in favor of a complete removal of the waste.
8. **Socio-economic impacts of the remediation** are considered in the press but also among some key actors and some members of the local population. A first discussion is about the wealth created by industry in Huelva. In addition, the impact in jobs is mentioned as an undesirable consequence of the closure of the factory. In addition, those in favor of the proposed remediation plan mention the effects of the controversy on tourism, accusing environmental organizations of creating alarm among tourists.
9. There has been very **limited information to the public and a limited and late stakeholder involvement** with low effects in the conflict resolution. It was not until 2014 that a Participatory Round Table was launched by the City Council to engage all the stakeholders in the remediation plan. It is constituted by different voices against and in favor of the remediation project presented by Fertiberia (political parties, authorities, industry, experts, and local associations). It has met three times since its creation, but the industry left it in 2016 claiming dialogue problems. The decisions taken by this Participatory Round Table are not binding so that it is more an Informative Assembly. For all this, it seems that this late and limited involvement strategy has not contributed to decrease the controversy.
10. Other relevant issues pointed out in the interviews are:
 - a. **Irreconcilable interests for the land uses** (industrial versus tourism and recreation) as one important cause of the controversy regarding the remediation project.
 - b. A **poor coordination between administrations** at the local, regional and national level. A complex system of competences between the different levels together with changes and disputes between the different political parties are the highlighted causes of this lack of coordination.

In the media news, technical uncertainties are highly mentioned while in the interviews they are mentioned less; even some interviewees affirm that technical uncertainties are nonexistent and that all

the controversy has to do with social aspects. On the other hand, in the newspapers they hardly talk about aspects of trust, communication and involvement, while in the interviews these aspects are of high relevance.

The interviews with the local population show that the knowledge about the issue among the people living in the area is quite limited. In that sense, some of the interviewees did not have a clear reasoned opinion about some of the issues we raised.

4.2. Stakeholders workshop conclusions

In the second part of this report, we propose the use of participatory MCDA as a tool to enhance the involvement process around the remediation of NORM sites by including relevant stakeholders' views and preferences in the decision-making process. We applied this methodology to the phosphogypsum ponds in Huelva (Spain) with a long-lasting contamination from more than 40 years and a considerable social conflict around the remediation decision.

We obtained that, from the point of view of the attendees, the most relevant aspects when evaluating a remediation strategy for NORM sites are:

1. Health and safety: effects on health and human safety due to remediation tasks.
2. Radiological risk: level in which remediation strategy reduce the radiological risk of the site.
3. Air quality: pollutant emissions to air due to the remediation strategy.
4. Soil: impacts on soil functions due to remediation strategy.

Nevertheless, other aspects were considered also important: chemical risk, administrative difficulties, technical viability, underground water, flora and fauna, direct costs, externalities, and acceptance of the community. This clearly pointed out the need to consider different criteria when taking the decision about remediation: environmental, radiological, but also social and economic aspects.

We proposed three prototypical remediation alternatives to the workshop participants and we found that the in-situ option appears as the most balanced in the four considered criteria (technical, environmental, economic and social). The ex-situ option is evaluated better in terms of social sustainability, while the combined option is valued better in terms of economic and environmental sustainability. Considering the sample of the workshop (N=14), the combined option is rated as the best with an average of 6.7 points (in a 10 points scale). The in-situ option obtained on average 5.8 points, while the ex-situ option obtained 5.4.

When including the views of other relevant stakeholders (that did not attend the workshop), such as the regulatory body, the assessment of the potential remediation options did not change substantially. Only the assessment of the in-situ option changed a little being evaluated as a bit better (6.1) but the combined option continued as the best option.

Regarding differences among stakeholders' groups, the results of the participatory MCDA pointed out that differences are not as big as it could be expected before the event, especially taking into account that there met together people with really opposite views. After the discussion, all stakeholders' groups assessed the combined option as the best one except for the industry representatives' that preferred in-situ option, but they assessed combined option as well enough. Participatory MCDA methodology made it possible to maintain a rational debate that could allow reaching certain agreement even in cases where there is a lot of controversy and very different points of views coexist.

During the debate, some controversial issues were raised as critical aspects or important challenges that have been affecting the decision-making on remediation in the Huelva case. These issues can be considered as lessons learned and can be considered in future similar cases.

