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Sustainability Material Topics and Materiality Analysis in the Chemical Industry

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Abstract: Chemicals are an essential ingredient for many industries. The chemical industry has a direct environmental and social impact and massive potential to contribute towards a more sustainable world. Environmental and social awareness and pressure from society are increasing, customers expect from companies to show increased corporate social responsibility (CSR), and there are increasing legal requirements for companies to disclose information on their social, economic, and environmental performance through CSR reporting. This paper explores the most material sustainability topics in the chemical industry. We reviewed 25 sustainability reports of some of the biggest companies in the chemical industry—in terms of annual sales. We studied the reports, created a database, and then analyzed the findings. We identified the topics that were most commonly reported as being material by the chemical industry. This enabled us to identify trends, differences, or similarities within the data. The industry's main environmental impacts are pollution and energy consumption, which is directly related to carbon emissions. Other material issues include health and safety, and water and waste management. Overall, it became apparent that the chemical industry recognizes the importance that the materiality assessment plays, but the content and detail of the sustainability reports can be improved.

Keywords: sustainability; CSR reporting; materiality analysis; chemicals industry sustainability; materiality; sustainability material topics

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1. Introduction

The industry of chemicals is virtually everywhere around us and impacts nearly every other sector of the economy. The chemicals industry utilizes raw materials such as fossil fuels, minerals, and chemical compounds to create different chemical products and materials, which, in turn, are used in different industrial applications, to produce various consumer goods.

Chemical companies use a vast amount of energy to operate, which results in high fossil fuel consumption and substantial GHG emissions accordingly. In terms of sourcing, the production of chemicals also has a large emission factor, as the use of natural resources has a significant impact on the environment. According to Jabouley [1], the chemical industry is one of the main greenhouse gas emitters, accounting for more than 2% of global emissions.

Plastic and micro-plastic pollution is another increasingly concerning issue the sector faces, given the very direct, obvious, and visual impact it can have on landscapes, oceans, and biodiversity. Several known disturbances caused by all kinds of toxic chemicals on both aquatic and terrestrial ecosystems have been observed [2]. Therefore, chemical companies have a massive impact and are expected to develop advanced technologies for chemical recycling, treatment, and biodegradation and adopt circular economy principles. According to Mann [3], 480 billion plastic bottles per year; 500,000 plastic straws per day; and 2 million plastic bags per minute are a few examples of plastic products that pass through the hands

of consumers, and in many cases end up as waste into the world's oceans, lakes, and rivers. Several chemical companies are aiming to limit the future environmental impact of plastics by prioritizing innovations that optimize recyclability while they simultaneously target reductions in production-related emissions and energy consumption.

Chemical manufacturing processes emit air pollutants that may cause health issues to people, while waste, leakages, and spills can also have a great negative impact on the local environment. However, Jabouley [1] notes that the sector is heavily regulated with regard to the registration, evaluation, authorization, and restriction of products, as regulators aim to protect end users and public health.

This paper attempts to provide an overview of the most significant sustainability issues of the chemical sector, and to outline the methods and approaches that chemical companies follow when performing a materiality analysis, to prioritize the most material sustainability topics. The aim of this work is to better understand how chemical companies define which topics are material for them and to use the available data to identify sustainability trends and risks in the sector. Our work attempts to add useful insights and data, to help academics and practitioners develop a more complete view of the current situation in the sector, in terms of materiality and sustainability reporting.

There is not a lot of research into this topic, even though materiality assessment should form a vital pillar of a company's strategy according to the international sustainability standards (such as GRI, AA1000) and Sustainability reporting European legislation (CSRD) [4]. The materiality assessment process helps companies identify and prioritize sustainability topics to focus on and provides them with deeper insights into their operating environment, while encouraging more effective allocation of resources. Until today, an international academic benchmark summarizing and describing the material sustainability topics in the chemical industry did not exist. This paper aims to fill this gap and provide an independent overview on the current situation around material issues and materiality in the chemicals sector.

Until the induction of CSRD and the European Sustainability Reporting Standards (ESRS), in 2023, there was a lack of regulatory frameworks regarding the exact content of sustainability reports. The concept of materiality is vital for companies, as it is a tool that helps them identify which sustainability topics are critical for them and which specific Key Performance Indicators (KPIs) to report on. A materiality analysis is essential for companies in order to fully understand on which sustainability topics their operations have a direct or indirect positive or negative impact. It helps companies identify which are the most significant topics that need to be further developed in the report [5].

A materiality analysis in sustainability reporting is a tool for directing corporate sustainability towards emerging economic, environmental, and social opportunities [6]. It has strong elements of subjectivity and relies on facilitating potential conflicts among different stakeholder groups and a wide scope of different topics [6].

Materiality assessments are formal exercises aimed at engaging all stakeholders to find out how material specific environmental, social, and governance (ESG) issues are to an organization. It is a vital step or tool, used by companies, to identify and prioritize the ESG issues that are the most critical for them. It is also a critical step for companies to become more sustainable. The first step towards preparing a list of sustainability topics that are material for a company is to understand the organization's context, activities, operations, and business relationships, along the whole value chain. This helps the company identify the actual and potential impacts it may have on the economy, environment, and people, including impacts on human rights, across the organization's activities and business relationships. These impacts can include a variety of impacts: negative and positive impacts, short-term and long-term impacts, intended and unintended impacts, and reversible and irreversible impacts [7]. Engaging with managers, senior executives, and experts is one of the most effective and efficient ways to identify and assess the actual and potential impacts (positive and negative) a company has, as those people have an in-depth understanding of how the organization operates and their views and insights are invaluable. The final critical

step after identifying the material topics is to prioritize them and define the most significant impacts, taking into account not only the company's, but each stakeholder group's views (clients, suppliers, employees, etc.).

A materiality assessment helps companies prioritize sustainability topics and provides them with deeper insights into their operating environment [7]. A materiality analysis help organizations to identify and prioritize their positive and negative social, environmental, and economic impacts. By definition, materiality refers to the measurement of how much something matters. In the field of sustainability, the definition is more complex, as it involves identifying to whom the subject matters, how much it matters, and the reasons behind its significance. A review of the literature revealed that a materiality analysis faces critical constraints and problems that limit its practical use in companies [8].

The materiality assessment is an essential and demanding step in sustainability reporting, serving as a basis for stakeholder engagement. Despite that, today, there is not any globally accepted model or framework. Internationally, companies fail to provide an accurate explanation of stakeholder engagement and the process used to carry out materiality assessment. This failure extends beyond the incompetence or inability to describe the materiality assessment methodology [9]. Therefore, we decided to study how some of the biggest chemical companies in the world approach materiality assessment, aiming to better understand their methods and practices.

According to Dewi [10], the significance of materiality has grown substantially for companies, and there has been an increase in their intention to disclose relevant information. However, the authors suggest that companies are expected to pay more attention to the accuracy and quality of the information they disclose. Due to its popularity and pressure from governments and regulations, there is a strong demand, mainly from investors but various other stakeholder groups too.

