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RESEARCH ARTICLE

A bibliometric review and science mapping research of oil spill response

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ABSTRACT

This study aimed to evaluate the research output of oil spill response and citations from 2000 to 2022 through a bibliometric analysis. The primary findings were as follows: there has been a noticeable increase in the number of publications. The most active journal was Marine Pollution Bulletin. Environmental sciences ranked as the most popular subject area. The United States of America (USA) published the greatest number of single-authored, internationally collaborative, first-authored papers. Oil spill(s) was the most widely queried research term, ranking first in the article title, abstract, and author keyword analysis, respectively. The Deep-Water Horizon disaster, the largest marine oil spill in 2010, was the most frequently analyzed oil spill accident in the research as a sample. This study makes a significant contribution to the field of oil spill response science by being one of the few that applies network visualization and mapping technique. Further research is recommended in light of longer-term data and the diverse Web of Science (WoS) categories found in oil spill science, which may be visualized using a variety of bibliometric visualization applications.

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Introduction

Oil, as a significant factor affecting economic development and human life (Prendergast & Gschwend, 2014) has increased the worldwide seaborne trade of oil via tankers, as well as the oil exploration and production industries, resulting in significant benefits for diverse locales, regions, and nations (Hung et al., 2018; Wang et al., 2022). According to data findings (Sirimanne et al., 2019), oil tanker deadweight tonnage increased from 0.337 billion in 1980 to 0.601 billion in 2020, while the number of oil tankers increased from 10,609 in 2010 to 11,268 in 2020. However, as oil transportation increased, the risk of oil spills affecting marine ecosystems and coastal resources enhanced, resulting in the loss of fisheries,

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aquaculture, and tourism industries, as well as severe damage to social and environmental values (Li et al., 2016; Hung et al., 2018; Chen et al., 2019). According to ITOPF (2021) statistical data report, statistics on tanker spills more than 7 tones have showed a substantial decline over the last half-century. However, tanker collisions resulted in roughly 10,000 tons of oil being lost to the environment in 2021. This is a significant increase over the prior two years, owing mostly to the one large occurrence oil spill accident reported. Nonetheless, despite significant technological advancements aimed at ensuring the safety of navigation in order to minimize the likelihood of oil leakage (Li et al., 2016; Bucelli et al., 2018), the possibility and severity of oil spills at sea cannot be completely ruled out, as evidenced by several recent severe accidents (Bonvicini et al., 2022; Wang et al., 2022). To mitigate these consequences, preparedness and response to any oil spill are always necessary and important for sensitive resources, including observation, detection, mitigation, response, and remediation of oil pollution (Li et al., 2016; Hung et al., 2018).

Despite the devastating effects of oil spills on marine ecosystems, social and economic life, and worldwide policies encouraging scientific research on the subject, the peer-reviewed literature on oil spill response systems is expected to widen in the future years (Neves et al., 2015; Murphy et al., 2016). Although many studies and equipment exist that support oil spill response planning, because of this issue there remains a need for a comprehensive and review of oil spill research and their consequences. Current and future researchers, as well as their funding agencies, will benefit from this information, which will help them better understand the nature of oil spill response research, as well as latest trends and gaps in the field.

The application of bibliometric network analysis has proven to be an effective method for statistically assessing academic literature trends and patterns (Pauna et al., 2019). The study aims to conduct a bibliometric network analysis of the scientific literature on the subject of oil spill response research. The purposes of this study are (1) to present a detailed review of the evolution of research in these particular areas; (2) to ascertain the distribution of contributing countries and the most prolific journals on specified topics; (3) to establish the most commonly appearing keywords on the subject; and (4) to establish the most productive authors who have made major contributions.

The contribution of this research is in determining the publishing and citation trends in this subject throughout time, as well as the productive authors who have extensive research. This analysis also identifies the most productive journals that publish the results of research on oil spill response science, as well as their co-citation links. This is followed by a discussion of the characteristics of the most frequently referenced articles, which include critical information for field scholars. Additionally, the most productive countries, organizations, and authors are explored, as well as scientific cooperation at the country/organization/author level. Additionally, the co-occurrence of keyword analysis identifies the most commonly used keywords over time.

Literature Review

The shipping sector has undergone a series of large-scale ocean oil spills such as M/T Sanchi oil tanker collision (2018- estimated 138,000 tones spill size) or M/V Wakashio capesize bulk carrier grounded (2020- estimated 1,000 tones spill size). These large-scale spills in highly dynamic aquatic ecosystems emphasize the importance of rapid response technology capable of mitigating potential damage (Prendergast & Gschwend, 2014; Chen et al., 2020). To mitigate the negative consequences of an oil spill, it is also vital to manage spilled oil in an orderly and timely manner (Mohammadiun et al., 2021; Yang et al., 2021). This requires the development of both short- and long-term contingency strategies (Chang et al., 2014; Wang et al., 2022). A range of response methods are included in the oil spill control strategy/contingency, with the purpose of limiting possible damage to human health and the environment by maintaining a timely and coordinated response (Li et al., 2016). Effective monitoring techniques can help with spill cleanup by detecting slicks early and specifying oil characteristics, estimating spill volume, and predicting oil movement (Robbe & Hengstermann, 2006).