A very relevant issue is the **perception of lack of a clear legal framework**, which in the view of some stakeholders, seems to make the management of the NORM sites very difficult. For example, phosphogypsum deposits are not considered soils and, therefore, the soil protection regulations cannot be applied to them. In addition, industrial activities that generate NORM are not well contemplated in the current legislation, because this type of industry does not directly carry out ionizing or radioactive practices and, therefore, the current regulation on radiation protection does not apply to them. Consequently, the owner of the industry decides the categorization of the waste that is generating and depositing. It was highlighted that, it could be necessary to adapt the regulation, but also to create a new and specific regulatory body for NORM. In a later meeting with representatives from the current regulatory body (Nuclear Safety Council) after the workshop, they clarify that in fact there exists enough regulation on the topic despite it is still pending the transposition of the last European directive (2013/59/EURATOM). In the view of CSN representatives' the problem could be that stakeholders are not aware enough of the regulatory framework and better communication efforts should be necessary to disseminate it. This, a clear need to clarify and better communicate the regulation stood out.

A second critical aspect is the **existence of other hazardous waste together with radioactive waste** in NORM contaminated sites. In the view of some of the workshop participants, this fact significantly complicates its management and remediation. Thus, it would be interesting to analyse the differences in protection objectives and potential assessment criteria for radioactive and other conventional pollutants. Perhaps the radiological legal framework could be integrated into the conventional pollutants' regulation, because the radiological part is only a little part of the problem. Ultimately, a harmonisation of both assessment processes would help in improving the decision-making about the management and remediation of NORM sites.

Another challenging aspect is the **politicisation of the conflict**. Some of the involved stakeholders pointed out that during the last decades the decision-making around the remediation has been conditioned to the political party that led the government. Even opposite decisions have been taken depending on who governed. It is attributed to a lack of long-term vision to solve environmental problems. In addition, there have been problems of **coordination between local, regional and national administrations**, due to the complexity of the competencies of each administration and the complexity of the procedures in relation to this. In addition, some stakeholders even perceive a lack of genuine interest among public authorities in solving the problem of the phosphogypsum in Huelva.

Besides, **economic responsibility** for the remediation seems to be a big issue affecting the decision. Some stakeholders perceived that it is the industry who has to assume all the costs, while others think that the industry has contributed to the economic growth of the region so that the costs have to be shared also with public administration. However, the industry argue that they are willing to assume all the costs of the remediation but other stakeholders perceive that it is not true.

Findings show that some social issues have not been adequately taken into account in the management and in the environmental remediation plan of the phosphogypsum ponds in Huelva. Aspects such as risk perception, social trust, or communication and dialogue with the local population and interested parties seem to be poorly considered during the last decades. Probably this has effected the social controversy around the proposed environmental remediation plans.

Thus, there is a need to consider the **different risk perceptions** of relevant stakeholders and affected population. Despite lots of radiological studies have been carried out in the site, different risk perceptions

coexist and generate very opposed views regarding the remediation strategy. Thus, it is important to provide adequate information to the involved stakeholders allowing them to understand what the remediation techniques can achieve, and also their limitations, side effects and costs that are associated with them (IAEA, 2016). In that sense, participants pointed out some issues regarding communication aspects:

- Lack of a responsible person to give information to the population.
- Lack of information about the risks among the affected population.
- Perceived concealment of information to the local community by the industry and the responsible authorities.

In that sense, findings show the need to adequately explain the proposed approach of the remediation, its risks, benefits, and impacts in a transparent manner. As suggested by Booth (2015) this could be crucial to obtain support and trust in the decision-making. The **implementation of a good risk communication strategy** would also help in the involvement process. In that sense, Covello (2003) established a list of seven best practices to deal with social communication such as: plan thoroughly and carefully; accept involved stakeholders as legitimate partners; be truthful, honest, frank, and open and meet the needs of the media. Also the SNIFFER report (SNIFFER, 2010) could be useful to establish the communication strategy in the specific situation of contaminated lands.

Finally, there is a need for **more dialogue and public participation** to achieve a social acceptance of the environmental remediation. It is necessary to establish a dialogue with stakeholders about the feasibility of different remediation options as soon as possible in the decision-making process. Thus, it would be useful to implement a good public and stakeholder involvement strategy around the remediation as the ones proposed by Heath, Pollard, Hrudehy & Smith (2010), Collier (2011) or IAEA (2016).

Engagement and cooperation between operators and regulators and other stakeholders can be mutually beneficial. Gaining the trust of stakeholders is important so that stakeholders will have confidence in technical judgements. Nonetheless, stakeholders often want to hear about technical issues and effective communication of these issues is therefore very important. Effective communication is not only useful in itself, it adds to credibility. Transparency of the value judgement aspects of an assessment is important and stakeholder input to such decisions may be helpful.

