

Review

Scientometric Review and Thematic Areas for the Research Trends on Marine Hoses

Chiemela Victor Amaechi ^{1,2,*} , Idris Ahmed Ja'e ^{3,4}, Ahmed Reda ^{5,6} and Xuanze Ju ⁷ ¹ School of Engineering, Lancaster University, Bailrigg, Lancaster LA1 4YR, UK² Standards Organisation of Nigeria (SON), 52 Lome Crescent, Wuse Zone 7, Abuja 900287, Nigeria³ Department of Civil Engineering, Universiti Teknologi PETRONAS, Seri Iskandar 32610, Malaysia⁴ Department of Civil Engineering, Ahmadu Bello University, Zaria 810107, Nigeria⁵ School of Civil and Mechanical Engineering, Curtin University, Bentley, WA 6102, Australia⁶ Department of Engineering, Qatar Energy, Doha 3212, Qatar⁷ Engineering Company, Offshore Oil Engineering Co., Ltd., Tianjin 300451, China

* Correspondence: c.amaechi@lancaster.ac.uk or chiemelavic@gmail.com

Abstract: For over three (3) decades, there has been an increase in research on energy sources from the production of oil using flexible marine risers, such as marine hoses. Marine hoses are conduits for special use as rubberized structures with hybrid polymer composites for offshore platforms in the oil and gas industry. This scientometric study uses qualitative, quantitative, and computational approaches. Data were retrieved using a research methodology that was created for this study using the SCOPUS and Web of Science (WoS) databases. This study provides a bibliometric literature review on marine hoses with an emphasis on the advancements made in the field from recent developments, geographical activity by countries, authorship histories, partnerships, funding sources, affiliations, co-occurrences, and potential research areas. The study found that the USA had the most publications, but there were fewer co-occurrences with connections outside the cluster. Due to the difficulty of adaptation, acceptability, qualification, and deployment of marine hoses in the offshore marine industry, this topic contains more conference papers than journal papers. Therefore, more funding sources and collaborations on marine hoses are required to advance the research. This study makes a contribution to scholarship on advances made in petroleum exploration and production for (un)loading hoses.

Keywords: marine hose; pipeline; marine bonded composite hose (MBCH); marine structures; research trend; research pattern; scientometric; bibliometric; scientific review; hoses; review



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1. Introduction

Currently, there is still a high global dependence on fossil fuels which require lighter sustainable materials for energy production [1,2]. Thus, the recent need to develop sustainable materials has led to the utilization of polymers as hybrid materials across different fields [3–6]. The interest in hybrid polymers such as elastomers has grown significantly over the past three (3) decades, along with scientific study. Hitherto, different literature exists offering a wealth of information for biomedical research facilities, oil corporations, engineering firms, and manufacturing companies such as hose manufacturers [7–12]. Additionally, the rising energy demand for fossil fuels has prompted an expansion in the oil and gas sector. This has led to subsequent operations seen in various exploration, drilling, and production activities [13–16]. Despite the diverse studies conducted on both conduits and subsea pipelines, the stress analysis of these subsea piping products is important to explore the characteristics of each hose/pipe product [17–27]. These studies consider the influence of global issues, technological changes, and climatic changes on the deployment of marine structures. Some of these studies used different weather conditions for different sea states to assess the performance of marine hoses [28–38]. Aside from environmental conditions,

the recent COVID-19 pandemic caused some changes in the trends of production, energy generation, distribution, supplies, and consumption [39–49]. However, the offshore marine industry has adapted different measures to ensure that there is the sustainable production of oil and gas products, particularly with (un)loading marine hoses [50–60]. These activities have stimulated the development of novel processes, technologies, and materials, as well as new adaptations in a number of industries, as recorded on hose development, hose modeling, hose failures, etc., from various publications. These are ascertained from different databases through the survey on “marine hose”, as shown in Figure 1. It shows that Academia had 6935 publications, followed by ScienceDirect, which had 6901 publications and then followed by Wiley Online, which had 3129 publications. It was followed by OnePetro which had 2364 publications, then Google Scholar, which had 2120 publications; Taylor & Francis, which had 2010 publications; ResearchGate, which had 1000 publications; ASME digital collections, which had 595 publications; Sage Journals, which had 590 publications; ASCE library, which had 346 publications; Scopus, which had 296 publications; and then Web of Science (WoS) had the least with 223 publications.

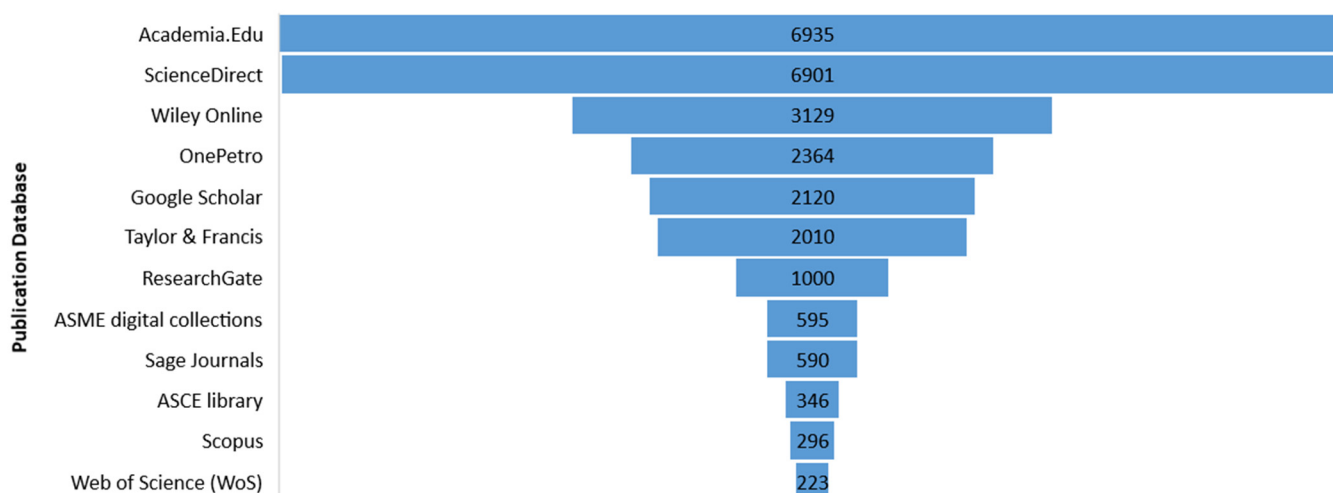


Figure 1. Result of literature search from different publication databases on “marine hose”.

Although the development of marine hoses is affected by the different factors, the rising cost of manufacturing different materials is an important factor, thus hose manufacturers seek to develop less expensive materials. Thus, there is an increase in material development research, such as elastomers for marine hose production [61–66]. In the marine industry, the application of rubber materials called elastomers, have been used over time for different offshore marine structures, such as offshore fender barriers, industrial hoses, flexible hose-lines, etc. Additionally, in the manufacturing industry, the increase in polymer production is one of the main production sources for marine hoses. Elastomers, for instance, have strong adsorption capacity, durability, and flexibility properties. Another important benefit of polymers is their high economic advantage. Additionally, both polymers and composites are potential materials that could be used to improve the performance of marine hoses. The hose materials are used to enhance the mechanical characteristics, longevity, fatigue resistance, and usability for marine applications [67–77]. Based on innovative designs, oil offloading lines (OOL) have found recent applications in deep water at offloading terminals [38–41,77]. Gonzalez et al. [78,79] investigated the axial and bending behavior of marine hoses using numerical models. Another important factor is the influence of wave loads under environmental conditions on marine hoses at SPM terminals. Amaechi et al. [80,81] investigated the strength performance and wave-current interaction (WCI) of marine hoses attached to catenary anchored leg-mooring (CALM) buoys under hydrodynamic loads for environmental conditions in the Gulf of Mexico (GoM) [82,83]. O’Donoghe and Halliwell [84,85] conducted mathematical modeling on the axial forces and vertical bending of floating marine hoses with experimental

models. Brown and Elliott [84,85] conducted dynamic analysis of floating hose-string using mathematical modeling to understand the hose response using two-dimensional (2D) and three-dimensional (3D) dynamic analysis for single point mooring (SPM) systems. Hasanvand and Edalat [86,87] conducted sensitivity analysis of marine hoses at CALM oil terminals under environmental conditions in the Persian Gulf region. Tonatto et al. [88,89] conducted computational modeling of marine hoses using parametric analysis with progressive damage models. However, some studies presented theoretical models on marine hoses by considering parameters such as internal pressure loads [90–94]. The literature search found some models conducted on the CALM terminals with marine hoses and floating buoys to understand the motion response using coupled models, computational fluid dynamics (CFD) models, hydrodynamic models, and experimental models [95–99]. However, important aspects of SPMs are their integrity management, life extension and reliability [100–110], mooring response, fluid-transfer mechanisms, and the response of the marine hoses at SPM terminals [100–110]. Another challenging area of marine engineering is failure modes of marine hoses and the installation of conduits such as pipelines, submarine hoses, umbilicals, and subsea marine risers [111–121]. Hence, there is a need to study the research patterns and advances made in this area as part of a systematic or scientific review.

In this paper, the scientometric review and thematic areas on the research patterns of marine hoses were conducted. Some introduction to this research is presented in Section 1, while the research methodology is presented in Section 2, with some discussion on the framework used to conduct the study by utilizing the data retrieved from SCOPUS and Web of Science (WoS) databases. The results and discussion are presented in Section 3, while Section 4 provides the thematic areas for the study with recommendations for future studies. Future research areas on marine hose are presented in Section 5. The concluding remarks are presented in Section 6.

2. Methodology

In this section, the methodology used for the data analysis and the research design for this study is presented.