To lessen the severity of marine accidents, emergency response is critical, and considerable work has been done in this area. Krohling & Campanharo (2011) proposed a fuzzy Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method for the selection of the best response technique to spill accident. Passos et al. (2014) presented a multi-criteria decision method for assessing oil spill risk assessment on the Brazilian shore. Su et al. (2014) studied the factors affecting emergency response ability throughout the full process of unexpected water contamination events in a systematic and complete manner, and developed an emergency capability evaluation index system model. According to Alves et al. (2015), who advocate employing chemical dispersants for emergency reaction to major unintentional oil spills in a matter of hours, The oil slick paths are impacted by prevailing winds and current factors. Li et al. (2016) aimed to provide a

comprehensive review of the current situations and impacts of offshore oil spills, as well as the policies and technologies in offshore oil spill response and countermeasures. This study focused on the emerging issues in cold and harsh environments due to the increased risk of oil spills in northern regions as the Arctic Passage expands. Bonvicini et al. (2022) is performed Response Gap Analysis (RGA) methodology, which is identified the environmental factors negatively influencing the emergency response in a given sea area. Mechanical, chemical, and thermal response techniques are analyzed based on 11 environmental factors of RGA methodology. Diverse research on the oil spill science have been presented in various countries, collaborations, or contexts, thus a study focusing on a better understanding of the knowledge structure in this field is necessary. As a result, the study intends to enhance the contributions of existing publications by providing a bibliometric analysis of this research subject. This is a quantitative tool for examining the impact of a given scientific topic.

Bibliometric network visualization has been utilized in recent years to assess the research trends of many scientific categories and applications in numerous scientific domains (Zou et al., 2018; Khalid et al., 2021). These studies have shown that analyzing published literature can reveal important details about research production and scientific value. Furthermore, it is a critical issue that describing patterns and characteristics of publications for a certain scientific topic might lead to cooperation between researchers and organizations.

Despite substantial research on bibliometric analysis from a variety of fields, there are just a few studies that specifically focus on the application of bibliometric studies to oil spill science and response techniques. Mohammadiun et al. (2021) used bibliometric mapping analysis to profile computational strategies for marine oil spill control, which is a multi-stage and timely sensitive process that should be adequately prepared before any spill incidents occur, using data from the Google Scholar database. Herraro-Franco et al. (2021), presents to utilize bibliometric methods to study the network structure of studies examining the oil and environment interaction of South American countries. This research allowed for the gathering of knowledge on environmental protection, solutions, and energy alternatives, with environmental sciences accounting for 47 percent of the publications. According to Lim et al. (2021), perform a systematic review of diesel pollution studies in Antarctica published in the Scopus database, compares historical and current approaches to the management of fuel oil pollution in Antarctica and highlights the potential of plant breeding as a new hope for bioremediation response technique. Another research of the diesel contaminated seawater bioremediation response technique with Bacteria provides an up-to-date summary of the role of bioremediation in diesel hydrocarbon degradation and the impacts of oil spills on the environment and living species (Khalid et al., 2021). Vasconcelos et al. (2020) is aimed to perform network analysis of 50 year's oil spill detection and mapping publications. This study is revealed that the detection of oil in the water has evolved significantly in recent decades, and there is a close link between technological advancements aimed at detection and the advancement of remote sensing data collecting methods.

Materials and Methods

Bibliometric network analysis is a powerful method for investigating certain fields of study by combining bibliometrics and network mapping analysis (Sweileh et al., 2017; Zou et al., 2018). In bibliometric science, network mapping and cluster analysis based on network data allow the application of systematic thinking and the conduct of detailed literature reviews (Pauna et al., 2019). This type of study enables the system of a network based on the relationships between countries, publications, organizations, authors, and keywords associated with the research topic (Chen et al., 2016). The availability of numerous scholarly databases, in particular as Web of Science (WoS), Scopus, and Google Scholar, significantly facilitates the process of searching for and retrieving scientific papers for bibliometric analysis (Wong et al., 2020). WoS is widely recognized as the most authoritative database for these purposes, as it includes the highest number of indexed journals and conference papers, spanning over 150 research areas (Gonçalves et al., 2019). As a result, the WoS database was utilized as the data source for this investigation.

