



FIC-FIGHTERS Deliverable D5.1

Base report on the social perception of phosphogypsum stacks

Summary:

The general goal of this deliverable is to establish a baseline understanding of public perceptions concerning phosphogypsum stacks across the project's case study locations through a mixed-method approach involving primary data (stakeholder interviews, social media and online public content), as from secondary information from media, reports, and academic sources. The analyses categorise perceptions into 6 key areas: community engagement, governance, health concerns, environmental and economic impacts, and proposals.

Across all case studies, stakeholders advocate for integrated solutions that harmonise environmental, health, and economic priorities within a robust governance framework. This includes the implementation of transparent environmental monitoring systems, stronger accountability mechanisms, and participatory decision-making processes that actively involve affected communities.

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1. Executive summary

The deliverable D5.1, prepared within the framework of the FICFighters project, presents an exploratory study on the social perception of PG stacks. This report is a foundational analysis supporting Work Package 5 (WP5), which addresses the Environmental, Social, and Governance (ESG) challenges associated with phosphogypsum (PG) stacks. The primary aim of D5.1 is to establish a baseline understanding of public perceptions concerning PG stacks across six European case study locations: Kutina (Croatia), Veles (North Macedonia), Barreiro (Portugal), Prahovo (Serbia), Turnu Magurele (Rumania), and Cartagena (Spain).

Through a mixed-method approach involving primary data from stakeholder interviews, social media and online public content, as from secondary data from media, reports, and academic sources, the deliverable categorises perceptions into key areas: environmental, health, community, economic, governance, and proposals. This multidimensional analysis provides insights into the concerns, attitudes, and beliefs of stakeholders directly and indirectly affected by PG stacks. The deliverable serves as a base report to inform subsequent project tasks aimed at integrating Environmental Social and Governance (ESG) considerations into the sustainable management of PG stacks.

The results of this analysis showed a significant level of concern around the environmental risks associated with PG stacks, with discussions frequently highlighting contamination of soil, water, and air across case studies and wider perspectives. These concerns are amplified by the perceived inadequacy of monitoring systems and inconsistent regulatory enforcement, which fuel distrust in governance structures. Health concerns also featured prominently among sources. Particularly fears about respiratory illnesses, toxic exposure, and the long-term health implications of living near PG stacks. Economic impacts add complexity to these discussions, as many regions grapple with the dual narrative of industrial dependency and the long-term costs of environmental degradation.

Despite these challenges, the proposals derived from the study suggest different pathways for addressing these intersecting concerns. Across all case studies, stakeholders advocate for integrated solutions that harmonise environmental, health, and economic priorities within a robust governance framework. This includes the implementation of transparent environmental monitoring systems, stronger accountability mechanisms, and participatory decision-making processes that actively involve affected communities.

2. Introduction

The D5.1 report presents an exploratory study on the social perception of phosphogypsum, hereinafter referred to as PG, stacks within the framework of the FIC-FIGHTERS project. This deliverable is framed as a base report to address the Environmental, Social, and Governance (ESG) challenges associated with PG stacks, which is the overall aim of WP5.

“Social perception” is understood as a multidimensional construct that reflects the ways in which different stakeholders, both directly or indirectly involved, interact, think, feel and respond to a relevant topic, in this case, PG stacks. For the purpose of this project, the analysis of social perception has been disclosed in several categories that help and support our goal to understand how PG stacks are perceived among stakeholders. Hence, environmental, economic, community, health, and governance have stood out as key agents to understand the general perception of PG. Social perception has proven to be a key aspect on how social reality is build, therefore, analysing the social perception on PG Stacks provide key information

on how the population based on the different case studies location, as well as their wider national perspective, interact, think, and feel about the stacks.

The primary objective of this report is to establish a baseline understanding of public perception surrounding PG stacks across several European case study locations, specifically the ones which are included in the FICFighters project up to date, i.e.: Prahovo (Serbia), Kutina (Croatia), Veles (North Macedonia), Barreiro (Portugal), Turnu Magurele (Romania) and Cartagena (Spain).

The cases of Łąka-Bolestawca (Poland) and Venice (Italy) were initially included in this research but both PG stacks have withdrawn from the project along this year due to different reasons, so regarding these sites' findings, the conclusions are described in Appendix 1 of this document.

The analysis presented in this report integrates primary data collected from interviews with key local stakeholders, such as technical professionals, representatives from public administration or citizens, as well as secondary data derived from social media platforms, news media, academic literature, and governmental reports. This comprehensive approach ensures a nuanced understanding of the concerns, beliefs, and attitudes held by different community segments, thereby highlighting the complexities involved in managing PG stacks.

The report explores the before mentioned 6 European case study locations, but also offers insights into broader patterns of perception at the national and EU levels, as other relevant PG stacks in Europe, even globally, have been analysed to enhance the overall conclusions.

3. Methodology

This section presents the refined methodology employed in the assessment of the social perception of PG stacks. The approach synthesises diverse data sources and analytical tools to provide a multidimensional understanding of public opinion, thematic trends, and social concerns both at case study sites and the EU level. The methodology was shared with project partners for initial validation, and multiple meetings were held to ensure alignment and integration across tasks.

The study adopted a mixed-methods approach to incorporate both qualitative and quantitative perspectives. Stakeholders' input and engagement has been integral to shaping the conclusions, together with the partners involved in this task, both for feedback and validation. The methodology's framework was designed to be adaptive and to accommodate emerging insights per case studies as well as per partner feedback.

3.1. Data collection and processing

The initial phase involved systematically collecting, categorising, and preparing data from diverse sources. Data were sourced from both primary and secondary channels, each of which was selected to provide insights into the public discourse surrounding PG stacks. The data collection focused on identifying trends in local and general perception, specific concerns of affected communities, and the portrayal of PG stacks in media and research.

3.1.1. Primary data sources

- **Interview with key agents:** Interviews were conducted with selected stakeholders, including local community members, technical professionals, academics, and representatives from public administration. A semi-structured interview guide was used to ensure consistency while allowing flexibility for stakeholders to express individual concerns and perspectives. The guide addressed themes such as environmental and health concerns, economic impacts, and trust in regulatory bodies, offering a comprehensive approach to understanding local social perception of PG stacks.

Prior to initiating the interviews, all participants were asked to sign a consent form outlining the project's purpose, data confidentiality measures, and their rights to withdraw at any time, ensuring ethical compliance.

The interview planned length was 45 to 60 minutes. Beginning with a clear explanation of the study's goals, the participants were also informed about recording, requesting their explicit permission.

- **Public online material:** Searches were conducted on platforms like YouTube and in podcast directories. The aim was to identify audio and video content that provided context on social perception on PG stacks.
- **Social media data:** Data were gathered from social media platforms, including X.com, Instagram and Facebook, where discussions around PG stacks were identified. This involved using web scrapping tools to collect publicly available posts containing relevant keywords and hashtags. Additional manual filtering was applied to categorise posts by sentiment and to assign them to specific locations or regions based on language and context.

3.1.2. Secondary data sources

- **Media coverage and news clipping:** News articles and opinion pieces were collected through systematic searches on platforms like Google News, focusing on local, regional, and national perspectives. Filters were applied to highlight coverage that specifically addressed PG stacks or related environmental issues. Searches were conducted both in external platforms as Google News and local media to ensure that all case studies were explored. The use of specific search syntaxes and posterior manual filtering and language identification provided a general overview of media perception on PG stacks in the relevant case studies, both local and national wide.
- **Academic sources:** Relevant studies and publications from peer-reviewed academic journals and conference proceedings were reviewed, with a primary focus on European-level research. These sources were selected to provide a broad, scientifically grounded context for the social and environmental impact of PG stacks across Europe. Academic sources helped establish a foundational understanding of the broader implications of PG on community health, environmental risks, and regulatory frameworks.
- **Governmental and NGO reports:** Documents from governmental institutions and local administrations, as well as reports from non-governmental organisations (NGOs), were collected to capture official policy statements, public health assessments, and regulatory positions specific to the regions of interest. These sources provided insights into local and national policies, initiatives, and

responses related to PG stacks, enriching the context for understanding community-specific concerns.

3.1.3. Results per case studies

This report on PG perception analysed information sources from the 6 case studies in FICFighters and at the international level, yielding the following results:

At the **international level**, a total of 53 sources were utilized. Academic sources were predominant with 42 entries, complemented by reports (12). The international level was only analysed for academic sources and reports, therefore no data has been gathered on news, social media, public content, or interviews. Furthermore, those academic articles provided by partners from the case studies, as well as those retrieved by SCK in Belgium.

In **Croatia**, 28 sources were identified, primarily from news outlets (27), with a minor contribution from reports (1). However, among the news outlets identified, they focused on the Sisak-Moslavina (17), region that includes the city of Kutina, the main case study, and Zadar (1) regions. No interviews were gathered at the moment of the completion of this report. Social media and public content were not retrieved among platforms. Consequently, Croatia's social perception of PG stacks has been studied from both from a regional and national wider perspective.

In **North Macedonia**, 34 sources were used, dominated by interviews (11) and news articles (23). Data gathered showed significantly that Veles is a key location of PG stacks discussion across media, representing 17 of 23 news retrieved on the topic. However, social media discussions were not retrieved in platforms such as X.com, Facebook, or Instagram after applying language discretionary filters to find exclusively Serbian language posts.

For **Portugal**, 10 sources were identified, with a relatively even distribution across academic sources (4), interviews (4), and a smaller representation from social media (2). The Barreiro region stood out, providing seven of these sources, primarily through interviews (4) and social media (1). Data retrieved in Portuguese was subjected to a rigorous region and language filter to discard data related to Brazilian PG stacks.

In **Serbia**, 16 sources were recorded exclusively from news content. Three interviews were conducted in the Prahovo case study framework, although 2 participants preferred to not be recorded. Partners confirmed that conclusions on their case study aligned with those from the interviews. Social media content was not available in Serbian language, after conducting a careful language discarding filter to differentiate those posts in Russian and Serbian languages. Finally, several academic sources were identified on the Serbian case but included in the international framework following the methodology established for this source of information.

Regarding **Romania**, 35 sources were used, dominated by interviews (15) and news articles (13), while 7 articles, reports or academic papers also mention the PG stack. They mostly centered on the hazardous PG waste at Bacău, describing its radioactivity, management problems, and proposed reuse, while also repeatedly citing the unresolved PG stacks at Turnu Măgurele and other sites, mentioning related residues and small remediation initiatives. Social media discussions were not retrieved in platforms such as X.com, Facebook, or Instagram after applying specific filters in Romanian language posts.

In **Spain**, 59 sources were recorded, with major incidence of media articles (52), while interviews (3) and social media content (4) had a reduced presence. Sources mostly centred on describing the current and

historic situation around “El Hondón” the area affected, which is relatively close to residential areas of Cartagena, and located at one of the main entrances of the city by land. Health concerns and environmental impact focus especially in the air distribution of heavy-metal and radioactive particles, which are insufficiently treated by local policies, escalating the effects on respiratory illnesses, cancer, as well as in urban growth, economic investment, and adjacent industrial effects on the agricultural sector.

Overall, the results indicate diverse patterns of information sourcing across case studies, with academic and formal sources dominating at the international level, while news and social media played a more prominent role in national and regional contexts.

3.1.4. Results per sources

Academic sources

A total of 49 academic sources (and grey literature) were retrieved and identified as relevant to the purposes of our project, hence publications regarding PG stacks were mostly technical accounts on radioactive materials and did not include relevant information on social perception. Search was conducted through specific scholarly platforms as Web of Science, where scrapping was conducted through Python scripts to obtain all related articles to “PG”, and “PG stacks”. Subsequently, manual filtering of the found papers was conducted to identify those relevant to our goals, and those exclusively providing scientific technical data.

Interviews

36 interviews were conducted across the case studies. In North Macedonia, 11 interviews were conducted, all related to the Veles region. In Portugal, 4 interviews were recorded related to Barreiro case study. In Prahovo, Serbia, 3 interviews were conducted, although 2 were not recorded due to participants’ preferences. 15 interviews have been conducted in Turnu Magurele (Romania), while 3 interviews were conducted so far in Spain related to the Cartagena case study. These interviews were uploaded by the local partners and transcribed both in the original languages and English for their integration on the overall results.

News articles

The search yielded 137 digital press articles that mentioned PG in the case studies’ countries. Search was conducted through global news platforms as Google News, and local media outlets to ensure the overall results reflect the media discourse around PG stacks. In Croatia, 27 articles were identified, with 17 from Sisak-Moslavina (same region as Kutina) and one from Zadar. North Macedonia accounted for 23 articles, of which 17 originated in Veles. Serbia provided 16 articles, with 12 focused on Prahovo. Portugal accounted for 4 articles, including 2 specifically related to Barreiro (Portuguese related searches were filtered by language and site to avoid information crossing with Brazilian media), 13 articles were analysed related to Turnu Magurele (Romania), while Cartagena (Spain) accounted for 52 media articles.

Public content (YouTube, podcasts)

Public content was examined on YouTube and overall search for related podcasts resulting in only 4 entries considered relevant in a European level. YouTube provided 3 videos related to PG, located in Spain (Huelva) and Brazil, but their general informative tone was deemed adequate to be included in this category. The only podcast entry selected is also related to the Huelva case in Spain, although its tone is more locally specific, it has been included into the data repository.

Reports

The search identified 10 reports at an international level. Reports were published by the European Commission, on the framework of the COMET Project, as well as part of the TERRITORIES project, the International Atomic Energy Agency (IAEA), the SAFEGROUNDS project, or the AIMC (“Research Association of Media Outlets”, in Spain). Also included, one report produced by the U.S. Fertilizer Institute was included among others. The reports search on the topic of PG stacks was thus conducted on an international level, searching for those relevant reports to our project’s goals.

Social media

A total of 22 social media posts were identified during the search. Focusing on platforms as X.com, Facebook and Instagram, as non-related content was found on other platforms as TikTok. X.com provided most information, due to the non-explicit location nature of the posts, those were linked to the case studies by filtering per language. Croatia, North Macedonia, Serbia or Romania did not show content on the mentioned platforms. Portugal, however, had a scarce social media discussion with just two posts, one of which was related to Barreiro. Similarly in Spain only a few posts were found relatively to the specific case study.

3.2. Data preparation for analysis

The collected data were meticulously organised into a structured database to ensure compatibility with analytical tools such as Atlas.ti, a qualitative data analysis software designed for researchers and analysts to systematically manage, code, and analyse unstructured data, such as text, audio, video, and graphics. This software is commonly used in quantitative and qualitative research to process high amounts of information. The data preparation process was carried out through a series of methodical steps aimed at ensuring the reliability and relevance of the final dataset.

First, data were collected from partners and relevant primary and secondary sources, including articles, reports, and social media posts. Following collection, separate databases were created for each source to maintain a clear structure and traceability of information. Next, the language of each source was identified, and texts were translated into English to standardise the working language. During this step, a validation process ensured that translations accurately reflected the original content. Simultaneously, irrelevant or extraneous text (e.g., metadata, unrelated annotations) was cleaned to retain only the core, source-relevant content.

Once validated, access to the final texts allowed for merging all information from primary and secondary sources into a single consolidated Excel database. This database underwent a standardisation process to unify nomenclature, align categories, and ensure consistency in the classification of topics and themes. Examples of recurring themes included environmental impact or health concerns, while data were also tagged for geographic relevance to facilitate detailed case study analysis.

The final Excel database was then imported into Atlas.ti for codification. Here, themes, categories, and geographic markers were applied systematically to segment the data for efficient thematic exploration and contextual analysis. This structured and rigorous preparation process ensures that the data are well-organised, comprehensive, and suitable for deriving locally relevant insights and broader project conclusions.

3.3. Analysis methods

Following data preparation, the analysis was conducted in two main stages to extract and interpret social perception trends.

3.3.1. Thematic coding with Atlas.ti

A systematic coding approach was applied to all collected data using Atlas.ti, focusing on specific themes derived from the project's objectives and preliminary findings (manual reading review and insights from interviews). Each piece of data was tagged according to a set of defined topics, enabling a structured organisation of insights across sources. These thematic categories were defined based on coded data and a thorough review by the research team, ensuring alignment with the main topics addressed across sources.

To ensure consistency and an in-depth analysis, a detailed codebook was developed. The codebook outlined the key themes, associated keywords and advanced GREP (Global Regular Expression Print) patterns, a command-line utility that matches syntax in various text processing tools and programming languages as Atlas.ti. GREP patterns allowed the identification of data segments relevant to the defined coding categories. The creation of the codebook involved the following steps:

1. Identification of core themes derived from the project goals, the manual review of the texts and key topics highlighted in the interviews.
2. Keyword selection for each topic to ensure the accurate identification of relevant data.
3. Integration of GREP patterns for efficient text retrieval in Atlas.ti.

The structured codebook provided a robust foundation for the systematic and replicable coding process. This coding framework enabled a detailed and systematic categorisation of data, facilitating both cross-case comparisons and in-depth thematic analysis. By structuring the data according to the following six core topics: *community engagement*, *governance and policies*, *health concerns*, *environmental impact*, *economic impact and proposals*, the project was able to uncover nuanced insights into the social perception of PG stacks across multiple levels of analysis.

Following the coding process, the exporting quotations feature in Atlas.ti was used to extract relevant coded data segments. This process selects the coded text segments based on the thematic codes identified before and export the quotations in Excel format including all the metadata, such as the quotation text, assigned codes. The data generated through this process has been used to feed the thematic analysis, ensuring findings are grounded in evidence.

3.3.2. Thematic analysis with NLP tools

The second stage of analysis involved a comprehensive thematic analysis using natural language processing (NLP) tools. This stage aimed to refine and deepen the understanding of social perceptions by detecting semantic patterns and trends across a wide array of data.

Following the export quotation process in Atlas.ti, the 6 main categories were used to structure the thematic analysis. The categories are described as follows:

1. **Community engagement:** Captured data on local community involvement and participation in discussions about PG stacks. This included perceptions of community-led initiatives, local awareness, and public involvement in decision-making processes.
2. **Governance and policies:** Focused on references to policies and governance practices related to PG stack management. This topic covered local, national, and EU-level regulatory frameworks, policy effectiveness, transparency, and the role of governing bodies in addressing community concerns.
3. **Health concerns:** Included mentions of health risks associated with PG stacks, such as respiratory issues, water contamination, and broader public health implications. This theme aimed to capture community concerns and scientific assessments regarding the potential health impacts of PG exposure.
4. **Environmental impact:** Focused on ecological effects related to PG stacks, such as pollution, habitat degradation, biodiversity loss, and contamination of natural resources. This topic encompassed both observed and perceived environmental risks linked to the presence of PG stacks.
5. **Economic impact:** Covered discussions on the economic implications of PG stacks for local communities, including effects on property values, job creation, tourism, and potential economic restrictions or benefits. This topic aimed to capture community perspectives on how PG stacks influence economic growth and sustainability.
6. **Proposals:** Collected data on suggested solutions, recommendations, and proposals for PG stack management. This included ideas for policy changes, community-led initiatives, and technical solutions aimed at mitigating the environmental and social impacts of PG stacks.

The identification of these categories was essential for the posterior analysis of the content generated and found within the different sources, as they provide specific scopes to organise the information. The analysis of the information based on the categories allowed to establish correlations, synthesise information and reach traceable general ideas and conclusions about each case study social perception, as well as for the European framework.

3.3.3. Quantitative analysis and term frequency

Additionally, we conducted several term frequency explorations using Atlas.ti's, to ensure a robust and systematic approach on findings.

Firstly, we gathered and classified 344 documents related to "PG". Documents were classified according to country and the type of source of information they belong to.

We conducted three analogous analyses according to level. This enabled the generation of frequency results that captured both general trends across all case studies, and unique patterns within each specific case.

- General: Including all 344 documents
- Country: one by each country (Italy, Croatia, Serbia, North Macedonia, Portugal, Spain)
- Source: one by each type of source. (Academic, News, Public content, Interview, Social Media)

Atlas.ti produced a detailed quantitative analysis showing a count of each term. Then we processed it with Excel removing irrelevant words (e.g., articles or prepositions) leaving only meaningful terms according to the scope of the project (i.e. PG, environment, waste, or health). The relevant terms include the key words and their lexemes and derivations (i.e. "PG", "phospho-", "gypsum", "phosp-"). This step ensured a more accurate representation of the occurrence of core themes.

Following the curation of the word list, a total of 20 key terms were selected based on their frequency and relevance to the project. These terms were visualized in a frequency graph to facilitate a clear understanding of their prevalence and distribution across the dataset. The process was replicated for each case study.

Final steps analysing the results both quantitatively (e.g., frequency counts and trends) and qualitatively (e.g., contextual usage and thematic importance). This dual approach provided nuanced insights into the patterns of language and terminology within and across the case studies

Consequently, a total of 12 term-frequency analyses and corresponding graph visualizations were conducted. Ensuring that there is both a general and a more specific account of the results, a location category was integrated into the analysis.

3.4. Report guide

Once the analysis was conducted reports per case study were created to provide specific information and findings on each location. The reports are structured to present the information efficiently and accessibly, facilitating a comprehensive understanding of the social perceptions surrounding PG stacks. The design of the report framework ensures that partners and stakeholders can easily navigate through the findings, while maintaining a logical progression from context to analysis and conclusions.

Each report begins with an introduction and contextual overview, which sets the stage by describing the geographical and historical significance of the case study location. By establishing this foundational context, partners and stakeholders across the project can gain an understanding of the local circumstances that shape the perceptions and challenges addressed in the report. Following the contextual overview, the reports provide a detailed account of the sources of information used to build the case study.