2.1. Data Retrieval and Research Design

A scientometric review and meta-science analysis of marine hoses were carried out in this study. “Marine hose” was used as the search term for the literature search. There was a thorough bibliometric literature evaluation, scientometric review, and meta-science analysis on different fields considered for this study [122–133]. The meta-science analysis on marine hoses was used to carry out the initial analysis from the bibliographical review. This was accomplished by gaining access to current academic works from two academic databases, which include high-impact journal papers and conference papers in the field. Additionally, a literature search and a few classifications were offered before being examined. An examination of the science, engineering, and general research from publications, including reviews, journal articles, and conference papers, was then conducted on marine hoses using scientometric analysis and text mining. Additionally, there was a major emphasis on the advances made on marine hoses for the offshore marine industry, as portrayed in earlier reviews on marine hoses [6–8,17–19].

To determine the impact of various international initiatives for research on marine hoses, the meta-analysis was created using data obtained from the SCOPUS and Web of Science (WoS) databases. These data were compared with data obtained recently, up to mid-2022, from the same database. With conceptual frameworks, theoretical formulations, and bibliometric analysis, bibliographic studies have developed a new method of analyzing theoretical literature in a range of fields, including engineering design, management science, and ocean engineering. As a result, a thorough meta-science examination of the bibliometric literature has been carried out in this section. This was accomplished by consulting recent academic papers from both databases, which included high-impact journal papers and

conference papers in the field. It was restricted to meta-science analysis because of the scope, which was also utilized to validate discoveries on the cutting edge of marine hose technology. The bibliometric methodology encapsulates the application of quantitative techniques (bibliometric analysis, e.g., citation analysis) on bibliometric data (e.g., units of publication and citation). To effectively implement such methods, specific bibliometric software such as Gephi, Leximancer, and VOSviewer can be used. In the present study, VOSviewer was used. Further description of the scientometric analysis on the marine hose is presented in Section 3. Based on the information gathered during the scientific literature review that was undertaken, the framework and direction took important meta-science factors into consideration, such as the impact on the offshore marine industry. The methodology is presented in Figure 2.

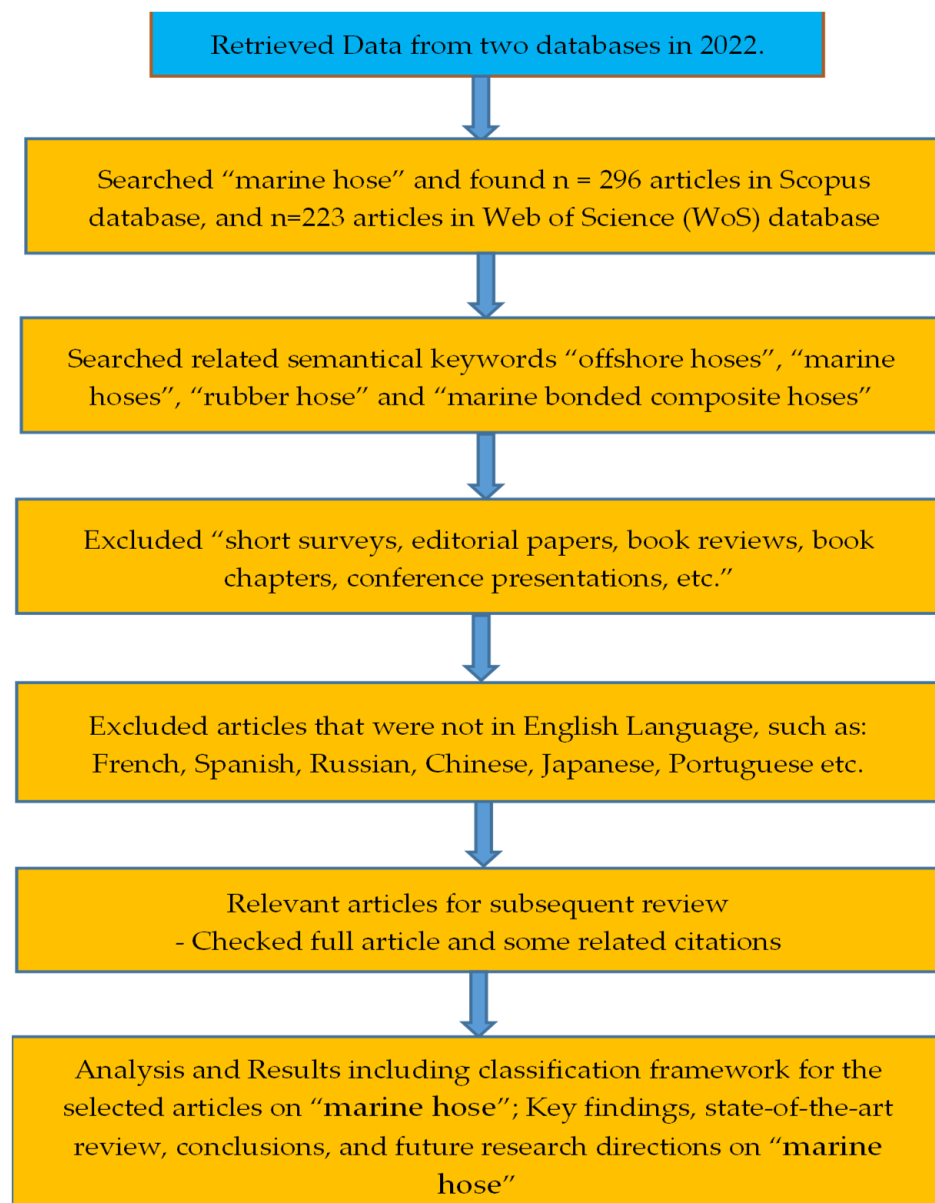


Figure 2. Research methodology on the scientometric review for marine hoses.

As indicated in Figure 2, the approach taken into account in the meta-analysis involved using an accessible academic database to extract data on the subject matter and exclude the resources that were not required. It responds to the question, “What are the trends in the research on marine hoses?” What collaborations have been established for marine hoses?

What can be learned from advances in marine hoses? What are the implications for the elaboration of guidelines and standards on marine hoses?

It is noteworthy to justify the need for this literature review in this subject area, considering that previous reviews on marine hoses exist, such as those authored by Amaechi et al. [17–19]. Thus, the requirement for the present study needs to be justified herein. Generally, there are conceptual differences between the presented study and the previous publication [17–19], as they all applied different methods and concepts, as follows:

- i. The present study is based on bibliometric data analysis to understand the trend in research from publications, while the former reviews were based on developments in marine research, looking more at practical works, mostly from the industry and hose manufacturers.
- ii. Additionally, the present study looks at metrics from citations, publication subjects, publication types, authorships, etc., while the former reviews looked at metrics from patents and state-of-the-art works from individual research outputs made on marine hoses as well as industrial marine hose products.
- iii. Lastly, the present study involves a systematic literature review called scientometrics which uses bibliometric data, while the former employed a traditional literature review which uses individual authored research, industry presentations, conference papers, and company reports to identify progress made in the industry and academia.
- iv. Both reviews present different findings on marine hose development and publication trends, despite the limited expertise required from this technical subject.

2.2. Scientometric Review: Tools and Framework

Recent growth in scientific research has provided us with access to a wealth of information on the offshore marine industry. Data retrieval and text mining tools such as CiteSpace are commonly used [125–131]. In order to improve technological methodology, research techniques, or the hit-to-lead identification process, publication databases may be helpful in minimizing hit multiplicity, as seen in recent scientometric reviews [132–140]. The avalanche of papers published each year could obscure most of this knowledge. An example is when scholars find it challenging to comprehend material that has been published more than once, as can be observed by looking for certain terms in the Scopus and Web of Science (WoS) databases, which return over 80,000 results for the year 2022. Each of those articles would undoubtedly be difficult for one person to read alone. However, more robust analytical techniques for text mining and scientometric analysis are now facilitating research by assisting in the finding of new data for the general advancement of research. Thus, scientometric analyses such as this current research presented herein are important. Scientometric reviews are conducted by different researchers on diverse areas using different tools [141–149].

The publications considered for this meta-analysis were only those that included genuine research, cutting-edge inventions, and theoretical analysis. The investigation articles that were chosen had to satisfy the following requirements: (a) clearly stated methodology, (b) thoroughly described results, and (c) a remark and a reference to its limitations. The conceptual articles needed to satisfy a number of criteria, including (a) a systematic baseline selection technique, (b) a time frame that was accurately described, and (c) an analytical procedure that included a critical review. The requirements for marine hose standards now used by the marine industry, such as those set forth by the API, OCIMF, PANC, DNVGL, ABS, or ISO, were also examined. As a result, the requirements for maritime hose qualification were examined. Finally, a tabular bibliography of a few of the chosen papers was created, including the research projects, author information, and the year of publication.

The method taken into account for choosing the academic papers in Section 2 is also a crucial component of the meta-science analysis carried out in this systematic literature review. Finding research threads, trends, and advancements in marine hoses is one of this

review's main goals. As stated in Figure 3, the first database, Scopus, was taken into consideration for this review in order to accomplish this objective. After various adjustments and exclusions to make sure the data utilized fits within the planned study on maritime hoses, 296 papers in total were taken into account in the meta-analysis. Descriptors in the English language were taken from the Scopus database. Additionally, since the non-English papers were all disqualified, only publication articles in the English language were taken into consideration. However, "marine hoses" was the major keyword that the research was focused on in order to determine the trend in development in other forms of flexible marine risers in comparison to marine hoses. The keywords chosen were author keywords from academic publications from the data retrieved from Scopus.