On February 02nd, 2022, the publications for this study were retrieved from the WoS search engine using the search terms "oil spill* AND (logic gate) response*" and any other related terms. The asterisk in the search string functioned as a wildcard operator, allowing for the addition of terms before by the asterisk. All data was stored as "Tab-delimited (Mac)" files that contained the contents of "Full Record and Cited References." The contents of "Full Record" and "Cited References" were used to conduct co-authorship and co-occurrence studies (e.g., network maps of authors, nations, and keywords), as well as citation analysis (e.g., network map of scientific journals). The search found 4620 items, which included a variety of different types of English language research papers published between 2000 and 2022 year.

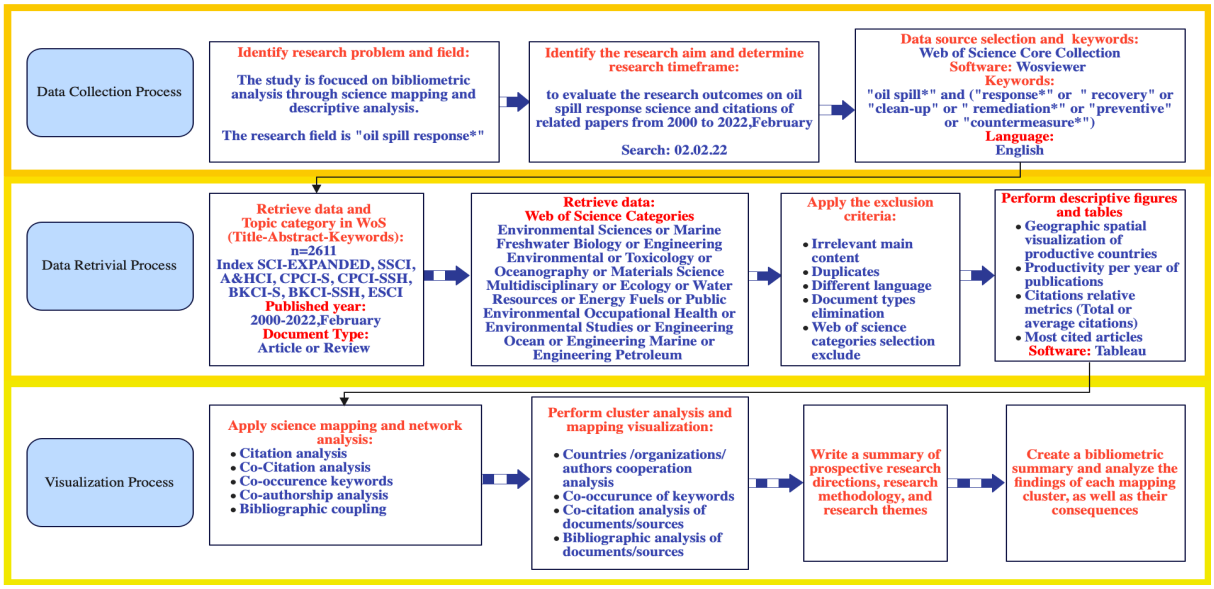

Figure 1. The conceptual framework of methodology

However, this analysis evaluated only articles and reviews with a limited WoS category, totaling 2611 publications. The WoS categories included in the research were limited to the maritime, environment and oceanographic sectors.

VOSviewer (version 1.6.18) software was utilized to conduct the bibliometric analysis in this research. This software enables users to create, visualize, and explore maps based on bibliometric network data (Van Eck & Waltman, 2013). The output findings are presented in sets to facilitate visualizing the existing relationships between bibliometric data.

The data analysis process was divided into two stages: To begin, we used Tableau software to conduct a geographic analysis of bibliometric data in order to identify the top countries by article count. The second stage was the production of bibliometric maps using the VOSviewer software, based on an examination of author co-citations, bibliographic coupling, and co-occurrence of the authors' keywords and most cited journals. A framework of the methodology, consisting of data collection, data processing and visualization stages, is shown in Figure 1.

For the aim of this study, the following terms of search results were included in the WoS queries (n=2611):

- ("oil spill*" and ("response*" or "recovery" or "clean-up" or "remediation*" or "preventive" or "countermeasure*") (Topic) and
- 2000-2022, February (Year Published) and
- Article or Review (Document Type) and
- English (Language) and
- Environmental Sciences or Marine Freshwater Biology or Engineering Environmental or Toxicology or Oceanography or Materials Science Multidisciplinary or Ecology or Water Resources or Energy Fuels or Public Environmental Occupational Health or Environmental Studies or Engineering Ocean or Engineering Marine or Engineering Petroleum (Web of Science Categories).

Finding and Results

From 2000 to 2022, all research and review articles on oil spill response were examined as follows. The aspects covered were the growth trajectory of publications and citations, the top cited of publication outputs, the distribution of publication outputs across subject categories and journals, and the publication outputs of individual countries; and the words in article titles, abstracts, and author keywords, as well as co-citation analysis, which is refers to the frequency with which two documents are mentioned by other documents. Figure 2 shows the scientific production of articles with citation analysis between 2000-2022, with a total of 2611 articles.