Al Shaer [11] investigated the impact of sustainability reporting on corporate sustainability performance. The author argues that companies that comply with the reporting guidelines and embrace the business case for corporate sustainability may not capture all sustainability aspects, and consequently may not create a real positive impact on sustainability. These findings hold significant implications for companies, urging them to re-evaluate their approach towards sustainability reporting and to move to approach sustainability more holistically, allowing it to shape and guide corporate decisions and actions. Companies that embrace corporate sustainability and communicate their efforts and goals are more likely to improve their sustainability performance.

The most important factor when determining the materiality of sustainability issues is the type of industry the company belongs to [12]. The industry factor is more important than the legal context and the board characteristics of companies (ibid). Another study confirms the above findings and highlights the importance of the sector on quantity and quality of sustainability information provided in the sustainability reports [5]. It is essential to understand the material sustainability issues for each industry in order to create sector-specific standards and so to significantly improve the capability of companies to create sustainability reports that matter [13]. That is another field that has not been studied a lot and which our work attempts to contribute to—more particularly, the sector of chemicals and the type and quality of information companies disclose in their sustainability reports. Another purpose of this paper is to examine whether some chemical companies implement any unique methods when carrying out their materiality assessment. It is not only the existing research gap that makes the research useful. The findings can play a vital role for sustainability practitioners worldwide and help to establish an international benchmark on the sustainability material topics of the chemicals sector. Moreover, the study adds useful data to the academic dialogue as it demystifies the under-researched area of materiality and continues the debate around sustainability.

Another parameter which we aim to investigate in this paper is to examine whether chemical companies present sufficient and clear information, in their sustainability reports,

on how they manage hazardous waste, as this topic can often be overlooked despite its significance and the impact it can have.

Hazardous waste is any waste with properties that make it potentially harmful for human health or the environment, if discarded untreated to the environment. It can be in solid, liquid, or gaseous form and needs to be handled with special care and following specific guidelines, depending on its properties.

In the chemical sector, hazardous waste usually includes manufacturing byproducts or discarded materials, such as chemicals and additives, or oils and solvents used for cleaning. This waste includes toxic chemicals, heavy metals, and other harmful substances that can contaminate the air, water, and soil. Proper management is therefore a critical issue for the chemical industry. Management includes the safe use, handling, storage, treatment, and transportation of such wastes.

Elliott and Frickel [14] suggest that four prominent sectors are responsible for hazardous waste generation, in terms of volume, and chemicals is among them. The chemical industry uses raw materials such as metals, natural gas, crude oil, and minerals and converts them into chemical products. Chemical industries produce a significant fraction of solid waste—most of which is metallic waste.

Figure 1 shows the different industry sectors and the chemical waste they managed, between 2012 and 2021. We can observe that the chemical sector has the most production-related waste.

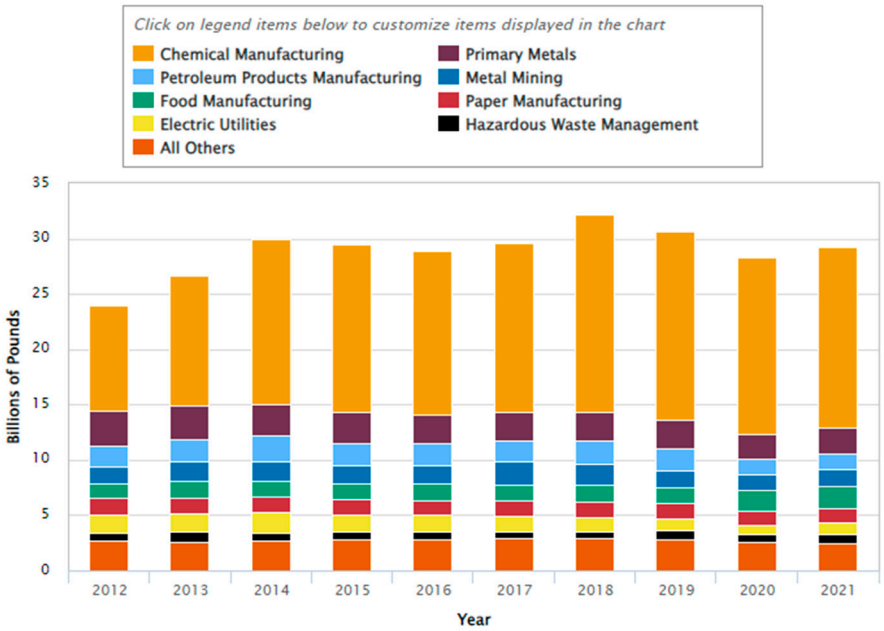

Figure 1. Production-related waste generation by industry [15].

The chemical manufacturing sector accounted for 40% of all production-related waste managed in 2012 and increased to 56% in 2021. The chemical industry is a vast industry that incorporates all different types of product-producing industries whose generation is based on the heavy use of chemicals [16].

The European IPPC Bureau has released Best Available Techniques (BAT) Reference Documents (BREFs) and guidance material for different industrial sectors. There are BAT available for the chemicals sector but also horizontal BREFs dealing with cross-cutting issues such as energy efficiency, waste, and emissions from storage with relevance for industrial manufacturing in general.

Overall, this paper attempts to

(a) highlight the most material sustainability topics within the chemical sector;

(b) better understand the methods used by chemical companies to perform their materiality analysis and to identify and prioritize their sustainability topics;
(c) investigate whether chemical companies present in their sustainability reports sufficient and clear information on how they manage hazardous waste.

2. Literature Review

The growing social awareness of Earth's limited capacity to maintain a resilient state, the climate crisis, and environmental pollution is undeniable. This increasing social pressure has been steering industries, including the chemical sector, towards sustainable development [17]. De Faria et al. [18] describe how concerns and pressure in terms of sustainability are expected to grow further across company's operations, the society, workers, engineers, and all employees. Therefore, companies must better understand and manage their impact on society and the environment. That includes realizing their impact, better managing it in order to mitigate it or even eliminate it, and communicating their relevant actions and goals. Consumers are becoming more sensible and increasingly demand products that are sustainable and do not harm the environment, animals, or human health. Governments and European legislation are also introducing stricter regulations putting great pressure on organizations to reduce their environmental and social impact [4,19].

In spite of international initiatives and efforts, and the growing social awareness, on reducing human-induced climate change, greenhouse gas emissions (GHG) have kept increasing, and the chemical sector contributes to that [15]. The products of the chemical industry have a vital role in the lives of humanity. However, producing such materials demands huge natural resources and generates large amounts of wastes and hazardous materials [20]. Rajeev et al. [21] stress that besides the direct environmental impacts the chemical sector has, it should also take into account and manage more sustainably the impact its whole supply chain may have on the environment and society. They conclude that it is necessary to better understand, as well as find ways to improve the sustainability aspects of the supply chain, across the whole value chain.