The next component of the structure focuses on a summary of the key findings, where the main themes emerging from the data are synthesized into a coherent narrative. This section captures the essence of how PG stacks are perceived across all sources. The summaries aim to distil the wealth of information into concise insights, ensuring that the core issues are accessible without oversimplifying the complexity of the topics.

The heart of the report lies in the thematic analysis presented in "Framework 1." This section provides an in-depth examination of the findings, structured according to thematic categories identified through the previous accounted analysis. Each theme integrates data from all found sources, creating a multidimensional perspective on the issues at hand. The thematic analysis is designed to align local perceptions with the broader goals of the Fic-Fighters project, while also identifying patterns and divergences in stakeholder views.

Overall, the structure of the case study reports reflects a deliberate effort to balance clarity, comprehensiveness, and relevance. This framework allows each case study to contribute meaningfully to the shared understanding and collaborative goals of the FICFighters project.

3.5. Ethical considerations and limitations

This study only included publicly available data to ensure privacy protection. No personal information was stored, and explicit informed consent was obtained from all participants prior to conducting interviews. The consent form provided detailed information about the study's objectives, procedures, and data management protocols. It emphasized the voluntary nature of participation, the right to withdraw at any time without consequences, and the measures taken to ensure confidentiality and anonymity. Participants were informed that their responses would be anonymized and used solely for the purposes outlined in the research framework, adhering to stringent ethical standards.

Despite comprehensive data gathering efforts, certain limitations impacted the study. Geographic data granularity on social media and variations in public media coverage across locations presented challenges, potentially influencing the regional representation within the analysis. Additionally, while the consent process guaranteed participants' comfort and willingness to share insights, it is possible that sensitive topics may have led to self-censorship or selective reporting, subtly affecting the breadth of qualitative data collected. These factors underscore the importance of contextualizing findings within the scope and methodology of the research.

4. Quantitative analysis

The analysis of terms frequency reveals a strong thematic focus on environmental and social issues related to PG across all sources. The most frequently term is indeed “PG”, appearing a total of 2.114 times – including different lexemes and derivations – what underscores its central role in discussions across our findings. The terms “environmental” and “waste” are the second and third most mentioned, with 1.998 and 1.586 occurrences, respectively, signalling a significant focus on the broader environmental context and waste management challenges associated with PG. Additionally, terms such as “risk” (1.459 mentions), “health” (839 mentions) or “public” (814 mentions) highlight concerns about safety and health hazards. The frequency of “land” (1.988 mentions) suggests a strong connection between discussions of PG and land-related issues. Combined with mentions of “environment,” “risk,” “waste,” and “health,” these discussions are likely tied to the environmental and social impacts of PG stacks.

The frequent mentions of “water” (635 mentions) and “soil” (616 mentions), common vectors in discussions of pollution, further suggest that PG impact on natural resources is a key concern. Meanwhile, terms as “community” (671 mentions) and “social” (621 mentions) suggest that there is some degree of societal interest on the impact of PG, extending beyond environmental and natural resource impacts. Overall, the term frequency analysis reveals that discussions about PG stacks are deeply intertwined with environmental, social and health-related concerns as indicated by the prominence of terms such as “waste”, “risk”, “land”, “health”, “community”, etc. This integrated perspective points to the multidimensional nature of PG issues, requiring holistic strategies that balance environmental sustainability, public health and community well-being.

Additionally, the term frequency results confirm the adequacy of the categories reached through the thematic analysis. Those categories, used to interpret and understand the content retrieved for the analysis of social perception of PG stacks, are confirmed as pertinent and relevant to the object of our investigation within the framework of this deliverable.

20 More frequent words

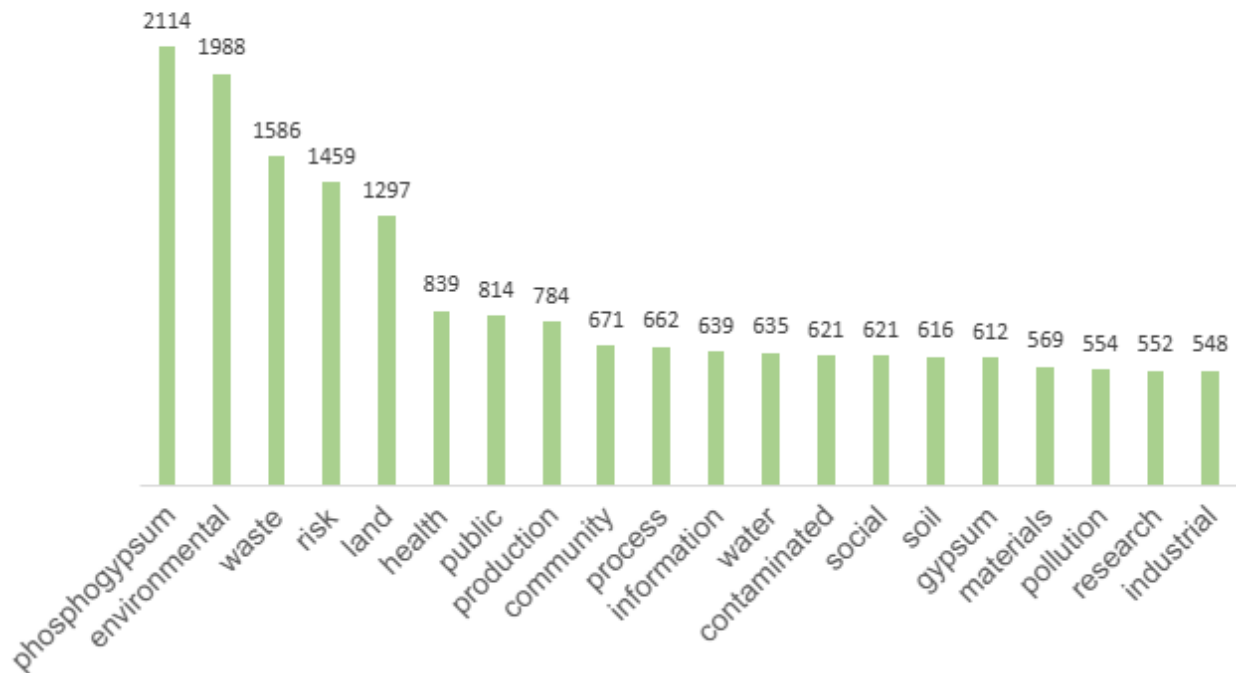


Figure 1. Top 20 Most Frequently Mentioned Terms Across Analysed Resources

Table 1. Term Occurrence Frequency Across Analysed Resources

Terms	Occurrences	Terms	Occurrences
PG	2.114	Information	639
Environmental	1.988	Water	635
Waste	1.586	Contaminated	621
Risk	1.459	Social	621
Land	1.297	Soil	616
Health	839	Gypsum	612
Public	814	Materials	569
Production	784	Pollution	554
Community	671	Research	552
Process	662	Industrial	548

5. Qualitative analysis at case study level

This section presents an overarching view of the social perception of PG stacks within each case study, aggregating insights from all sources and covering all topics. Here, we synthesise what is being said within each case study by integrating perspectives on community engagement, governance, health concerns, environmental and economic impacts, and proposals for PG stack management. The goal is to identify broad themes, shared concerns, and unique country-specific issues.

5.1. Social Perception of PG stacks in North Macedonia

In North Macedonia, the PG landfill near Veles stands as a testament to the country's industrial legacy and its pressing environmental issues. With concerns ranging from contamination of soil, air, and water to gaps in governance and policy, the landfill has become a subject of public interest.

This report examines the social perception of the PG stacks in Veles, synthesizing findings from interviews and news sources. By analysing community engagement, governance, health concerns, environmental impact, economic implications, and proposals, the study provides a nuanced understanding of how various stakeholders view these issues.

5.1.1. Case study: Veles, North Macedonia

Context

Veles, a city located in central North Macedonia along the Vardar River, has been a country's challenge to address environmental issues stemming from its industrial legacy. For decades, Veles was home to a fertilizer production facility that generated large quantities of PG as a by-product of phosphoric acid production. These PG stacks, left largely unmanaged after the factory ceased operations, remain a pressing environmental liability for the region.

The PG landfill near Veles has been a subject of ongoing local and national concern due to its potential environmental, health, and economic impacts. The stacks, which are stored in an open, unfenced area, are vulnerable to weathering and dispersion, raising concerns about contamination of nearby soil, water, and air. Proximity to agricultural land and the Vardar River amplifies these risks, as the spread of pollutants could directly affect crops and water resources. Despite being classified as a "hot ecological spot", the site has received minimal regulatory attention, with authorities designating it a low-priority hazard.

The environmental impact of the landfill has raised concerns among residents and environmental advocates, particularly regarding the presence of naturally occurring radioactive elements within the PG. These fears are compounded by a lack of consistent monitoring and transparency about the risks.

However, the PG stacks in Veles also present opportunities for innovation and remediation. Discussions around the potential reuse of PG in industries such as construction have gained some traction, reflecting an interest in aligning with circular economy principles. These opportunities are tempered by the need for rigorous safety evaluations and clear governance to ensure such initiatives do not exacerbate existing risks.

Sources of information

The case study on PG in North Macedonia identified a total of 34 sources, distributed across three categories: interviews, news articles, and social media. Below is a detailed summary of these findings.

Interviews

11 interviews were carried out, all originating from the Veles region. These interviews provided direct insights from local stakeholders, including industry representatives and environmental authorities, discussing the impacts, management, and challenges associated with PG in the region.

News Articles

23 news articles were located, with the majority (17) focused on the Veles region. These articles covered topics such as local developments, environmental concerns, and public discourse around PG, reflecting its relevance as a significant issue in this area.

Social Media

No social media sources related to PG were identified for North Macedonia. Searches were conducted in different platforms and results were filtered to find those exclusively written in Serbian languages, additionally the key search words of PG and Veles were used to identify posts, but none delivered results.





Figure 2. Aerial views of Veles

5.1.2. Conclusions

Community engagement

Community engagement regarding the PG landfill near Veles reflects a complex interplay of awareness, resistance, and disengagement, underscored by limited public involvement and institutional shortcomings. Across interviews and news articles a recurring theme is the insufficient information available to local residents about the landfill's environmental and health risks. Older residents, particularly those familiar with the site's industrial origins, demonstrate greater awareness but often express scepticism about authorities' intentions and capabilities. Conversely, younger generations display minimal concern or knowledge about the issue, a trend attributed to the lack of environmental education and public discourse on waste management.

News sources highlight sporadic engagement, often prompted by alarming events or media reports, but the general population has largely resigned itself to minimal involvement. The interviews emphasize frustration with institutional inaction and the absence of consistent communication channels. While NGOs like Vila Zora have sought to raise awareness, their efforts are hampered by limited resources and lack of support from government agencies, such as the Ministry of Environment and Physical Planning and the Radiation Safety Directorate. These agencies have been criticized for deferring responsibility to one another, further eroding trust.

Residents frequently express a sense of exclusion from decision-making processes. Municipal meetings, one of the few formal channels for updates, are perceived as inconsistent and inadequate. Many residents and activists advocate for regular workshops, public forums, and adherence to the Aarhus Convention,

which mandates public access to environmental information. However, institutional and bureaucratic challenges have stalled such initiatives, leaving the community feeling disconnected and distrustful.

Overall, the limited influence of NGOs, sparse media coverage, and inconsistent communication efforts contribute to a general sentiment of disillusionment. While some calls for action persist, including the establishment of structured engagement platforms and transparent information-sharing practices, the community's trust in institutional processes remains fragile.



Figure 3. Upper part of the Veles PG stack

Key findings:

- Limited public knowledge and awareness about landfill risks, particularly among younger generations.
- Sparse and inconsistent communication from authorities and lack of responsive governance.
- Minimal impact of NGO efforts due to institutional barriers and resource constraints.
- Persistent distrust toward authorities and demand for structured public engagement.

Governance and policies

In Veles, the governance and policies surrounding the PG landfill are perceived as fragmented and ineffective, marked by a lack of accountability, unclear roles, and minimal regulatory action. The division of responsibilities between the Ministry of Environment and Physical Planning and the Radiation Safety Directorate creates confusion, as both agencies defer accountability to one another. Due to their measurements showing non-hazardous radioactivity level, the Directorate treats it as a waste, placing responsibility on the Ministry, while the Ministry defers to the Directorate for issues related to radioactivity. This ambiguity undermines coordinated action and reinforces public scepticism about the state's commitment to addressing the landfill's risks.

The landfill's designation as a low-priority environmental hazard has further limited regulatory focus, funding, and resources for remediation. Interviewees report that the absence of a comprehensive environmental management plan has delayed essential actions, such as regular inspections, fencing, and signage to mitigate public exposure. Media coverage highlights similar concerns, emphasizing that this low-priority status perpetuates neglect and inaction.

Inconsistent enforcement of environmental policies compounds the community's dissatisfaction. While laws exist, their application in industrial legacy regions like Veles is often weak. This has eroded trust in government agencies, particularly as formal communication channels with local communities remain inadequate. Residents and activists stress the importance of transparency and compliance with the Aarhus Convention, which advocates for public engagement and access to environmental information.

Both interviews and news sources underscore the need for systemic reforms. Proposals include establishing a unified oversight body to centralize landfill management, ensure regular environmental monitoring, and improve communication with the public. Until these changes are implemented, the community's trust in governance efforts to address the landfill's risks remains tenuous.

Key findings:

- Ambiguity in responsibilities between the Ministry of Environment and Physical Planning and Radiation Safety Directorate.
- Limited prioritization, funding, and action for landfill remediation.
- Weak enforcement of environmental policies in industrial legacy regions.
- Advocacy for unified oversight and improved transparency and public engagement.

Health concerns

The health implications of the PG landfill in Veles dominate local concerns, with residents and environmental advocates raising alarm over potential exposure to hazardous substances. Despite periodic assurances from the Radiation Safety Directorate that radioactivity levels remain within acceptable limits, widespread mistrust persists due to inconsistent monitoring and inadequate communication of findings. Both interviews and media reports point to a notable absence of systematic health impact studies, leaving the community in a state of uncertainty regarding the landfill's long-term health effects.

Clear health warnings and physical barriers, such as fencing, are frequently proposed as immediate measures to limit exposure, but their implementation remains absent. The lack of proactive health

assessments and open communication continues to deepen the community's mistrust in authorities and their ability to mitigate the potential health risks posed by the landfill.

Key findings:

- Public fears regarding exposure to hazardous chemicals and radioactive materials.
- Lack of consistent health data and systematic monitoring efforts.
- Advocacy for regular health assessments and accessible reporting.
- Recommendations for physical protections and health-related transparency.

Environmental impact

The environmental impact of the PG landfill in Veles remains a critical concern, as the site's unmanaged and exposed nature poses risks to the surrounding ecosystems and communities. The landfill, a by-product of fertilizer production, holds significant quantities of PG, including naturally occurring radioactive elements such as radium and uranium. Its open structure, combined with inadequate containment measures, allows wind and rain to carry contaminants into the nearby soil, water, and air. Residents and environmental advocates frequently highlight its proximity to agricultural lands and the Vardar River, raising fears of pollutants infiltrating groundwater and affecting irrigation systems crucial for local farmers. During dry or windy periods, dust particles can travel beyond the site, intensifying concerns about broader ecological degradation.

Despite official claims from the Radiation Safety Directorate that radiation levels are within acceptable limits, both local residents and environmental groups question the reliability of these assessments due to a lack of consistent monitoring and transparency in reporting. News and interviews with local stakeholders underscore that the classification of the landfill as a low-priority hazard has stymied proactive remediation efforts, leaving the site without fencing, signage, or vegetation buffers to prevent further environmental exposure.

Efforts by environmental groups, such as advocating for continuous environmental monitoring and the installation of protective barriers, have gained some attention but remain largely unsupported due to limited funding and regulatory focus.

Recommendations include creating buffer zones of vegetation to stabilise the landfill and regular soil and water testing to track contamination levels. However, the lack of a comprehensive environmental management plan has perpetuated the perception among residents that authorities undervalue the environmental risks posed by the landfill, contributing to long-standing distrust.

Key findings:

- Risks of contamination to soil, water, and air from PG exposure.
- Persistent concerns about dust dispersal during windy conditions and its impact on agriculture and ecosystems.
- Lack of comprehensive environmental monitoring and consistent testing.
- Calls for immediate protective measures, including fencing, vegetation buffers, and regular contamination tracking.

- Perception of government inaction due to the landfill's low-priority status.

Economic impact

The economic implications of the PG landfill in Veles present a divided perspective, as evidenced by interviews and news reports. While some see the potential for economic reuse of PG in industrial applications such as construction, others raise significant concerns about the environmental, health, and financial challenges tied to such initiatives. News sources highlight local officials and experts suggesting the integration of PG into products like cement or gypsum-based materials, aligning with circular economy principles that could stimulate local employment and economic activity. Interviews with residents, however, reveal widespread scepticism about the feasibility and safety of these plans.

A recurring theme in interviews is the substantial financial and logistical barriers to safely repurposing PG. Stakeholders point out that significant upfront investments are needed for contamination control, material stabilisation, and infrastructure development. Without clear regulatory guidelines or frameworks, these costs remain a major obstacle. News sources further corroborate these concerns, emphasising the absence of comprehensive safety assessments and the regulatory ambiguity surrounding industrial reuse, which raises doubts about the practicality and sustainability of such projects.

Farmers and property owners near the landfill express apprehension during interviews about the potential devaluation of their lands and products. The stigma associated with potential contamination—whether substantiated or not—creates additional economic uncertainty. For farmers, concerns over soil and water contamination from the landfill could impact agricultural productivity and the reputation of their produce, potentially leading to significant financial losses. Media coverage also highlights these economic fears, stressing that local sentiment leans towards protecting agricultural and property values over pursuing speculative industrial gains.

While some community members express cautious support for exploring the landfill's economic potential, this support is conditional upon strict adherence to safety and transparency standards. Interviewees emphasize the need for thorough environmental impact assessments and detailed safety protocols to ensure any reuse does not exacerbate existing health and environmental risks. Media reports align with these views, noting calls for clear regulatory frameworks and community involvement in decision-making processes.

Overall, while both interviews and news accounts indicate interest in transforming the landfill into an economic asset, the prevailing sentiment prioritises health and environmental protections. The community's willingness to support such initiatives hinges on assurances of safety, tangible local benefits like job creation and infrastructure improvements, and a transparent, participatory approach to planning and execution.

Key findings:

- Concerns over the high costs and logistical challenges of safe material reuse.
- Proposals for industrial applications such as construction products and their alignment with circular economy principles.
- Apprehensions about property devaluation and impacts on agricultural productivity near the landfill.

- Calls for strict safety guidelines, transparent oversight, and inclusive community engagement in economic reuse initiatives.

Proposals

The proposals for addressing the challenges posed by the PG landfill focus on immediate containment measures and long-term strategies that prioritize environmental safety, public health, and community involvement. Both interviews and news highlight a range of actionable steps to mitigate risks while exploring opportunities for reuse, ensuring a balanced approach to the landfill's management.

The establishment of a comprehensive environmental monitoring programme is emphasized in interviews with environmental activists and local representatives, includes regular testing of soil, water, and air quality to track contamination levels and identify risks early. News findings echo the importance of such a programme, noting that it would align with Aarhus Convention principles by ensuring the community has access to reliable, up-to-date information. Transparent communication of monitoring results is seen as essential for restoring public trust and alleviating the prevailing uncertainty among residents.

Immediate containment measures are also prioritized, with calls for the installation of fencing around the landfill to prevent unauthorised access and reduce the risk of accidental exposure to contaminants. Warning signs detailing potential hazards were proposed as an additional measure to increase public awareness, particularly for those living in proximity to the site. Interviewees also suggested the creation of a buffer zone of vegetation, which would stabilize soil, limit the dispersal of dust particles, and act as a natural barrier against contamination, especially during windy conditions.

Long-term solutions proposed centre on the potential reuse of PG in industrial applications, such as construction. Both interviews and news identify this as an opportunity to transform the landfill into a resource, potentially generating economic benefits while reducing its environmental footprint. However, stakeholders unanimously agree that this approach requires stringent safety evaluations, regulatory oversight, and significant upfront investments to ensure the feasibility and safety of reuse. The community, as reflected in interviews, supports industrial reuse only if it is preceded by detailed environmental impact assessments and robust consultations with local residents and experts.

Structured public engagement emerges as a recurring theme in proposals. Town hall meetings, workshops, and open forums were suggested as platforms to involve the community actively in decision-making processes. Such initiatives would enable residents to voice concerns, propose ideas, and receive updates on remediation efforts. Both interviewees and news stress the importance of adhering to Aarhus Convention principles, advocating for transparency and participatory governance as critical components of any future management strategy.

In sum, the proposals underscore the necessity of combining immediate action with forward-thinking strategies. By integrating safety, transparency, and community involvement, these recommendations aim to balance the immediate need for containment with the potential for long-term economic and environmental benefits.

Key findings:

- Establishment of a comprehensive environmental monitoring programme with public access to contamination data.

- Implementation of immediate containment measures, such as fencing, warning signs, and buffer zones.
- Exploration of industrial reuse options, contingent on thorough safety and feasibility assessments.
- Structured public engagement through town hall meetings, workshops, and forums in line with Aarhus Convention principles.