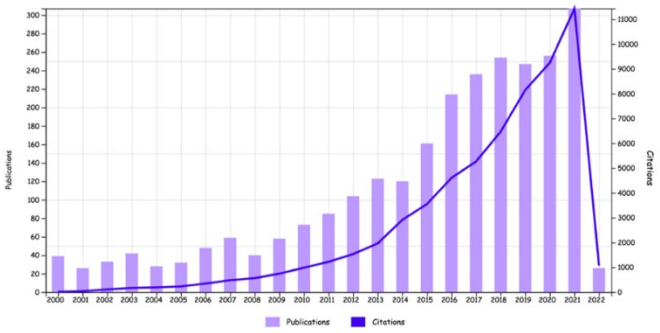

Figure 2. Times cited and publications over time

With 59 articles and 485 citations, the first peak in productivity was seen in the mid-2007s, accounting for 2.3 percent of overall productivity for the study period. Between 2016 and 2021, the highest peak of productivity was seen, with

1514 and 45260 citations respectively. This decadal period has by far the most publications, accounting for 57.9% of the total number of articles published over the length of this 20-year span. Figure 3 shows a bibliometric network to visualize collaboration nets and the distribution of publications across the world regarding the application of oil spill response query.

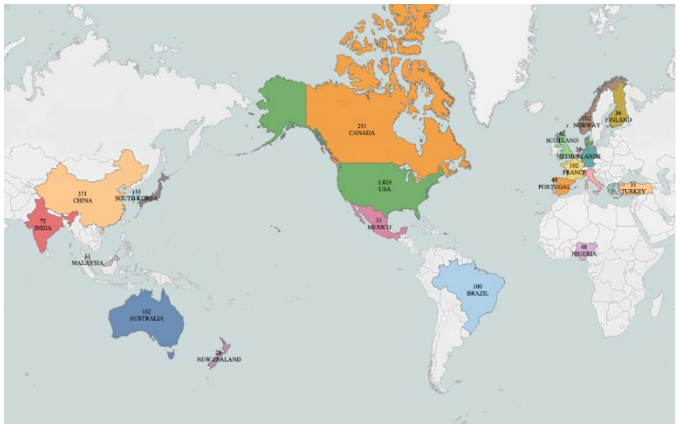

Figure 3. Most productive countries/territories of articles on oil spill response

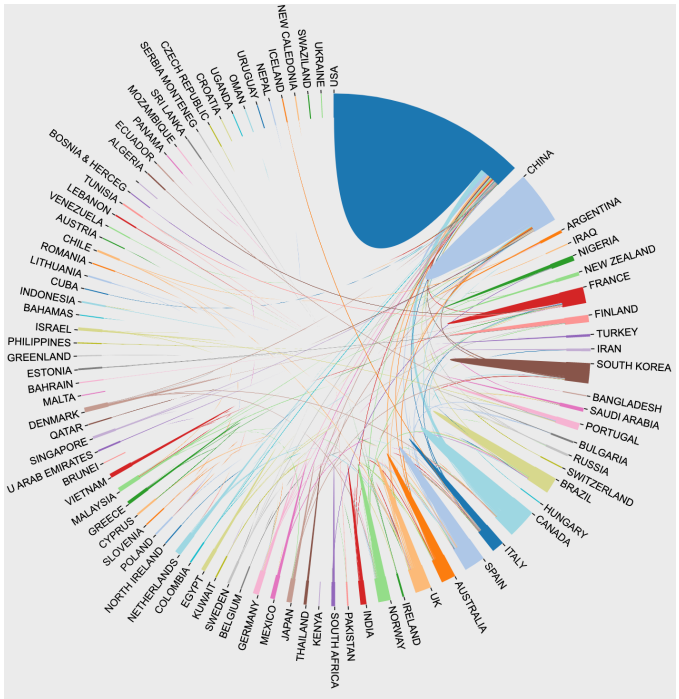

Figure 4. Interactions among the countries featured in the articles (Online platform: http://bibliometric.com/)

Results show a total of minimum 5 publications number of articles from different countries with at least one connection with each other. United States of America (USA) ranked first, with a total of 1028 (i.e., 39.3% of the total) documents, followed by China (371 docs~14.2% of the total) and third one is Canada (251 docs~9.6% of the total). Regarding the number of citations by countries, the United States ranked first, with a total of 26898(32% of the total) documents, followed respectively by China with 10017(11.9% of the total) and Spain 4341 (5.17% of the total). Figure 4 shows interactions among the countries related to oil spill response articles.

As shown in Figure 4, the most intensive link strength was between the USA and China, followed by the USA and Canada. These linkages are stronger between countries, indicating a high level of scientific cooperation on the subject. Figure 5 depicts on most productive journal in the context on oil spill response science.