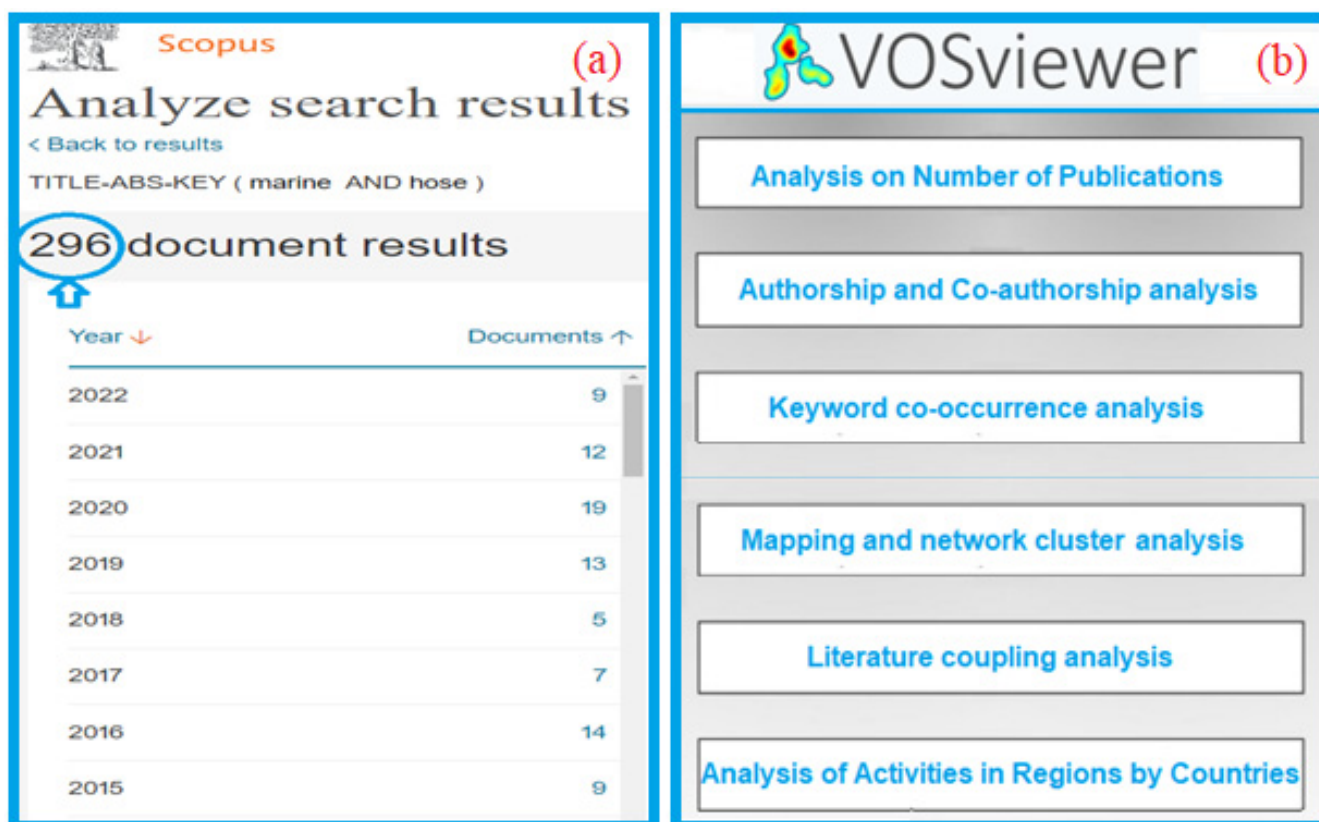


Figure 3. Image showing (a) the interface of the Scopus database used for the data analysis on "marine hose" and (b) the VOSviewer interface with some areas that can be analyzed.

With reference to this study, data from the databases were used to conduct the scientometric review. Using desired variables, networks, and exported variables, it was further postprocessed. In order to create the visualization map and graphical interpretations, tools could be used for further processing, such as CiteSpace [125–131] and VOSviewer [150–159]. Section 4 presents the findings of the scientometric analysis. The extrapolated data were used in the study to create the co-occurrence network and co-citation network as they appeared in publications. The main parameters used to dictate the research pattern include authorship, author keywords, index keywords, publication subject, publication type, and publication country location.

It is important to provide a brief overview of the taxonomy that has been used to analyze scientific publications, such as journal articles and conference papers. In order to achieve this, the criteria taken into account for the taxonomy are based on the comprehension of the most recent advancements in developing marine hoses. This will also provide researchers in both academia and industry with a thorough history of the technology, highlight its advantages, and detail its economic effects. With that goal in mind, a

thorough analysis of marine hoses in relation to the suggested future research topics will be made available.

Thus, the taxonomy framework under consideration includes a systematic and in-depth review of the literature that emphasizes and highlights novelties, the emergence of research directions, research sources, publication gaps, a key component of marine hose designs, chronological advancements, and important elements. Therefore, the following criteria apply to the taxonomy framework and cover the publication sources displaying publishers and articles, research designs, research methods, marine hose technology, drivers, benefits, issues (or barriers), and applications. The taxonomy framework criteria listed herein provided the basis for the theme areas further discussed in Section 5, including the following: (1) classification and impact of marine hose development; (2) certifications and technology adaptation for marine hoses; (3) frameworks and research designs; (4) assessments and research methods; (5) drivers; (6) benefits or importance; (7) issues or barriers; (8) application of marine hoses.

3. Results and Discussion

In the research, a scientometric study was conducted on the research area to ascertain the contribution made to knowledge by “marine hose”, as detailed in recent literature [7,8,17–21]. There were 296 publications from the Scopus database and 223 publications from the Web of Science (WoS) database. The result of the publication search is presented in Figure 4, while the type of publications by classification and subject area are shown in Figure 5. As seen in Figure 4, it was observed that the highest generated publications were 19 publications in 2020, followed by 14 publications in 2014 and 2016, then 13 documents in 2019, and 12 documents in 2021. However, there are limited publications found on the installation of marine hoses [160–170] compared to other marine systems [171–180].

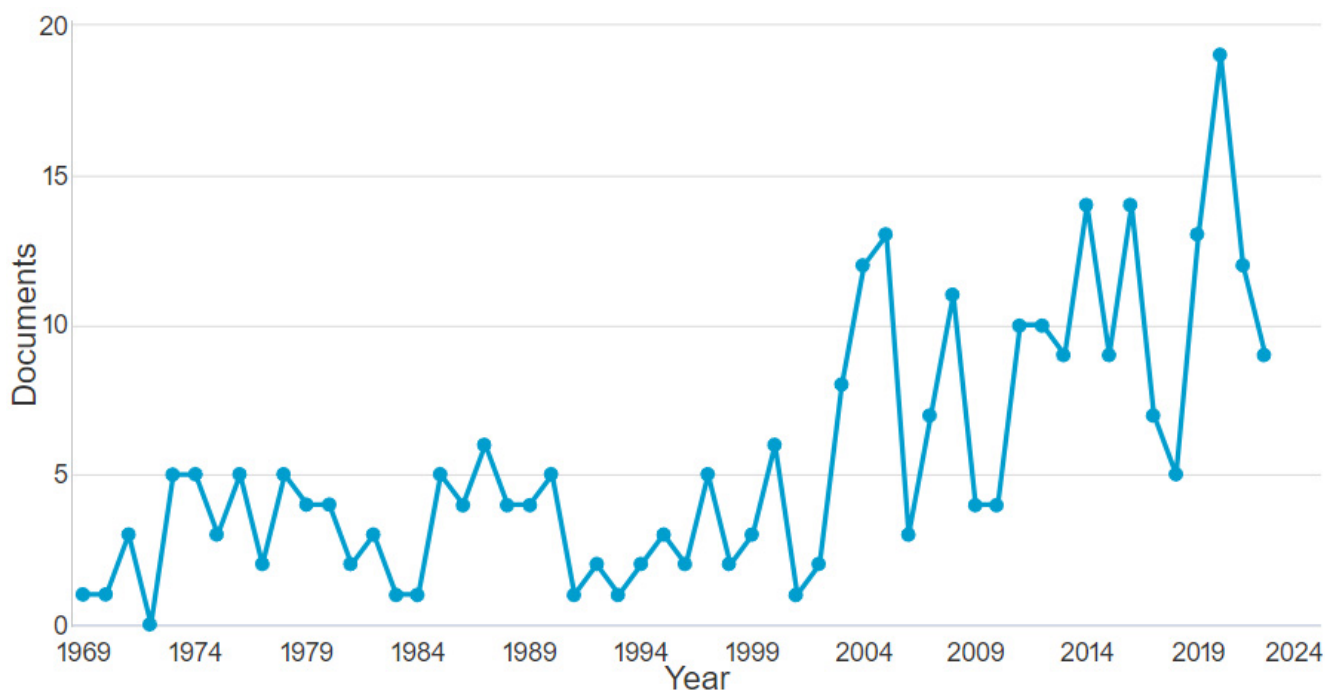


Figure 4. The number of publications on “marine hose” research (data retrieved from Scopus database, 24 July 2022).

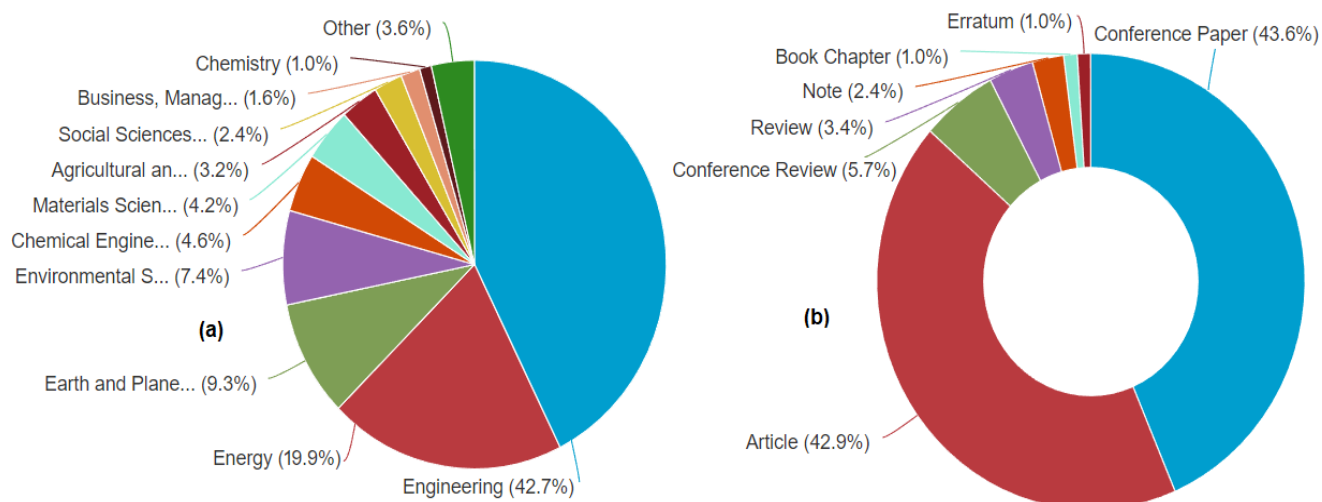


Figure 5. The research on “marine hose” showing (a) subject area and (b) document type (data retrieved from Scopus database, 24 July 2022).