5.2. Social perception of PG stacks in Portugal

5.2.1. Case study: Barreiro, Portugal

Context

Barreiro, a municipality located in the Setúbal District on the south bank of the Tagus River, represents a critical site in Portugal's efforts to address environmental liabilities related to industrial waste. For decades, Barreiro was home to a major industrial complex at Arco Ribeirinho Sul, S.A., where phosphoric acid production from 1950 to 1989 generated significant quantities of PG, a byproduct that remains stockpiled in the area. These PG stacks, stored in retention lagoons and large heaps within Arco Ribeirinho Sul, S.A., have become a symbol of both the region's industrial heritage and its environmental challenges.

The PG stacks have long been a subject of local and national concern due to their potential environmental, health, and economic impacts. The PG stacks are located in the Arco Ribeirinho Sul, S.A. jurisprudence territory, in the municipalities of Barreiro and Moita. In terms of percentage of PG stacks, around 30 to 40% are located in the territory of municipality of Barreiro while 60 to 70% are located in the territory of municipality of Moita, however they are owned by Arco Ribeirinho Sul, S.A. which is a public company managed by the National Government.

Both local governments really want this problem to be resolved so that this entire privileged area can be the target of recovering its environmental liabilities and can be the target of sustainable interventions that return this coastline to the population. Despite the decades that have passed since industrial operations ceased, the PG stacks remain largely unmanaged, presenting both risks and opportunities for the region.

The environmental impact of the stacks includes potential contamination of soil, water, and air, posing risks to the surrounding ecosystems and communities. Residents have raised concerns about health risks associated with prolonged exposure to contaminants, while the industrial image of the area has negatively influenced property values and economic development. However, the presence of the stacks also offers an opportunity for innovative remediation and revalorisation projects. Initiatives such as the ETAR Barreiro-Moita, that was inaugurated on April 2012 and whose implementation was preceded by an environmental impact study, involved structural changes to the initial PG pile, giving it its current structure and form. This project illustrates the potential for regional collaboration in addressing these environmental liabilities.



Figure 4. Aerial views of Barreiro

This case study focuses on the social perception of the PG stacks in Barreiro, examining how the community, local authorities, and stakeholders perceive the environmental, health, and economic implications of the stacks, as well as their expectations for remediation. Through a detailed exploration of community engagement, governance, and proposed solutions, this case aims to provide insights into the challenges and opportunities of addressing PG liabilities in Barreiro, setting a potential precedent for similar efforts in other regions.



Figure 5. Barreiro PG stack and Tagus River

Sources of information

The case study on PG in Portugal resulted in the identification of 10 sources across four categories: academic sources, interviews, news articles, and social media. Below is a detailed presentation of these findings.

Academic sources

One academic article was found related to Barreiro case study.

Interviews

Four interviews were recorded all associated with the Barreiro region. These interviews provided firsthand accounts from local stakeholders, including industry representatives and environmental professionals, addressing specific challenges and opportunities related to PG in this area.

News Articles

Four news articles were located, two of which were specific to the Barreiro region. These articles covered local events, discussions, or controversies related to PG, offering a broader understanding of how the issue has been publicly reported and perceived in Portugal.

Social Media

Two social media posts were identified, with one specifically mentioning Barreiro. These posts highlighted local discussions or awareness campaigns regarding PG, reflecting the role of digital platforms in disseminating information and engaging the public on this issue.

5.2.2. Conclusions

Community engagement

The community's interaction with the PG stacks in Barreiro is characterised by a complex relationship of familiarity, resignation, and a growing demand for active participation in decision-making processes. Residents have lived alongside these stacks for decades, which has normalised their presence in the landscape. However, this familiarity does not equate to acceptance. Interviews with local stakeholders reveal a deep-seated frustration due to the prolonged lack of decisive action by authorities. For many, the stacks are a visible reminder of unfulfilled promises to address environmental and public health concerns. Younger generations have grown up viewing the stacks as a naturalized part of the environment. This normalization has been further reinforced as nature has "camouflaged" the stacks over time, making them appear like any other unused land rather than hazardous industrial waste.

The lack of transparent communication from authorities has further strained the relationship between the community and decision-makers. Residents frequently noted that information regarding the risks and remediation plans for the stacks is sparse and inconsistently shared. This information gap has left many community members feeling excluded from discussions about the future of the affected areas. While some studies have been conducted on the environmental and health implications of the stacks, the findings have not been effectively disseminated, limiting the community's ability to engage meaningfully in remediation or revalorisation efforts. There is also a growing recognition of the importance of preserving the historical memory of Barreiro's industrial legacy, not only as a lesson to prevent future environmental mistakes but also as a point of civic pride in addressing and overcoming these challenges.

Despite these challenges, there is a strong appetite within the community for involvement in shaping the future of the PG stacks. Interviews and local discussions highlight widespread support for projects that transform these liabilities into assets through sustainable development. Residents have expressed particular interest in converting the remediated areas into public spaces, such as parks or recreational facilities, that would benefit the wider population. Such spaces are seen as a form of compensation for decades of exposure to industrial liabilities and as an opportunity to reconnect the community with its natural surroundings.

This aspiration is paired with a call for authorities to establish regular channels of communication, such as public forums or updates, to ensure that the community remains informed and involved at every stage of the remediation process.

Key findings:

- The PG stacks are perceived as a longstanding but unresolved issue in Barreiro's landscape.
- Residents feel excluded due to limited information and lack of proactive communication from authorities.
- The community strongly supports sustainable development projects, particularly those that provide public and recreational spaces.
- There is a clear demand for transparency and regular public engagement in the planning and execution of remediation efforts.

Governance and policies

The governance surrounding the PG stacks in Barreiro has been a consistent source of contention for the local community, marked by a perception of inefficiency, delays, and insufficient transparency. Residents and stakeholders repeatedly cite a lack of decisive action from authorities, despite the clear environmental and social liabilities posed by the stacks. Interviews, news articles, and academic sources collectively highlight overlapping responsibilities between local, regional, and national institutions, which have contributed to a fragmented approach and slow progress in addressing the issue. Institutional actions are perceived as largely reactive, addressing specific problems as they arise.

Interviews reveal widespread frustration with the bureaucratic complexities involved in managing the PG stacks. Residents frequently point to the absence of a comprehensive environmental assessment as a critical failure of governance. This baseline evaluation, which would characterise the contaminants present in the stacks and their risks, is viewed as an essential first step toward effective remediation. However, decades have passed without such an assessment being completed, leaving stakeholders with little confidence in the authorities' commitment to resolving the issue.

The reliance on higher-level governmental approvals, such as the environmental impact declaration required for PG excavation and removal projects, exemplifies the delays inherent in the governance structure. News reports confirm that Arco Ribeirinho Sul, S.A. has received and evaluated proposals for excavation, but the work remains stalled, awaiting the Secretary of State for the Environment's decision. This delay has fuelled public scepticism about the capacity of governmental bodies to prioritise and implement environmental policies efficiently.

Institutions like the Portuguese Environment Agency (APA), local councils, and public utilities such as SIMARSUL (responsible for wastewater management) play key roles in managing the environmental challenges of Barreiro. While these entities have established frameworks for addressing industrial liabilities, interviews suggest that their actions are perceived as reactive rather than proactive. For instance, SIMARSUL's involvement in the ETAR (wastewater treatment plant) Barreiro-Moita project is seen as a critical step forward, but its dependency on bureaucratic approvals has limited tangible progress, as highlighted in both interviews and news articles.

The community has consistently voiced a demand for greater transparency and accountability in policy formation and implementation. Interviews reveal a sense of exclusion among residents, who feel that they are not adequately informed about remediation plans or timelines. Public forums and updates are frequently recommended as mechanisms to rebuild trust between authorities and the community. This sentiment is echoed in news sources, which report on local leaders advocating for collaborative

governance models that include community input and foster alignment between municipal and national priorities.

Residents and local leaders alike emphasise the need for clearer policies with actionable and accountable steps. This includes prioritising environmental assessments, streamlining approval processes, and allocating dedicated funding for remediation efforts. Interviewees specifically suggest that partnerships between public and private entities are also seen as crucial for overcoming bureaucratic inefficiencies and ensuring that solutions reflect community priorities.

Key findings:

- Fragmentation and delays in governance, with overlapping responsibilities complicating progress.
- Perceived inaction and a lack of prioritisation by local, regional, and national authorities.
- Community frustration over the absence of a comprehensive environmental assessment.
- Calls for transparent, inclusive governance models that involve the public and streamline bureaucratic processes.
- Recommendations for dedicated funding and public-private partnerships to expedite remediation efforts.

Health concerns

Health concerns regarding the PG stacks in Barreiro are a significant point of concern for the local community, driven by the lack of comprehensive studies and accessible information about the potential risks associated with long-term exposure to these industrial by-products. Both interviews and news reports highlight that the community is particularly worried about contaminants such as heavy metals and radioactive elements, which are believed to pose threats to air, soil, and water quality.

Interviews reveal that residents are acutely aware of the potential health implications but feel uninformed due to the absence of systematic health monitoring or impact assessments. Many expressed frustrations over the lack of transparency from authorities about the specific risks associated with the stacks. The absence of systematic health monitoring and detailed impact assessments has heightened the concerns and distrust towards authorities in health-related fields.

The community's unease is heightened by the potential vulnerability of children and the elderly, who are seen as particularly susceptible to environmental pollutants. This concern is often tied to fears of airborne dispersion of contaminants or leaching into water sources, especially in areas close to residential zones or natural resources like the Tagus River. News articles report similar sentiments, noting that public discussions often focus on the need for preventative measures to mitigate exposure risks, even as remediation plans remain in bureaucratic limbo.

Residents consistently call for health-focused evaluations, including regular environmental monitoring and detailed studies on the potential impacts of the PG stacks. The demand for transparency extends to regular updates from authorities about ongoing or planned remediation efforts and their implications for public health. Interviews also indicate that the absence of such measures has contributed to a broader sense of distrust toward governmental institutions, further exacerbating concerns.

Key findings:

- Strong community concern over potential health risks due to contaminants in the PG stacks.
- Lack of comprehensive health impact studies or systematic monitoring exacerbates uncertainty.
- Particular concern for vulnerable populations, including children and the elderly.
- Calls for regular environmental monitoring, detailed health assessments, and transparency from authorities.
- Perceived link between health concerns and broader distrust in institutional accountability.

Environmental impact

The environmental impact of the PG stacks in Barreiro is a central concern for both residents and stakeholders, reflecting broader fears about contamination, ecological degradation, and the long-term consequences of inaction. Over decades, the PG stacks have come to symbolise both the industrial legacy of the region and the pressing need for sustainable environmental management. Interviews, news articles, and academic sources converge on the understanding that the stacks pose significant risks to soil, water, and air quality, while also serving as a visible blight on the local landscape. For instance, interviews reveal that the leaching from the stacks to nearby water sources, as the Coia River, is a persistent concern among the residents.

Residents consistently voice frustration over the lack of tangible progress in remediating the area, despite the well-documented risks associated with PG as hazardous waste. Interviews highlight concerns about leaching from the stacks into nearby water sources, such as the Coia River, and the potential for airborne contaminants to spread through wind and rain, further affecting local ecosystems and public health. News reports confirm that some remediation efforts, such as the removal of other industrial waste in Barreiro, have begun but have been slow to address the PG stacks specifically.

The visual impact of the stacks is another critical issue raised by the community. Residents describe the industrialised appearance of the area as a barrier to its ecological and aesthetic restoration. For many, the PG stacks not only degrade the immediate environment but also perpetuate a negative stigma that hinders the region's potential for tourism, biodiversity enhancement, and community well-being. Furthermore, the visual industrial appearance may be reinforcing a stigma that affects negatively the overall perception of Barreiro as a resilient and sustainable community. As from the interviews, there is a growing interest in exploring integrated solutions that combine environmental restoration with sustainable land use, as in areas like Parque das Nações, cited as a potential model for this case.

Despite these challenges, there is strong support within the community for comprehensive environmental remediation. Interviews and news articles consistently mention the desire for solutions that go beyond merely removing visible waste. Residents advocate for holistic plans that include soil decontamination, water quality restoration, and the establishment of green spaces that integrate with the surrounding natural landscape. These efforts are seen not only as a path to environmental recovery but also to rebuild trust in the institutions responsible for managing the site.

However, progress remains limited by bureaucratic delays and insufficient funding. The dependency on environmental impact declarations, as highlighted in news reports, is emblematic of the broader systemic hurdles that have stalled comprehensive action. While local stakeholders recognise the complexities of

the situation, there is a growing demand for authorities to prioritise the environmental health of the area and deliver measurable results.

Key findings:

- Significant risks of soil, water, and air contamination linked to the PG stacks.
- Frustration with the slow pace of remediation and the visible degradation of the landscape.
- Community desire for comprehensive environmental recovery, including soil decontamination and biodiversity enhancement.
- Support for transforming the area into green spaces that benefit the environment and the community.
- Bureaucratic and funding challenges as key obstacles to environmental progress.

Economic impact

The economic impact of the PG stacks in Barreiro is a dual-edged issue for the community, viewed both as a burden that stymies local development and a potential opportunity for economic revitalisation if appropriately addressed. The presence of the stacks has contributed to a decline in property values and deterred investment in the region, particularly in residential and tourism sectors. Interviews and news reports highlight that this industrial liability has created a perception of Barreiro as a polluted and less desirable area, hindering its appeal for new businesses and environmentally conscious industries. However, the interviews also reveal that the inaction surrounding the PG stacks have supposed missing opportunities in the field of tourism.

Local stakeholders' express frustration over the missed economic opportunities resulting from the inaction surrounding the PG stacks. Many residents believe that the remediation and repurposing of the land could unlock substantial economic benefits, from increased property values to the development of new industries. News sources report discussions about integrating the land into regional development plans, with ideas ranging from recreational spaces to renewable energy projects. One prominent proposal, supported by both interviews and public commentary, is the establishment of solar energy farms on remediated land, which could simultaneously address environmental concerns and contribute to the local economy. These projects are perceived to reframe Barreiro's industrial legacy into a model for sustainable and innovative development.

However, interviews reveal scepticism about whether such initiatives will be realised or if they will benefit the community directly. There is a prevailing fear that economic revalorisation efforts could prioritise external commercial interests over local needs. Residents emphasise the importance of ensuring that any redevelopment aligns with community priorities, particularly in creating accessible public spaces and supporting sustainable economic growth.

Additionally, stakeholders highlight the need for targeted policies and investments to ensure that Barreiro can fully leverage the economic potential of the remediated land. This includes allocating dedicated funds for comprehensive remediation, incentivising green industries, and fostering partnerships between public and private sectors. The community's vision for economic development is not solely focused on financial returns but also on improving the quality of life for residents and transforming Barreiro into a model of sustainable urban and environmental planning.

Key findings:

- Decline in property values and investment due to the industrial liability posed by the PG stacks.
- Community interest in repurposing remediated land for sustainable development, such as renewable energy projects and recreational spaces.
- Concerns about economic initiatives prioritising external interests over local benefits.
- Desire for economic strategies that align with community priorities and support green industries.
- Recognition of the need for dedicated funding and public-private partnerships to maximise economic opportunities.

Proposals

Proposals for addressing the PG stacks in Barreiro reflect a mix of community aspirations, institutional planning, and sustainable development strategies. Both interviews and news articles reveal a strong focus on transforming the site into a valuable resource for the community while resolving the environmental liabilities. These proposals range from comprehensive remediation to innovative land use ideas that balance environmental restoration with economic growth.

A central theme in the proposals is the removal of PG through excavation and safe disposal. Although not officially confirmed, news reports highlight that Arco Ribeirinho Sul, S.A. has already conducted a public tender for PG removal, with a budget of 800,000 euros. However, this initiative is contingent on an environmental impact declaration, illustrating the bureaucratic dependencies that have delayed implementation. Despite these hurdles, the community views the removal of PG stacks as a foundational step for any future land use.

Beyond removal, residents and local stakeholders envision a range of transformative projects for the remediated land. One of the most frequently mentioned proposals is the creation of green spaces, such as public parks or ecological reserves, that could enhance quality of life and support local biodiversity. Interviews underscore the community's desire for accessible spaces that reconnect residents with the natural landscape and provide recreational opportunities.

Renewable energy projects also feature prominently in the proposals. Solar energy installations are often cited as a viable option for repurposing the site, offering both environmental and economic benefits. Interviews and public commentary suggest strong support for leveraging Barreiro's industrial heritage into a symbol of sustainability through solar farms or similar initiatives.

Community inclusion is another recurring theme in the proposed strategies. Residents emphasise the importance of transparent and participatory planning processes to ensure that projects reflect local priorities and values. Regular updates, public forums, and collaboration with local institutions are seen as essential for maintaining trust and ensuring that proposed solutions meet the community's needs.

Key findings:

- Removal of PG stacks as a foundational step, pending environmental impact declaration.
- Strong community support for transforming remediated land into green spaces or ecological reserves.
- Interest in renewable energy projects, particularly solar farms, as a sustainable use of the site.

- Emphasis on transparent planning and active community participation in decision-making processes.
- Vision of the site as a model for sustainable redevelopment that benefits both residents and the environment.

5.3. Social Perception of PG stacks in Serbia

5.3.1. Case study: Prahovo, Serbia

Context

Prahovo, a small industrial town located on the banks of the Danube River in eastern Serbia, has become a focal point in discussions about the environmental and social implications of industrial waste management. At the heart of this discourse lies the management of PG stacks, a byproduct of phosphoric acid production. The chemical company Eliksir, which assumed control of the once-stagnant industrial complex in Prahovo, now operates these repositories. While Eliksir's presence has injected new life into the local economy, providing jobs and infrastructure development, the environmental and social challenges associated with PG storage have raised concerns among residents, environmentalists, and public health advocates.

PG is known to contain impurities such as heavy metals and radioactive elements, making its storage and management critical to ensuring public and environmental safety. In Prahovo, the location of the PG stacks near the Danube River heightens concerns about potential contamination of one of Europe's major waterways. Local residents, particularly those living in proximity to the site, have expressed fears regarding dust emissions, water contamination, and the long-term health effects of exposure to pollutants. These concerns persist despite Eliksir's claims of compliance with Serbian and EU environmental standards.

This case study examines the social perception of PG stacks in Prahovo through the lens of six key themes: community engagement, governance and policies, health concerns, environmental impact, economic impact, and proposals. Drawing from interviews, news articles and academic references, it explores the complex relationship between economic development, environmental sustainability, and public health in the region.

The analysis reveals a community navigating a delicate balance between the economic benefits provided by Eliksir—such as employment and regional revitalisation—and the perceived risks to their health and environment.

Sources of information

The case study on PG in Serbia is based on 25 sources, categorised into academic materials, news articles, and interviews, providing a quantitative foundation for the analysis of social perceptions in this area.

Academic sources

A total of 6 academic sources were identified. These focus on the scientific and technical aspects of PG management, addressing its environmental implications and potential applications in industrial contexts.



Figure 6. Aerial views of Prahovo

News articles

The majority of the sources—17 in total—are news articles, with 13 of them specifically discussing developments in Prahovo. These articles report on events, community reactions, and industrial practices, highlighting the region's significance in the broader context of PG management in Serbia.

Interviews

Three interviews were conducted as part of the data collection, providing qualitative insights from local stakeholders regarding the challenges and opportunities associated with PG storage and disposal.

5.3.2. Conclusions

Community Engagement

Community engagement is a pivotal theme in the social perception of PG stacks in Prahovo, as reflected in both news articles and interviews. Elik sir, the company managing the PG repositories, has made efforts to position itself as a key community partner. News sources highlight Elik sir's active support for local events, including sponsorships of cultural and sports festivals such as the "Days of Mokranjac," and contributions to infrastructure improvements like school renovations and sewage systems. These actions are coupled with job creation, which has been vital for an economically vulnerable region.

Despite these efforts, interviews with community informants reveal a nuanced response. While some residents appreciate the economic and social benefits Elik sir provides, others view these initiatives as insufficient to address deeper environmental and health concerns. For instance, the idea of establishing a "green chair" within local governance was proposed to ensure that environmental issues receive a formal platform for discussion and advocacy. This reflects a sentiment that community engagement needs to go beyond corporate-led activities and include structured opportunities for public input.

A generational divide in awareness further complicates the dynamics of community engagement. Interview data suggest that younger residents are largely uninformed about the risks and implications of PG stacks. This gap in knowledge highlights the need for targeted educational initiatives to equip younger generations with an understanding of environmental risks and encourage informed participation in local governance.

While news reports and Elik sir's public statements portray a company working to foster positive relations, the interviews reveal underlying scepticism among residents. Many perceive community engagement efforts as superficial or as strategies to improve the company's image rather than genuine attempts to address core issues. This scepticism underscores a need for deeper, more transparent dialogue between Elik sir and the community, with a focus on building long-term trust.

Key findings:

- Perception of economic dependency and cautious acceptance of corporate outreach.
- Recognition of the need for structured public involvement, such as a dedicated environmental advocacy role in local governance.
- Generational divide in awareness, underscoring the importance of educational initiatives for younger residents.

Governance and policies

Governance and policies surrounding PG management in Prahovo play a crucial role in shaping public perceptions of Elik sir's operations. News sources highlight the company's compliance with Serbia's Waste Management Law and EU environmental standards, framing this adherence as a demonstration of responsible industrial practices. Elik sir has also worked closely with local authorities, streamlining

administrative processes to facilitate infrastructure projects such as the development of Prahovo's port. These actions are presented as evidence of robust regulatory oversight and corporate alignment with legal requirements.