IAEA (2016) clearly point out that experiences from different environmental remediation processes show that the appropriation of the contamination problem by key stakeholders, meaning their affirmation of willingness to take action and also the identification of a solution concept that they can live with, is a necessary ingredient for the economic, social and political viability of the remediation solution. In that sense, the implemented participatory workshop allowed the discussion among some of the main actors regarding the most important aspects to be considered when deciding about the remediation. This kind of participatory processes could help ensuring a technically sound and socially acceptable decision that meets norms of adequacy or satisfactory performance in relation to a whole range of different concerns as stated by the IAEA (2016).

The participatory workshop serve as a communication forum and allowed to collect stakeholders' views and concerns as well, which encourage cooperation and understanding between different interested parties. It was useful to explain different remediation options and involve stakeholders in the assessment of each remediation alternative in a rationally manner. In that sense, some previous emotional beliefs of some stakeholders' groups such as the desire to see the contaminated land totally 'decontaminated' or fully 'cleaned up', could be discussed and assessed considering more rational criteria (the costs, the radiological effects of the remediation, etc.). The workshop provided the valuable opportunity to meet many of the most relevant local stakeholders together and speak. At the end of the day, the differences

were not as big as it was expected. The evaluation questionnaire shows the attendees valued the experience as very positive.

In the view of the authors, participatory MCDA could be a useful tool to involve stakeholders in the management of other NORM sites. Despite the limitation of the present study, findings from this event could help the establishment of future involvement strategies to be implemented in the early-phases of future NORM contaminated sites, to avoid social conflict and public distrust, respecting not only the radiological criteria but also social, environmental, political and economic dimensions.

4.3. Limitations and future studies

The qualitative exploratory analysis carried out in the first part of the present report (case study) has the limitations usually associated with this type of research, mainly aspects related to the generalization of the results: it is difficult to extrapolate the results to broader populations or draw general or long-term conclusions.

However, the advantages of qualitative methods exceed the limitations in this case, especially their capability to access exhaustively and deeply to the different discourses and current debate topics. Regarding the sampling, in the case of key actors, we achieved to cover a great range of stakeholders groups, and were able to interview the most important actors of the case, saturating the speech well enough. It was also the case for the media analysis, the analyzed news were enough to gain in-depth understanding about the main actors and the main aspects affecting the social controversy. In the case of the local population interviews, a survey within the local population would be of interest for future studies; with the aim of obtaining quantitative data regarding the levels of awareness, knowledge, risk perception, trust in different actors or information and engagement needs among the Huelva population.

The second part of the report dealing with the participatory workshop has similar limitations: the findings were derived directly from the views of the involved stakeholders and cannot be generalized neither to all stakeholders of the Huelva site nor to all NORM contaminated sites. In fact, the ultimate goal of the exercise was to test the methodology for decision-making improvement of future cases. Nevertheless, the main local actors of the Huelva site were involved and we achieved to involve two important national stakeholders after the event. Decision-makers could not be involved and this is a clear limitation for the findings. Nevertheless, interesting recommendations could be derived from the reported experience of the participants that could help to improve the management of future NORM site.

As future studies, studies of communication strategies and other participatory approaches to gain trust and involve the affected actors in the decision-making are of clear interest. In addition, it would be interesting to better understand stakeholder concerns, needs and interests, risk perception and trust, for instance by means of a survey at the Huelva city level. The models developed by Slovic (1993), Siegrist, Gutscher and Earle (2005), Kasperson, Golding and Tuler (1992) or Sjöberg (2004) could be good starting points.