As observed in Figure 5a, the highest publications by subject area were in engineering, with 212 publications (42.7%), energy, with 99 publications (19.9%), earth and planetary sciences, with 46 publications (9.3%), environmental science with 23 publications (7.4%), chemical engineering with 23 publications (4.6%), materials science with 21 publications (4.2%), and agricultural and biological sciences with 16 publications (3.2%), among other subject areas. This shows that there are more technical publications on this subject area which is expected due to the expertise required in manufacturing marine hoses and the limited number of marine hose manufacturers [181–187]. In addition, the materials used for the manufacture of marine hoses have unique properties that confine them to certain tests, such as those recommended by industry standards (see specifications particularly in GMPHOM OCIMF 2009 and API 17K, among others) [188–197].

Based on the classification of these publications, the systematic search was also looked at to ascertain the areas of interest by authors. As seen in Figure 5b, there were 129 conference papers (43.6%), 127 journal articles (42.9%), 17 conference reviews (5.7%), 10 review papers (3.4%), 7 notes (2.4%), 3 book chapters (1.0%), and 3 errata (1.0%). This suggests that the volume of publication outputs, which predominately include research articles, reflects the scrutiny given to the research on marine hoses.

Additionally, the author’s keywords obtained from Scopus were used to develop the word cloud using Voyant tools. To achieve this, two limits were set on the Voyant tools to produce the word cloud and postprocessed using its Corpus uploader, Cirrus viewer, TermsBerry, and Trend exporter. There were 1712 words and 916 unique word forms obtained from the index keywords. This shows more contributions to the research area, with an average words per sentence of 856.0, a vocabulary density of 0.535, and a readability index of 22.283. The results of this study were postprocessed with the keywords to develop two sets of word clouds. While the cloud in Figure 6a is lighter with fewer words, the cloud in Figure 6b is very dense and busy. The word clouds showed that some keywords had a higher density than other keywords, which also implies that they are more considered by authors in this field. The most-dense keywords are represented with larger font sizes and unique font colors. These keywords are visualized in order using the Voyant word cloud generator, which shows the highest to the lowest as boldest to the least bold. The detailed results of these keywords obtained are seen in Figure 6.

From the search data from the Scopus database compared with the Scopus data, it was observed that there are different keywords used by the authors in this subject area; however, the most frequently used keyword was hose (68 times). The other keyword frequencies are: marine risers (47 times), offshore oil well production (42 times), marine pollution (22 times), oil spills (17 times), mooring (17 times), arctic engineering (17 times), offshore technology (15 times), offshore structures (13 times), ships (12 times), marine environment (12 times), marine engineering (12 times), seawater (11 times), finite element method (11 times), offshore oil wells (10 times), hydrodynamics (10 times), buoys (10 times), pipelines (9 times), ocean engineering (9 times), reinforcement (8 times), pumps (8 times), mooring cables (8 times), design (8 times), single point mooring (7 times), shipbuilding (7 times), oil tankers (7 times), offshore drilling (7 times), liquefied natural gas (7 times), cryogenics (7 times), crude oil (7 times), article (7 times), technical presentations (6 times), submersibles (6 times), stress analysis (6 times), rubber products (6 times), rubber (6 times), petroleum industry (6 times), offshore pipelines (6 times), offshore oil fields (6 times), marine applications (6 times), loading (6 times), LNG (6 times), infill drilling (6 times), gas industry (6 times), floating liquefied natural gas (6 times), failure analysis (6 times), environmental protection (6 times), crude petroleum (6 times), buoyancy (6 times), tubing (5 times), tanker ships (5 times), submarine pipelines (5 times), stainless steel (5 times), software testing (5 times), seismology (5 times), safety engineering (5 times), ports and harbors (5 times), marine technology (5 times), marine hose (5 times), marine engines (5 times), flexible hose (5 times), environmental impact (5 times), water waves (4 times), unloading (4 times), United States (4 times), tubular steel structures (4 times), technology (4 times), technical seminars (4 times), tandem offloading (4 times), surveys (4 times), submarine hose (4 times), steel pipe (4 times), ship (4 times), semisubmersibles (4 times), safety factor (4 times), safety (4 times), riser systems (4 times), riser (4 times), remotely operated vehicles (4 times), remote control (4 times), reinforced plastics (4 times), piles (4 times), petroleum transportation (4 times), overhead lines (4 times), oil terminals (4 times), offloading operations (4 times), ocean waves (4 times), ocean currents (4 times), floating hose (4 times), flexible risers (4 times), catenary anchor leg mooring buoys (4 times), etc. Using these keywords on Voyant tools, the most frequent words in the corpus were: marine (35), hose (35), model (18), sea (17), and oil (16), as seen in Figures 7 and 8. This investigation showed that the most commonly used words were marine and hose, which appeared 35 times each with a relative frequency of 0.0093458.

The publication citations were also analyzed in this study. One crucial criterion that we considered was the ratio of publications to citations in this domain. The strength of a study area, the scientific importance, and the influence of the articles in the field were evaluated using citations. The h-index is one of the metrics used in this evaluation. The Times Cited count is used to rank a list of publications in descending order to determine the h-index value. An index of “h” denotes the existence of “h” papers, each of which has received at least “h” citations. Additionally, the h-index is determined by the depth of years of your chosen timeframe and the WoS database product subscription. The estimate did not take into account the source items that are not covered by the WoS database product subscription. In a ratio of 296:223 representing Scopus-to-WoS citations, there were fewer publications from WoS while there were more from SCOPUS. An h-index of 36 and an average of 19.43 citations per publication were noted. There were 3724 citing articles in the overall number of documents on the topic, whereas 3663 publications lacked self-citations. The total number of citations for these articles was 4334 times cited, compared to 4115 times for the publications without self-citations. The citation information is demonstrated across the publication record, as displayed in Figure 9. The study shows the most significant changes in the slope of the cumulative publications. It shows significant growth seen as a plateau pattern in recent years, demonstrating the relevance of recent marine hose research. Furthermore, the figures for 2021–2022 show a decline because it is mid-2022 when it is anticipated to rise. While the slope of the cumulative publications barely altered from 2009 to 2013, the number of documents showed an increased growth rate.

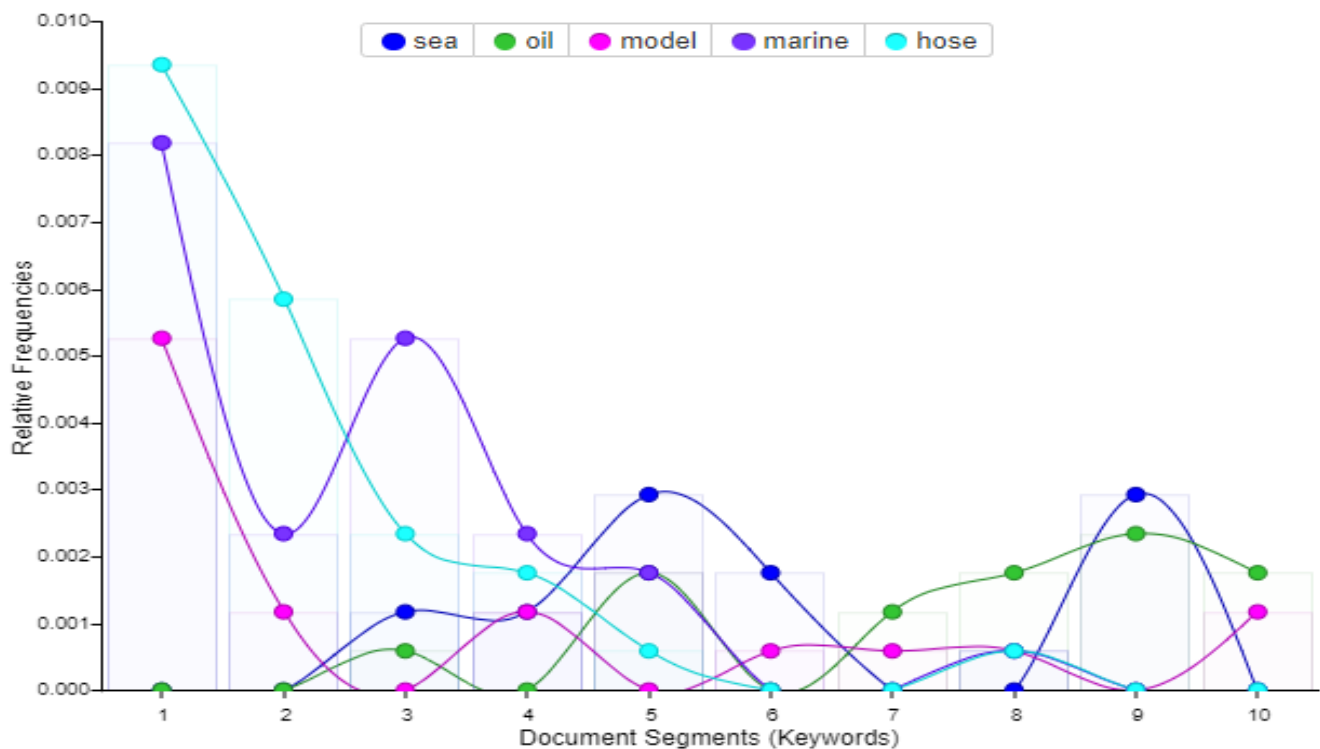


Figure 7. Result of relative frequency and trend from the most frequent author keywords on “marine hose” generated using Voyant tools.