Scholars can better grasp the academic preferences of each journal in the subject of oil spill by conducting research on high-quality journals, and thus be more focused when subscription to journals and publishing articles. As a result, we calculated the number of articles in the primary journals for oil spill response science research and ordered the top 10 journals by the number of articles published, as shown in Figure 5. A total of 107 journals, which are focused on a minimum number of five publications, were analyzed according to the number of articles. "Marine Pollution Bulletin" (n= 275, 10.91%), "Chemosphere" (n= 77, 2.94%), and "Environmental Pollution" (n= 75, 2.87%) were the most productive journals. The evaluated journals' WoS category was largely environmental science, and the 5-year impact factor weighted score was estimated as 6.645, implying that the selected articles were subjected to careful and stringent quality control by editors and peer reviewers. Table 1 summarizes the most cited articles related to oil spill response science between 2000 to 2022.

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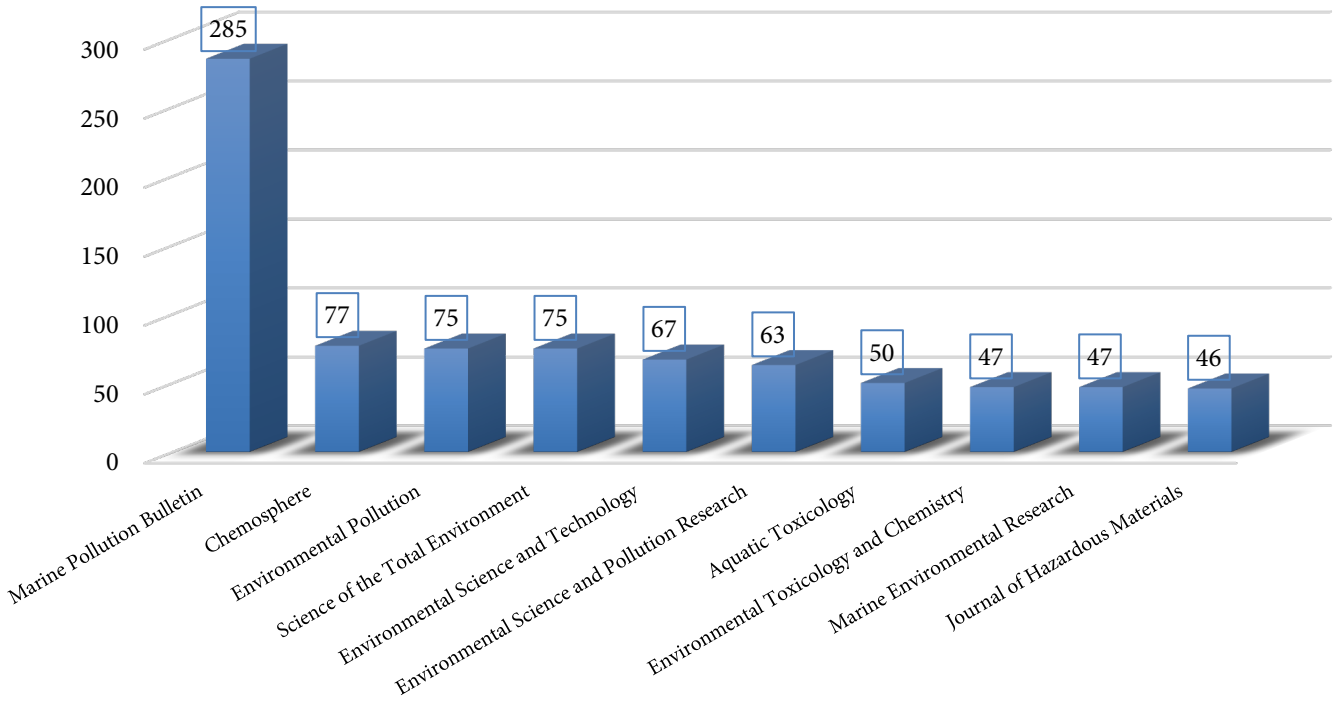

Figure 5. Most influential journal of oil spill response science

The most cited publications are also the most prominent in the subject of research. The first is by Xue et al. (2011) (1225 total citations), who presenting a proposal of materials that can be used in an innovative oil pollution response technique. The second is by Yuan et al. (2008) (883 total citations) carried out an experimental study presenting a self-assembly method to absorb oils up to 20 times, forming thermally stable, self-contained nanowire membranes in oil spill response. The third article is by Korhonen et al. (2011) (587 total citations) develop a product that is reusable, recyclable and has a high absorbent oil capacity to control oil spills. Figure 6 shows network mapping of co-authorship author analysis related to oil spill response studies.