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6. Annexes

Annex 1. Chronology of the case

Year	Event
1965	The factory of the company Fosfórico Español, S.A. (FESA) is set up in the city of Huelva. This company is dedicated to the production of phosphoric acid. The manufacture of phosphoric acid leads to the production of a residue called phosphogypsum.
1967-1968	In order to proceed with the stacking of the phosphogypsums in ponds, two concessions are approved by ministerial order (one in 1967 and the other in 1968). These concessions allow the company to occupy a plot located on the bank of the Tinto River and build there a decantation tank for the dumping of phosphogypsum.
1986	The Environmental Agency of the Andalusian regional government, which has administrative competencies regarding discharges into the sea, approves the Industrial Discharge Correction Plan. This plan does not allow that Fertiberia continues to dumping the phosphogypsum in open circuit.
1995	Fertiberia presents, before the Department of the Environment of the Andalusian regional government a Project of Reorganization of phosphogypsum discharges.
1996	The Andalusian regional government approves the Project of Reorganization of phosphogypsum discharges presented by Fertiberia. This approval implies the authorization to stack the phosphogypsum in closed circuit and in height.
1997	Fertiberia requests to the Coasts Head Office belonging to the Ministry of the Environment the modification of the concessions, in order to adapt them to the Project of Reorganization of discharges.
1998	The Coasts Head Office draw up a sanction proceeding against Fertiberia for breach of the conditions contained in the concessions.
1999	The Spanish Government resolves the sanction proceeding and imposes to Fertiberia an economic fine of 60.000€ for several breaches.
2000	Fertiberia files an administrative appeal with the High Court of Justice of Andalusia against the sanction imposed by Coasts Head Office for the breach of the concessions.
	The Ministry of the Environment denies the request of Fertiberia to modify the concessions.
	Fertiberia fills an appeal against the decision.
2001	The Ministry of the Environment rejects the appeal interposed by Fertiberia.
	Fertiberia interposes an administrative-contentious appeal before the National Court.
2002	The association Mesa de la Ría is constituted.
2003	The National Court dismisses the administrative-contentious appeal of Fertiberia. The request to modify the concessions is rejected.
	An Order from the Ministry of the Environment declares the expiration of the concession granted to Fertiberia to occupy the plots due to non-compliance.
	Fertiberia interposes cassation appeal before the High Court against the judgment of the National Court.
2004	Fertiberia interposes an administrative-contentious appeal against the Order from the Ministry of the Environment. The company continues to stack the phosphogypsum in height, stacking even above the permitted height.
	The High Court dismisses the appeal of Fertiberia and confirms the sanction of 60.000 €. In response to that, Fertiberia does not formulate any appeal.

2007	The association Mesa de la Ría organise the first demonstration against the phosphogypsum.
	The National Court dismisses the appeal filed by Fertiberia against the Order of the Ministry of Environment of 2003 declaring the expiration, due to non-compliance, of the concession.
	Fertiberia interposes a cassation appeal against the judgment of the National Court.
	The High Court dismisses the cassation appeal presented by Fertiberia against the judgment of the National Court which denies Fertiberia's request to modify the concessions to stack the phosphogypsum in height.
2008	The Coasts Head Office requests to Fertiberia a closure plan to comply with the judgment of the National Court.
	Fertiberia presents a plan for the completion of operations before the Coasts Head Office.
	Thousands of residents of Huelva attend a demonstration called by the association Mesa de la Ría.
	The Coasts Head Office communicates to Fertiberia that the proposed plan for the completion of operations is not admissible.
2009	The High Court dismissed the Fertiberia's request for precautionary suspension of the judgment by the National Court that declared the expiration of the concession.
	The National Court issues an execution order and command the effective cessation of the dumping of phosphogypsum.
	Fertiberia interjects an appeal against the execution order.
2010	The phosphogypsum stacking is prohibited as of December 31. Fertiberia definitely stops dumping phosphogypsums.
2011	The Foret company closes its phosphate plant after 42 years of activity in the province.
	Mesa de la Ría presents to the municipal elections. Get more than 3.300 votes and a city councillor in Huelva City Council.
	The National Court imposes to Fertiberia a guarantee of EUR 21.9 million to cover the costs of decontamination of the area. They also ask to the company the presentation of a plan to restore the phosphogypsum ponds.
2014	The Participatory Roundtable of Phosphogypsums is constituted. This body aims to gather the opinions of the administrations and sectors involved in the problem and agree joint actions.
2014	Fertiberia presents before the Ministry of the Environment the project to restore the phosphogypsum ponds. They also present the environmental impact assessment.
2015	The Ministry of the Environment considers the Fertiberia project suitable. However, they request additional studies and justifications.
	The National Court widens the bond imposed to Fertiberia for the regeneration of the Huelva estuary to EUR 65.9 million. Thus, the National Court estimates the WWF's request to increase the bond to Fertiberia to ensure the remediation of the ponds.
	Fertiberia makes an appeal against the extension of the bond.
	The Committee of Experts of the Phosphogypsum is constituted. It is a body composed of technicians from different disciplines responsible for evaluating the conditions of the ponds and presenting viable solutions to recover the affected area.

2016	The Ministry of the Environment gives green light to the remediation project of the phosphogypsum ponds presented by Fertiberia.
2017	The High Court rejects the cassation appeal presented by Fertiberia and upholds the judgment of the 2015 National Court in which extends the guarantee to Fertiberia of EUR 65.9 million to clean the phosphogypsum ponds.
	The Ministry of the Environment has taken to a public consultation the remediation project of the phosphogypsum ponds and the environmental impact assessment for the closure of the area.
	The City Council of Huelva and the Andalusian regional government, among others, presents allegations to the Fertiberia project for the remediation of phosphogypsum ponds.
2018	Appeals presented to the project are being studied by Fertiberia.