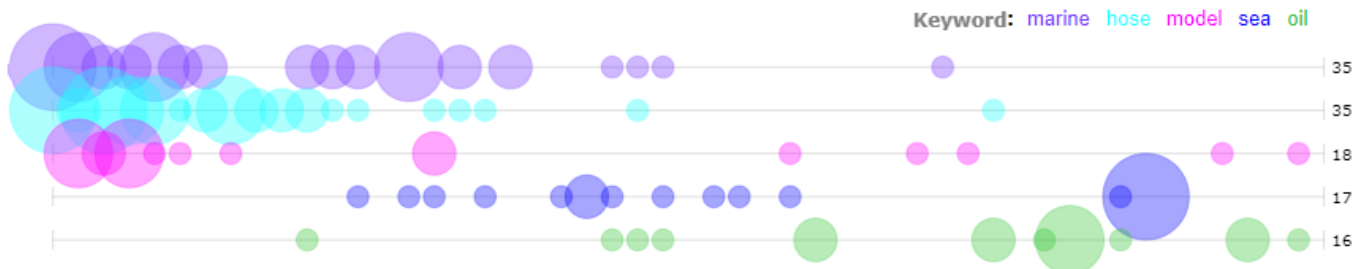


Figure 8. Bubblelines from the most frequent author keywords on “marine hose” generated using Voyant tools.

Understanding the influence of institutions or organizations, referred to as affiliations, on the research requires looking at the findings of bibliometric analyses of publications connected to the subject. To evaluate the research effect from the institution or organization, which is provided as a breakdown of publication volume from different departments, it is vital to discuss the support from different affiliations towards marine hose research. Marine hoses have also been used in offloading applications, shipbuilding, fluid mechanics, mechanical engineering, ocean engineering, offshore applications, and marine engineering. As a result, the results from Scopus and WoS databases were papers that cut across different fields. The scientific literature on marine hoses is now being contributed to by numerous research institutions, polytechnics, universities, and businesses. Figures 10 and 11 show the result of affiliations by academic institutions and affiliations by industry companies, respectively. Currently, it shows that Lancaster University has 11 publications, Tsinghua University has 10 publications, and the University of Sao Paulo has 6 publications. These institutions were followed by five publications produced by the Technical University of Denmark and the University of Tokyo, and four publications produced by the Dalian University of Technology and Harbin Engineering University. The progress of this research area is promoted by the increased funding for marine hoses and related systems.

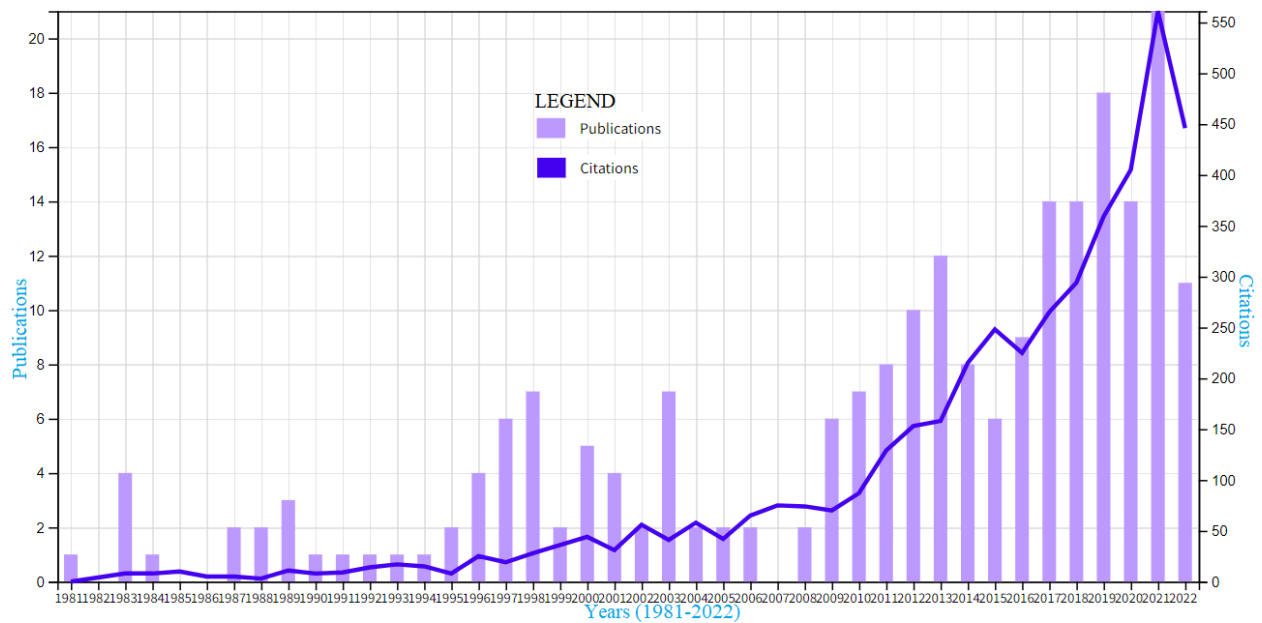


Figure 9. The number of citations and number of publications from 1981 to 2022 for the research on “marine hose” research (data retrieved from WoS database, 24 July 2022).

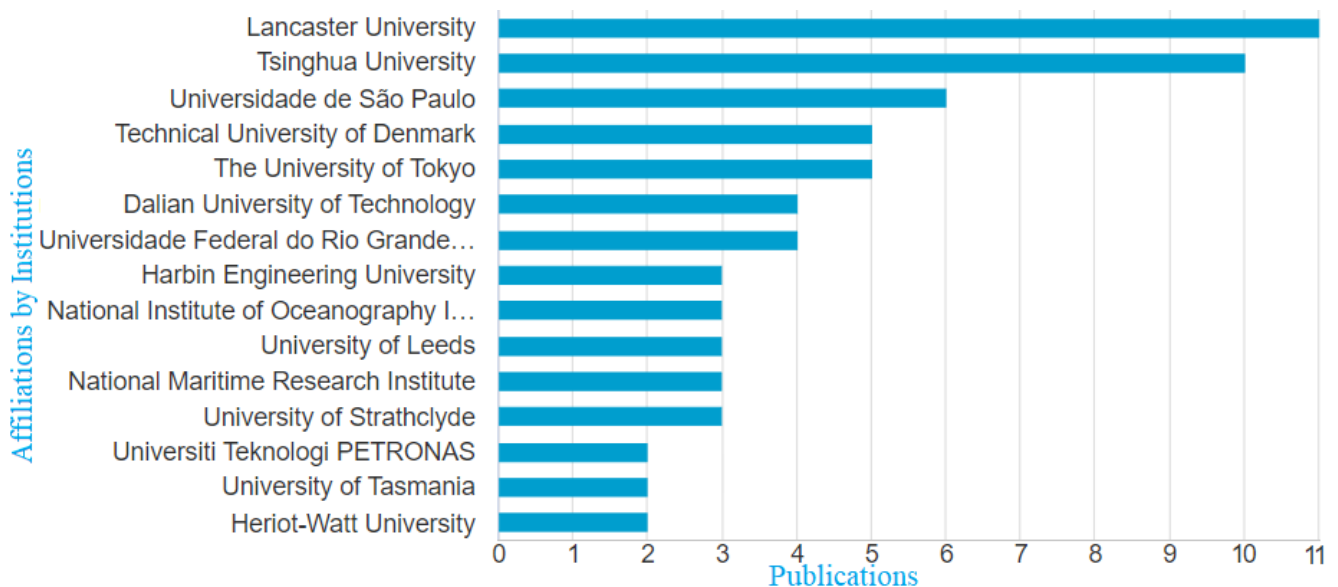


Figure 10. The affiliations by academic institutions for the research on “marine hose” (data retrieved from Scopus database, 24 July 2022).

Another important aspect of the study is the funding for research on marine hoses by different funding sponsors. The author’s funders, as well as the project funders in the research area, were further filtered to ascertain their influence on the quality of publications published annually in this field to visualize the influence of funders on the affiliations. This also makes it easier to understand how the institution’s funders have affected the calibre of that field’s research. For instance, in the UK, one of the identified funders, the Engineering and Physical Sciences Research Council (EPSRC), which is a part of the United Kingdom Research Council (UKRI), was identified as one of the major funders of research related to marine hoses. However, according to the data in Figure 12, it was identified that EPSRC was second with 8 publications, while the first is the National Natural Science Foundation of China (NSFC) with 14 publications. It was followed by Conselho Nacional

de Desenvolvimento Científico e Tecnológico with three publications, Coordenação de Aperfeiçoamento de Pessoal de Nível Superior with 2 publications, and the National Science Foundation also funded two publications. The second (EPSRC) funded approximately half the amount of the highest (NSFC). Additionally, it was found that those who funded the least research had funded at least one marine hose research, as seen across 27 funding agencies or funding sponsors. The details of funding with grant numbers for the top funding agencies on marine hose research are presented in Table 1. It shows that grant number: 51922064 is the highest funding recorded on marine hoses.