Industrial sustainable chemistry is not an emerging trend, but is already a reality through the application of green chemistry and engineering expertise [22]. Green chemistry research enables an even more sustainable future for the chemical industry. The term "green chemistry" is defined as the invention, design, and application of chemical products and processes to reduce or to eliminate the use and generation of hazardous substances [23]. The significance sustainability can have for the future of the chemical and process industry is described by J. García-Serna [24]. New trends in product design include The Natural Step, Biomimicry, Cradle to Cradle, Getting to Zero Waste, Resilience Engineering, Inherently Safer Design, Ecological Design, Green Chemistry, and Self-Assembly [24]. On the same page, the importance of technology advancements and lowering the infusion of a circular economy can definitely play a vital role towards the transformation of the highly resource-dependent chemical industry into a more sustainable industry [25]. However, specific indicators and tools are required to assist the practitioners in driving the circularity forward. On the other hand, while green chemistry and corporate social responsibility define much of the industrial sustainability agenda, previous studies are insufficient to deliver the holistic changes necessary to achieve long-term social and environmental sustainability [26].

Te Liew et al. [27] used text mining to identify sustainability trends and practices in the process industries. The top sustainability focuses of the industry were found to be health and safety, human rights, reducing GHG emissions, conserving energy, and community investment. These days, all companies, regardless of size, report on sustainability matters and inform stakeholders regarding their actions and goals [28]. The chemical industry, more than others, is faced with pollution and hazardous substances. For these reasons, the authors claim that it is necessary to promote sustainability and to adopt sustainable technologies and new regulatory strategies that promote sustainable products and processes. To mitigate potential hazards, the chemical industry can develop sophisticated Environmental Management Systems (EMS) and adopt specifically developed programs such as ISO 14001,

the Eco-Management Audit Scheme (EMAS), and the Responsible Care Program (RCP). One of the biggest challenges the sector faces, according to De Faria et al., [18] is conducting sustainable operations within safe planetary limits, while being socially sound and profitable. The National Research Council [29] claims that another challenge for the chemical sector is that it needs to be balanced economically, environmentally, and socially, but lacks a coordinated effort to generate the science and technology to make this all possible.

Axon and James [30] discuss how the chemical industry could contribute to the United Nations (UN) Sustainable Development Goals (SDGs). They claim that the chemical industry, through its close relationship and investment in R&D, has historically provided science and technology with solutions that address many global challenges. The UN SDGs provide a frame of reference to allow the industry to assess how it impacts the planet and how it could make a positive contribution. Pan Fagerlin et al. [31] argue that the 17 SDGs and their 169 targets are often viewed as hyper slogans, but are too theoretical and lack a common ground. They claim that contextualization of the SDGs, in accordance with a firm's business practices, is required for the generation of a local understanding of sustainability. Authors suggest that translating the SDGs into a common language that organizational members can better understand is a good starting point.

The bibliography on materiality assessment and the material sustainability topics of every industrial sector, including the chemical sector, is poor. There are a few studies that focus on materiality and sustainability materiality topics of different industries, but our review of the existing literature did not identify any major academic studies that focus on the material topics and materiality in the chemical sector.

"Responsible Care" is the global chemical industry's voluntary initiative to drive continuous improvement in safe chemical management and achieve excellence in environmental, health, safety, and security performance. According to the initiative's 2018 report [32], the global chemical industry is committed to accelerating progress towards the United Nations Sustainable Development Goals (SDGs). Some sustainability Key Performance Indicators (KPIs), to measure progress, are health and safety, emissions to air, discharges to water, greenhouse gas emissions, energy consumption, energy intensity, and water consumption [32].

Mann [3] stresses the importance of health and safety in the chemicals business. In evaluating the potentially material environmental and social factors for the sector, he focuses on safety and sustainable product innovation. In addition, he identifies environmental issues, such as greenhouse gas emissions, air quality, and water management, as equally important topics for chemical companies. Mann claims that "safety is a highly material social factor as it speaks not only to management's focus on employee well-being, but also to the reliability of a company's plant operations and ultimately its profitability".

The European Chemical Industry Council (CEFIC) published a report in 2020 [33,34] on the progress made by the sector with regard to sustainability. According to CEFIC [33], "a thriving and sustainable chemical industry is an essential solution provider to the many challenges facing society today and tomorrow". CEFIC stresses the importance of stakeholder engagement and lists the following topics as being material for the chemical sector: GHG emissions, energy, waste and water management, resource efficiency, operational safety, biodiversity, and circularity.

Companies tend to highlight their most material sustainability topics in their reports without, however, offering thorough details on how or why they consider these topics as the most material. A study of 132 sustainability reports from 33 companies of 110 in the HDAX German Stock Market between 2014 and 2017 showed that companies do not fully disclose every step they make in order to carry out their materiality analysis including their stakeholder engagement techniques and their topic identification and prioritization methodology [35].

Another recent study offers insights on the material topics of the listed companies of Latin America. On average, the total number of topics considered material and disclosed by listed Latin American companies in their sustainability reports is 19. Eleven of them

are social topics (including six general social topics, three topics on labor practices, one in product liability, and one in human rights) as well as five environmental and three economic [36].

A study that assessed the materiality in the airport industry found that 52% of the material topics in the sustainability reports examined were social while 14% were economic, 20% environmental, and 14% were topics on corporate culture [37]. In the maritime sector, a study revealed that among 90 sustainability reports, the most common material topics were occupational health and safety, air emissions, energy management, innovative technologies, and security systems [38].

3. Methodology

In order to examine which sustainability topics are considered most material in terms of impacts' significance and importance within the chemical industry, 25 recent sustainability reports were reviewed and a content analysis was carried out. Firstly, we read the reports, secondly, we created a database, and thirdly, we analyzed and interpreted the findings.

The 25 companies were selected based on their chemical sales ($ millions) ranking, according to the list published by the *Chemical & Engineering News* magazine in 2020 [39]. The companies were selected solely based on their revenue, as it is an indicator of how big a company is and the impact it may have. The fact that all 25 companies already had a sustainability report in place was very helpful in our research and enabled us to make analyses and comparisons. The number of the reports we researched offered us satisfactory data and a plethora of information. Thus, we believe that 25 is an adequate amount of reports for the purpose of our research.

A content analysis was performed. The most recent (published before March 2023) sustainability report of each of these companies was reviewed to identify their material topics and compare the findings. Upon examination of the reports, a dataset comprising the topics that each chemical company reported as being material was developed and analyzed. This enabled us to define the most commonly reported topics globally and identify any trends, differences, or similarities within the data. We measured in how many reports each topic was brought up as being material. The frequency, or numbers of appearances within the 25 reports, is an indicator of significance.

The tailor-made character of a materiality analysis encourages differentiations among companies of the same sector. For instance, if a company has production lines near a protected area or near Indigenous people, that would affect its material topics. Nevertheless, the results would not affect the main material issues of the sector. On the other hand, if a topic only appears as material in only a few sustainability reports, that is an indication that it is not as material throughout the chemical sector.

The database we created also includes information on reporting standards used, reporting period covered, length of the report, company's headquarters location, report title, whether external assurance was provided, and number of topics reported as material.

We also examined each company's materiality assessment methods, to identify any differences or similarities and to highlight any unique approaches. There are different ways to carry out a materiality assessment and different standards and guidelines do not oblige companies to follow a comprehensive step-by-step methodology (only general guidelines included in GRI Standards [7]). Materiality assessments aim at identifying and prioritizing the most important impacts an organization has. Through the process, companies perform their own assessment and engage stakeholders to find out how important; material; and significant specific environmental, social, and governance (ESG) issues are to them. Materiality assessment gives a holistic view of all stakeholders and each company regarding the positive and negative impacts an organization has on the environment, the economy, and the society. The materiality concept is apparent in all sustainability reporting standards and guidelines and offers the outlines of every sustainability report. Companies that publish a

sustainability report state in a graph or a list the most material topics for them and their stakeholders following the international standards, guidelines, and trends.