Annex 2. Invitation letter and leaflet



Apreciado X,

En el marco del proyecto europeo TERRITORIES (<http://territories.eu>) sobre incertidumbres en la gestión de situaciones de contaminación por NORM (*Naturally Occurring Radioactive Material*) estamos organizando una sesión de reflexión el próximo 6 de Marzo en el Hotel AC de Huelva.

El objetivo de esta sesión es discutir los criterios relevantes (técnicos, económicos, sociales, ambientales) en la toma de decisiones entorno a la remediación de emplazamientos NORM. Estamos invitando a investigadores, autoridades públicas y técnicos, organizaciones medioambientales, etc.

Nos encantaría contar con su participación. La comida y los gastos de desplazamiento (de aquellos participantes que vengan de fuera de Huelva) correrán a cargo del Proyecto TERRITORIES.

Por favor, **confirme su asistencia lo antes posible** a través de un correo electrónico a roser.sala@ciemat.es.

Un saludo,

CIEMAT-CISOT
Departamento de Medio Ambiente
Tel: 93 586 87 89





WORKSHOP

CRITERIOS DE DECISIÓN EN LA REMEDIACIÓN DE EMPLAZAMIENTOS NORM



6 DE MARZO DE 2019



DE 9.30H A 16.00H



HUELVA

(LUGAR POR DETERMINAR)

ORGANIZADO POR:



GOBIERNO
DE ESPAÑA

MINISTERIO
DE CIENCIA, INNOVACIÓN
Y UNIVERSIDADES

Ciemat
Centro de Investigaciones
Energéticas, Medioambientales
y Tecnológicas

CONTACTO:

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Annex 3. Presentation of the remediation options

Evaluación de Opciones de Remediación

Huelva, 6 de Marzo 2019

CIEMAT

Unidad de Protección Radiológica al Público y el Medio Ambiente



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 642287.

Tecnologías y Opciones de Remediación

- Existen una serie de opciones de remediación y tecnologías, y es importante que las partes interesadas entiendan lo que estas técnicas pueden lograr, y también sus limitaciones, efectos secundarios y costos que están asociados con ellos.
- Se pueden enfocar principalmente en cuatro categorías diferentes. Sin embargo, la descripción no pretende proporcionar un examen exhaustivo de la cuestión. Es importante darse cuenta de que las tecnologías siempre evolucionan, y que hay una serie de fuentes a partir de las cuales se puede obtener información actualizada y detallada.



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Tecnologías y Opciones de Remediación

- **Separación:** Esta técnica es aplicable a suelo y aguas subterráneas contaminadas. Es aplicable a las opciones de remediación in situ o ex situ después de la excavación y remoción del material contaminado.
- **Eliminación o remoción del material:** Esta tecnología normalmente aplica a suelos, así como a acuíferos y aguas superficiales contaminados donde la contaminación se puede remover a través del bombeo y retención de los contaminantes. Este tipo de tratamiento se complementa con el almacenamiento de los contaminantes separados en otro almacenamiento específico.
- **Confinamiento:** Consiste en la instalación de barreras entre el medio contaminado y el entorno para prevenir la migración de la contaminación. Esto incluye principalmente la cobertura con materiales en forma de barrera de contención y cobertura en superficie acorde al entorno.
- **Inmovilización:** Se le añaden materiales al medio contaminado con el objetivo de vincular los contaminantes y reducir su movilidad. Ejemplo son la solidificación con cemento o la inmovilización en forma química.

This project has received funding from the European research and training programme 2014-2020 under grant agreement No 642287.

Opción de remediación in situ

- Esta opción considera el acondicionamiento en el mismo emplazamiento de las balsas de fosfoyeso y conlleva varias actividades como son el confinamiento de la lixiviaciones a aguas subterráneas y superficiales.
- Recondicionamiento geomorfológico y cubrimiento con diferentes materiales para mantener el contorno y evitar desprendimiento.
- Cubrimiento con suelo y cobertura vegetal con el objetivo de integrarlo lo mejor posible con el entorno antes del almacenamiento de los residuos.



This project has received funding from the European research and training programme 2014-2020 under grant agreement No 642287.

Opción de remediación ex situ

- Esta acción considera la remoción y transporte del material hacia otra ubicación que pueden ser vertederos convencionales o destinados para este propósito.
- Suele ser una opción muy costosa y es solo fiable para cantidades pequeñas de material y con facilidad para ser confinados en bidones, contenedores etc.