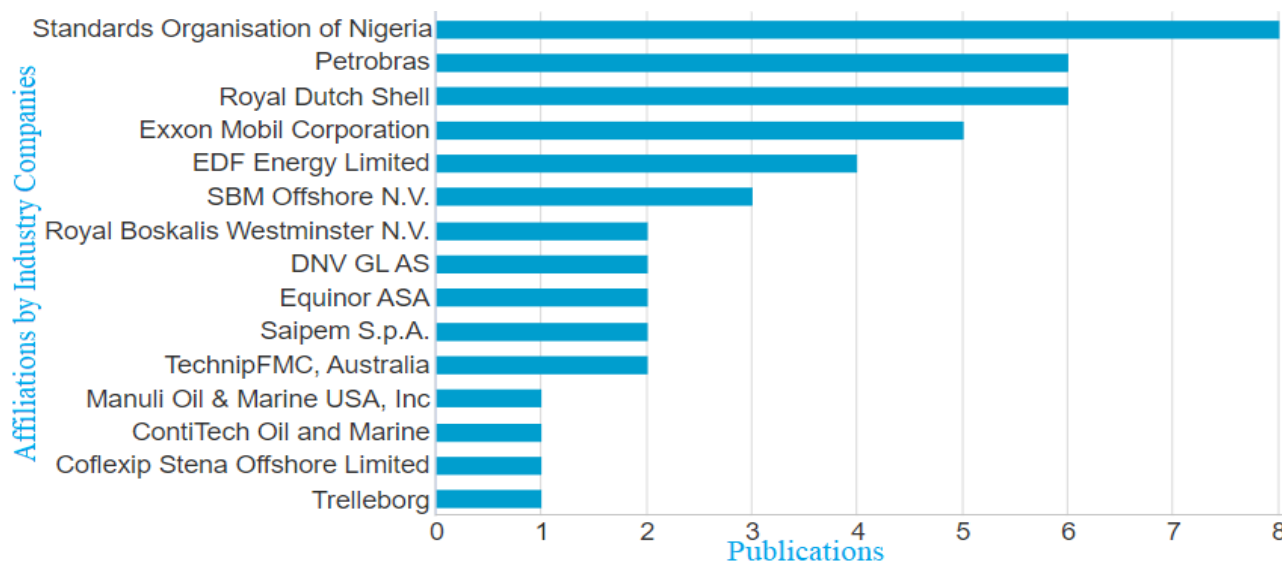


Figure 11. The affiliations by industry companies for the research on “marine hose” (data retrieved from Scopus database, 24 July 2022).

Another important aspect of the study is the selection of journals for the submission of publications on the research for marine hoses. It is evident in Table 2 that the highest number of publications by the publishers was published in the *Journal of Marine Science and Engineering (JMSE)* with 10 published works, followed by *Marine Environmental Research* with 7 published works, and *Marine and Freshwater Research* with 6 published works. The next set of journals has five publications, such as *Climate Dynamics*, *Journal of Coastal Research*, *Ocean Engineering*, and *Quaternary Science Reviews*. Then, the next set of journals has four publications, which are *Marine Structures* and the *Marine Technology Society Journal*. The study showed that the publications on marine hoses were both presented as conference proceeding papers and journal articles. Additionally, it showed that there are more papers published as journal articles on marine hoses, as seen in Table 2.

As seen in Figure 13, it was observed that the country with the highest number of publications was the United States of America (USA), which generated 55 publications, followed United Kingdom (UK), which generated 28 publications, and China, which generated 27 publications. Brazil generated 17 documents, followed by Canada, which generated 14 documents. The Netherlands and Nigeria each generated 11 documents, followed by Japan which generated 10 documents. Next, Denmark, India, and Norway each generated nine publications, followed by Australia, which generated seven publications, France, which generated six publications, New Zealand, which generated four publications, and Germany, which generated three publications. As observed in Figure 13, the highest number of publications in mid-2022 was generated by the USA, and it was double the amount generated by the second country (the UK). Additionally, the USA, the UK, China, Brazil, and Canada, which have the broadest global network of collaboration, are at the vanguard of academic engagement. It is hoped that other nations will close the gap in

terms of the publication ratio from that of the top countries, such as the USA, which has 55 publications, almost doubling the second (the UK), which has 28 publications.

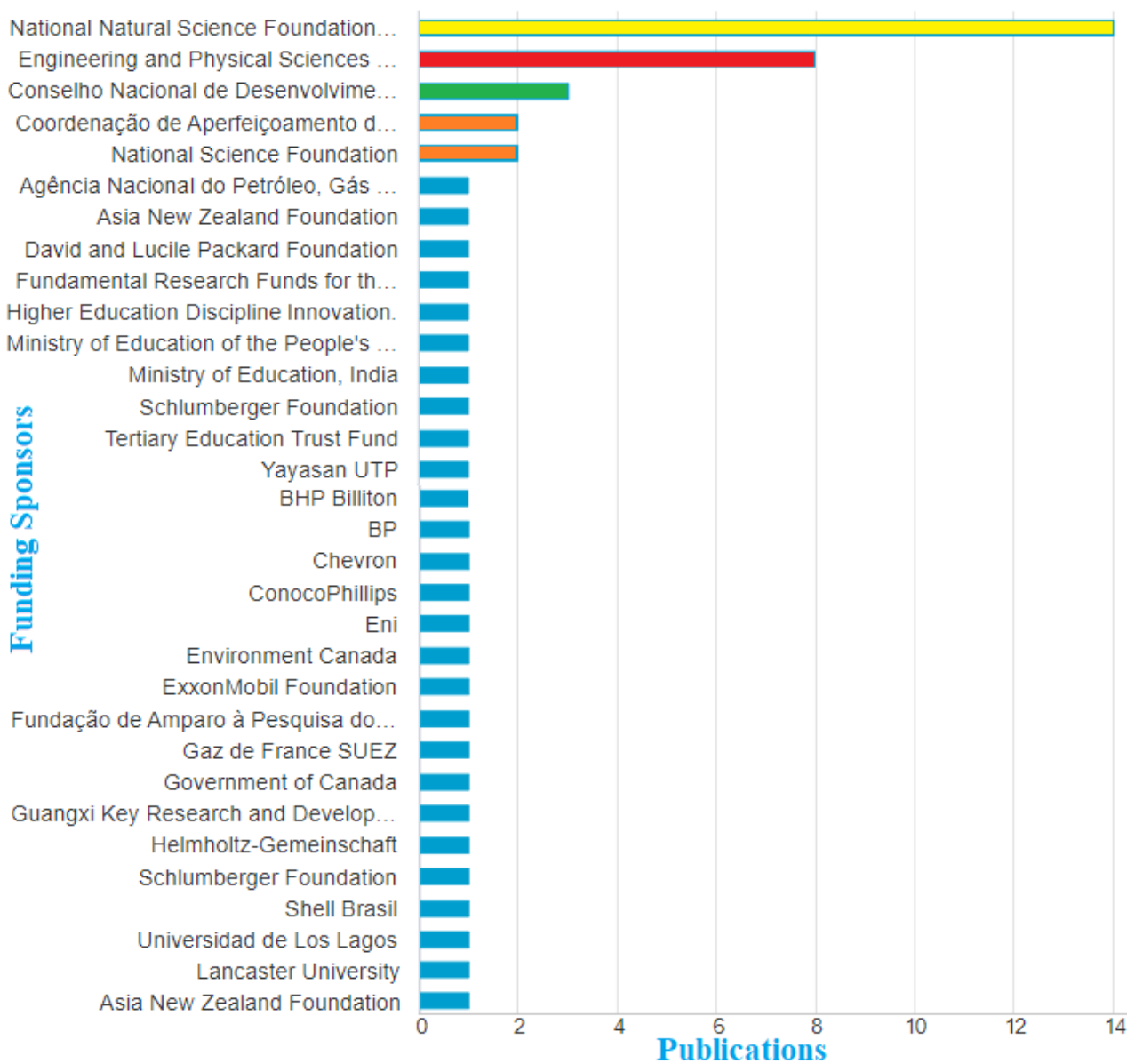


Figure 12. The affiliations by industry companies for the research on “marine hose” (data retrieved from Scopus database, 24 July 2022).

Table 1. Funding details of the top fundings on marine hose research (data retrieved from WoS database, 24 July 2022).

Grant Numbers	Record Count	% of 223	Grant Numbers	Record Count	% of 223
51922064	10	4.484	919929	1	0.448
51879143	5	2.242	943682	1	0.448
2000.0067652.11.9	4	1.794	1048926	1	0.448
200020_172476	3	1.345	1061335	1	0.448
17h06323	2	0.897	1063441	1	0.448

Table 1. Cont.

Grant Numbers	Record Count	% of 223	Grant Numbers	Record Count	% of 223
2017561	2	0.897	11170682	1	0.448
22101005	2	0.897	11171068	1	0.448
243908	2	0.897	1118615	1	0.448
Jp1801633	2	0.897	1129580	1	0.448
Nrg-2006.06	2	0.897	118	1	0.448
S-10	2	0.897	1266	1	0.448
Sg-06-267	2	0.897	139656	1	0.448
325421	1	0.448	1401778	1	0.448
325556	1	0.448	1401802	1	0.448
744636	1	0.448	14gs0202	1	0.448

NB: Please see Supplementary Data for detailed list.