We looked into the methodologies, standards, and approaches followed by the 25—under review—chemical companies, to identify any similarities, patterns, or differences between them. We attempted to better understand the reasons why chemical companies consider materiality assessment an important tool and what methods they use to carry it out. Notably, when reading the reports, it became apparent that the information provided on the companies' hazardous waste management practices was not sufficient. So, we decided to also review the hazardous waste management practices followed by these 25 big chemical companies. This is a topic which may get overlooked, even though hazardous waste is a stream that represents a significant percentage of the total solid waste chemical companies produce and, if not managed properly, can have a massive impact on our health and the natural environment.

A list of the 25 companies reviewed in this paper is presented in Table 1, which also entails the following information:

- Companies' location (country and continent);
- Title of the report;
- Reporting period;
- Whether the report was externally assured and by whom;
- Which reporting standard they used (if any).

Table 1. CSR reports—Database.

A/A.	Company	Country (Continent)	Reporting Standards Used	External Assurance	Title	Reporting Period
1	BASF	Germany (Europe)	GRI Standards—comprehensive, UNGC, HGB	KPMG AG	Integrated corporate report on economic, environmental, and social performance	2021 business year
2	Sinopec	China (Asia)	GRI Universal Standards—with reference, TFCD, Climate Disclosure Guidance by Hong Kong Stock Exchange (HKEx), UNGC, ESG Reporting Guide Hong Kong Stock Exchange (HKEx), Self-Regulatory Supervision of listed companies of Shangai Stock Exchange (SSE)	KPMG Hua Zhen LLP	Sustainability Report	2021 calendar year
3	Dow	USA (America)	GRI Standards—comprehensive, SASB, Greenhouse Gas (GHG) Protocol, TFCD, World Economic Forum Stakeholder Capitalism Metrics Disclosure Report, Non-GAAP Financial Measures	Deloitte & Touche LLP	ESG Report	2021 calendar year
4	Sabic	Saudi Arabia (Asia)	GRI Standards—core, UNGC, Internal SABIC's Reporting Criteria	KPMG AG	Sustainability Report	2021 calendar year
5	Ineos	Great Britain (Europe)	GRI Standards, UNGC	KPMG AG	Sustainability Report	2021 calendar year
6	Formosa	Taiwan (Asia)	GRI Universal Standards—with reference, AA1000, CSR Best Practice Principles for TWSE/GTSM Listed Companies of Taiwan, IR, TFCD, SASB	BSI	Sustainability Report	2020 calendar year
7	ExxonMobil	USA (America)	GRI Universal Standards—with reference, Sustainability Reporting Guidance for the Oil and Gas Industry (4th edition, 2020) by IPIECA and API, International Association of Oil and Gas Producers (IOGP)	Lloyd's (LRQA)	Sustainability Report	2021 calendar year

Table 1. *Cont.*

A/A.	Company	Country (Continent)	Reporting Standards Used	External Assurance	Title	Reporting Period
8	Mitsubishi	Japan (Asia)	Japanese Ministry of the Environmental Reporting Guidelines (2018) and Environmental Accounting Guidelines (2005 edition)	Deloitte	Sustainability Report	2020 fiscal year
9	Lyondellbasell	Netherlands (Europe)	GRI Standards, UNGC, SASB	None	Sustainability Report	2021 calendar year
10	Linde	Germany (Europe)	GRI Standards—core	Carbon Verification Service	Sustainable Development Report	2021 calendar year
11	LG Chem	Korea (Asia)	GRI Standards, IIRC, SASB, TFCD, CDP, ESG Information Disclosure Guidance Korean Exchange	Lloyd's (LRQA)	Sustainability Report	2021 calendar year
12	Air Liquide	France (Europe)	SASB, GRI (only linkage to specific GRI KPIs), TFCD, URD 2019 (Air Liquide's own reporting tool)	Cofrac	Extra-financial performance declaration & environmental and social reporting	2021 calendar year
13	PetroChina	China (Asia)	GRI Standards, UNGC, TFCD, Sustainability Reporting Guidance for the Oil and Gas Industry by IPIECA and API	PWC zhong tian llp	ESG Report	2021 calendar year
14	DuPont	USA (America)	GRI Standards—core, SASB, TFCD	WSP USA	Sustainability Report	2021 calendar year
15	Reliance Industries	India (Asia)	GRI Standards, Integrated Reporting (IR), TFCD	KPMG AG	Integrated Annual Report	2021 fiscal year
16	Toray	Japan (Asia)	GRI Standards, SASB, ISO26000	Lloyd's (LRQA)	CSR report	2020 fiscal year
17	Sumitomo	Japan (Asia)	GRI Standards—core, Japanese Ministry of the Environmental Reporting Guidelines and Environmental Accounting Guidelines (2005 edition), ISO26000, TFCD	KPMG AG	Sustainability Data Book	2021 fiscal year
18	Evonik	Germany (Europe)	GRI Standards—core, SASB, TFCD	KPMG AG	Sustainability Report	2021 calendar year
19	Shin-Etsu	Japan (Asia)	GRI Standards, Japanese Ministry of the Environmental Reporting Guidelines (2018) and Environmental Accounting Guidelines (2005), UNGC, UN International Bill of Rights UDHR, UN Guiding Principles on Human Rights	Three Outside Audits and Supervisory Board Members	Sustainability Report	2021 fiscal year
20	Covestro	Germany (Europe)	GRI Standards—core, German Commerial Code HGB	KPMG AG	Combined management report	2021 calendar year
21	Braskem	Brazil (America)	GRI Standards—core, SASB	Redes Sociales	Sustainability ESG Report	2021 calendar year
22	Lotte	South Korea (Asia)	GRI Standards—core	Lloyd's (LRQA)	Sustainability Report	2021 calendar year
23	Yara	Norway (Europe)	GRI Universal Standards—with reference	Deloitte AS	Sustainability Report	2021 calendar year
24	Solvay	Belgium (Europe)	GRI Universal Standards—in accordance, SASB, TFCD	Deloitte Bedrijf-srevisoren	Annual Integrated Report	2021 calendar year
25	Mitsui	Japan (Asia)	GRI Universal Standards—with reference, TFCD	SGS Japan Inc	ESG Report	2020 fiscal year

We chose the above parameters because the same information is being used when performing a benchmarking study for each industry in order to identify material topics for a company that wishes to create a sustainability report. The benchmarking study is

very common in the sustainability-reporting consulting industry and acts as the first step of identification of material topics that are included in the materiality analysis process.

4. Findings

4.1. Material Issues in the Chemical Sector

On average, the 25 companies reported 15 sustainability topics as being material. The range was between 7 and 25 topics. The average length of the reports was 159 pages. However, this cannot be considered as a very accurate indicator, as some reports (six) were integrated reports, including financial and other technical data, apart from information on sustainability matters. The reports' length ranged between 84 and 354 pages, indicating that all the reports we examined were significant in terms of volume and content.