To better understand the structure of scholarly contributions in this discipline, co-authorship and citation analyses were used. The examination of co-authorship analysis based on authors was limited to articles having a maximum of 25 authors per document, yielding a total of 10024 researchers. This number was subsequently decreased to 188 by only including authors who have published at least five times. Strongly collaborative authors from cluster 1 (20 authors, red) include Antonietta Quigg (Professor of Marine Biology, Texas A&M University, USA) and Samantha Joye (Professor of Oceanography, University of Georgia, USA). In cluster 2 (12 authors, blue), the most productive author includes Lee Kenneth (National Senior Science Advisor, Oil Spill Research, Preparedness, and Response for Fisheries and Oceans, Canada). In cluster 3 (11 authors, yellow) Lawrence S. Engel (UNC Gillings School of Global Public Health, USA) and Richard K. Kwok (National Institute of Environmental Health Sciences, U.S.A.) emerge as strong contributors. The striking detail in the co-author analysis is the researchers' work on the topics of oil pollution intervention after the BP Deep water horizon accident and its impact on human health. Figure 7 depicts co-word occurrence network analysis focusing on keywords that can be used to determine the state-of-the-art.

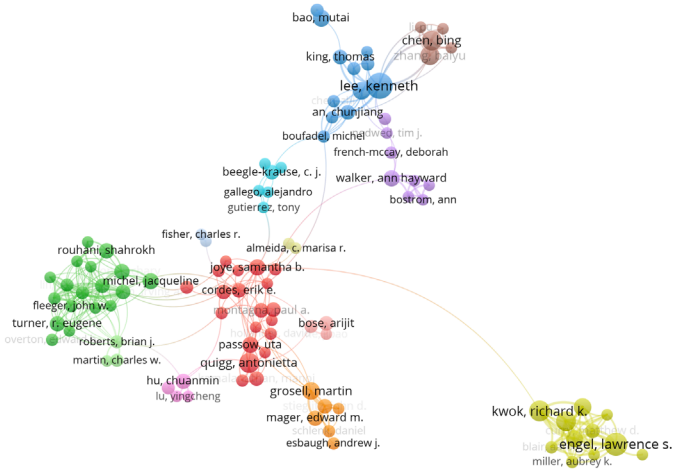

Figure 6. Oil spill response studies network map of co-authorship authors analysis

Table 1. Most cited articles related to oil spill response between 2000 to 2022

ID	Authors and Publication Year	Source Title	Total Citations	Average Per Year	Scientific Contribution	Aim of the Study	Methodology
1	Xue et al. (2011)	Advanced Materials	1225	102.08	To provide unique oil/water separation materials that have a high separation capacity, are resistant to oil fouling, and are completely recyclable.	To create an oil spill response material produced from recyclable, economical and environmentally friendly materials with high oil separation capacity	The theoretical and experimental analysis
2	Yuan et al. (2008)	Nature Nanotechnology	883	58.87	To propose an innovative material that could be favorable in the elimination of organics, notably in the field of environmental cleanup.	To present a self-assembly method for absorbing oils up to 20 times, forming thermally stable, self-contained nanowire membranes in oil spill response.	The theoretical and experimental analysis
3	Korhonen et al. (2011)	ACS Applied Materials & Interfaces	587	48.92	To pave the way for nanocellulose-based oil absorbents with long-term applications.	To develop a product that is reusable, recyclable or has a high absorbent oil capacity	Experimental analysis
4	Kujawinski et al. (2011)	Environmental Science and Technology	582	48.5	To offer essential geochemical parameters for future toxicological assessments and provide important restrictions on proper modeling of the deep-water dispersion	To perform experimental synthesis of environmental fate of dispersant on deep-water applications	Sample analysis and using ultrahigh resolution mass spectrometry and liquid chromatography
5	Boopathy (2000)	Bioresource Technology	507	22.04	To reveal all the factors affecting the bioremediation technique and determine the restrictions of application	To determine the different issues that limit the application of bioremediation technology, including various factors.	Review
6	Choi et al. (2011)	ACS Applied Materials & Interfaces	468	39	Ease of use, thanks to processes that are recyclable and have a simple preparation procedure	To create an innovative sponge that is recyclable, environmentally friendly and has a high oil absorption capacity	Experimental analysis
7	Atlas & Hazen (2011)	Nature Nanotechnology	459	38.25	Contribution to advanced molecular techniques to characterize microbial communities in oil pollution bioremediation technique	To offer a series lesson on the role of microbial biodegradation in determining the fate of the spill about two major oil spills	Review
8	Ge et al. (2017)	Environmental Science and Technology	388	64.67	A Joule-heated sorbent design has been developed for the first time to achieve high-speed cleanup of viscous crude-oil spills.	To propose an innovative sponge that reduces the viscosity grade of crude oil products	Experimental analysis and Optimization of efficiency
9	Ge et al. (2016)	Advanced Materials	354	50.57	To make implications for the production of next-generation oil absorbent materials, the production of oil absorbers, and the recycling of both oils and absorbent materials	To define the processes of manufacture, design, modification along with additional features that need to be developed for petroleum sorbents	Comparison between oil sorbents on technical, design and modification process
10	Singer et al. (2000)	Marine Pollution Bulletin	297	12.91	To standardize the preparation, analytical measurement and exposure method of the toxicity test environment used in the oil pollution response that can be used by all researchers.	To compare toxicity prediction tests that standardize both biological and analytical methods and provide a reliable and consistent database	Comparison between toxicology testing