However, interviews with local informants reveal a more complex picture. While some acknowledge improvements in regulatory enforcement, skepticism remains about the effectiveness and transparency of governance structures.

The need for greater transparency and public engagement in governance processes emerges as a recurring theme. Suggestions include the establishment of regular public channels to provide updates on environmental monitoring and to allow residents to voice concerns directly to both regulatory bodies and Elikvir representatives.

The perceived close relationship between Elikvir and local authorities is another point of contention. While this collaboration has enabled rapid industrial development, it has also led to concerns about regulatory independence. Informants suggest that independent oversight, perhaps involving external environmental experts, could alleviate doubts about the integrity of governance structures and policies.

In summary, governance and policy frameworks are seen as both a strength and a weakness in PG management. While legal compliance and collaboration with local authorities have facilitated industrial progress, there is a clear demand for greater independence, transparency, and public involvement to address community concerns and build confidence in regulatory systems.

Key findings:

- Skepticism over the transparency and effectiveness of regulatory enforcement.
- Concerns about governance prioritising economic interests over public welfare.
- Calls for public forums and transparent data sharing to strengthen trust.
- Advocacy for independent oversight to ensure rigorous environmental and health protections.

Health Concerns

Health concerns are a central and persistent theme in the community's perception of PG stacks in Prahovo. Both news articles and interviews highlight a widespread fear of potential health risks associated with the storage and management of PG, particularly linked in the public discourse to rising rates of respiratory illnesses and cancers within the local population, due to the long-term health implications of exposure to pollutants, sparking a perception of direct correlation between industrial activities and declining community health.

Residents in the affected areas describe frequent encounters with airborne pollutants and dust particles, which they suspect contain harmful chemicals and radioactive elements present in PG. Environmental advocates and local health professionals have voiced similar concerns, urging that comprehensive, independent health assessments be conducted to investigate and verify potential health risks.

Interviews reveal that, while Eliksir claims to follow EU standards and employ controlled management practices, these assurances have not fully alleviated public concerns. Informants emphasize the lack of independent, accessible health data as a major issue, arguing that existing safety measures appear reactive rather than preventive. This perception has fostered a climate of mistrust, with many residents calling for transparent and regular health monitoring to address fears about potential exposure.

Local discussions amplify these concerns, with repeated calls for independent health studies to examine the long-term impacts of PG storage on the local population. Residents suggest that these studies should focus on specific health issues, such as increased rates of cancer and respiratory conditions in affected areas. They also advocate for clearer communication from both Eliksir and regulatory bodies, including public reporting of health data and updates on protective measures.

It is also highlighted the psychological toll of living near PG stacks, noting that the fear of unknown health risks contributes to a general sense of insecurity and dissatisfaction. This emotional dimension underscores the need for proactive health measures that not only address physical risks but also rebuild trust within the community.

In summary, health concerns dominate the social perception of PG management in Prahovo. The community's demands for independent health assessments, transparent data sharing, and preventive safety measures reflect a deep-seated desire for reassurance about their well-being. Addressing these concerns through credible and consistent health initiatives could be a key step in mitigating public fears and building trust.

Key findings:

- Widespread fear of health risks linked to radioactive and chemical elements in PG.
- Perception of existing safety measures as reactive rather than preventive.
- Demand for independent health studies and regular, transparent health monitoring.
- Emotional and psychological impact of living near PG stacks, contributing to community mistrust.

Environmental Impact

Environmental concerns are a prominent and recurring theme in the social perception of PG stacks in Prahovo. Both news articles and interviews underscore that community members and environmental groups have voiced strong concerns about the potential contamination of air, soil, and water resources and the potential long-term ecological damage caused by PG storage in the region.

The proximity of the PG stacks to the Danube River—a vital waterway for both local ecosystems and agriculture—amplifies fears of contamination, which could have far-reaching consequences for the environment and livelihoods dependent on the river and concerns about whether regulatory bodies are sufficiently rigorous in enforcing environmental safeguards.

Interviewees emphasize concerns about the adequacy of existing containment measures. While Eliksir has implemented practices such as installing impermeable liners and adhering to EU waste management standards, residents remain skeptical about whether these measures are sufficient to address the

cumulative environmental risks. Instances of dust emissions and leaks into nearby water sources are frequently cited, raising doubts about the effectiveness of safeguards in protecting local ecosystems. There is the perception that economic priorities may overshadow environmental protections.

In addition to water contamination, concerns about air quality were highlighted in the interviews. Dust from the PG stacks is perceived as a significant issue, with community members attributing it to soil degradation and reduced agricultural productivity in surrounding areas. This concern is particularly acute given the region's reliance on farming, which is seen as a critical component of local economic and environmental sustainability.

The need for PG stacks management emerged as a key focus in both news and interview sources. Informants suggested aligning PG production with its reuse in industrial applications, such as construction materials, to minimize waste accumulation and environmental impact. This aligns with a broader community interest in turning a potential environmental liability into an economic asset, provided these applications are safe and thoroughly evaluated.

The historical context of environmental neglect in the region further complicates perceptions. Prahovo has faced decades of industrial activity with limited environmental oversight, leading many residents to question whether current measures can adequately address long-standing pollution. This distrust underscores a demand for continuous environmental monitoring and transparent reporting on air, soil, and water quality to rebuild public confidence.

In summary, while Eliksir's environmental management practices represent a step forward, they have not fully mitigated community concerns. Persistent fears about the adequacy of safeguards, the vulnerability of the Danube River, and the long-term sustainability of PG storage highlight the need for enhanced transparency, sustainable practices, and robust environmental monitoring to address public apprehensions.

Key findings:

- Concerns over potential contamination of the Danube River and regional ecosystems.
- Distrust in the sufficiency of environmental safeguards and waste management practices.
- Issues with air quality and agricultural productivity due to dust emissions.
- Interest in sustainable PG reuse to minimise environmental risks.
- Demand for continuous and transparent environmental monitoring to rebuild trust.

Economic Impact

The economic impact of PG stacks in Prahovo presents a dual narrative of opportunity and caution. Both news articles and interviews highlight Eliksir's contributions to regional economic stability, particularly through job creation, infrastructure development, and industrial revitalisation. The company's operations have provided a significant boost to Prahovo and the surrounding area, transforming a previously stagnant industrial site into a centre of economic activity. Improvements such as the development of Prahovo's port and investments in infrastructure are seen as important drivers of local economic growth.

Interviews reinforce this perspective, with informants acknowledging the economic benefits tied to Eliksir's activities, including the sale of PG byproducts. This reuse not only generates additional revenue but also helps reduce the volume of stored waste, presenting an intersection of economic and environmental goals. For many residents, Eliksir's presence offers critical employment opportunities and financial stability in a region with limited alternatives.

However, caution and scepticism temper this narrative. Interviewees express concerns about the long-term sustainability of economic dependency on a single industry. There is a recognition that while the chemical industry brings financial benefits, it also carries significant environmental and health risks that could undermine other vital sectors, such as agriculture. Informants emphasized the importance of ensuring that economic growth does not come at the expense of public health and environmental quality.

Distrust towards private industry also emerged as a theme in the interviews, with some residents perceiving that companies may prioritize profit over public welfare. This sentiment raises questions about the true cost of economic gains if environmental degradation and health impacts remain unresolved. Additionally, fears were expressed about potential future liabilities associated with industrial waste management, which could impose economic burdens on the community in the long term.

To address these concerns, interviewees proposed diversifying the local economy as a strategy to reduce reliance on Eliksir and enhance regional resilience. This approach would involve fostering investment in alternative industries that align with environmental sustainability and public health priorities. By broadening the economic base, the community could mitigate risks associated with over-dependence on a single industrial player.

Key findings:

- Recognition of Eliksir's role in providing employment and regional economic stability.
- Economic benefits tied to PG reuse and by-product sales.
- Concerns about economic dependency on a single industry and associated risks.
- Distrust of private companies prioritising profit over public welfare.
- Advocacy for economic diversification to reduce dependency and foster resilience.

Proposals

Proposals for improving the management of PG stacks in Prahovo reflect a combination of community concerns and corporate initiatives aimed at addressing environmental, health, and economic challenges. Insights from news articles and interviews suggest that while Eliksir has introduced measures to mitigate risks, residents and stakeholders call for more comprehensive and inclusive approaches to ensure long-term sustainability and trust.

At a corporate level, Eliksir has announced initiatives aimed at improving waste management practices, including the construction of new storage facilities for PG that meet EU standards. These facilities incorporate impermeable liners to prevent groundwater contamination and dust control measures to minimize air quality issues. The company has also implemented recirculation systems to prevent wastewater discharge into the Danube River, addressing one of the community's primary environmental

concerns. Additionally, future investments in infrastructure, such as port improvements, are positioned as steps towards sustainable regional development.

From the community perspective, interviews highlight a range of community-driven suggestions to complement or enhance Elixir's efforts. A recurring theme is the demand for independent and transparent monitoring systems for health and environmental impacts. Regular assessments of air, soil, and water quality, with publicly accessible results, are viewed as essential to rebuilding trust. Informants advocate for involving external environmental and health experts to ensure accountability and objectivity in oversight processes.

Another prominent proposal involves exploring sustainable uses for PG to reduce waste volume and mitigate environmental risks. Suggestions include repurposing PG in construction materials or other industries, provided these applications are thoroughly evaluated for safety. This aligns with broader community interests in balancing economic and environmental goals, turning waste into a potential resource (as FICfighters project aims).

Community members also emphasized the importance of education and public engagement. Proposals include organizing forums where residents can discuss PG management with company and government representatives, as well as educational programs targeting younger generations to raise awareness about environmental issues. The idea of creating a "green chair" within local governance was specifically mentioned as a means to institutionalize environmental advocacy and ensure that community voices are heard in decision-making processes.

The community also proposed diversifying Prahovo's economy to reduce reliance on the chemical industry. By investing in alternative sectors, such as sustainable agriculture or eco-tourism, the region could mitigate the risks associated with dependence on a single industrial player. This approach would not only enhance economic resilience but also address concerns about the potential long-term costs of industrial pollution.

In summary, the proposals underscore a shared vision for improved PG management that prioritizes transparency, sustainability, and community involvement. While Elixir's initiatives address some immediate concerns, residents call for expanded measures that integrate independent oversight, sustainable practices, and proactive community engagement to balance industrial benefits with public welfare.

Key findings:

- Corporate initiatives such as new storage facilities and infrastructure investments.
- Community demand for independent health and environmental monitoring systems.
- Advocacy for sustainable PG reuse in safe industrial applications.
- Proposals for increased public engagement and environmental education.
- Emphasis on economic diversification to reduce dependency on the chemical industry.

5.4. Social Perception of PG Stacks in Croatia

5.4.1. Case study: Kutina

Context

Kutina, a historic town in the Moslavina region of central Croatia, has long been shaped by its industrial roots and connection to the surrounding natural environment. Nestled in a region known for its agricultural and mineral resources, Kutina became a hub of industrial development in the mid-20th century. Central to this transformation was the establishment of Petrokemija, a major producer of mineral fertilizers, which brought economic growth and employment opportunities to the area. However, alongside this industrial legacy, the town also inherited significant environmental challenges, particularly from the production of PG, a by-product of fertilizer manufacturing.

The story of Kutina's PG stacks is closely intertwined with the town's industrial evolution. During its peak production years, Petrokemija generated substantial quantities of PG, which were deposited in large stacks near the facility. While these stacks symbolized industrial progress at the time, they have since become a reminder of the environmental costs of rapid industrialization. Today, these PG stacks remain a prominent feature of Kutina's landscape, posing ongoing challenges for environmental management and community health.

Over the years, the town has grappled with the dual legacy of its industrial past: on one hand, the economic contributions of Petrokemija; on the other, the environmental and social impacts of its by-products. Local residents have voiced concerns about potential contamination of soil, water, and air from the PG stacks, as well as the long-term health implications for the community. The stacks have also influenced the town's economic prospects, with fears of declining property values and limited investment due to the environmental risks associated with industrial waste.

Despite these challenges, Kutina's history offers a foundation for resilience and adaptation. The community has a rich tradition of agricultural innovation and environmental stewardship, which can be leveraged to address the current issues. Proposals for managing the PG stacks include advanced containment technologies, regular environmental monitoring, and stronger community engagement in decision-making processes. These initiatives reflect a growing recognition of the need to balance the town's industrial heritage with sustainable environmental practices.

In the sources analysed, Sisak is frequently mentioned alongside Kutina (which are part of the same region). Located near the confluence of the Sava, Kupa, and Odra rivers, Sisak has been an important industrial centre, particularly in steel production and chemical manufacturing. This legacy has left environmental challenges, including concerns over PG waste. Residents in this region have raised alarms about potential health risks, such as respiratory issues and water contamination, as well as the broader environmental impact of industrial by-products.

This case study delves into the social perception of the PG stacks in Kutina and Croatia, exploring how the town's history shapes its current challenges and opportunities, using primary and secondary sources.



Figure 7. Aerial views of Kutina

Sources of information

The case study on PG in Croatia identified a total of 28 sources, all from news articles. Below is a detailed summary of these findings. While other sources as social media, or public content, were not found the social perception analysis of this case study has been completely based on the media outlet discourse around PG stacks.

News Articles

27 news articles were identified. These articles were associated to two regions:

- Sisak-Moslavina contributed 17 articles, highlighting significant regional reporting on PG-related topics. These articles contained specific information on Kutina as they outlined the regional and local level.
- Zadar contributed one article, indicating limited coverage in this area.
- Country level: 10 articles.

5.4.2. Conclusions

This section analyses the social perception of PG stacks in Croatia across news sources available and themes like community engagement, governance, health concerns, environmental impact, economic implications, and proposals for improvement. The collected data offers a comprehensive view of news discourses around this topic, revealing a strong consensus around the risks and responsibilities associated with PG stack management.

Community engagement

The social perception of PG stacks in Croatia, particularly within communities like Sisak, reflects a growing unease and active public involvement. Local residents are increasingly concerned about the potential hazards of PG, with community representatives and environmental activists pushing for stronger safety measures. News captures this sentiment through coverage of a local council meeting where both officials and residents demanded clear answers and protective actions from government authorities regarding the health and environmental risks associated with nearby PG sites. This scenario highlights that the public does not view the current regulatory measures as sufficient, leading to a sense of urgency and frustration within the community.

The media also depicts community engagement as sporadic, often rallying in response to specific incidents rather than through sustained dialogue. Some news reports on grassroots campaigns and awareness efforts led by local environmental groups. These campaigns are driven by a strong sense of community responsibility and a desire to hold PG producers accountable for the perceived environmental neglect. The public is not only interested in transparency but is actively advocating for increased corporate accountability, signalling a deep-rooted perception that industrial interests are not prioritising community welfare.

Overall, social perception around community engagement is characterised by a demand for transparency, a cautious distrust towards both governmental and corporate entities, and a reactive pattern of activism. The community sees itself as the primary advocate for safety and environmental standards, filling a

perceived gap left by insufficient official action. This reactive mobilisation underscores a social narrative where citizens feel compelled to step in due to a perceived lack of consistent government oversight, making community-led efforts both vital and symbolically significant in the broader debate over PG stack management in Croatia.

Key findings:

- Public distrust: Perception that government and industry lack sufficient action on safety.
- Reactive activism: Community rallies around specific incidents, not through continuous dialogue.
- Demand for transparency: Calls for clearer information and accountability from authorities and companies.
- Local advocacy: Community sees itself as a primary protector of environmental and health standards.
- Grassroots campaigns: Local environmental groups push for awareness and corporate responsibility.

Governance and policies

Public perception of governance and policy regarding PG stacks in Croatia centres on the belief that regulatory actions are predominantly motivated by EU mandates rather than proactive national policies. Some articles report that Petrokemija, a major industrial company in Kutina, faces regulatory pressure to secure a 35-million-euro investment specifically to meet EU environmental standards, suggesting that compliance efforts are often driven by external obligations rather than domestic environmental initiatives. This reliance on EU standards rather than locally driven policy reinforces a social perception that Croatian authorities lack a comprehensive framework to manage industrial waste.

Government funding efforts, such as the 69 million kuna for landfill remediation in Sisak, are frequently seen as temporary responses to public pressure. Data analysed documents this one-time allocation, indicating that stakeholders view such funding as an isolated fix rather than part of a structured, sustainable policy framework. This perception of short-term financial intervention feeds into a broader view that policy action is fragmented, with resources made available only in response to urgent issues rather than as part of an integrated approach to environmental safety.

A lack of transparency around regulatory actions also contributes to public scepticism. Data reflects that residents feel uninformed about government plans for managing PG, with limited details available on specific measures or long-term strategies. This perceived opacity further reinforces doubts about the consistency and accountability of policy actions, leading communities to view governance efforts as reactive and insufficiently committed to public and environmental health.

Key findings:

- EU-driven compliance: Pressure on companies like Petrokemija highlights reliance on EU directives rather than proactive domestic policy.
- Temporary funding: The 69 million kuna allocated to Sisak is perceived as an ad hoc solution rather than sustainable support for landfill management.

- Transparency concerns: Limited public information on policy measures contributes to public distrust, as noted in community reactions.
- Perceived policy fragmentation: Policy responses are seen as piecemeal and reactionary rather than as part of a consistent governance strategy.

Health concerns

Health risks associated with PG stacks are a major source of concern for residents in Croatia, especially those living close to disposal sites. Data analysed highlights local concerns in Sisak, where residents have voiced fears about potential respiratory problems and water contamination, citing the proximity to PG stacks as a possible cause of serious, long-term health issues. This reflects a perception within the community that PG stacks pose an immediate health threat, with pollutants from these sites seen as directly impacting the air and water quality for those nearby.

Although there have been efforts to raise awareness, such as environmental health campaigns, these are viewed as insufficient without comprehensive health assessments. Data shows a recent campaign aimed at educating the public about the health dangers of exposure to PG waste. However, many residents expressed frustration with the campaign, noting that it lacked the in-depth, government-led health impact assessments they believe are necessary to provide meaningful reassurance. This response suggests that while information campaigns are welcomed, they fall short of addressing the community's demand for formal studies and data on health risks.

Furthermore, communication around health risks is often seen as opaque. Articles analysed reported that residents feel they are left in the dark regarding studies or findings on the potential health impacts of PG stacks, which fuels distrust toward both local and national authorities. This perceived lack of transparency, combined with the absence of systematic studies, contributes to a heightened sense of vulnerability among residents, who feel unsupported in their calls for clearer, science-based information on how PG waste may affect their long-term health.

Key findings:

- Respiratory and water safety fears: Concerns over respiratory issues and drinking water contamination from PG pollutants.
- Frustration with awareness efforts: Community views health campaigns as insufficient without formal health assessments.
- Criticism of data opacity: Perceived lack of transparency about health impact findings, increasing public distrust.
- Sense of vulnerability: Absence of conclusive studies contributes to a feeling of health insecurity among residents.

Environmental impact

Environmental impacts from PG stacks in Croatia are widely perceived as severe, particularly regarding risks to soil, water, and air quality. Communities near PG disposal sites express significant concern that these environmental hazards are not adequately managed. Some media highlights fear of groundwater contamination in rural areas around Sisak, where local residents worry that pollutants from PG waste may

seep into aquifers, potentially affecting local water supplies and agriculture. This concern reflects a broader social perception that PG stacks represent an ecological threat, especially in regions where natural resources are vulnerable to industrial pollutants.

Local stakeholders voice dissatisfaction with the containment measures in place. Media reports criticism from residents who argue that inadequate waste containment increases the risk of pollutants spreading into surrounding ecosystems. This perception that the current measures are insufficient underpins a lack of confidence in industrial efforts to safeguard environmental health, with communities feeling that the ecological risks are being downplayed or inadequately addressed.

Public scepticism is further reinforced by the lack of consistent environmental monitoring and reporting. Articles analysed indicate that community members are frustrated by the sporadic nature of government intervention and a perceived lack of commitment to regular environmental assessments around PG sites. The absence of clear, ongoing data on environmental quality has led to a sense of abandonment among residents, who view the government's approach as reactive rather than preventive. Overall, the social perception surrounding PG stacks is characterised by concerns over their environmental impact, a belief in inadequate containment, and frustration over the lack of transparent, systematic environmental oversight.

Key findings:

- Groundwater contamination fears: Concerns in rural areas near Sisak about pollutants reaching aquifers.
- Inadequate containment in Kutina: Criticisms of Petrokemija's containment measures, seen as insufficient for protecting ecosystems.
- Lack of regular monitoring: Perceived absence of consistent environmental assessments around PG sites, contributing to distrust.
- Perception of reactive governance: Communities feel that government actions lack a preventive strategy, leading to frustration and a sense of environmental neglect.

Economic impact

Local government funding, meanwhile, is viewed as intermittent and insufficient for the scale of remediation needed. Articles cover a recent allocation by regional authorities aimed at addressing immediate remediation needs, yet local stakeholders argue that such funds are merely short-term fixes without a stable economic commitment for continuous environmental management. This pattern of sporadic government funding adds to a public belief that financial interventions lack the foresight and commitment required for sustainable waste management.

Beyond the direct costs of remediation, PG stacks pose broader economic risks for surrounding communities. Some articles indicate an inadequate PG management that could lead to decreased property values and deter potential investors, as environmental concerns make affected areas less attractive for development.

Key findings:

- Industrial compliance costs: Petrokemija's 35-million-euro investment requirement underscores financial challenges for companies managing PG waste.