Out of the twenty-five biggest (based on sales) chemical companies, twelve are based in Asia (five in Japan), nine in Europe, and four in the Americas (three in the United States of America and one in Brazil). Eighteen reports referred to the 2021 calendar year, while four referred to the 2021 fiscal year (April to March) and three referred to the 2020 fiscal year. With regard to external assurance, only 1 company out of 25 did not perform one. This offers increased credibility to the sustainability reporting of the chemical sector.

In total, 30 sustainability topics were reported by the 25 chemical companies as material for their operation, in terms of the impact they can have on the environment and society. Table 2 summarizes these thirty material topics, which have been clustered into three main categories, namely, Environmental (E), Social (S), and Governance (G). Ten out of the thirty material topics fall under the "Environmental" umbrella, nine are "Social" topics, and eleven are topics related to "Governance" and the overall way a company is managed. That indicates that there is a balance and that chemical companies do not prioritize one of these three categories as more significant.

Table 2. Material Issues.

Material Topic	Category	Sub-Topics	Appearances
Climate change	E	CO_2 emissions, GHG reduction, carbon-neutral growth, climate neutrality, climate response, GHG emissions	23
Occupational health and safety	S	Reduce process safety incidents, lost-time injury rate	22
Responsible procurement	S	Supply chain management, supplier social assessment, supplier environmental assessment, value-chain transparency, responsibility within the supply chain, CSR procurement, sustainability in sourcing	19
Environmental pollution	E	Emissions, air pollution, oil products transportation and storage, reducing impacts to land and habitats, clean air, environmental protection, oil spills, reduction in environmental impact, air quality, protection of ecosystems	18
Corporate governance	G	Governance integrity, public policy, sustainability governance, responsible business practices, code of conduct, appeal as an employer, fair corporate activities, new business models, establishment of sound governance, business integrity, corporate citizenship, corporate culture	17
Circular economy and materials	E	Recyclability, reuse, packaging, end-of-life solutions, full life-cycle considerations	17
Sustainable water management	E	Water intensity	16
Waste and effluents	E	Resource recycling and reuse, plastic waste in the environment, waste reduction, contribute to recycling	16
Diversity, inequality, and equal opportunity	S	Increase share of women in leadership positions, fair and inclusive workplace, equity, and inclusion	16

Table 2. *Cont.*

Material Topic	Category	Sub-Topics	Appearances
Research and innovation	G	Digital transformation, sustainability solutions, innovative transformation, sustainable innovation, digitalization, R&D, contribution to industry, R&D-based innovation, clean tech, lifecycle management	16
Economic performance	G	Grow sales, increase dividend per share, green investment, Responsible finance and investment, longevity, bolster competitiveness, growth, sustainable finance, new growth, entrepreneurship and agility, profitability	16
Product quality	G	Product responsibility, product safety, sustainable product portfolio, product stewardship, customer satisfaction, product safety and quality assurance, safe chemistry, product design	15
Energy management	E	Invest in new energy, energy transition, energy intensity, energy efficiency, energy saving, renewable energy	15
Compliance	G	Environmental, socioeconomic, legal	15
Local community rights and engagement	S	Support common prosperity, community communication and development, philanthropic spend, community development, contribution to social initiatives, social engagement, social investments	14
Human rights	S		14
Employee well-being and satisfaction	S	Integrity, work environment, finding and nurturing talent, healthy working environment	13
Training and education	S	Information and communications technology, vocational training, continuing professional development, talent acquisition and training, employee enablement	12
Business ethics and anticorruption	S	Transparency, stewardship, ethical management	11
Biodiversity and land use	E		10
Employment	G	Taxation and job creation, compensation and social protection, labor management, securing and developing human resources, human capital	10
Emergency preparedness	G	Security, emergency response, management of external crises, disaster preparedness, disaster prevention, plant safety, catastrophic events	9
Risk management and operation continuity	G		9
Natural resources	E	Resource efficiency, material loss, sustainable use of natural capital, efficient use of scarce resources, resource circulation	8
Information security and cybersecurity	G	Data security, cybersecurity, confidentiality, data privacy, intellectual property	6
Stakeholder engagement	G	Information disclosure and communication with stakeholders, stakeholder communication, board composition and oversight, partnerships	5
Customer health and safety	S	Industrial and public safety	3
Sustainable agriculture	E	Sustainable farm management, food security	3
Hazardous chemicals management	E	Hazardous materials	2
Transportation safety/logistics	G		1

In their reports, different companies may use different wording, terminology, or phraseology to describe the same broad material topic. Column three in Table 2 presents the different ways different companies refer to the material topics of column one. Finally, column four shows how many times each material topic was reported, in the 25 reports that were examined. This provides us with a good indication of which topics are most commonly reported as material, by major chemical companies.

In total, the 30 topics appeared 371 times in the 25 reports we studied. Figure 2 presents the distribution of these 371 appearances into the three main categories (E, S, and G). The topics belonging to the three different categories were equally often reported, by the chemical companies, as being material. Nonetheless, if one focuses solely on the top ten (most commonly reported) material topics of Table 2, it becomes clear that Environmental issues are more often reported as material. As presented in Table 3, five out of the ten most material topics for chemical companies are Environmental issues, three are characterized as Social and only two belong to the Governance category. This can also be noticed by paying attention to the color coding purposefully used in Figure 3.

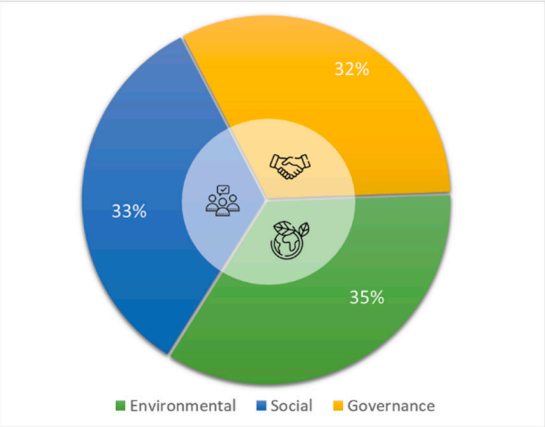

Figure 2. Appearances of material issues (clustered).

Table 3. Purposes of a materiality assessment according to companies' disclosed Sustainability reports.