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Opción de remediación combinada

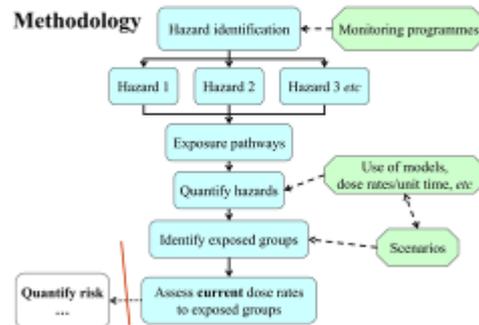
- Cuando hablamos de opción de **remediación combinada** hablamos de la opción en que se puedan utilizar de manera parcial las descritas con anterioridad
- Además se tendrán en cuenta la posible reutilización del fosfoyesos como material comercial para la construcción de carreteras y material de construcción de viviendas (ej. producción de baldosas cerámicas, como para la fabricación de ladrillos).
- También considera la reutilización de este material para enmendar suelos salinos.
- Utilización de nuevas tecnologías para encapsular estos materiales a diferentes matrices.
- Conversión química del fosfoyeso en otros tipos de materiales, extracción química. Reciclado de fosfoyesos. Captura de CO₂.



This project has received funding from the European research and training programme Horizon 2020 under grant agreement No 862287

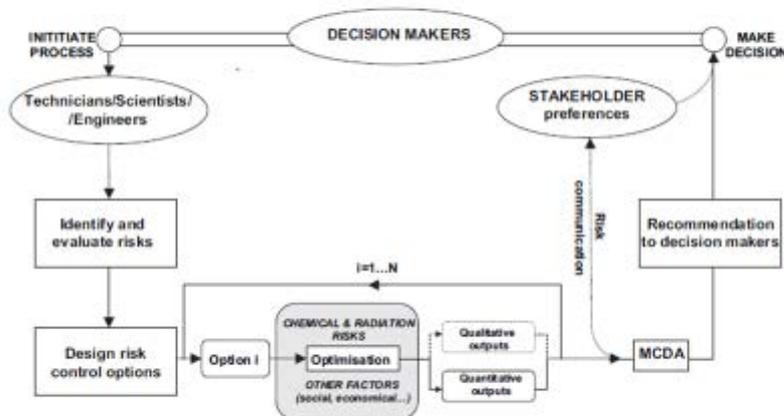
Usos futuros del emplazamiento

- Es importante considerar como se quiere utilizar el emplazamiento en un futuro ya que eso conlleva la utilización de una opción de remediación u otra.
- Se pueden definir escenarios genéricos de utilización como son:
 - Recreativo
 - Industrial
 - Residencial
 - Agrícola

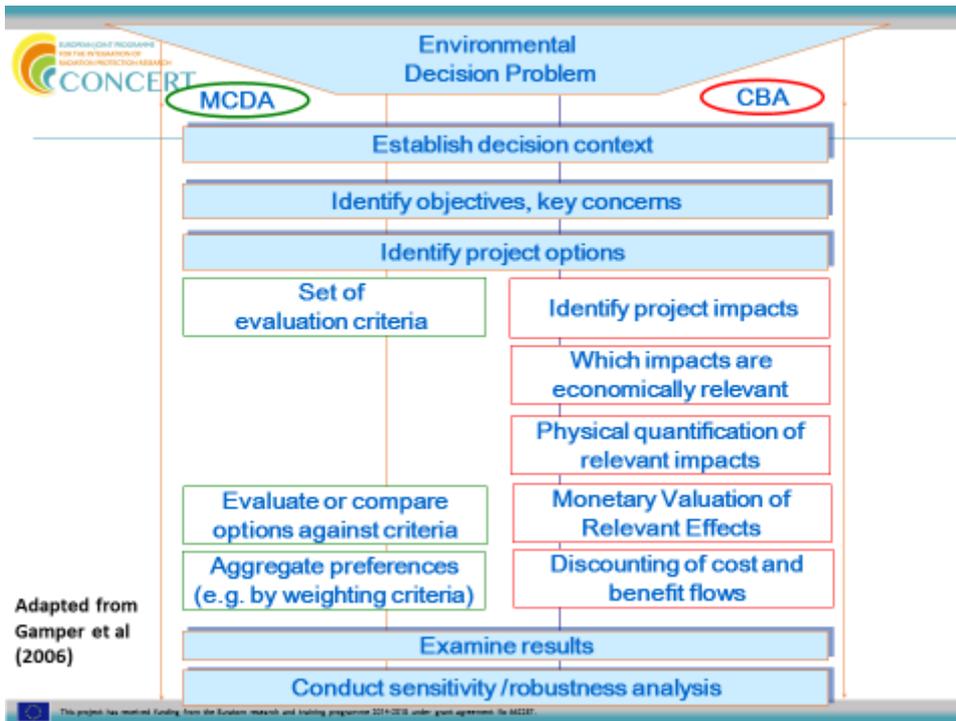


The project has received funding from the European research and training programme 2014-2020 under grant agreement No 642227.