- Intermittent government funding: Regional remediation funds are viewed as short-term responses, lacking stable economic commitment.
- Property and investment risks: Public concerns about potential declines in property value and reduced investment appeal in affected areas.
- Need for sustainable funding strategy: Absence of a long-term economic plan raises doubts about the viability of PG management initiatives.

Proposals

Collected data on proposals for PG stack management in Croatia reveals a mix of suggested policy changes, technical solutions, and community-driven initiatives aimed at addressing the environmental and social challenges posed by these waste sites.

One common proposal is the call for stricter regulations on PG stack containment and ongoing oversight. Environmental groups have advocated for the implementation of more rigorous containment standards to prevent pollutants from leaching into surrounding areas. This push for regulatory tightening highlights a public desire for enhanced protective measures that would align with broader environmental standards.

In addition to policy recommendations, technical solutions are frequently suggested to mitigate PG-related hazards, like modernising containment facilities at sites like Petrokemija in Kutina, including improved lining and filtration systems designed to limit the migration of contaminants into soil and water sources. This technical approach, as advocated by both industrial stakeholders and environmental activists, reflects an understanding that reducing the environmental footprint of PG stacks requires targeted engineering solutions alongside policy reforms.

Community-led initiatives also play a role in the proposals for PG stack management, like the experience of a local campaign where residents called for government-backed health and environmental monitoring around PG sites, aiming to improve transparency and accountability in waste management practices.

Overall, the proposals collected from various sources reveal a combination of technical, regulatory, and community-based approaches that reflect a holistic view of managing PG stacks sustainably. Each proposal underscores the perceived need for a structured, multi-faceted strategy that combines stricter governance, advanced containment technology, and active community participation to address the long-term impacts of PG waste.

Key findings:

- Stricter regulatory standards: Calls for enhanced containment requirements to prevent environmental contamination.
- Technical upgrades: Suggestions for improved lining and filtration systems to control contaminant migration.
- Community oversight: Proposals for regular health assessments and public access to environmental data to improve transparency.
- Integrated management approach: A need for a combined strategy of governance, technology, and community involvement to manage PG stacks effectively.

5.5. Social perception of PG stacks in Romania

5.5.1. Case study: Turnu Magurele

Context

The Turnu Magurele phosphogypsum site is located 5 km from the city of Turnu Magurele, in proximity to the river Danube. The company operating at Turnu Magurele site (S.C. Turnu –S.A.) was a main chemical fertilizer producer for several decades. In 2004, it was privatized as DonauChem S.R.L, experiencing financial problems and several stops and (partial) restarts of activity, finally reaching bankruptcy in 2021. Since then, there have been several attempts to sell the company by the financial liquidator, but they have been unsuccessful (situation in September 2025, the time of data gathering).



Figure 8. Aerial view of Turnu Magurele

The PG stacks occupy an area of approximatively 68,5 ha, representing one of the largest deposits in Romania. The PG originated from the production of chemical fertilizers by a local chemical plant, from the reaction of sulfuric acid with phosphatic rock imported from Kola peninsula and Tunisia. Based on previous environmental assessments, the PG residues were classified as non-hazardous waste.



Figure 9. Turnu Magurele PG stack

However, the site is complex from several points of view. First, the industry that operated on site consisted of several factories, the operation of which produced several types of waste streams (Figure 12). Notably, in addition to PG stacks, there are also stacks of burnt pyrite ash on site (~53 ha, classified as hazardous waste) and calcium carbonate (1.2 ha in 2017, non-hazardous waste).

Additionally, knowledge about the residues in general, and PG stacks in particular, among the population and other local stakeholders, including policy agents, is fragmented. There is also uncertainty, particularly among citizens, about the owner and the surface that the PG stacks occupy. For these reasons, when investigating social perceptions, it is often difficult to disentangle the perception of PG stacks from perceptions of residue stacks in general (incl. pyrite), or the abandoned chemical plant site.

In general, the industrial ecosystem created by the chemical plant was entwined with the socio-economic development of the city (“backbone of the city”), as it provided jobs, contributing to increase in population, city development, living standards, skills and knowledge, and innovation (e.g. valorisation of pyrite ash). Local actors often refer to economic advantages outweighing any disadvantages (e.g., pollution). However, some respondents recall the visible air pollution (smell of gases, smoke, dust) during plant operations, the negative health impact of the plant in this period (e.g., lung cancers) and indicate the waste generated as a negative outcome of industrial activities. Nowadays, the site is seen as degraded because of the plant closure, with land occupied by abandoned buildings and residue stacks.



Figure 10. Ruins of the chemical fertilizer factory at Turnu Magurele

In terms of community assets, findings from interviews and an art residency project in Turnu Magurele reveal some strong aspects, pertaining to social (tight community bounds; resilience); natural (e.g. Danube river); built (renovated port, riverfront); cultural (e.g. Turnu fortress, cathedral, historical heritage); or political capital (e.g., volunteering projects, the Urbanium NGO). The potential to develop leisure spots (beaches, a port), trips to the neighbouring country, small restaurants, short cruises on the Danube, and areas for sports, cultural activities are seen as important assets that can make the city one of the most important tourist cities in the south of the country.

Degraded or weak capitals are also frequently mentioned in interviews, e.g. economic (loss of jobs, poverty); human (aging, decreased population; loss of skills and plant knowledge; gaps in civic, environmental and health education; resignation); natural (urban waste management; degraded nature due to presence of industry on site). The PG stacks and ruins of the old factory represent the connection between the inhabitants, especially those over a certain age, and the past.

Sources of information

The case study is based on sources of information identified in the period June-September 2025, providing qualitative data about the social perception of the PG stacks, and more broadly the residues at Turnu Magurele site or the site itself.

Academic sources

Three academic documents (one scientific article, one PhD and one conference paper) were identified and four grey literature documents (two activity reports from regulator, one presentation from the accredited

radiological expert that assessed radiological risk due to PG stack at Turnu Magurele, and one city hall report from a city in the same county as Turnu Magurele city). Documents focused on the mineralogical content of PG stacks, and the presence of radium-226 as main radionuclide, as well as U-238, and some rare earths; the evaluation of radiological risk for the environment and the population, which is found to be not significant; the variability in Ra-226 content between different PG sites / stacks. Some of the documents refer to potential risks from PG, e.g., if used as a house building material, while another argues that the best management option is encapsulation of PG stacks.

Media

13 sources from digital media were identified. Comments from readers were also included in the analysis. In general, PG stacks at Turnu Magurele site received very little attention in media, which focused more on: the chemical plant (restarting/stopping activities, bankruptcy, attempts to find a buyer, economic losses); social and political issues (e.g. corruption, worker protests for not receiving salaries, the former owner failing to respect environmental commitments) and the hazardous burnt pyrite residues; or the PG site in Bacau, where waste was classified as hazardous and the Ministry of Environment was subject to an infringement procedure from the EU.

Interviews

15 interviews were carried out with representatives of local authorities, teachers in a local secondary school and a local college, employees of a local hospital, citizens (including former employees of the chemical plant or having relatives working in the plant, local tourist guide), a former director of the chemical plant, representatives of a local NGO, the nuclear regulator, and technical experts (geology, radiation measurements). Environmental authorities were also contacted, and discussions regarding an interview are still ongoing. In general, as the social and political issues are intertwined, we also observed some potential participants' reluctance to take part in an interview.

Social media

A social media search was carried out resulting in no hits or not directly relevant. Only one post was deemed more relevant, as it mentioned interest in installing photovoltaics on the stacks. A further search in local Facebook groups resulted in no relevant hits on PG.

Participant observations

A FIC-FIGHTERS team member participated on 31 October 2025 in the public presentation of results from an art residency project in Turnu Magurele with the topic [“Reclaiming Post-Industrial Futures”](#). The project involved various participatory activities with citizens.

5.5.2. Conclusions

Community engagement

Although the industrial site near the Danube River and the plants that it hosted played a key role in the Turnu Magurele community in the past, its current role seems to be rather marginal. Some older inhabitants seem to look at it with some feelings of nostalgia, while for others it plays mostly a role as a historic remnant of industries which provided employment but also negative impacts such as environmental pollution and detrimental health effects. This also means that currently, community engagement on and around the site and the PG stacks is minimal. Recently, a local NGO (Urbanium) which unites various community members

and stakeholders around local development and art projects, organized an art residency of foreign artists, one of which also focused on the industrial character and heritage of the community. This effort also made some of the heritage of the industrial activities more visible and prominent in the city.

The current apparent lack of community engagement around the site and the stacks does not mean that community members and other stakeholders do not see such engagement as a potentially desirable process. First, some respondents indicate that if decisions are taken that could have an environmental impact and hence require authorization, some form of public debate is legally required (cf. environmental impact assessment procedures). This would take, for instance, the form of announcing the potential decision and debating it, e.g., through town hall discussions. Furthermore, interviews also indicated that respondents consider it important that local community members are involved in any (future) initiatives around the site or specifically the management of the stacks. While for some, such involvement is limited to receiving more and/or more adequate information, others argue for a stronger agency also in terms of taking part in decision-making processes. Respondents do see a range of factors that could impact the potential engagement of Turnu Magurele community members in the site and/or stack management. These include (dis)interest in the site and/or the stacks, (a lack of) communication, (a lack of) historic precedents and examples of community engagement, public scepticism/trust, (a lack of) economic incentives, and (a lack of) empowerment.

Several interview participants indicated a lack of (previous) interest in finding out more about the residues left on site. Consequently, all participants argued that more information is needed, although some condition the need for information with the presence of risks (if there are risks, then information is needed).

Governance and policies

Both interviews and media refer to a perceived lack of action and coordination from responsible authorities. Additionally, media articles often refer to the former plant owner's non-compliance with environmental obligations and corruption.

While interview respondents are often uncertain about the decision steps towards the management of the site and its environmental remediation, most recognise that expert evaluations and studies, a concerted and collaborative action by responsible authorities and coordinated information campaigns are needed.

Various key actors are identified, for instance state institutions, notably the Ministry of Environment (seen as key decision maker as regards environmental remediation), National Agency for Environmental Protection, National Institute for Public Health, as well as Ministry of Economy, Digitalization, Entrepreneurship and Tourism through the Mineral Resources Directorate, to coordinate, take responsibility, inform; media, for providing public information; research institutions, to conduct studies on materials, site and options, and informing other actors; NGOs, to inform citizens, organize debates, put pressure; policy makers and regulators, to create legal frameworks (e.g. for the valorisation of PG), decide; local authorities, as involved party (although some seem to be sceptical), the European Union, to put pressure on national actors in order to fulfil environmental obligations; and citizens, to get actively engaged in environmental protection actions.

While some interview respondents express trust in these actors (e.g. local authorities, EU, scientific experts) others express lack of trust in some actors (e.g., authorities, media, the EU). Scepticism and disappointment are also reported by some respondents.

Health concerns

Regarding health concerns, interview respondents linked potential health impacts mostly to the historic operations of the industries on the site. These entailed both direct impacts for the workers (e.g., in the form of industrial accidents such as burns), but also more indirect or long-term impacts for the wider community. Some respondents referred to a heightened number of cancers in the immediate environment of the chemical plants, which were perceived to be linked to industrial pollution during the plant operation. This pollution was experienced, for example, in the form of smog which was affecting the community in the form of smell, irritation, and visible air pollution. Some participants remarked that in general, people immediately connected to the plant did not live to an old age and often died before they were 75 years old.

In terms of current impacts of the PG stacks and other residues, many respondents are uncertain about the potential health effects. It is considered that in contrast to the past, when the pollution of the plant operations was sometimes very visible in the city, the pollution of the stacks is more invisible. For some, this seems to mean that no negative health impacts persist today; they indicate no health concerns related to the PG stacks or residues in general. Nevertheless, others consider that such negative impacts do persist, e.g. due to invisible pollution of the soil and the water or the spread through dust. Others refer to potential accumulation over time, with some interview respondents indicating the need to monitor pollution (including radioactivity) to identify such accumulation in the environment. Overall, a pressing need for more information in the form of studies and research is identified.

Academic documents and reports as well as few media articles mention the evaluation of radiological risk for the environment and the population, which is found to be not significant. However, dose measurements are sometimes contested by readers of the media articles. Some interview participants also refer to the radioactivity in the PG; even when this is deemed low, it still raises concerns. This is mirrored in some technical reports and media articles which refer to potential risks from PG, e.g., if used as a house building material. Interviews revealed ongoing uncertainty among technical experts about how low doses of radioactivity should be communicated to the public. Some misunderstandings were revealed by interviews with citizens, e.g., related to the presence of strontium in the PG residues (it is present as stable strontium, not as a radionuclide).

Finally, the lack of scientific certainty does not impede some interviewees from perceiving a direct negative health impact from the stacks, e.g. for children playing in their vicinity.

In the media articles, when PG is reported together with other residues (notably the burnt pyrite ash), there is more focus on danger to health than in very few media articles which focus only on PG.

Environmental impact

As with health impacts, a distinction can be made between current environmental impacts linked to the presence of PG stacks and other residues on the site, and environmental impacts in the past, which were linked to the operation of the plants on the site. It is perceived that in the past, the site's surroundings suffered negative environmental effects due to the release of harmful pollution during plant operations (e.g., release of sulfuric acid). A recurring example which is mentioned, is the destruction of flower plantations on the Bulgarian shore of the Danube, which according to some could be linked to pollution caused by the chemical plants in Turnu Magurele.

In the present, the PG stacks and other residues are perceived by some to have negative environmental impacts, although the precise effects are not clearly pinpointed. The fact that these materials are still on the site, and are currently perceived to be unmanaged, entails a clear environmental risk for these respondents. Some refer to the absence of vegetation as a sign of pollution. Others, however, are more uncertain, and state that information is currently lacking on the presence and environmental impacts of the remaining PG stacks and residues. Yet another group of interviewees indicate that after the plant stopped operating, the negative environmental impacts have significantly decreased or even disappeared altogether. This is exemplified by references to perceived returns of some birds and animals in the areas around the site and the gradual restoration of vegetation.

Additionally, several interview respondents refer to the current state of the site as abandoned, with buildings in ruins (figure 12 “very large structures, phantasmagorical”), and large volumes of PG (figure 11 “mountains”), occupying a lot of land.

Most respondents indicate that no remediation action has been undertaken; opposite to this is the belief that a cover has been installed on top of the PG stacks.

Economic impact

The economic situation of the city of Turnu Magurele is perceived to be intimately tied to the past operations and current shutdown of the chemical industries on the site. More specifically, it has been argued that the start of the industry brought economic development to the region, by providing jobs, and hence attracting new people to the city and improving the livelihoods of the inhabitants. In the same manner, the closure of the industry for many seemed to have had detrimental effects on the local economy of the city, with rising unemployment numbers and a decreasing number of (particularly young) inhabitants.

The perceived economic impact of the PG stacks is more ambiguous. While numerous respondents do not see any immediate economic impacts, there are some who point to the loss of economic potential that the presence of these materials bring. This is mostly related to the difficulty of developing the area while the stacks are present; they indicate that the land could also be used for other economic purposes, or recreational activities which could further develop the area around the Danube shores. Finally, some see economic opportunities in the potential valorisation of the PG stacks and/or some of the other residues left on the site, although it is also recognized that no concrete plans on what such valorisation could entail seem to exist.

Proposals

Various future options are recognized in interviews and media articles reporting on the PG stacks. Such options are linked to remediation allowing for site revitalization and its further use for tourism, recreation, or other economic activities (e.g. waste processing plant).

While some respondents are hopeful about future site remediation, others are sceptical that anything will happen or consider it highly uncertain. Several potential (barriers) and drivers towards site remediation are highlighted: (lack of) economic development potential; (lack of) knowledge, information and know-how; (lack of) collaboration between various stakeholders, notably policy agents; (lack of) financial and human resources; (lack of) determination and interest; (lack of) pressure/involvement from EU; (lack of) clarity on ownership; (lack of) political decision.

Most participants indicate some form of recycling or valorisation as an important, legitimate or preferable option. To this end, the potential valorisation of materials (e.g. PG) still on site is also indicated as a possibility. Specific drivers for PG valorisation include its contribution to circular economy, the opportunity to learn from other countries' experiences, and a stronger (and dedicated) legislative framework. Specific challenges related to PG valorisation are seen to be the lack of reprocessing capacities; a perceived over-emphasis on radioactivity; or the degradation of materials. Some interview participants question whether PG valorisation would bring important benefits for the local community, given that the site is privately owned; they also mention that valorisation of PG residues offers only a short-term perspective and that there is a need for additional economic activities to ensure the long-term economic development of then city.

Partial preservation of site or industrial elements (preservation of industrial heritage) is also indicated as an option for the future use of the site. In that sense, the buildings remaining from the industrial past are referred to as an asset, that could receive further use, e.g., repurposed as a recreational or creative space for youth or further industrial activities.

Some participants mention past (mostly failed) attempts to valorise the PG, but they are uncertain about it. Such attempts include the use of PG as construction material (project existed for Bacau PG site, but seen as potential also for Turnu Magurele), as fertilizer or as road filling. Covering the site with solar panels, proposed in the past, is not seen by interview respondents as solving the problem.

The participatory activities within the art residency project also revealed a divide between generations in terms of expectations and how they imagine the future. For instance, the older age group still hopes for the city's reindustrialization and potentially the reopening of the factory. This is in contrast with the wishes of the younger people who do not want the plant to reopen. While inhabitants from the older age group just want to have a job, especially those who are close to retirement, and wish to ensure, through the presence of young people, a future for the area, younger inhabitants wish the alignment of Turnu Magurele with the standards of a big city where there is better infrastructure, better connections with the outside world and places for entertainment and recreation.

5.6. Social perception of PG stacks in Spain

5.6.1. Case study: Cartagena

Context

El Hondón area, located at the northern entrance of Cartagena (Murcia, Spain) and close to residential areas, is one of the city's most relevant environmental legacies from the industrial age. For decades, the zone hosted phosphate-processing plants operated first by Potasas y Derivados and later by Ercros. Their activity generated large volumes of phosphogypsum—locally referred to as “yesos de fosfato”—and other industrial by-products such as pyrite cinders and chemically contaminated soils. When the plant ceased operations around 2001, the installations were dismantled, yet the waste deposits and underlying contamination remained entirely in place. This pattern was not unique: neighbouring industrial sites such as Zincsa and Peñarroya followed similar trajectories, leaving behind an extensive contaminated corridor at the city's threshold.



Figure 11. Aerial view of El Hondón (Cartagena, Spain)

Over the last twenty-five years, Cartagena’s authorities, the Regional Government of Murcia, Ercros and local residents have engaged in several waves of planning and negotiation to address the environmental and social consequences of abandonment. Initial remediation strategies relied heavily on real-estate development as a financing mechanism, tying clean up to the construction of a large residential district. When this model collapsed during the economic crisis, further technical studies were commissioned—particularly by the Technical University of Cartagena (UPCT)—to reassess the composition, risks and possible treatment of the residues. New technical studies were commissioned, in particular from the Polytechnic University of Cartagena (UPCT), to reassess the composition, risks and possible treatment of the waste. Alongside the technical studies, these years have been marked by political disagreement and community mobilisation.

In 2019, the Region of Murcia formally declared El Hondón a contaminated soil, establishing official responsibility for remediation and triggering both administrative and judicial processes involving Ercros. More recently, in early 2024, the Spanish radioactive-waste agency ENRESA removed a limited volume of the most radioactive phosphogypsum for disposal at the national El Cabril repository, drawing new public attention to the unresolved status of the site. Today, El Hondón remains the object of different remediation proposals: the one proposed by the company based on *in situ* remediation, and the one defended by the Regional and local administrations that advocate for the removal of the deposit.

Sources of information

The case study on PG in Cartagena identified a total of **59 sources**, distributed across three categories: interviews, news articles, and social media content. These sources reflect a long-standing public, institutional, and media interest in the El Hondón site and its associated phosphogypsum deposits. Below is a detailed summary of these findings.

Interviews

Three interviews were conducted for this case study. These interviews involved local institutional and expert stakeholders with direct knowledge of the El Hondón site and its regulatory, environmental, and social context. The interviews provided in-depth qualitative insights into the historical evolution of the site, the roles of different administrative actors, the interaction with affected communities, and the range of remediation proposals discussed over time.

Media articles

A total of 52 news articles were identified, making this the most significant source of information for the Cartagena case. These articles span local, regional, and even national media outlets and cover a wide range of issues related to the phosphogypsum deposits and contaminated soils in El Hondón. Media articles cover a wide geographical site, with its epicentre in Cartagena:

- **Cartagena (Murcia)** constitutes the core geographic focus of the news coverage, with repeated references to the El Hondón area and neighbouring districts affected by contamination or urban development projects (Torreciega, Los Mateos, Media Legua, Sector Estación, San Ginés, Santa Lucía and Escombreras).
- **Regional context (Sierra Minera–Mar Menor)** appears frequently in the articles, linking the Cartagena case to nearby municipalities and environmental hotspots such as La Unión, Llano del Beal, Portmán Bay and the Mar Menor.
- **National level** references are present in relation to other Spanish sites with anthropogenic radioactivity or phosphogypsum deposits (e.g. Palomares, Huelva, Flix, Jarama riverbanks), mainly for comparative or contextual purposes.

Social media

A social media search was carried out resulting in four social media posts identified, all originating from the platform X (formerly Twitter). These posts primarily reflect reactions to recent institutional actions, judicial decisions, or media reports related to El Hondón. While limited in number compared to news coverage, social media content provides additional insight into moments of heightened public attention and serves as an indicator of how the issue circulates in more informal public discourse.