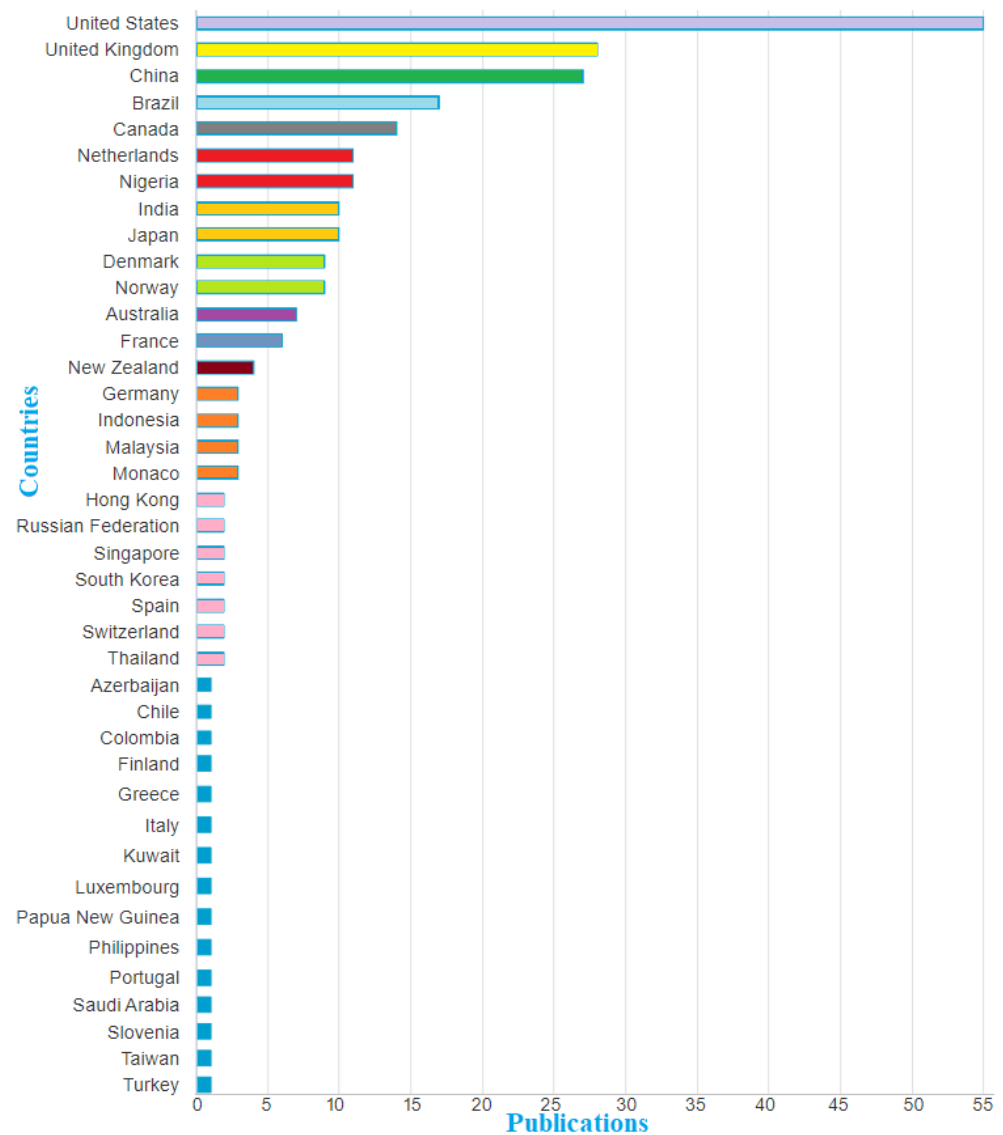


Figure 13. The research on “marine hose” research (data retrieved from Scopus database, 24 July 2022).

Table 2. Funding details of the top funders on marine hose research (data retrieved from WoS database, 24 July 2022).

Publication Titles	H-Index	Record Count	% of 223
Journal of Marine Science and Engineering	29	10	4.484
Marine Environmental Research	100	7	3.139
Marine and Freshwater Research	93	6	2.691
Climate Dynamics	172	5	2.242
Journal of Coastal Research	95	5	2.242
Ocean Engineering	109	5	2.242
Quaternary Science Reviews	192	5	2.242
Marine Structures	71	4	1.794
Marine Technology Society Journal	45	4	1.794
Proceedings of the International Offshore and Polar Engineering Conference	49	3	1.345
Science of the Total Environment	275	3	1.345
Engineering Structures	155	2	0.897
Environmental Science Technology	425	2	0.897
ICES Journal of Marine Science	125	2	0.897
IOP Conference Series Earth and Environmental Science	34	2	0.897
Proc. of the ASME Inter. Conf. on Ocean Offshore Mech. and Arctic Engin.-OMAE	47	2	0.897
Proc. of the Inst. Of Mech. Engin. Part L Journal of Materials Design And Appli.	38	2	0.897
Proc. of the Inst. of Mech. Engin. Part M Journal of Engin. for The Maritime Env.	36	2	0.897
Ships and Offshore Structures	32	2	0.897
Engineering with Computers	60	1	0.448
Environmental Health Perspectives	297	1	0.448
Environmental Research Letters	142	1	0.448
Fluids	18	1	0.448
Frontiers in Earth Science	35	1	0.448
Inventions	18	1	0.448
Journal of Advances in Modeling Earth Systems	69	1	0.448
Journal of Composites Science	23	1	0.448
Journal of Engineering Mechanics ASCE	131	1	0.448
Journal of Marine Science and Application	25	1	0.448
Journal of Marine Science and Technology	50	1	0.448
Journal of Ocean University of China	26	1	0.448
Maritime Policy Management	61	1	0.448
Ocean Coastal Management	90	1	0.448
Ocean Dynamics	61	1	0.448
Ocean Science	60	1	0.448
Science	1229	1	0.448
Science Advances	178	1	0.448

NB: Please see Supplementary Data for detailed list.

Another parameter investigated is the authorship of the research pattern for marine hoses. The impact of authorship on the research and its breakdown of publication volume is understood in the first part of the component meta-analysis. The scholarly material on marine hoses used to visualize the mapped network was authored by a variety of researchers. Looking at the publication output based on the influence of authors in Figure 14, the author with the most publications was identified as Amaechi C.V., with 11 publications in this study area. They were followed by Wang F., 10 publications, and Ye J., 9 publications, then Brown M.J. with 5 publications. Next, a set of authors published four publications, which were Amico S.C., Butler H.O., Chesterton C., and Tonatto M.L.P. They were followed by the next set of authors who published three publications, which were Forte MMC, Hvidbak F., Moffatt C., Tita V., and Yang Z. The last set of authors published two publications and included authors such as Ahlf J. and Halliwell A.R.

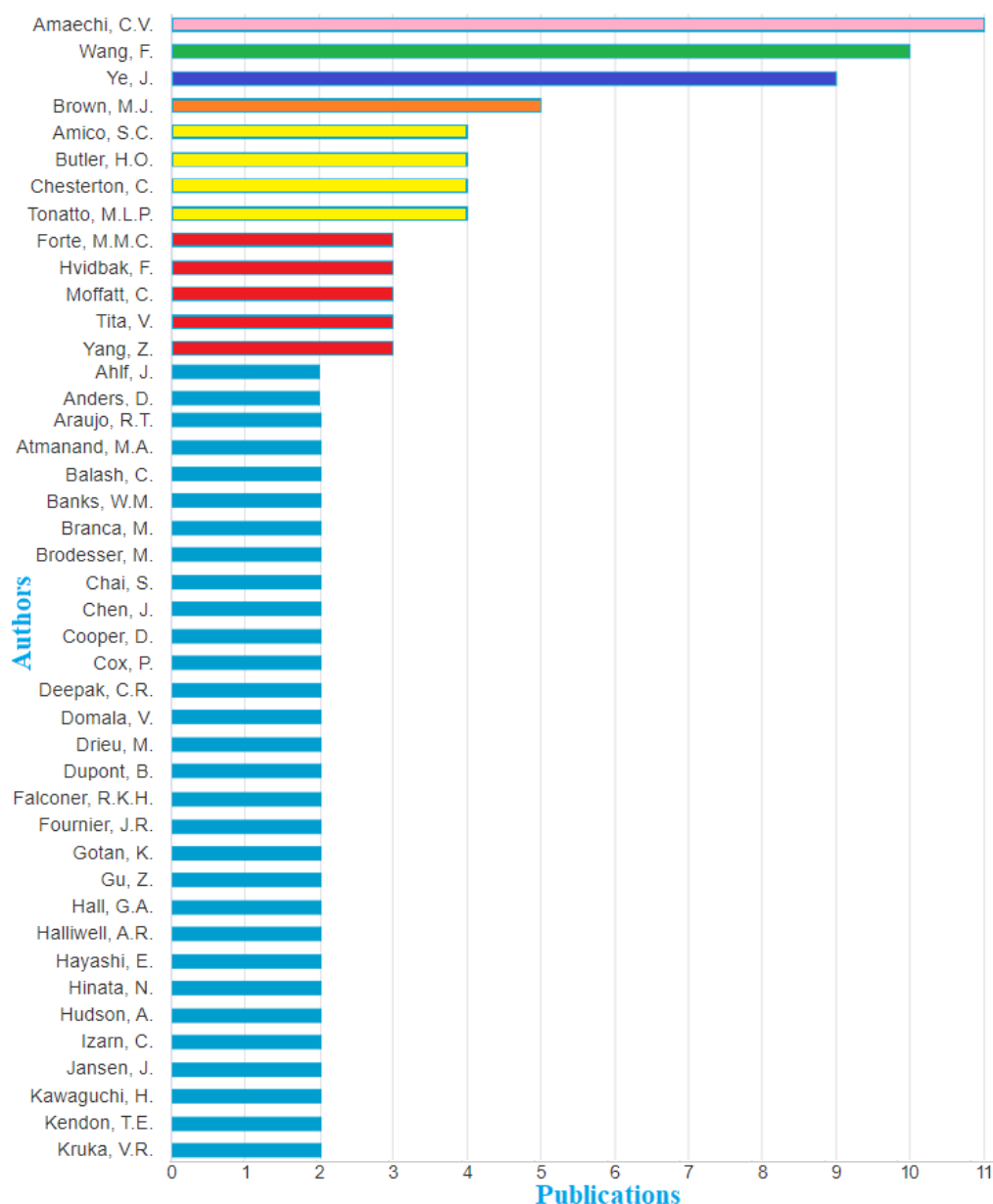


Figure 14. The authorship for the research on “marine hose” showing the top authors in chronological order (data retrieved from Scopus database, 24 July 2022).

The authors’ names were further filtered to check how many papers were created annually on this topic to visualize the influence of affiliations. This search made it easier to

understand how the author's research interests affected the calibre of that field's research. However, there were several other authors that were not included in this bar chart in Figure 14 based on other authors that also published works on marine hoses, with over 80 authors having two publications each and 70 authors having one publication each. This study shows that there are more recent studies in this area. The authors with the highest number of citations per publication were also further investigated. It should be noted that the most extensively cited related works are the contributions of the most recent works by authors with the highest h-index. However, authors with the greatest h-index are among those who have conducted extensive research on the topic of marine hoses over a long period of time. The postprocessing of the authorship data was conducted in VOSviewer, as shown in Figure 15. It shows 13 clusters for different authorships as coloured nodes on the density visualization map.