Proceso de Toma de Decisiones



The project has received funding from the European research and training programme 2014-2020 under grant agreement No 642227.



MCDA en la restauración ambiental

Criterion	Weighting Factor (%)	Option 1: Natural Restoration ¹	Option 2: Revegetation with Peat ¹	Option 3: Revegetation with Commercial Biochar ¹	Option 4: Revegetation with Local Biochar ¹
Environmental: Biodiversity	16	27	89	100	85
Environmental: Air Quality	12	100	46	42	39
Environmental: Greenhouse Gases	19	100	66	69	97
Social: Occupational Risks	4	100	78	63	67
Social: Community Involvement	6	25	25	19	100
Social: Land Use	6	24	100	50	89
Economic: Project cost	11	100	64	20	59
Economic: Project risks	15	25	98	77	100
Economic: Economic Opportunities	11	18	23	30	100
Overall Stakeholder's Opinion	n/a	72	81	70	100

Note: ¹ Results are presented as a percent of the maximum score, i.e. the highest choice was given 100%, and the following choices were valued relatively to the maximum score.

Annex 4. List of criteria presented to workshop participants

Name: _____ Institution: _____

A set of criteria and sub-criteria that might be considered when assessing the remediation strategy of a NORM site are presented below. Please, read the criteria and sub-criteria and add the aspects that you think have not been included.

Criteria	Sub-criteria	Definition
Technical (performance and feasibility)	Radiological risk	Level which remediation strategy reduce the radiological risk of the site
	Chemical risk	Level which remediation strategy reduce the chemical risk of the site
	Waste	Level which remediation strategy removes the waste from the site
	Administrative difficulty	Administrative complexity to implement the remediation strategy
	Technical feasibility	Ease of application, operation and maintenance of the remediation
	Duration	Time required to conduct the remediation
Environmental	Soil	Impacts on soil functions (e.g. in pH, organic content, water retention capacity).
	Ground water	Impacts on ground water quality due to remediation process
	Surface water	Impacts on surface water quality due to remediation process
	Flora and fauna	Impacts on flora and fauna due to remediation process
	Air quality	Pollutant emissions to air (e.g. greenhouse gases, acidifying substances, particulate matter)
	Non-renewable natural resources	Utilization of non-renewable natural resources to implement the remediation strategy (e.g. fossil fuels, use virgin soil and rock materials for filling, occupation of other areas for waste disposal)
	Non-recyclable waste	Non-recyclable waste production due to remediation actions
Economic	Direct costs	Investments in infrastructures and technology of the remediation strategy (e.g. labour and equipment)
	Employment	Employment creation (short and long term) associated with the implementation of the remediation strategy
	Externalities	Economic benefits or damages associated with the remediation strategy (e.g. sales of scrap materials for reuse, changes in the value of the property, image costs such as the reluctance to buy local products or the drop in tourism)
Social	Land use	Impact of the remediation strategy on the land use (e.g. recreational, houses, industrial)
	Health and security	Effects on health and human safety due to remediation tasks
	Impact on the neighborhood	Negative impacts on the local community (e.g. dust, noise, smell and vibrations) during the remediation works
	Equity/ Justice	Unequitable distribution of costs and benefits among different social groups of the community (e.g. negative effects on vulnerable groups)
	Community acceptance	Level of acceptance, trust and local community support in the implementation of the remediation strategy
	Community involvement	Participation and involvement of the local community in the decision-making process about the remediation

Annex 5. Questionnaire for the weighting of criteria

Name: _____ Institution: _____

Please, distribute 100 points between the different criteria according to their relevance. Subsequently, distribute 100 points among the different sub-criteria.