5.6.2. Conclusions

This section analyses the social perception of PG stacks in Cartagena across news sources available and themes like community engagement, governance, health concerns, environmental impact, economic implications, and proposals for improvement.

Community engagement

Community engagement around El Hondón remains socially uneven and internally fragmented. Mobilisation has been mainly led by neighbourhood associations from the districts closest to the site, particularly Sector Estación, Torreciega and Los Mateos, where the residents perceive themselves as directly exposed to contamination risks. These associations have articulated concerns for years through public meetings, media interventions, administrative complaints and judicial actions, becoming the main civic interlocutors in the conflict.

The social profile of the most active participants is relatively homogeneous. Engagement is driven mainly by older residents and retirees, many of whom previously worked in the industrial facilities that generated the phosphogypsum and other residues. Their mobilisation is rooted in personal experience and long-term territorial attachment, combining health-related anxieties with deep mistrust toward public institutions. By contrast, younger residents and immigrant populations living in the same neighbourhoods remain largely disengaged from the issue, either because they are less informed, feel less connected to the industrial past of the area, or prioritise more immediate socio-economic concerns.

Community engagement has also been shaped by internal divisions. Interviews point to a rupture within the neighbourhood movement following the creation of a specific federation focused on heavy-metal contamination (FAVEZIP). This process introduced a more polarised dynamic, separating traditional neighbourhood associations from a more confrontational platform centred on environmental health claims. These tensions have limited the emergence of a unified civic front and have contributed to a fragmented representation of community interests.

Furthermore, a distinctive feature of the Cartagena case is the prominent role of an external technical advisor in sustaining mobilisation. Thus, an independent researcher has become a central reference for neighbourhood associations and local media, acting as a key provider of technical interpretations and a critical counterweight to official narratives. Despite controversies surrounding his academic profile, residents grant him high credibility, often relying on his assessments to frame legal actions and public demands. In parallel, the company Ercros has attempted to shape community perceptions through professional communication strategies aimed at generating acceptance for its in situ remediation proposal.

However, environmental NGOs have played a comparatively marginal role, as they have prioritised other regional environmental conflicts—particularly the Mar Menor—leaving El Hondón largely outside their main agendas. As a result, community engagement has remained centred on neighbourhood organisations rather than broader environmental coalitions.

Although the number of actively involved residents is limited, these groups have had a significant impact on the public agenda. Through sustained pressure, extensive legal complaints against urban development

projects on allegedly contaminated soils, and repeated denunciations of administrative inaction, they have positioned themselves as unavoidable stakeholders in the remediation debate. Social media discourse reinforces this pattern, expressing feelings of exclusion, fatigue and abandonment, as well as frustration at being labelled “alarmist” when raising concerns about cancer risks or radioactive exposure.

At present, organised residents tend to adopt a pragmatic stance. While distrust toward institutions remains high, there is a clear preference for remediation options capable of delivering visible and effective results within a realistic timeframe. Many favour solutions that would allow El Hondón to be transformed into a green or public-service space, provided that contamination risks are credibly addressed and long-term monitoring and institutional accountability are ensured.



Figure 12. Landscape at El Hondón (Cartagena, Spain)

Governance and policies

The sources show that governance arrangements around El Hondón are perceived as legally uncertain, constantly shifting around different policy models, and also they show a persistent view of conflict between administrative levels. For much of the post-industrial period, the site has existed in what many stakeholders describe as a form of regulatory limbo, particularly regarding the management of radiologically contaminated soils. Although the Spanish Nuclear Safety Council (CSN) has been aware of the presence of radioactive materials at El Hondón for years, the site was not formally classified as contaminated until relatively recently. This delay is linked to the absence of a specific and updated regulatory framework addressing soils affected by technologically enhanced natural radioactivity.

According to some sources, existing legislation—most notably the Nuclear Energy Act of 1964—is widely regarded as obsolete, and its reform has been repeatedly postponed at national level. In practice, this has led the CSN to operate on a case-by-case basis, intervening primarily when risks are considered imminent, a situation that has contributed to perceptions of institutional passivity.

Policy approaches to El Hondón have evolved through two markedly different phases. In the years following the closure of the industrial facilities (2001–2015), governance relied on an urban-development model. Remediation was tied to a large residential project whose expected capital gains were meant to finance the excavation and transfer of contaminated materials to an external landfill site. This model ultimately collapsed due to the real-estate crisis, administrative inertia and strong opposition from neighbouring municipalities such as La Unión, which rejected hosting the waste. As a result, remediation remained largely stalled for more than a decade.

A second phase began in 2019, when the Regional Government of Murcia formally declared El Hondón a contaminated soil. This decision represented a significant shift in governance, moving from a voluntary and market-dependent approach to one based on legal obligation and regulatory enforcement. The declaration clarified responsibilities by identifying Ercros as the primary party responsible for remediation, while assigning subsidiary responsibility to the City of Cartagena and other landowners should the company fail to act. This new framework, however, also triggered the judicialisation of the process, with Ercros challenging administrative decisions and extending the conflict into the courts.

Institutional relations throughout this period have been characterised by tensions and mutual deflection of responsibility. Sources describe a recurring pattern in which the regional administration points to the lack of state-level regulation, while the City Council refers technical responsibility back to the regional environmental authority. From the perspective of neighbourhood associations, this dynamic is perceived as a failure of leadership, with local authorities seen as aligning with regional positions rather than actively defending residents' health and environmental concerns. The intervention of the “Defensor del Pueblo” has reinforced this critique, highlighting the prolonged lack of response to recommendations on decontamination and warning of potential political and technical responsibilities arising from accumulated delays.

Currently, the conflict centres on the application of the “polluter pays” principle and on how remediation should be executed. Ercros submitted a project based on in situ confinement and capping of the residues using engineered barriers. While the CSN considered the proposal acceptable from a radiological perspective the Regional Government rejected it as environmentally and technically insufficient. According to the sources, the plan was seen as a minimum-cost solution that would severely limit future land uses, preventing vegetation, public facilities or infrastructure development. In response, the regional administration has announced its intention to carry out remediation subsidiarily, potentially using public and European funds and later reclaiming the costs from the company. However, the absence of a fully defined technical project and the expected duration of administrative procedures—estimated at several additional years—continue to generate uncertainty.

Another important aspect around governance and policies is the critics for lack of transparency and limited participatory openness. Neighbourhood groups report difficulties in accessing urban-planning and environmental documentation related to contaminated areas such as Los Mateos, citing unanswered requests and administrative silence. Some sources also point to the fragmentation of projects into phases

as a strategy to avoid comprehensive environmental impact assessments. Interviews suggest that this opacity is partly driven by political caution, with authorities seeking to avoid opening parallel debates with civil society in a context already heavily judicialised. As a result, governance of El Hondón remains defined by procedural complexity, legal conflict and low levels of public trust.

Health concerns

Health concerns represent the most emotionally charged and conflictive dimension of social perception around phosphogypsum in Cartagena. At the centre of community concern is a perceived direct association between the contaminated soils and serious illnesses, particularly cancer. Neighbours frequently link the presence of residues to lung and laryngeal cancer, as well as to cardiopulmonary diseases. In social media and local discourse, claims circulate that cancer incidence rates in Cartagena are higher than in other regions, such as Galicia or Asturias. Experts interviewed note that social narratives often merge different types of cancer and health conditions without distinguishing between environmental, occupational or endocrine origins, yet these perceptions remain powerful drivers of anxiety and mobilisation.

Residents consistently identify airborne dispersion as the primary threat of exposure pathways, rather than direct contact with contaminated soils. El Hondón is perceived as a primary source of dust containing heavy metals and radioactive particles that get distributed by the wind over several kilometres, residents in the area claim that these particles can reach homes, schools and public spaces. Containment measures are generally seen as insufficient.

Institutional risk framing and community perceptions consistently disagree regarding the exposure to radioactivity in the area. From the perspective of the CSN, the main radiological concern associated with phosphogypsum is the emission of radon gas. Official assessments indicate that, under current conditions and provided that materials remain undisturbed, radon disperses in the atmosphere without posing a significant radiological risk to the general population. By contrast, residents do not differentiate between radionuclides or exposure mechanisms. Radioactivity is perceived as a generalised and immediate threat linked to uranium-238 and ionising radiation, with fears centred on cellular damage and long-term health consequences.

Medical treatment and monitoring are exposed as direct consequences of the exposure of heavy metals. Sources document that at least 17 families are under medical monitoring due to blood lead levels exceeding 3.5 mg/dl. Reports also refer to the presence of arsenic, cadmium, zinc and mercury in urban and peri-urban environments. These risks are further amplified by allegations of contamination of agricultural products—such as broccoli and lettuce—grown in areas influenced by the Sierra Minera, raising fears about impacts on the food chain.

The emotional climate surrounding health risks is frequently described as one of fear, particularly following proposals to build social housing on soils containing industrial residues. Neighbourhood groups argue that public authorities tend to minimise health implications, treating contaminated soil as an administrative inconvenience rather than as a public health issue requiring urgent and transparent intervention. This perception of downplayed risk and insufficient communication has reinforced distrust in institutions.

The removal in 2024 of the most radioactive fraction of phosphogypsum by ENRESA has played a symbolic role in consolidating these concerns. Although the volume involved was limited and the operation targeted specific materials exceeding regulatory thresholds, it publicly confirmed the presence of residues requiring specialised management. As a result, perceived health risks continue to play a central role in community mobilisation, even as official assessments emphasise differentiated and context-dependent levels of risk.

Environmental impacts

Environmental impacts associated with phosphogypsum in Cartagena are described in the sources as a case of systemic and long-term degradation rather than as an isolated waste deposit. When contamination is referred, it involves the coexistence of PG with other substances: in addition to PG, the area contains pyrite cinders and residues from metallurgical and chemical processes accumulated over decades. The sources confirm the presence of uranium-238, which lead the CSN to include El Hondón among the limited number of locations in Spain affected by anthropogenic radioactivity. In nearby sites linked to the former Zinsa plant, soils are described by experts as having absorbed contamination to the point of functioning as a “sponge” of industrial pollutants.

As mentioned previously, air mobility of contaminants remains a major concern, both in health and in environment. The stacks are perceived as ongoing sources of toxic dust, with wind-driven dispersion identified as a key pathway for spreading heavy metals and radioactive particles. This concern has led to precautionary measures in nearby facilities, including the impermeabilisation of school playgrounds to reduce children’s exposure to particles carried by wind and rain.

Water contamination constitutes another critical dimension of environmental impact. Sources describe persistent risks of leaching from highly acidic residues, with the potential to reach groundwater and surface waters. The Segura River Basin Authority (CHS) has warned of the high permeability of parcels within El Hondón, which are located in an area of significant vulnerability for the Quaternary aquifer. Inspections by environmental enforcement bodies have documented ponds with intensely coloured, acidic waters and strong chemical odours, reinforcing concerns about uncontrolled seepage toward surrounding water bodies, including the port area and, indirectly, the Mar Menor.

The impact on biodiversity is also documented, especially the contact between wildlife and contaminated liquids, which has been linked to the death of protected bird species. Beyond direct mortality, researchers and local actors express concern about broader ecological effects, particularly the potential transfer of heavy metals from contaminated soils into agricultural products and, ultimately, into the food chain.

Environmental degradation at El Hondón also has a strong visual and symbolic dimension as the deterioration and external image of the area’s landscape. As the stack is located close to one of the main entrances to Cartagena, the image of the city may be affected as it is already described as “dystopian”. This degraded environment is perceived as incompatible with the city’s cultural, residential and touristic ambitions, and is often cited as tangible evidence of an extractive and unsustainable industrial development model that has transferred environmental costs to future generations.

Economic impacts

According to the sources, contamination at El Hondón has generated long-term constraints on urban development, financial risks for both private and public actors, and broader effects on the city's image and productive sectors. The urban growth is marked as one of the most significant economic impacts, especially toward the eastern edge of the city where affected soils act as a physical and legal barrier preventing urban expansion of residential areas and public facilities. As heavy metals and PG were found, projects of social housing were halted, for example.

This situation has created legal uncertainty for investors and public authorities alike, compounded by complex property trajectories involving failed developers, financial institutions and asset management companies. The resulting ambiguity over ownership and responsibility has discouraged private investment and delayed any form of redevelopment.

The afore mentioned presence of large contaminated areas at one of the main entrances to Cartagena also affects the city's tourism strategy. Sources frequently highlight the contrast between the degraded landscape of El Hondón and efforts by the local tourism sector to promote Cartagena as a destination based on cultural heritage and high-quality experiences. The visual impact of waste deposits and abandoned industrial land along the A-30 motorway is perceived as damaging to the city's image, undermining local pride and raising concerns about reputational harm in a competitive tourism market.

On another side, remediation costs themselves represent a major economic burden as it is estimated that around €20 million are invested to clean heavy-metals and PG in the area. At the same time, neighbourhood groups express strong opposition to scenarios in which public authorities acquire contaminated land, fearing that this would effectively transfer private liabilities to municipal budgets and ultimately to taxpayers.

Beyond the urban context, sources also point to potential economic impacts on the agricultural sector. Although contamination is concentrated in industrial and peri-urban areas, public allegations regarding heavy metals in soils raise concerns about the reputation and marketability of agricultural products from surrounding zones. Crops such as broccoli, lettuce and coriander are mentioned as vulnerable to reputational damage in international markets if food safety is called into question.

Proposals

Over the years, proposals to address phosphogypsum and heavy metal contamination at El Hondón have evolved through several major phases, reflecting changing regulatory frameworks, economic constraints and levels of institutional involvement:

- Urban-development-driven removal (early 2000s): The earliest proposals linked remediation to large-scale residential development. Full excavation of contaminated soils and residues was planned, with external disposal in an engineered landfill outside Cartagena. The model relied on real-estate capital gains to finance clean-up. This approach ultimately failed due to the real-estate crisis, administrative delays and opposition from neighbouring municipalities designated to host the waste.

- In-situ engineered confinement options (academic and technical proposals): Studies developed by the Polytechnic University of Cartagena (UPCT) and independent experts explored containment solutions within the boundaries of El Hondón. These proposals aimed to immobilise contaminants on site, reducing transport needs and costs. Suggested measures included multilayer capping systems, use of impermeable substrates, engineered “technosols” to stabilise surfaces and manage runoff, and combinations of physical and chemical treatments to limit the mobility of heavy metals.
- Ercros’ in-situ sealing and capping project: The Spanish Nuclear Safety Council issued a favourable radiological assessment to Ercros’ proposal, subject to radon control and long-term monitoring. The company actively promoted the proposal among neighbourhood associations through communication and legal advisory strategies, presenting it as the fastest and least disruptive option to reduce airborne dispersion. In 2024, however, the Regional Government rejected the project, considering it a minimum-cost solution that limited future land uses and failed to address large areas contaminated by heavy metals.
- Subsidiary execution by the Regional Government: Following the rejection of Ercros’ proposal, the Region of Murcia announced its intention to assume remediation through subsidiary execution. This approach would involve public leadership of the technical project, potentially supported by European funds, with subsequent recovery of costs from the company under the “polluter pays” principle. While marking a shift toward stronger public intervention, this option remains at an early stage, with several additional years anticipated for project design, administrative processing and implementation.
- Scientific and bioremediation-oriented approaches: More recently, the regional administration has incorporated expertise from the CSIC to explore bioremediation techniques and to develop a longer-term scientific roadmap for the 108-hectare site. These approaches are presented as complementary to physical containment or removal strategies rather than as standalone solutions.
- Post-remediation land-use proposals: Various future uses have been discussed once contamination is addressed. Neighbourhood groups frequently express a preference for transforming El Hondón into a large green area or urban forest as a form of environmental and symbolic compensation. Other proposals include renewable-energy installations in areas unsuitable for residential use. Previous plans for social housing on adjacent plots remain suspended due to contamination concerns and ongoing legal disputes.
- Immediate precautionary measures: Alongside long-term proposals, environmental organisations and neighbourhood associations call for urgent actions to reduce current risks. These include effective perimeter fencing and surveillance, protection of sensitive environments such as school playgrounds, and emergency interventions in the most critical hotspots—particularly former industrial basins at risk of overflow during heavy rainfall.

6. Analysis at European and international level

6.1. Introduction

This section contains the conclusions extracted mainly from the literature review. The analysis is presented in the same 5 categories used in the case studies: community engagement, governance and policies, health concerns, environmental and economic impacts, and management proposals. It draws on academic articles and documented experiences in affected regions with an international scope.

A preliminary conceptual introduction is often presented to frame the conclusions regarding PG perception. PG is an industrial by-product primarily composed of gypsum, created during the production of phosphoric acid in phosphate fertilizer production. It presents significant management challenges due to its chemical and radiological composition, including trace amounts of radioactive elements like radium-226 and heavy metals, which can affect both human and ecosystem health. It is known for containing naturally occurring radioactive materials (NORMs) and requires careful handling.

In some areas, PG is typically stored in large stacks, often in open, uncovered areas, which presents additional risks. Examples from industrial sites illustrate that this method of storage can lead to radon emission into the surrounding atmosphere and leaching of contaminants into local water sources. Communities located near PG stacks, particularly in regions where regulatory standards may be less stringent, face ongoing exposure risks, albeit indirectly. Managing these residues has thus become not only a technical challenge but also a social one, requiring careful engagement with the local community.

6.2. Main insights

6.2.1. Community engagement

Public perception and community engagement is crucial in PG management, particularly in impacted communities where these stacks are a visible and persistent issue. Some residents express concerns about health and environmental risks, while others criticize the lack of effective solutions. Community organizations have led a variety of protests across different affected sites, demanding greater transparency and involvement in decision-making. Field studies reveal a collective petition for more inclusive governance approaches, where authorities and industries actively collaborate with the community to develop safe and practical solutions.

In response to community concerns, experts and government bodies have proposed several remediation strategies. These include containment, removal, and transformation of the PG, each with its own set of risks and benefits. However, effectively communicating these options to the community has proven challenging. Workshops and interviews with local stakeholders have aimed to clarify remediation goals and gather public input, but differences in understanding and priorities persist.

Moreover, studies have shown that the community's concerns are often intensified by the lack of consistent information on the radiological and chemical properties of PG. Local communities show distrust in regulatory bodies due to perceived gaps in communication, which has resulted in public pressure for clearer, more transparent data. Engagement workshops and participatory meetings with different approaches (e.g. participatory Multi-Criteria Decision Analysis (MCDA) in the case of Ría de

Huelva, the largest PG stack in Spain) have been implemented in some regions, allowing residents, industry representatives, and officials to discuss priorities openly.

These initiatives also highlight the challenge of aligning scientific and technical language with community understanding. A significant barrier to effective community engagement has been the complex and sometimes technical nature of PG management. Many residents are unfamiliar with the scientific aspects of remediation, leading to misunderstandings and a sense of exclusion, underscoring the need for communication strategies that simplify complex information while maintaining accuracy.

Political differences have also influenced community engagement in some cases. For example, polarized opinions about responsibility and acceptable remediation standards have stalled consensus. This politicization underscores the need for transparent communication strategies that emphasize shared goals and clear timelines.

6.2.2. Governance and policies

A crucial step in managing PG has been categorizing it within existing waste frameworks. PG disposal typically involves addressing both chemical and radiological risks, given its unique composition. According to various assessments, the radioactivity levels in certain disposal sites are considered within acceptable limits, though this is not universally the case.

PG regulation faces challenges due to its classification as a Naturally Occurring Radioactive Material (NORM), which requires strict documentation and monitoring.

In Europe, the lack of harmonized regulations has resulted in inconsistent practices across jurisdictions, complicating industry efforts and generating public uncertainty.

In some cases, local authorities have initiated projects to manage these deposits, yet the absence of a cohesive national framework complicates effective implementation. Coordination issues between local, regional, and national authorities have sometimes hampered the decision-making process, creating further public disillusionment.

In response, collaborative approaches have been proposed, integrating local-regional authorities, environmental/radiological (national) agencies, academia experts and community representatives to align management standards with societal expectations.

One significant regulatory challenge involves balancing local and international standards on radioactive waste. Some countries employ stricter limits on PG applications due to variations in national regulations, which results in discrepancies in waste handling and reuse practices.

The International Atomic Energy Agency (IAEA) has been involved in assessing radiation levels and developing guidelines to harmonize these standards. Despite these efforts, national and regional differences persist, such as distinct thresholds for radon emissions in building materials, complicating broader regulatory coherence. Increased international collaboration on standard-setting could aid in establishing more consistent PG handling practices, easing compliance and improving community trust.

The governance and policies around PG disposal reveal a complex landscape of regulatory challenges, public concerns, and collaborative opportunities. Effective management requires not only technical oversight but also active engagement with affected communities and stakeholders. Moving forward, the establishment of more consistent regulatory frameworks and clearer guidelines on safe disposal practices will be essential in balancing environmental protection with sustainable development goals.

6.2.3. Health concerns

One of the primary health concerns surrounding PG is its radioactivity. As noted in various studies, PG contains radium-226, a naturally occurring radioactive material that emits radon gas as it decays. Radon is a well-documented health hazard, particularly for lung cancer, when inhaled over extended periods. People exposed to high levels of radon, especially in confined spaces, are at a greater risk of developing respiratory issues.

Given that radium has a long half-life, it poses enduring risks to both current and future generations in affected areas. This situation exemplifies the necessity for effective containment and the environmental monitoring of PG sites to prevent both immediate and cumulative health impacts.