Purpose—Objectives of a Materiality Assessment
▪ Identify and manage potential opportunities and risks
▪ Identify key ESG issues and continuously optimize the company's ESG management
▪ Identify policy trends and business opportunities
▪ Define topic boundaries, consistent with the GRI Reporting Principles
▪ Integrate ESG within the enterprise risk management process
▪ Create sustainable value

Table 3. *Cont.*

Purpose—Objectives of a Materiality Assessment
▪ Align the organization's strategy and operations with universal principles
▪ Contribute global value to the organization's broader commitment to sustainable innovation
▪ For the purposes of reporting and compliance
▪ Address the demands of society in order to achieve sustained growth
▪ Contribute to realizing a sustainable society
▪ Understand the organization's sustainability context
▪ Identify the topics that are pertinent to the organization's business and stakeholders
▪ Integrate the main risks and opportunities into the group's strategy
▪ Increase attention and feedback from stakeholders
▪ Become a benchmark for the plastic industry through good ethical, social, and environmental practices
▪ Advance action on the organization's set 2030 goals
▪ Provide focal points for the organization's sustainability management activities
▪ Renew the organization's strategic sustainability priorities and provide insight on the changing risk landscape
▪ Create value for all stakeholders and stay competitive
▪ Align with the world we live in today and the key challenges facing the organization's customers and the global stakeholder community

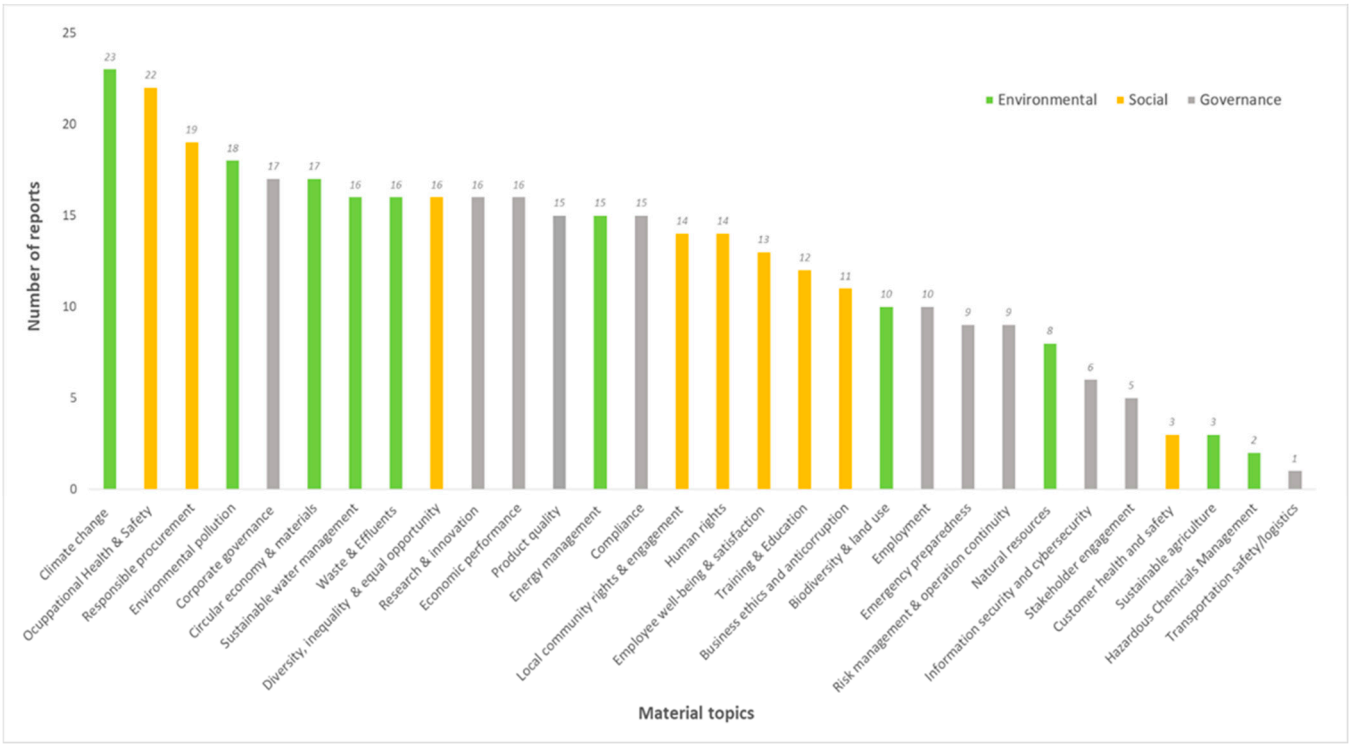

Figure 3. Material topics and count of appearances within the 25 reviewed reports.

The nine most commonly reported material topics, within the 25 reports that we studied, are climate change; health and safety; responsible procurement; environmental pollution; corporate governance; circular economy; waste; water; and diversity and equal opportunity, while the tenth place is shared between research and innovation and economic performance.

4.2. Materiality Assessment—Purpose and Approach

Another objective of this work is to examine how these 25 major chemical companies carry out their materiality assessment. We decided to study this as, like we already discussed previously, the significance of materiality has grown substantially for companies and is expected to grow further. However, many companies still fail to provide a clear and accurate description of the process used to carry out materiality assessment. The results of this paper can shed light into how chemical companies carry out materiality assessment and why they consider it important. After all, materiality assessment is the most critical step to fully realize the impact a company has and to properly mitigate and manage the associated risks and opportunities.

Table 3 summarizes the findings of our review, in regard to the reasons why chemical companies conduct materiality assessments. We looked into the methodologies and approaches that each one of the twenty-five under-review companies follow when conducting a materiality assessment. We want to better understand why chemical companies consider materiality important and what tools they use to carry it out.

Different companies use different phrasing or terminology to describe the purpose of carrying out a materiality analysis. Therefore, it was challenging to group them all into just a few categories. Instead, we present all of the different phrases/sentences used in the 25 reports, which each individual company used to describe why they think a materiality assessment is important. This gives us a good overview of how chemical companies approach materiality assessment and the reasons why they believe they need to do it.

The most commonly used words in the list above are value, opportunities, and contribute. This indicates that the companies we reviewed aim to use materiality as a tool to simultaneously contribute to the society and the environment, while at the same time

spotting opportunities for them to grow, comply with, and improve their overall image. It becomes apparent that all of them understand the value of materiality and recognize the materiality exercise as an opportunity to recognize their impacts, understand possible risks, and perform targeted sustainability actions. According to their statements in the sustainability reports, they see materiality as part of their business strategy that helps them to navigate in dealing with their business impacts. In Table 3, there are two statements that indicate how some companies might view materiality as solely a reporting requirement: define topic boundaries, consistent with the GRI Reporting Principles, and for the purposes of reporting and compliance. These statements are pragmatic and are valid for all sustainability reporters who follow international reporting standards. However, presenting them as a reason why your company is carrying out a materiality analysis might be an indication that the approach is superficial and that sustainability is not integrated in the overall business strategy.

Table 4 summarizes the different approaches and methods used by the 25 chemical companies, which were reviewed in this work, when carrying out their material assessment. This provides us with a complete overview of how chemical companies may approach the materiality assessment exercise. Some of the sentences in Table 4 overlap each other, but we decided to present them all and use the sentences in the exact words in which they were used in the relevant sustainability reports. Sometimes different words and phrasing can shift the emphasis of a phrase and place more gravity on different issues or meanings.

Table 4. Materiality assessment approaches according to companies' disclosed Sustainability reports.