Score	Criteria	Score	Sub-criteria
_____	Technical (performance and feasibility)		Radiological risk
			Chemical risk
			Waste
			Administrative difficulty
			Technical feasibility
			Duration
		<u>100</u>	
_____	Environmental		Land / Soil
			Ground water
			Surface water
			Flora and fauna
			Air quality
			Non-renewable natural resources
			Non-recyclable waste
		<u>100</u>	
_____	Economic		Direct costs
			Employment
			Externalities
		<u>100</u>	
_____	Social		Land use
			Health and security
			Impact on the neighborhood
			Equity/ Justice
			Community acceptance
			Community involvement
<u>100</u>		<u>100</u>	

Annex 6. Questionnaire for the evaluation of the remediation options

Name: _____ Institution: _____

Type of remediation: _____

Please, rate from 1 to 10 this remediation strategy for each sub- criteria:

Criteria	Sub-criteria	Rating										
		Very negative	Acceptable	Very positive								
Technical (of performance and feasibility)	Radiological risk	1	2	3	4	5	6	7	8	9	10	NS
	Chemical risk	1	2	3	4	5	6	7	8	9	10	NS
	Waste	1	2	3	4	5	6	7	8	9	10	NS
	Administrative difficulty	1	2	3	4	5	6	7	8	9	10	NS
	Technical feasibility	1	2	3	4	5	6	7	8	9	10	NS
	Duration	1	2	3	4	5	6	7	8	9	10	NS
Environmental	Land / Soil	1	2	3	4	5	6	7	8	9	10	NS
	Ground water	1	2	3	4	5	6	7	8	9	10	NS
	Surface water	1	2	3	4	5	6	7	8	9	10	NS
	Flora and fauna	1	2	3	4	5	6	7	8	9	10	NS
	Air quality	1	2	3	4	5	6	7	8	9	10	NS
	Non-renewable natural resources	1	2	3	4	5	6	7	8	9	10	NS
	Non-recyclable waste	1	2	3	4	5	6	7	8	9	10	NS
Economic	Direct costs	1	2	3	4	5	6	7	8	9	10	NS
	Employment	1	2	3	4	5	6	7	8	9	10	NS
	Externalities	1	2	3	4	5	6	7	8	9	10	NS
Social	Land use	1	2	3	4	5	6	7	8	9	10	NS
	Health and security	1	2	3	4	5	6	7	8	9	10	NS
	Impact on the neighborhood	1	2	3	4	5	6	7	8	9	10	NS
	Equity/ Justice	1	2	3	4	5	6	7	8	9	10	NS
	Community acceptance	1	2	3	4	5	6	7	8	9	10	NS
	Community involvement	1	2	3	4	5	6	7	8	9	10	NS

Annex 7. Workshop evaluation questionnaire

CUESTIONARIO DE EVALUACIÓN DEL WORKSHOP DE TERRITORIES

1. Creo que las personas que participaron en el workshop son una representación acertada de las personas que tienen algo que decir sobre estos temas.

Muy en desacuerdo	En desacuerdo	Ni de acuerdo ni en desacuerdo	De acuerdo	Muy de acuerdo
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

2. Las personas que moderaron la discusión promovieron una visión neutral hacia las cuestiones tratadas.

Muy en desacuerdo	En desacuerdo	Ni de acuerdo ni en desacuerdo	De acuerdo	Muy de acuerdo
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

3. La organización del workshop me permitió expresar mi opinión con libertad

Muy en desacuerdo	En desacuerdo	Ni de acuerdo ni en desacuerdo	De acuerdo	Muy de acuerdo
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

4. Tuve claro lo que se esperaba de mí durante toda la reunión.

Muy en desacuerdo	En desacuerdo	Ni de acuerdo ni en desacuerdo	De acuerdo	Muy de acuerdo
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

5. La organización del workshop permitió dar el tiempo suficiente a todos los que querían contribuir con su opinión.

Muy en desacuerdo	En desacuerdo	Ni de acuerdo ni en desacuerdo	De acuerdo	Muy de acuerdo
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6. La discusión que tuvo lugar durante el workshop me pareció interesante.

Muy en desacuerdo	En desacuerdo	Ni de acuerdo ni en desacuerdo	De acuerdo	Muy de acuerdo
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

7. Estoy satisfecho con mi asistencia al workshop

Muy en desacuerdo	En desacuerdo	Ni de acuerdo ni en desacuerdo	De acuerdo	Muy de acuerdo
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

8. La jornada cumplió con mis expectativas

Muy en desacuerdo	En desacuerdo	Ni de acuerdo ni en desacuerdo	De acuerdo	Muy de acuerdo
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

9. La jornada me ha ofrecido algunas ideas nuevas sobre el tema tratado

Muy en desacuerdo	En desacuerdo	Ni de acuerdo ni en desacuerdo	De acuerdo	Muy de acuerdo
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

10. El evento me ha aportado ideas útiles para mi trabajo diario

Muy en desacuerdo	En desacuerdo	Ni de acuerdo ni en desacuerdo	De acuerdo	Muy de acuerdo
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

11. ¿Qué es lo que más le gustó del workshop?

12. ¿Qué es lo que menos le gustó del workshop?

13. ¿Qué es lo que hubiera hecho diferente?

Muchas gracias por su participación.