Additionally, PG contains heavy metals, such as arsenic, which can leach into soil and groundwater, impacting human health and nearby ecosystems. Studies conducted at industrial facilities have documented radon and other contaminants in the air and water surrounding PG stacks, underscoring the importance of effective containment and safe storage practices to protect public health.

Therefore, beyond radon exposure, PG also introduces risks from heavy metals and other toxic elements. Research has documented the presence of metals like lead and cadmium in groundwater near storage sites, especially in regions lacking robust containment measures.

These metals can bioaccumulate in local fauna and flora, potentially entering the food chain and increasing health risks for nearby populations. Studies emphasize that populations near PG stacks are not only exposed to radiation but also face risks from these contaminants, raising concerns about long-term health outcomes. Therefore, stricter monitoring and containment policies are recommended to prevent environmental transfer and minimize exposure to hazardous substances.

6.2.4. Environmental impact

The environmental impact of PG is well-documented. Its storage in large, open stacks facilitates the leaching of heavy metals and radioactive elements into nearby soil and water bodies. Case studies from various facilities show how these contaminants can accumulate in surrounding ecosystems, affecting biodiversity and posing risks to nearby communities. A leaching study documented variations in pH and sulphate concentrations under different exposure scenarios, highlighting contamination patterns that demand regulatory attention to protect natural resources.

Additionally, microbial interactions with PG contaminants have been explored as a factor in environmental impact. For instance, certain bacteria can either exacerbate or mitigate contamination by interacting with heavy metals, influencing their mobility and bioavailability. In regions where PG is exposed to natural elements, these microbial processes could amplify contamination risks, particularly in water bodies adjacent to storage sites.

Given the risks associated with PG, several approaches have been explored to mitigate its environmental impact. Some research suggests the use of microorganisms to stabilize or even detoxify PG waste. Valls and de Lorenzo discuss how certain bacteria can transform toxic elements in the PG, reducing their bioavailability and, by extension, the risk to ecosystems. However, these bioremediation strategies are still in the experimental phase and require further research to assess their feasibility on a larger scale.

Studies also point to soil degradation and altered nutrient balances due to the presence of PG stacks, with adverse effects on local flora and fauna. These findings underline the importance of developing advanced containment strategies and exploring bioremediation as a potential tool for environmental management.

6.2.5. Economic Impact

PG offers potential economic benefits if repurposed safely. Its use in construction materials, such as cement and plaster, and as a soil amendment in agriculture presents an opportunity to reduce disposal costs. However, this reuse must be carefully managed due to the before-mentioned presence of radioactive and toxic elements. Countries like Brazil and Tunisia have documented economic benefits from repurposing PG for local applications, but they also caution about the need for stringent regulations to avoid long-term adverse effects.

In addition to construction and agriculture, PG has potential applications in water purification and environmental remediation. For example, certain studies indicate that it can be effective in absorbing heavy metals, making it a cost-efficient material for water treatment in industrial areas. Utilizing PG for such purposes could present dual benefits: addressing pollution and reducing waste management costs.

However, its use in these applications requires careful evaluation of radiological safety and comprehensive guidelines to ensure that reapplication does not introduce new environmental or health risks. As industries explore the economic viability of PG reuse, balancing cost savings with safety remains a critical concern.

6.2.6. Management proposals

Current proposals for sustainable PG management include bioremediation and reuse in construction. Research suggests that certain microorganisms can reduce PG toxicity by stabilizing or transforming hazardous elements, although this technique remains experimental. Additionally, developing composite materials based on PG is a promising alternative.

However, a comparative cost study on PG treatment underscores that these proposals require significant investment and strict quality controls to be feasible in the long term.

Another promising area of research involves transforming PG into a stable, low-risk material through chemical treatments. Studies have tested the effectiveness of adding stabilizing agents, such as calcium and silica, to reduce PG leachability and radioactivity. While some chemical stabilization methods have shown positive results in small-scale experiments, scalability remains a challenge. The costs and technical complexity of these methods can be prohibitive, suggesting the need for further innovation and investment (FICfighters' goals). Implementing large-scale stabilization could make PG more viable for broader industrial applications, potentially enabling safer reuse and reducing environmental burdens.

PG presents both a challenge and an opportunity. While there are still obstacles to overcome, ongoing research and proposal development continue to provide insights into safe and effective ways to handle this by-product. Through careful management and innovative applications, PG might eventually transition from a waste product to a valuable industrial resource, contributing to more sustainable industrial practices.

7. Conclusions

The analysis of social perception of PG stacks conducted for this deliverable D5.1 in the framework of the FICFighters project reveals multifaceted views shaped by public discourses. While data collection has shown great disparities among the different selected sources as well as among case studies, the thematic analysis of the content retrieved has probed to contain general lines of perception specifically linking PG stacks to environmental and health challenges.

The first stage of data collection revealed that discussions around PG stacks and PG in general, were mainly held through news outlets and social media. Although the number of sources identified show significant disparities among case studies, as for example the cases of Serbia and Portugal, where both social media and news articles displayed fewer conversations being held rather than cases as Cartagena, that stood out by a more intensive discourse held on media, both local, regional and national digital press, as well as in Veles (North Macedonia), where this topic was actively discussed, while social media remained unaccounted for with no posts related to the relevant topics.

Academic articles and publications, although analysed in a wider European level, provided key information on social perception among different stakeholders and the scholarly community, as well as research proven insights on perception around PG stacks specifically concerning environment and health challenges. However, other sources explored in wider levels as the online public content and official reports, were scarce, with few being retrieved.

Although disparities were at hand at data collection, the second stage involving thematic analysis and qualitative interpretation of the contents revealed certain key convergence points among all case studies. The retrieved content analysed showed the feeling of concern through the discourses, as identified as words as “risk”, “contaminated” and “pollution” were linked to those of “PG”, “health”, “community”, “waste”, or “soil” and “water”. Furthermore, the in-depth thematic analysis held by the different categories built using quantitative term frequency methods and coding through software as Atlas.ti. The analysis through these categories revealed recurring themes across case studies, despite variations in the intensity and focus of public discourse.

The results of this analysis showed a significant level of concern around the environmental risks associated with PG stacks, with discussions frequently highlighting contamination of soil, water, and air across case studies and wider perspectives. These concerns are amplified by the perceived inadequacy of monitoring systems and inconsistent regulatory enforcement, which fuel distrust in governance structures. These narratives resonate across all case studies, though they manifest differently; for instance, Cartagena demonstrates a robust discourse linking PG stacks to soil contamination, while Prahovo, Turnu Magurele and Barreiro show more subdued discussions, referring to general industrial impacts.

Health concerns also featured prominently among sources. Particularly health concerns circled fears about respiratory illnesses, toxic exposure, and the long-term health implications of living near PG stacks. These worries are exacerbated by a lack of comprehensive health impact assessments, leaving communities feeling vulnerable and unsupported. Economic perceptions add complexity to these discussions, as many regions grapple with the dual narrative of industrial dependency and the long-term costs of environmental degradation. While regions like Kutina, Prahovo, Turnu Magurele and Barreiro acknowledge the historical economic contributions of PG-related industries, they also recognise the pressing need for sustainable economic alternatives to mitigate the adverse effects on community well-being and future development.

Despite these challenges, the proposals derived from the study suggest different pathways for addressing these intersecting concerns. Across all case studies, stakeholders advocate for integrated solutions that harmonise environmental, health, and economic priorities within a robust governance framework. This includes the implementation of transparent environmental monitoring systems, stronger accountability mechanisms, and participatory decision-making processes that actively involve affected communities. While the specific recommendations vary to suit local contexts, the overarching demand is clear: a cohesive and inclusive approach is essential to balance industrial legacies with sustainable development, ensuring equitable outcomes for all stakeholders.

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Appendix 1. Social Perception of PG stacks in Venice (Italy) and Łąka (Poland)

The case studies in Venice (Italy) and Łąka, Bolestawca (Poland) were initially part of the FICfighters project but they withdrew from the project for different reasons. The texts analysing both case studies are included below (included in the first version of 2024), while this updated version includes those from Turnu Magurele (Romania) and Cartagena (Spain).

A) Case study of Venice

Context

Port Marghera and the nearby Campalto area, part of the municipality of Venice in Italy, represent significant case studies in Europe regarding the PG stacks management challenges. Located at the gateway between Venice and Mestre, close to the Liberty Bridge that leads to Venice, two sensitive sites can be found: Pili area, a site of historical industrial activity, and Passo a Campalto area (by San Giuliano Park). Both have accumulated a legacy of contamination, particularly from PG from the 1970s.

Pili area, spanning 42 hectares, was acquired in 2006 by Porta di Venezia, a company owned by the current mayor of Venice, Luigi Brugnaro. However, despite its strategic location, the site remains heavily polluted, containing radioactive PG and other industrial residues.

Two main approaches have been proposed for the area:

1. Industrial perspective: some actors, such as The Filctem-CGIL union believes the area should remain industrial to preserve jobs and continue reindustrialization efforts in Marghera, exemplified by Eni's investments in converting its refinery into a biorefinery to produce fewer polluting biofuels, considered a national model for industrial revitalization.

2. Urban regeneration and lucrative perspective (commercial and recreational facilities area):

Brugnaro has proposed converting the area into a sports and entertainment hub, including a sports arena, restaurants, and shopping centres. Other foreign investment proposal (Kwong) aims to transform the Pili area into a tourist and commercial destination, including a sports complex designed to attract thousands of visitors, a casino, and luxury waterfront villas in a new residential neighbourhood. However, these development plans face significant criticisms:

- The landfill within the area contains 380,000 cubic meters of industrial waste, including PG, which remains unsafe and non-compliant with environmental laws.
- The proximity of these developments to fuel tanks, the biorefinery, and hazardous industrial sites raises concerns about public safety and potential accidents.
- The high costs and complexity of reclaiming and decontaminating the land make the project's feasibility uncertain.

The debate centres on whether to preserve the Pili area as industrial or convert it into a commercial and recreational hub. While the industrial approach prioritizes safety, job preservation, and economic sustainability, the redevelopment proposals by Kwong and Brugnaro envision a lucrative transformation of

Marghera into a mixed-use urban and tourist centre. However, the unresolved environmental, health, and financial risks highlight the challenges of such an ambitious project.

The environmental impacts of the PG deposits are substantial, with the risk of soil, water, and air contamination threatening both human health and the surrounding ecosystem. Public concerns have also been raised about radon gas emissions from the site, which contribute to fears of long-term health consequences. The presence of these hazards has affected the area's potential for economic development, as the contaminated land has remained largely unused despite its high real estate value.





Figure 13. Aerial views of Pili (left) and Passo a Campalto (right) areas in Venice

The PG stacks in the Pili area of Marghera and in Campalto (parco di San Giuliano) have been a longstanding concern due to their environmental, health, and socio-economic impacts, due to their proximity to a populated area and to sensitive ecosystems like the Venetian Lagoon. While remediation efforts have been mandated by the Ministry of Environment, progress has been slow, and the community continues to live with the risks associated with the toxic legacy.

Sources of information

The case study on PG in Italy identified a total of 68 sources, distributed across four categories: interviews, news articles, and social media. Results showed that discussion around this topic is led by social media with a specific focus on the Veneto region. Below is a detailed summary of these findings.

Interviews

One interview was conducted, providing insights into the local context of PG management in this case study.

News Articles

28 news articles were identified, with significant contributions from specific regions. The Veneto region accounted for 17 articles, while Sicily contributed one.

Social Media

A total of 39 social media entries were identified, making it the most prominent source type in Italy. Of these, 26 entries were linked to the Veneto region, 6 to general discussions within Italy, 4 to Basilicata, 2 to Calabria, and 1 to Sicily. These posts reflect discussions, awareness campaigns, or public concerns related to PG across these sites.

Conclusions

The social perception of PG stacks in Italy reveals a public that is concerned and actively engaged with the environmental, health, governance, and economic implications of PG waste management. Across various sources, including social media, news, and 1 interview, express significant concern over the long-term risks associated with PG stacks, particularly in Pili and Campalto areas (Venice lagoon). This concern extends beyond immediate health risks, reflecting broader fears of environmental degradation and the potential for economic impact on property values and investment in affected areas.

There is a strong public demand for transparency and accountability from both government authorities and industry operators. Economic considerations also play a significant role in shaping public sentiment, with residents worried about the high costs of remediation and whether current government funding is sufficient to manage long-term impacts. The potential economic drawbacks of living near PG stacks, such as diminished property values, reinforce a collective call for a well-funded, balanced approach that prioritises environmental safety alongside economic stability.

Overall, the Italian public's perception of PG stacks is one of caution and proactive advocacy, with communities striving for a management model that incorporates novel governance, technological solutions and community involvement. The general sentiment underscores a demand for a transparent approach that aligns with both local priorities and broader EU standards, ensuring that industrial waste management protects both public health and environmental integrity, especially in this highly sensitive site, such as the Venice lagoon.

Community engagement

In this case study social perception around PG stacks reveals a community deeply concerned with the environmental and health impacts of this industrial waste. Across various platforms, residents express frustration with perceived environmental degradation, and they frequently call for more transparency and accountability from local government.

Public sentiment reflects a collective demand for clear communication and involvement in decisions impacting community health and local ecosystems. This community engagement highlights a broader environmental awareness, with people seeking sustainable practices and a responsible approach to waste management that prioritises local well-being. News coverage often reinforces these calls, underscoring the importance of responsive action and consistent policy enforcement as residents advocate for long-term environmental protections.

Although much of the discussion occurs on social media, which provides a direct outlet for concerns and information sharing, interviews and news articles also capture local leaders and environmental advocates supporting grassroots efforts. These sources together illustrate a public commitment to active participation in management decisions and a desire for sustained oversight to ensure safe environmental practices.

The interview with a community member from Marghera reveals a significant gap in public awareness about the PG deposits near their area. Despite working in proximity to these deposits, the interviewee was unaware of their presence and mentioned that neither their workplace nor media sources provided information about this environmental hazard. This lack of awareness underscores a need for improved community engagement and transparency from both authorities and industries regarding this issue in the

area. The interviewee expressed a desire to be informed and involved in decision-making processes yet emphasised that previous clear and accessible information is essential for meaningful participation. It was suggested that more proactive outreach and regular updates on safety and remediation efforts would foster a stronger sense of community involvement and trust in ongoing projects.

Key findings:

- Transparency and accountability: Community demand for open communication and responsible practices.
- Long-term awareness: Public awareness includes historical context of industrial pollution.
- Public and media reinforcement: News amplifies community concerns, strengthening advocacy.
- Call for participatory management: Consistent push for community involvement in environmental decision-making.

Governance and policies

Public perception of governance and policies around PG stacks in this case study reflects concerns about inconsistent and reactive regulatory measures. Many residents express doubts about the adequacy of governmental oversight, with social media posts frequently criticising perceived gaps in policy enforcement and the limited transparency surrounding PG stack management decisions. This sentiment is particularly visible in posts discussing Marghera (Pili area), where regulatory measures appear driven more by isolated incidents than by a cohesive, long-term strategy for PG waste management.

There is a strong public call for alignment between local regulations and EU standards, but with an emphasis on adapting these broader directives to the specific needs and conditions of industrial areas like those in Veneto. This expectation for location-specific governance is reflected in discussions that urge Italian authorities to adopt a more proactive stance, enforcing stricter regulations that prioritise both health and environmental considerations.

News sources often amplify these public concerns by reporting on regulatory delays or inconsistencies, which strengthens community scepticism regarding governmental commitment to effective waste management. Community sentiment suggests a perceived need for regular inspections and a robust policy framework that goes beyond meeting basic compliance to ensure sustained environmental safety and public health.

They also highlight the community's demand for stricter governance to prevent similar situations in the future. Critics argue that regulatory loopholes and weak oversight have permitted this project to move forward despite unresolved safety issues. There is a prevailing expectation for the government to implement clearer policies that enforce stringent safety measures, ensuring that new developments align with public health and environmental protection standards.

The media also captures calls for increased transparency in policy decisions and regulatory actions, particularly concerning updates or changes to PG stack containment practices. Residents and activists often argue for clear, publicly accessible information about governmental plans and monitoring efforts, reflecting a broader demand for policies that involve and inform affected communities directly.

Key findings:

- Perceived inconsistency: governance on PG stacks seen as reactive, lacking consistent oversight.

- Distrust in governance and potential conflicts of interest. Perceived political and commercial influence over environmental safety policies
- Transparency in policy: Demand for open communication about government decisions and policy updates.
- Adaptation to EU standards: Calls for regulatory alignment that addresses specific regional needs.
- Stricter regulations: Calls for proactive, health-oriented regulatory measures beyond basic compliance.

Health concerns

Health-related perception concerning PG stacks in Venice area focus primarily on potential long-term exposure risks, particularly for communities near industrial areas like Marghera or San Giuliano Park users in Campalto. Social media posts reflect a strong public awareness of potential respiratory issues and contamination threats from PG sites, with residents sharing concerns over air and water quality. This discourse often highlights perceived shortcomings in health monitoring, with calls for more consistent, transparent assessments to gauge the health implications of PG waste exposure. The general sentiment on social media suggests a lack of confidence in the sufficiency of current health safeguards around PG stacks. Comments suggest that residents are wary of local authorities' assurances of safety and are calling for independent health assessments to be conducted before any further steps are taken.

Despite calls from the Ministry of the Environment to address contamination, the site remains polluted and continues to pose potential health hazards. The PG waste and other pollutants present risks not only to local workers but also to any future visitors to the site, prompting widespread fears about the consequences of exposure to toxic materials.

News coverage, such as articles from *Il Gazzettino*, amplifies these concerns by reporting on public dissatisfaction with the infrequent health assessments conducted by authorities. Such media coverage reinforces the community's demand for rigorous, regular health studies to detect any adverse health impacts early. Reports on radiological assessments and chemical exposure risks from news outlets have bolstered the public's call for accountability in health management related to PG stacks.

This lack of comprehensive, ongoing health data contributes to a perception of neglect, with the public feeling that health protections near PG stacks are not a top priority for policymakers. Interviewees point to the need for more transparent public health reports, particularly data that is accessible and understandable to local residents.

Overall, the discourse around health concerns related to PG stacks in Italy illustrates a pronounced desire for stronger health protections, more frequent and detailed health assessments, and clear communication of findings to the affected communities. This reflects a general mistrust in current measures and a demand for a more proactive approach to safeguarding public health in PG-affected areas.

Key findings:

- High public concern about health risks associated with radioactive materials. concerns over air and water quality: Public fears of respiratory issues and contamination.
- Calls for independent health assessments. General mistrust in official safety assurances from local authorities

- Call for regular health assessments: Demand for frequent, consistent health monitoring.
- Lack of transparency: Public desire for clear, accessible reporting on health risks.

Environmental impact

Public perception in Venice case study regarding the environmental impact of PG stacks reflects considerable worry, especially around contamination risks to soil, water, and the surrounding natural ecosystems. Social media discussions frequently highlight the perceived ecological hazards associated with PG waste, often mentioning concerns about groundwater contamination and soil degradation. The environmental impact of developing Pili area zone is substantial and a major point of concern. Reports indicate high levels of toxic waste, including radioactive substances and heavy metals, within the soil and surrounding water systems. The containment measures previously implemented have not entirely prevented the spread of contaminants, posing risks to the local ecosystem and lagoon. Environmental organisations and community members advocate for extensive remediation before any new projects begin. Many argue that without a complete cleanup, the proposed commercial centre could exacerbate existing environmental issues.

Many users share information on the toxic history of the site, describing it as heavily contaminated with pollutants like PG and hydrocarbons. There are also concerns about the potential spread of contaminants into the lagoon and nearby ecosystems, especially as the site's safety has not been sufficiently secured.

Users frequently advocate for complete environmental remediation as a prerequisite for any development, with some proposing that the land be preserved as a green buffer zone. This widespread call for ecological preservation reflects a community preference for sustainable, low-impact uses of the land rather than commercial projects that could exacerbate contamination.

Media outlets add to these concerns by reporting on potential pollutant migration from PG stacks into surrounding areas, where risks of leaching into agricultural land are particularly troubling to nearby residents. Articles in Italian news, such as *Il Gazzettino*, echo community fears that the environmental footprint of PG waste might extend beyond the immediate disposal sites, thereby exacerbating ecological degradation in the vicinity.

There is also a strong public call for improved containment measures to minimise the environmental damage associated with PG stacks. News sources and social media alike reflect demands for advanced technologies and monitoring systems to prevent pollutants from infiltrating local ecosystems. Public discourse often highlights the need for comprehensive environmental monitoring to detect early signs of contamination, reinforcing a desire for pre-emptive action from both industry and government agencies.

Overall, the environmental concerns associated with these PG stacks underscore a collective demand for more stringent safeguards and regular monitoring. The social perception, as observed through media and social platforms, suggests a belief that the current containment and remediation efforts are inadequate to prevent potential ecological harm, signalling a call for a more robust, transparent approach to protecting local environments.

Key findings:

- Groundwater and soil contamination risks: Public concerns about pollutants affecting essential natural resources.

- Extended ecological footprint: concerns over the impact of PG waste beyond immediate containment sites.
- Demand for advanced containment: Public advocacy for improved containment and monitoring technologies.
- Community demand for complete environmental remediation before development
- Preference for preservation as a green buffer zone
- Desire for stringent environmental protections: Community demand for proactive, transparent environmental measures.