Materiality Assessment Approaches
▪ using the concept of double materiality
▪ taking into account positive and negative impacts, along the whole value chain
▪ systematically evaluating sustainability criteria
▪ reviewing and evaluating material issues on a regular basis
▪ a Corporate Sustainability Board (experts) supported the board of executive directors
▪ on-going dialog with stakeholders and an internal analysis
▪ invited key stakeholders to evaluate the identified issues from their perspectives
▪ conducted stakeholder research and expert consultation
▪ each topic was assessed in terms of scale and likelihood of negative and positive impacts
▪ determined where in the value chain the impacts are more relevant

Table 4. *Cont*.

Materiality Assessment Approaches
▪ studied macro-policies and industry trends
▪ verification by strategy and risk functions and approved by CFO
▪ used the SASB Materiality Map prioritization criteria
▪ evaluation of relevance and significance for each material topic
▪ benchmark with the sustainability performance of industry peers
▪ analyze the organization's internal and external stakeholder needs
▪ key sustainability issues are listed for each department
▪ in reference to ISO 26000 core topics
▪ assess and score the impacts for material significance
▪ feedback from investor-focused rating agencies
▪ anonymous complaints mechanism for employees and external stakeholders
▪ organized externally facilitated thematic workshops
▪ surveyed stakeholders—questionnaires to internal and external stakeholders
▪ on- and offline surveys
▪ individual qualitative stakeholder interviews
▪ assess the significance and probability of moderate- and high-impact issues
▪ customer engagement exercises

Table 4. *Cont.*

Materiality Assessment Approaches
▪ followed the AA1000 Stakeholder Engagement Standard
▪ followed the Ipieca/API/IOGP Guidance
▪ hearings with external experts
▪ successful cases of domestic and foreign companies were benchmarked
▪ COSO-WBCSD guidance on applying enterprise risk management to ESG risk
▪ a specialized consultant was appointed to support the internal stakeholder teams

The analysis of the materiality approaches used by the 25 chemical companies showed that the most common approaches of conducting materiality assessment are stakeholder interviews and surveys, examining the impacts across the whole value chain, benchmarking with the sustainability performance of industry peers, and consulting a group of experts. This is expected as 24 out of 25 companies reference GRI Standards, which clearly require companies to perform a materiality analysis (although without suggesting a specific step-by-step methodology). Most companies follow at least one of the steps presented in Table 5. Only one company refers to the double materiality concept but this is expected as the concept of double materiality is relatively new and was first introduced under the sustainability context by the European Commission in 2019 [40], with its Guidelines on Non-financial Reporting. Double materiality implies that a company has to report both on how its own business is or can be affected by sustainability issues ("outside in"), as well as how their own operation impacts society and the environment ("inside out"). In addition, GRI Standards that all companies refer to have not included the concept of double materiality in their mandatory requirements.

Table 5. Most commonly reported material sustainability topics in the chemicals sector.

Most Commonly Reported Material Topics within the 25 Sustainability Reports	
1	Climate change
2	Health and safety
3	Responsible procurement
4	Environmental pollution
5	Corporate governance
6	Circular economy
7	Waste
8	Water
9	Diversity and equal opportunity
10 11	Research and innovation Economic performance (both topics ranked 10th)

Moreover, Table 5 shows that companies understand the need to include stakeholders in the materiality analysis process (as the international reporting standards such as GRI Standards require). It is most common practice to seek the need of external experts and consultants to perform the materiality exercise. They perform the analysis using on-going dialogue and engagement with internal and external stakeholders and the company's own internal analysis.

4.3. Unique Approaches and Projects

Most of the reporting companies do not go into much detail when describing their materiality approaches. They tend to simply reproduce the international standards and follow the guidelines. This is sufficient and ensures the accurate identification and prioritization of material topics and the impact they have on them. Two out of the twenty-five reviewed companies used a unique approach when performing the materiality analysis. Their approaches are described briefly below and they could be used as case studies.

Back casting from its vision of an ideal society in 2050, Mitsubishi Chemical Holdings (MCHC) formulated a medium- to long-term basic management strategy named KAITEKI Vision 30 (KV30). The strategy clearly defines the vision and the goals of the group for 2030 and its growth path. MCHC has furthermore identified the material issues to be addressed by the MCHC Group as part of the new medium-term management plan, APTSIS 25, which is based on KV30. Sharing MCHC's material issues, Mitsubishi Chemical is working toward the realization of KAITEKI —the sustainable well-being of people, society, and our planet Earth.

Another example of a unique approach is what DuPont does. One of the cornerstones of the materiality assessment was a set of workshops sponsored by the World Business Council for Sustainable Development (WBCSD) aligned with COSO WBCSD guidance on applying enterprise risk management to ESG risk. The externally facilitated workshops brought together stakeholders and leaders from across DuPont's global businesses and functions. The outcome was a holistic view of our most material ESG issues, aligned with feedback from investor-focused rating agencies, and market-focused input from our global businesses, ranked according to impact, likelihood, and management preparedness.

4.4. Hazardous Waste Management

As we already discussed previously, some products or materials, commonly used in the chemical industry, can be hazardous or contaminated with compounds that are characterized as hazardous for either human health or the environment. Any hazardous compounds or substances have to be properly separated from potential secondary resources and if this is not possible, they must be disposed of safely. In order to protect the environment, governments have created very strict regulations governing chemical waste management. Major chemical companies must comply with those regulations, manage their waste accordingly, and disclose relevant information.

When performing the contextual analysis of the 25 reports, we realized that only 2 out of the 25 chemical companies included hazardous waste management in their list of material topics, even though chemical companies manage hazardous substances and wastes. Therefore, we decided to look deeper and study whether chemical companies present sufficient information on hazardous waste management in their sustainability reports, as this topic can often be overlooked, overshadowed by other more popular (at this time) topics, such as plastic waste management or zero-waste initiatives. We scanned the reports and looked for information and data on hazardous management. The review we carried out revealed that all chemical companies, examined in this work, refer to managing plastic waste and they all refer to zero waste and/or the circular economy. They utilize their sustainability reports to describe how they manage these topics in substantial detail, and they set specific targets, to minimize waste quantities and implement relevant projects to better manage such waste streams. However, they do not describe their approaches and practices when it comes to hazardous waste management.

In total, 23 out of 25 companies provide numerical data on the volume of the hazardous waste they produce and they also mention what final management methods they use, such as "recovery", "treatment", etc. Nevertheless, none of the companies go into more detail to explain and describe what types of hazardous waste they produce, and how exactly they handle, store, transfer, or manage such waste streams. The description is superficial, restricted to numerical data, and does not always present clear treatment methods or approaches. None of the reports go into more details to explain and describe what types of hazardous waste are produced and how exactly such waste streams are handled, stored, transferred, or treated/disposed of.

Our view is that the topics of hazardous waste, with all the risks and implications it involves, should be discussed in more depth. More relevant information must be disclosed to provide clarity and a better understanding of how chemical companies manage the associated risks and approach this hot topic.

The list below summarizes the findings of our review, presenting the information that chemical companies disclose in their reports, regarding hazardous waste management. Below is a list of the exact phrases found in the reports that we studied. This is an indication of the level of detail chemical companies go into when describing their hazardous waste management approach.