Oil spill(s), deep water horizon, crude oil, bioremediation, Gulf of Mexico, biodegradation, dispersant, biomarkers, and polycyclic aromatic hydrocarbons were the ten words with the largest number of co-occurrences with repeating at least five keywords in general. These words are a strong indicator that they represent major conceptual and methodological structures in the literature on oil spill response. The greatest set of common word networks covering all years are correlated with phrases related to oil pollution response systems and the world's worst environmental disasters as can be seen in Figure 7. Oil spill response studies network map of co-cited references is shown in Figure 8.

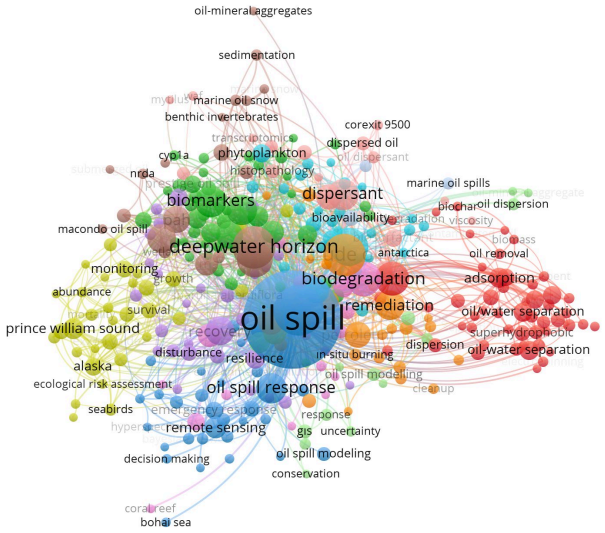

Figure 7. Network map of keywords related to oil spill response studies during 2000–2021

Co-citation, which is presented in science by Henry Small, indicates that two articles were cited jointly in the references of a third publication (Tan et al., 2021). A connecting line between two references indicates that two articles from separate journals are mentioned in the same article, and the strength of the connecting line indicates the degree of co-citation between the two articles (Herrera-Franco et al., 2021). Figure 8 depicts the co-citation networks of references as a visual representation of these articles, with red, green, yellow, and blue indicating the four primary clusters of co-cited articles and associated themes. Co-citation analysis of the 330 most relevant references with at least 20 citations from 2000 to 2022 revealed six clusters. The most prolific articles in Cluster 1 (red color), consisted of 92 articles, were Hazen et al. (2010) based on citations, and strength of link. In the reviewed article, a comprehensive study was carried out on the biological impacts of oil and its effect on indigenous oil-degrading bacteria after the Deep-water horizon blowout accident. Cluster 2 (green color) comprised of 89 publications that primarily used an environmental toxicology approach. The most cited article in Cluster 2 was by Singer et al. (2000), who standardize the preparation, analytical measurement and exposure method of the toxicity test environment used in the oil pollution response that can be used by all researchers. The other most prolific reference is Adebajo et al. (2003) in the Cluster 3 (Blue color). The synthesis and absorbing capabilities of a wide range of porous sorbent materials that have been researched for use in the removal of organics, notably in the area of oil spill cleanup, are reviewed in this paper.

Our research examines the evolution of research trends and recent theoretical dynamics from many perspectives and makes contributions in a variety of ways. First of all, the study makes an exploratory analysis to trace the highly cited research publications in oil spill response and summarizes the leading authors, revealed aim, methodology, and scientific contributions of literature related to oil spill response science. Second, this study makes a methodological contribution to the field of oil spill response science by presenting a bibliometric mapping that enables for the evaluation of scientific presentation as well as its visual analytics using three bibliometric mapping techniques (co-occurrence keyword analysis, author co-citations analysis, and co-authorship analysis), allowing for a better understanding of the field's structure and development.