Economic impact

Discussions around the economic impact of PG stacks focus on the significant financial burden associated with environmental compliance and long-term remediation. Social media posts and news reports reflect concerns that the costs of managing PG stacks, especially in the Pili area strain local governments and industries. This economic strain is seen as limiting the resources available for consistent environmental and health monitoring, which are viewed as critical for community safety.

News sources highlight intermittent government funding, which communities perceive as insufficient to address the ongoing management and remediation needs associated with PG stacks. This perception is compounded by the high financial requirements for upgrading containment and monitoring technologies, with some expressing doubt about whether these costs are realistically sustainable in the long run.

The proposal for a new sports and commercial centre in Porto Marghera, spearheaded by Mayor Luigi Brugnaro, has ignited considerable public debate. Unions, community members, and local environmental groups have voiced strong reservations about building such a project near industrial facilities. The CGIL union, representing chemical workers, has expressed safety concerns about the centre's proximity to high-risk industrial zones, including the Eni biorefinery and storage tanks. These objections underscore a community perception that prioritises public safety over commercial development, fearing that the project may disregard the well-being of local residents and workers.

While the proposed development is framed as an economic opportunity that could create local jobs, many in the community question whether the potential benefits outweigh the associated risks. Proponents argue that the sports arena and commercial centre could stimulate economic growth and job creation; however, union leaders and local officials emphasise the importance of maintaining industrial jobs, particularly in light of recent investments in the Eni biorefinery.

Community members are sceptical about the economic viability of the project, fearing that hidden costs associated with environmental damage and public health risks could outweigh its benefits. Additionally, there is concern that the short-term economic gains may compromise long-term safety and sustainability, as local advocates argue for employment opportunities that prioritise both economic and environmental stability.

Beyond safety issues, there is also concern about the upkeep and monitoring of safety measures in the area, with reports highlighting instances of broken fences and unrestricted access to contaminated areas. This lack of strict control over potentially hazardous sites has deepened public distrust, with some arguing that past oversights in safety reinforce the need for more transparent and responsible community engagement moving forward.

Additionally, public discussions raise concerns about the potential impact of PG stacks on local property values and investment prospects. The presence of industrial waste sites is seen as a deterrent to residential and business investment in affected areas, reinforcing calls for an economically viable, long-term strategy that can balance environmental management with community development needs.

Key findings:

- High compliance and remediation costs: Financial strain on local industries and governments.
- Perceived inadequacy of government funding: Intermittent support seen as insufficient for sustainable management.
- Impact on property values and investments: Concerns about PG stacks as a barrier to local economic growth.
- Scepticism about economic promises overshadowing health and environmental risks
- Concerns over tourism-driven development versus community-oriented benefits
- Fear of economic prioritisation compromising local well-being

Proposals

This section relates closely to the previous one, devoted to the economic impact and the different approaches to manage the future of the PG stacks, mainly in the Pili area.

It is remarkable, as mentioned before, that several alternative proposals have emerged, focusing on transforming the area into a public green space rather than a high-density commercial zone. Unions and environmental groups suggest that the land should be restored and used for low-impact public areas that benefit the community. Advocates argue that this approach aligns with both environmental safety and community interests, calling for government intervention to prioritise remediation and sustainable land use.

The community's vision for the site includes expanding green spaces or recreational areas, rather than high-traffic commercial centres. There is a consensus among local groups that the land's contamination requires extensive remediation before any development, with calls for sustainable policies that support long-term community and ecological well-being. Posts frequently suggest that any development plan should first address full site remediation, with long-term community health and ecological preservation as core objectives. The community's preference leans heavily towards lower impact uses that enhance quality of life rather than high-risk commercialisation

Moreover, there is a call for the establishment of advisory panels that include community representatives, enabling residents to participate directly in decision-making processes related to PG management. Such proposals suggest that community inclusion could enhance policy responsiveness and ensure that management practices reflect local needs and concerns.

Key findings:

- Preference for community-centred green spaces over commercial development
- Emphasis on complete remediation and environmental health
- Strong advocacy for sustainable, low-impact land-use strategies.
- Community advisory panels: Proposals for resident-led panels to participate in decision-making and policy discussions.

B) Case study: Łąka, Bolesławca

The case study of Łąka k. Bolesławca, was proposed as one of the 6 case studies of the FICfighters project and it was initially included in this research. In the process of preparing the round of interviews, we were informed about the legal difficulties to keep this site as a case study within the project, so the social perception on the PG stacks in Łąka has not been analysed in a deeper level and the conclusions are considered as exploratory.

Context

Situated in a region with a rich industrial history, the Wizów chemical plant began operations in 1948 and was involved in sulphuric acid production by 1951. Phosphoric acid and salt production facilities followed between 1969 and 1979. The company faced bankruptcy in 2006, leaving behind an estimated amount of 4,690,000 tonnes of PG waste, and still remaining a challenge for environmental management due to its legacy of industrial activity. The current owner is a changing complicated issue, because since the bankruptcy of the company, the remains of Wizów have been owned by several other companies.

For the social perception analysis, this site provides a unique opportunity to understand local attitudes towards industrial residues and their reuse. Social dynamics surrounding Łąka k. Bolesławca are influenced by the community's proximity to the site and historical experiences with the industry. Key stakeholders, including local authorities and the site's current owner, are involved in ongoing discussions to promote valorisation.

Sources of information

The conclusions for this case study in Poland is based on 123 sources, specifically categorized as news articles and social media posts. It must be considered that in Poland there are 3 different PG stacks located in:

- Łąka, k. Bolesławca (the stack initially included in the project, most typically referred to as "Wizów"), which is a closed landfill.
- Wiślinka (Grupa Azoty Zakłady Fosforowe Gdańsk Sp. z o.o.), also a closed landfill.
- Police (Grupa Azoty Zakłady Chemiczne "Police" S.A.) - the only factory still producing PG in Poland.



Figure 14. Aerial views of Łąka

News articles

A total of 62 articles have been retrieved. News articles provided information regarding the local communities' concerns on health and environmental issues that are perceived as directly related to PG stacks. Although most information is not specifically covering a specific area, it reveals that public discussions are also held around the Wiślinka's case.

Social media

61 posts were analysed revealing a widespread community concern around health issues. Posts convey predominantly negative sentiments on PG, emphasizing the perception of it as a hazard to human health and the environment.

Conclusions

As the analysis on this case study has not been conducted in a deeper level, the conclusions reached are considered as exploratory rather than final thoughts and ideas on the social perception of PG stacks in Poland. However, manual analysis has been conducted of the data encountered to grasp a general understanding on how PG stacks are perceived in the framework of the relevant topic areas selected through thematic analysis.

Community engagement

Social perception of PG stacks highlights a multifaceted landscape of community engagement and local participation characterized by challenges and initiatives aimed at bridging gaps among the related stakeholders and locals. The sources showed a growing awareness and concern among residents regarding the environmental and health impact of PG stacks. It can be appreciated a growing sense of urgency to establish an open dialogue and participation practices among the community stakeholders and policymakers.

Residents and community petitions around PG stacks in their vicinities also highlight their concerns about the impact on local tourism as a consequence to the potential deterioration of the natural landscape. Local communities also demand more transparency among the realization of plans and viability tests on the stacks specially concerning health-risk factor studies and liquidation plans of the stacks. These local demands also reflect some degree of scepticism on policymakers due to the perceived sense of inaction and misinformation and the regular requests for more open dialogue and accountability.

Local communities look forward to being included more closely in the decision-making processes affecting directly their well-being and request the governance to have a more visible impact on results and actions around the radioactive contamination of lands and water.

Governance and policies

Sources retrieved revealed a sense of public criticism and scepticism around the governance and policies surrounding PG stacks in Poland. Primarily, policy-making criticism stand for the reactive actions rather than focusing on prevention of risks and safety. Although the remediation plans in the areas are put in place, a growing sense of mistrust due to the lack of active results in the area has risen. Therefore, authorities' accountability and effectivity regarding the management of PG stacks as in prevention plans,

rigorous inspections, landfills closings, are generally considered deficient and disconnected with the local communities' demands.

Policies are generally understood as inconsistent and biased by economic potential benefits and considerations. News media point out conflicting decisions are perceived as failed attempts to bridge the gap among local community and policymakers, as for instance, the approvals of storage expansion simultaneous to the request of closing sites. This overall disconnection among policies and residents' priorities seem to decimate the credibility and trust among citizens and public opinion, mostly shown in social media.

Health concerns

Health and mortality concerns are significantly expressed among the sources found. For instance, in social media, PG is repeatedly compared to poison and associated with cancer diagnosis in the area. Cancer diagnosis is a key part at the health discussion surrounding the PG stacks current situation in Poland. The stacks are held as accountable for the increasing risk to develop cancer and radioactivity related diseases. Wiślinka surroundings is particularly signalled as one of the most affected areas in Poland by cancer diagnosis among its residents, and public opinion relates directly this situation with this stack. This high incidence of cancer has been linked to a chronic exposure to substances such as uranium, fluorine and heavy metals that consistently contaminate the environment and local resources.

PG wastes are also perceived as source of other diseases besides cancer. As show per news articles that back their conclusions up with scientific studies, PG stacks proximity is seen as the potential origin of metabolism disorders, chronic diseases, asthma, respiratory diseases, and even skeletal forming disorders. Children health is also mentioned as part of the collective health concern.

There is a growing urgency arising from the community to conduct more comprehensive and extensive medical examinations and long-term health monitoring while demanding more effective mitigation efforts among policymakers.

Environmental impact

The environment is revealed by the sources as one of the key issues and concerns among the population. In particular, the accumulation of radioactive materials and a consistent questioning on the capability to manage and prevent risks, is a key topic area on public discussions around PG stacks. Concerns around water contamination, at groundwater level, as well as rainwater, are key in the environmental discussions around the site. Water is considered to be contaminated by heavy metals leaked from the stacks, which are seeing as potential hazards and poisonous. Equally, soil contamination from PG stacks is considered as a source of farmland decimation and PG landfills are considered responsible of losing crops.

Environmental damage prevention is seen to be insufficient as shown by news articles highlighting the mistakes and inconsistencies of inspections of PG stacks. Therefore, there is a sense of natural resources being unprotected and left out for potential contamination caused by a lack of effectiveness and consistency in regulatory actions and inspections. Environmental protection has revealed to be one of the key concerns among public discussions in Poland, providing the sense of PG stacks being perceived as hazardous for the biodiversity and the state of soil and water in the surrounding areas.

Economic impact

PG stacks are perceived both as an economic opportunity and challenge. On one side, there is a growing tendency to understand that the repurposing and processing of phosphate-contaminated waters into fertilizers or construction materials is a profitable way to conduct environmental remediation. However, remediation plans are also seen as an economic burden related to the management of the stacks. The conversion of polluted waters is therefore seen as a mixed balance among ecological concerns and the industrial stakeholders' economic interests. The contrast between the economic exploitation and benefits of PG stacks and the environmental challenges they suppose is a constant discussion among news articles. While in social media, benefits are scarcely noted opposed to the high mention of health and ecological harms of PG stacks.

The economic discussions reveal the aim to both contain and reduce the risks and negative environmental and health impacts of PG stacks, with a repurposing perspective on products and materials that provide economic benefits to all stakeholders.

Proposals

Following the main areas of concern, such as environment, health and economic viability, proposals around PG stacks future and current management combine a balanced approach to these challenges. Sources revealed that managing the contents of the stacks following a recycling circular economy model by repurposing wastes and transforming them in new products that can represent a profitable advantage for stakeholders. However, these processes are requested to be closely accompanied by a more solid regulatory framework focusing on conducting in-depth inspections specially concerning the contamination of soil and water associated both with ecological and health issues.

Local stakeholders and community members demand more transparent and open conversations around the management and remediation processes. Consequently, potentially improving local communities' trust on policymakers and inspections which could significantly affect the overall perception of hazard and risk for human health and mortality in the area.

Appendix 2. Interview guide

Semi-Structured Interview Guide: Social Perception of PG

Introduction

- Briefly explain the project:

Thank you for agreeing to participate in this interview. This interview is part of the FIC-FIGHTERS Project, funded by the European Union under Horizon Europe. The project aims to develop circular and sustainable solutions for the regeneration of PG stacks in Europe.

- Confirm the participant has read and signed the consent form.

Before we begin, have you had a chance to read and sign the consent form?

- Explain the structure of the interview: duration (45-60 minutes), recording for accuracy, and confidentiality. Ask for permission to record the interview.

The interview will take about 45 to 60 minutes. With your permission, I'd like to record our conversation to ensure accuracy. All your responses will be kept confidential."

Do I have your permission to record the interview?

- Address questions:

Do you have any questions before we begin?

Section 1: Personal Context and Knowledge

Tell me about your relationship with the community where the PG stacks are located and how you became aware of this issue?

Key themes to explore:

- Duration of residence/work in the area.
- Self-assessed knowledge about PG stacks (on a scale from 0-10).
- Sources of information and types of contaminants known.

Section 2: Information Availability and Trust

How would you describe your level of information about the PG stacks, and what factors contribute to you feeling well-informed or not?

Key themes to explore:

- Perception of available information about PG stacks.
- Trusted sources of information (e.g., media, local authorities, scientific reports).

- Suggestions for improving the flow of information to the public.

Section 3: Risk Perception and Concerns

What concerns do you have about the health or environmental risks posed by the PG stacks? Have you or anyone you know experienced health or environmental effects that you attribute to the PG stacks?

Key themes to explore:

- Specific health or environmental concerns.
- Comparison of PG stack risks with other local environmental risks (e.g., traffic, industrial emissions).
- Impact on the town's image and identity.
- Personal agency in reducing potential risks to health.

Section 4: Social and Economic Impacts

What do you believe are the socioeconomic benefits and risks associated with the PG industry in your community?

Key themes to explore:

Socioeconomic benefits (e.g., jobs, local economy).

Balance between benefits and health/environmental risks.

Observations of changes in social cohesion or community relationships due to PG stacks.

Section 5: Trust in Institutions and Actors

Which institutions or actors do you trust to manage the PG stacks, and why?

Key themes to explore:

- Trust in local, regional, and national authorities.
- Role of private companies, NGOs, and international bodies.
- Steps that institutions can take to increase public trust.

Section 6: Awareness and perception of Remediation Processes

Are you aware of specific remediation initiatives for the PG stacks? What is your opinion on these efforts?

Key themes to explore:

- Knowledge of any restoration initiatives.
- Perceived effectiveness of restoration measures.
- Main concerns and hopes for restoration initiatives.

- Willingness to support or propose alternative solutions.

Section 7: Willingness to Engage and Participate

How willing are you to engage in decision-making or consultation processes regarding the PG stacks? What factors facilitate or hinder your participation in decision-making processes related to the PG stacks?

Key themes to explore:

- Past involvement in decision-making processes.
- Interest in participating in the FIC-FIGHTERS project or similar initiatives.
- Barriers to participation.
- Suggestions for improving public engagement in these processes.

Section 8: Demographic-Specific Questions

For younger respondents:

- As a member of the younger generation, how do you see your role in addressing the issue of the PG stacks?

For Older Respondents:

- How has the perception of the PG stacks evolved over time, and what lessons from the past could inform future management?
- Key themes to explore:
- Future perspectives on PG stacks.
- Role of their generation in addressing the issue.
- Changes in perception over time.

Section 9: Future Perspectives

What specific measures would you like to see implemented in the future management of the PG stacks?

Key themes to explore:

- Desired actions for the future (e.g., specific steps for remediation, restoration, or policy changes).
- Vision for an ideal resolution for the community.
- Critical steps that need to be taken to address community concerns.

Closing

- Is there anything else you'd like to share about your views on the PG stacks?

- "Do you have any questions for me about this research or how the information will be used?"
- Would you recommend someone else who might provide valuable insights on the topic of PG stacks and their management?
- If so, could you share their contact information or connection to the issue, if you're comfortable doing so?

Final Remarks:

If you have further questions or would like to learn more about the results of this research, please feel free to contact us.

Thank you very much for your time and valuable contributions.

General Notes for Interviewer

Before the Interview:

Introduce Yourself and the Project:

- Begin by introducing yourself and explaining the purpose of the study in detail.
- Provide comprehensive information about the FIC-FIGHTERS project, emphasizing its scientific objectives and how the participant's insights will contribute to developing sustainable solutions for PG stack regeneration.

Obtain Informed Consent:

- Ensure the participant has read and signed the consent form.
- Explain that while personal names and specific job titles will be anonymized, it may be possible to identify the organization or institute unless they prefer otherwise.
- Emphasize adherence to ethical principles, including confidentiality and the right to withdraw at any time.

Set Clear Expectations:

- Inform the participant that the interview will take approximately 45 to 60 minutes.
- Explain that the interview will be semi-structured, allowing for open discussion while covering key topics.
- Mention that you would like to audio-record the interview to analyse the responses accurately and in more depth, ensuring no details are missed.

Address Questions and Concerns:

- Encourage the participant to ask any questions or express concerns about the study or the interview process.
- Offer clarification on any aspects they might not understand.
- Invite them to inform you if they encounter any problems understanding the questions during the interview.

Arrange a Comfortable Setting:

- Whenever possible, conduct the interview in a quiet, distraction-free environment chosen by the participant to ensure their comfort.
- Ensure that the setting is conducive to open and honest communication.

During the Interview:

Active Listening:

- Listen attentively without unnecessary interruptions to allow the participant to share their experiences fully.
- Show that you are engaged by using appropriate body language—maintain eye contact, nod, and smile where appropriate.
- Use verbal encouragers like "I see," "Go on," or "That's interesting" to facilitate the conversation.

Use Open-Ended and Neutral Questions:

- Ensure all questions are open-ended, neutral, and understandable, promoting detailed and sincere responses.
- Avoid 'leading' or 'loaded' questions that may influence the participant's answers.

Probing and Follow-Up:

Encourage the participant to elaborate on their responses with probing questions like:

- "Can you tell me more about that?"
- "What did you mean when you mentioned...?"
- "How did that experience affect your perspective?"
- Note down key points for potential follow-up questions later in the interview.

Allow for Reflection:

- Use appropriate pauses and silence to give the participant time to think and reflect on their responses.
- Do not rush them; allow them the space to articulate their thoughts fully.

Manage the Flow of Conversation:

- While the interview is semi-structured, be flexible in the order of topics based on the natural flow of the conversation.
- If the participant brings up a relevant point in a different section, adapt accordingly to explore that topic thoroughly.

Address Participant Questions:

- Be prepared to answer any questions the participant may have during the interview.
- Provide clear and concise answers, maintaining transparency about the research process.

Maintain Professionalism and Neutrality:

- Keep your own opinions and biases in check to avoid influencing the participant's responses.
- Remain neutral, especially on sensitive topics, to create a safe space for open dialogue.

After the Interview:

Express Gratitude:

- Thank the participant sincerely for their time and valuable contributions.
- Acknowledge the importance of their insights to the success of the research.

Debriefing:

- Briefly explain the next steps in the study and how the data will be used.
- Reassure them about the confidentiality of their responses and the ethical handling of the data.

Offer to Share Results:

- Inform the participant that they can receive a summary of the research findings if they are interested.
- Offer to provide them with any publications or reports generated from the study for their feedback before publication, if appropriate.

Follow-Up:

- If appropriate, send a thank-you email or letter to the participant after the interview.
- Provide your contact information in case they have further questions or wish to add more information later.

Recording and Documentation:

- Ensure the audio recording is saved securely and that any notes taken are stored confidentially.
- Write 'field notes' immediately after the interview to capture observations, thoughts, and ideas that may aid in data analysis.

Ethical Considerations:

Confidentiality and Anonymity:

- Uphold the highest standards of confidentiality.
- Anonymize personal identifiers unless the participant has given explicit permission to use their details.

Informed Consent:

- Reiterate that participation is voluntary and that the participant can withdraw at any time without any negative consequences.
- Ensure they understand how their data will be used and stored.

Data Protection:

- Comply with data protection regulations, securely storing recordings and transcripts.
- Use the data solely for the purposes outlined in the consent form.
- General Tips for Interviewers:

Build Rapport:

- Start with light conversation to make the participant feel at ease.
- Show genuine interest in their experiences and perspectives.

Cultural Sensitivity:

- Be mindful of cultural differences and respectful of the participant's background and beliefs.
- Adapt your communication style if necessary to accommodate these differences.

- Time Management:
- Be aware of the time to ensure all key topics are covered without rushing the participant.
- Prioritize topics if time becomes limited, focusing on areas most relevant to the research goals.

Adaptability:

- Be flexible in your approach, allowing the participant to guide parts of the conversation.
- Be open to exploring unexpected but relevant topics that may arise.

Professional Conduct:

- Dress appropriately and arrive on time.
- Turn off or silence your mobile devices to avoid interruptions.

Self-Reflection:

- After each interview, reflect on your performance.
- Consider what went well and what could be improved for future interviews.

Clarity and Understanding:

- Ensure that the participant understands each question.
- Rephrase or clarify questions if the participant seems unsure.

Neutrality and Non-Judgment:

- Remain non-judgmental, regardless of the participant's views.
- Encourage honesty by creating a supportive environment.

Encourage Depth:

- Prompt the participant to provide examples or anecdotes to illustrate their points.
- Ask them to elaborate on statements to gain deeper insights.

Ending the Interview:

- Summarize the key points discussed to confirm understanding.
- Ask if the participant would like to add anything else.
- Confirm whether they know anyone else who might be interested in participating, respecting confidentiality protocols.