- We continuously identify and evaluate the safest and most environmentally sound disposal routes for hazardous waste;
- Most of our hazardous waste was incinerated, where possible with energy recovery;
- We revised the Hazardous Waste List, in line with the National Directory;
- Strengthening waste reduction from source, process control, and end treatment;
- Carried out research on reducing hazardous wastes;
- We simplify the procedures for hazardous waste identification;
- Waste is tracked and categorized based on chemical properties, physical state, local governmental regulation, and hazard classification;
- Unusable, or non-recyclable hazardous waste is treated before disposal to eliminate or reduce the hazardous nature and volume of waste;
- Treatment may include destruction by chemical, physical, biological, or thermal means;
- All waste is recorded and monitored within a waste inventory system;
- Waste is transported to a certified waste disposal facility for destruction or landfilling;
- Waste is shipped to specialist waste treatment facilities;
- Ensuring the safe transport of hazardous materials;
- Educate our business partners about the hazardous properties of our waste and safety;
- Accelerate the development of technologies, organizations, and projects, which focus on the recovery and recycling of waste;
- Conduct stringent inspections on substances that are subject to management from the raw material handling stage;
- All materials are purchased after a review;
- Product development that incorporates life cycle assessment for environmental protection and sustainable development;
- Creating a chemical substance inventory and building a global chemical substance regulatory database to check our compliance with each regulation online;
- Evaluate risks that may arise from hazardous chemical substances, and maintain a database of products containing hazardous substances;
- Reducing the use of oil-based mud through layered drilling;
- Tighten controls over inappropriate disposal of waste;
- Developing specific milestones for reducing hazardous waste;
- Hazardous waste is recycled as alternate fuels and raw material for the cement industry;
- Implement chemical substance risk assessments;
- The process of waste storage is strictly managed and monitored.

By studying the reports, it became apparent that the reports that we reviewed only superficially discuss how these companies approach hazardous waste management. The

list certainly gives a good overview, but only a few companies describe in a bit more detail how they manage their hazardous waste. This, however, is not an indication that they do not have well-designed hazardous management practices in place. It suggests that these particular companies preferred or decided to discuss other topics in more detail, in their reports, and present less information on hazardous waste management.

5. Discussion

There is still a notable research gap related to the material sustainability topics that should be included in and define the content of sustainability reporting in the chemical industry. The absence of a clearly defined framework and guidelines on how to identify and prioritize material topics leaves room for uncertainty and inconsistency. At the same time, there are no sector standards to guide chemical companies to better understand what sustainability information needs to be provided in sustainability reports. Even though the sector is heavily regulated when it comes to the quality and safety of chemical products, the regulatory framework around sustainability reporting is rapidly evolving and still not concrete and clear. This results in inconsistency between the reported material topics across chemical companies and differences in terms of how they perceive, value, and carry out a materiality assessment.

While reviewing the existing literature, it became apparent that not enough information is available about how chemical companies approach materiality and which topics are typically material in the sector. Our work adds to the existing literature, aiming to contribute towards minimizing the gap. It offers an overview of the current situation and summarizes the material topics reported by some of the biggest chemical companies in the world. We reviewed 25 sustainability reports of some of the biggest global companies in the chemical industry—in terms of annual sales. This allowed us to identify which topics were most commonly reported as being material, within the chemicals sector, and to compare the findings. This enabled us to identify trends, differences, or similarities within the data. We also explored how chemical companies approach materiality assessment and if they disclose enough information on hazardous waste management, which is a topic that often gets overlooked, despite its impact.

The nine most commonly reported material topics, in the 25 reports that we studied, are climate change; health and safety; responsible procurement; environmental pollution; corporate governance; circular economy; waste; water; and diversity and equal opportunity, while the tenth place is shared between research and innovation and economic performance.

As discussed previously, materiality assessment is the most critical step, for an organization, to identify their impact, risks, and opportunities. Despite that, not all companies are absolutely certain about how to properly conduct a materiality assessment, and why it is of such great importance for themselves, the environment, and society. By reviewing the 25 reports, it became clear that these major chemical companies all take materiality assessment seriously, and they understand its importance and perform materiality assessments, following well-established guidelines. All of them follow certain standards and it is common practice to collaborate with external experts to identify the most material issues for them, and to design methods and tools to better manage the impact their operations (along the whole value chain) can have on the environment, the economy, and the society.

Our review identified "health and safety" and "GHG emissions" as material sustainability topics for the chemicals industry. This is in agreement with Te Liew [17]. However, at the same time, other topics that Te Liew identified as material, such as human rights, conserving energy, and community investment, were not among the most commonly reported material topics by the 25 companies we studied. The global chemical industry's voluntary initiative "Responsible Care" [3] focuses on health and safety, emissions to the air, discharges to water, water consumption, and greenhouse gas emission. Our results are in agreement with that, as all of these topics were also among the most commonly reported material topics by the 25 companies we examined. "Responsible Care" overlooks or does not give enough attention to some of the topics that our work classifies as material for the

chemicals sector, such as responsible procurement, corporate governance, circular economy, diversity and equal opportunity, research and innovation, and economic performance. On the same note, our research comes to be in line with the focus of the European Chemical Industry Council (CEFIC) on topics such as GHG emissions; energy; waste and water management; resource efficiency; operational safety; and circular economy. At the same time, it identifies topics that are being neglected by the CEFIC and should be considered as material based on the industry's impacts. These topics include responsible procurement; environmental pollution; corporate governance; and diversity and equal opportunity.

Our work highlights the need for more effort and targeted actions on topics that are material for the sector and can have significant impact on the environment and society. One of those topics is hazardous waste. The chemical sector is among the biggest producers of hazardous wastes, and the nature and properties of hazardous wastes can make them a significant threat and hazard to human health and the environment (particularly water). Despite that, our work shows that chemical companies use their sustainability reports to present numerical data, but they do not describe in detail how they manage hazardous waste. The description is superficial and often restricted to numerical data. This does not necessarily mean that these companies do not do enough. It is only an indication that they prioritize in discussing and presenting other topics in their reports. We suggest that companies should include more details about how they manage hazardous wastes in their reports.

One of the biggest challenges the chemicals sector faces today is maintaining a balance between being sustainable, socially sound, and profitable. However, due to the rapidly changing regulatory framework and customers' behavior, it seems like there is an absence of coordinated efforts to achieve this. Many different professionals from different backgrounds must work together (sustainability, sociology, law, business management, technology, I.T., applied sciences, etc.) to come up with feasible solutions. Our work can be seen as a starting point and a benchmark for future combined well-coordinated efforts.

The chemical industry is undoubtedly becoming more sensible towards sustainability; it incorporates sustainability in actions, plans, and decisions and it approaches the subject with increased responsibility. This is evident in the quality and content of the reports we reviewed in this work. However, the reporting standards, frameworks, and relative legislation need to be more consistent and uniform to help companies improve their sustainability reporting further.

Overall, our paper provides a useful overview of the current situation, in terms of materiality within the chemicals sector. This information can be useful for academics, researchers, practitioners, and the industry itself. This paper aims to serve as a materiality benchmark for the chemicals industry. In addition, our methodology and paper could also be used as an example to explore the material sustainability topics among other sectors. Future research is required to see how the materiality analysis and therefore the focus on sustainability topics will evolve in a few years, due to the new reporting standards and legislation, which rapidly change.

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