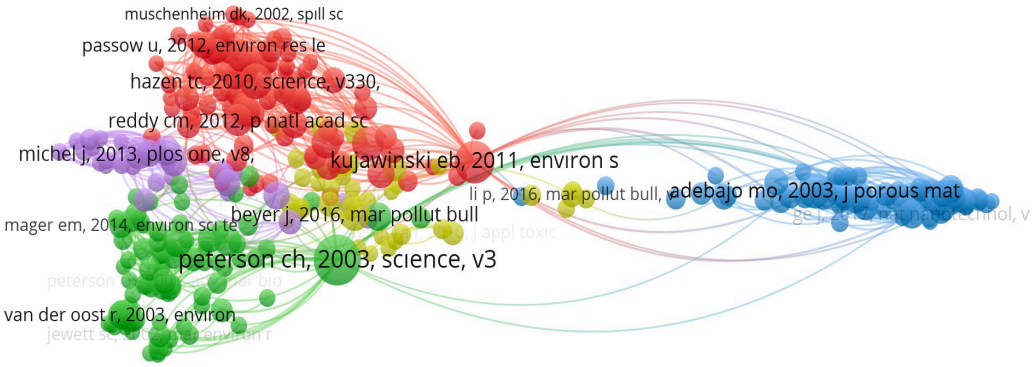

Figure 8. Oil spill response studies network map of co-cited references

The 2611 publications and research that have been mapped by imposing a minimum limit of 5 documents produced by 188 authors and their study presented in 107 journals, from universities and research centers in 58 countries, demonstrate growing interest in the topic. Xue et al. (2011) (who studied chemistry and molecular science) is the most mentioned article in these contributions (see Table 1), followed by Yuan et al. (2008). Both authors have made major contributions to the field of oil spill response science by conducting an experimental analysis and proposing a new and recyclable material for use in oil spill response. The usage of bibliometric maps creates a visual history of the research topic that is both interesting and informative. These maps enable us to draw the following conclusions:

- Keyword co-occurrence analysis indicated existing subjects as well as substantial improvements in the intellectual structure of oil spill response, as well as the stability and strength of other subjects (see Figure 7). Over an 87-day period, the Deepwater Horizon oil catastrophe dumped 134 million gallons of oil into the Gulf of Mexico, contaminating 1,300 miles of shoreline across five states. According to scientists, the Deepwater Horizon oil spill killed thousands of marine species and sea turtles while poisoning their ecosystems. It shows that the Deepwater Horizon catastrophe is regularly replicated in word analysis, and that the intervention approaches created as a result of accident analyses contribute significantly to this science. When the study development in Figure 2 is analyzed, it reveals the significance of the accident that occurred in 2010 in relation to our research topic.
- The most problematic topic is controlling and cleaning up marine oil spills, because it is difficult to retrieve all of the oil that has been spilled into the water. Physical, chemical, thermal, and biological cleanup approaches are current response techniques used (Dave & Ghaly, 2011). Many oil spills have already been treated with bioremediation, notably the one in Prince William Sound (which is the second most considerable accident frequently repeated in analyzes see in Figure 7). The bioremediation technique emerges as the leading technique when considering the materials developed in the studies as well as other clean-up techniques. This method of accelerating oil degradation by augmenting bacteria and nutrients to oil spills has a lower environmental impact than other recovery methods (Khalid et al., 2021). This will make communities more resistant and help them recover sooner after a spill.
- We identified the United States, China, Canada, and Spain to be the top four countries in terms of the number of publications, funding, and number of authors. The co-authorship examination of countries determined that China, the United States, Canada, and Italy were at the core of international cooperation, demonstrating this pattern (see Figure 4). When looking at the ITOPF (2021) study, it was discovered that oil pollution accidents, which have resulted in major environmental disasters around the world, occur in and around these four countries, and that research institutes are making progress on these concerns.
- Environmental Sciences, Marine Freshwater Biology, and Engineering were determined as the most prominent subject categories of knowledge in terms of the number of publications. The number of articles in each category reveals this, indicating that the field of oil spill response is likely relevant in terms of the themes addressed by the frequency of publications. Furthermore, when the categories of the most productive journals (see Figure 5) in Web of Science are studied, it is clear that the journals with the highest impact factor in the field of environmental science are those ranked by Journal Citation Indicator by Clarivate, Thomson Reuters.

This was the first attempt to map the oil spill response field in a methodical way. However, there are certain limits to our bibliometric analysis to consider. For instance, we only used one database (Web of Science) to assess impact, and we only used citations to do so. As a result, impact factors limited this approach, and it did not include all scientific publications. We analyzed peer-reviewed research articles, and pertinent review articles written in the English language in the sample to ensure homogeneity. Other publications, such as conference proceedings, book chapters, and reports could be useful in the future. We established a minimum threshold level between 2000 and 2022 because it is a new and emerging subject, and clusters were formed based on that threshold; this is a restrictions of this bibliometric mapping analysis because some potentially intriguing articles may have been removed. To summarize, the field of oil spills has expanded significantly, but more multidisciplinary research is required to completely investigate the numerous topics. Importantly, the study of response strategies needs more attention and emphasis in order to lead future research in this area. Further research is

recommended in light of longer-term data and the diverse WoS categories found in oil spill science, which may be visualized using a variety of bibliometric visualization applications.

Compliance With Ethical Standards

Authors' Contributions

MB: Conceptualization, Software, Resources, Investigation, Methodology, Visualization, Formal analysis, Writing – review and editing

BK: Conceptualization, Writing – review and editing, Resources, Supervision, Investigation, Visualization

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

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