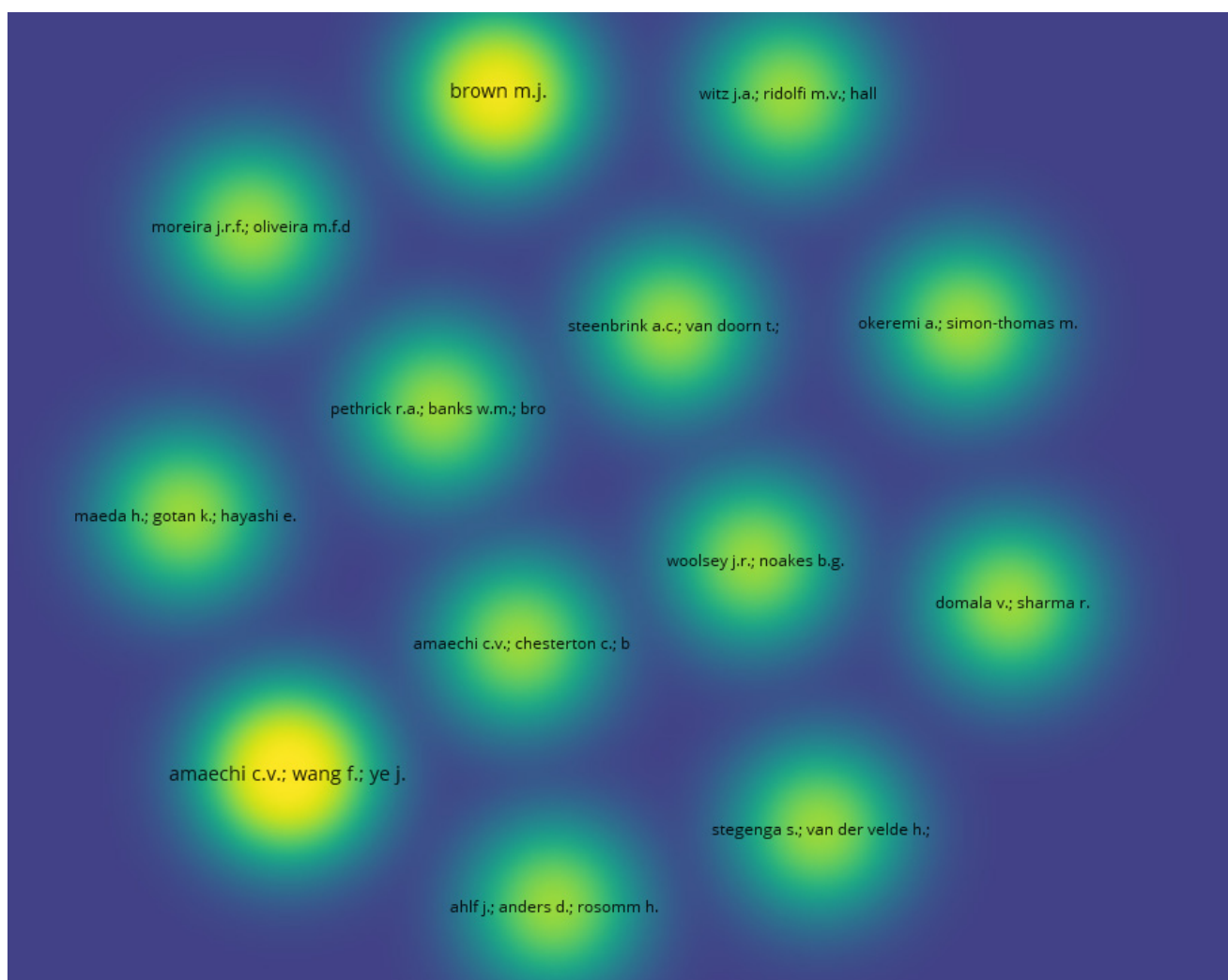


Figure 15. The density visualization map on co-authorship for the research on “marine hose using VOSviewer (data retrieved from Scopus database, 24 July 2022).

4. Thematic Areas for the Research Trends on Marine Hose

The consideration of thematic areas from the meta-analysis on marine hoses has been presented using standard research methods. The goal of this section is to examine themes for conducting thematic analysis based on qualitative research. The procedure involves findings obtained from the literature search, analyzing the data, and reporting patterns (themes) within the subject area. In principle, thematic analysis is similar to a literature review, which is an evaluation of prior research on this particular topic of marine

hoses [7,8,17–21]. The taxonomy framework criteria listed in Section 3 were used to identify the thematic areas for the research trends on marine hoses. However, future research should include both qualitative and quantitative analyses in relation to the highlighted issues, such as performance gap, market value, constraints, etc. Table 3 lists the subject areas that were discovered through references to marine hose research.

The findings from the research trends on applications for marine hoses are seen in various industry standards [188–199], design specifications in various literature [200–211] and other industry regulations [188,192,212–215]. The future marine hoses research area is described in this section. In upcoming scientific literature reviews on research trends for marine hoses, visualization mapping and network mapping are proposed as potential areas for future study. Due to the difficulty of adaption, acceptance, qualification, and application of composites on marine hoses in the industry, this topic requires further study concerning marine hose development. Therefore, future efforts should focus on adapting novel rubber and composite material models for marine hoses.

Table 3. Thematic area for research trend on marine hose.

No.	Thematic Areas	Sources
1	Classification and Impact of marine hose research	[7,8,17–21]
2	Technology Adaptation on marine hoses	[4–6,8–13]
3	Frameworks and Research Designs	[14–16]
4	Assessments and Research Methods	[20–25]
5	Drivers of marine hose technology	[26–29]
6	Benefits or Importance of marine hose	[36–45]
7	Issues or Barriers of marine hose	[46–49]
8	Certifications, Guidelines, and Standardization	[8,17–19,189–199]
9	Application of marine hoses on SPMs	[7,70,111,200–211]

5. Future Research Areas on Marine Hose

Some areas require further research and development work involving collaboration between industry and academia to enable marine hose development with FRP composites. This will enable the optimization of marine hoses for deep-water applications. More research and collaboration on the application of marine hoses in the offshore oil and gas industry is recommended. To enable FRP composites to be used for critical deep-water applications in the offshore oil and gas industry, more research and development work involving collaboration between industry and academia is needed in the following areas:

1. There is a need for the design of more novel configurations for both flexible and rigid marine risers and pipelines for deep water applications using more numerical models. Since marine hoses are represented by beam elements, the effect of internal pressure on the performance of the hoses is not directly involved. Further research on the effect of the stiffness of the beams can be investigated to represent the effect of internal pressure. Further recommendations include conducting structural verifications on the marine hose model. It could include studying each hose section in local design for tensions and moments. Additionally, structural verifications should be obtained regarding crucial points, end fittings, couplings, and hose end valves (HEVs). This could be achieved using a specified and examined model for the full hose under global loads. The adequacy of all sections to bear the pressures and moments owing to global loads can be validated.

2. Given that cyclic loads are indicative of a continuous process during hose tests, it is evident that loading affects the hose behavior, and this may result in increased fatigue of the hose, particularly indicating the potential for fatigue studies on various bonding layers used in the submarine hose. Additionally, there is a requirement for the assessment of long-term characteristics of composite materials in deep-water environments in the oil and gas industry. More work is needed to develop precise, detailed designs of the connectors, marine hose joints, end valves, and hose layers. Additionally, future work could include

the application of additive manufacturing in the oil and gas industry for marine hose development. Further work can be continued in manufacturing components for marine hoses, such as end fitting and hose section couplings.

3. The cost implications of marine hoses should be considered in future research. Additionally, the implication of global events such as oil price fluctuation, economic recession, and the COVID-19 pandemic on marine hose development can be studied in future studies. Based on recent findings on marine hoses, it is recommended that a new standard on guidance for the design, utilization factor, and material combinations for marine hoses be elaborated. This is proposed based on the findings of assessing the strength of submarine hoses attached to CALM buoys. Additionally, hose connections to FPSOs under water waves and global loading should be proposed for elaboration in future research.

4. More understanding on the motion of submarine hoses and floating hoses using fluid–structure interaction (FSI) and computational fluid dynamic (CFD) models is recommended on marine hoses for oil and gas applications. A typical hose motion behavior that requires more studies is the snaking behavior of marine hoses. Additionally, the determination of the dynamic responses of marine hoses, such as the surface current effect, the wave–current interaction (WCI), and vortex-induced vibrations (VIV), is required.

5. Due to the short service life of marine hoses, further study on the reliability analysis of the marine hose is recommended in future research. There is limited literature in the public domain on the reliability analysis of marine hoses, reliability analysis of CALM buoy systems, and structural verification of marine hoses, which are all significant gaps in the literature. Additionally, safety analysis of single point mooring system (SPM) terminals is also recommended in future research to include hawsers and other mooring lines.

6. Creation of databases for the development of marine hoses. Additionally, update the existing manufacturing technology to develop faster and more cost-effective manufacturing processes. Furthermore, the creation of specific databases to record accidents related to marine hoses and failures of marine hoses is suggested. However, existing industry databases, such as HSE's RIDDOR, consider marine risers and pipelines.

7. Further study is recommended on the analysis methods for hose designs using specialized software, such as Orcaflex, for assessing the fatigue of marine hoses and for the investigation of the behavior of marine hoses is recommended. More research is required to include fatigue analysis of submarine hoses in future research. Future research can look into developing a specialized FE code for marine hose analysis. This can be achieved through collaboration between engineering fields and computer code developers on the influence of debonding on the performance of the marine bonded composite hose (MBCH).

8. A full sensitivity study could be included in the global analysis based on different layers designed for hose sections to examine the resilience of the hose model and provide further validation, even if another FEA convergence study is not required. The effect of the shortest period (T_z) or peak period (T_p) on the marine hose structure per hose section can be studied. Additionally, the effect of different fluid densities in the marine hose under global design is recommended in future research. Based on the novel method for the assessment of the strength of marine hoses proposed in this study, that is, the guidance values using the proposed DAF_{hose} method, we recommend that more work is conducted to develop a table of these values for different types of marine hoses, and different bore dimensions. This will serve as design guidance for hose designers and hose manufacturers.

9. Future research should also work towards implementing a new manufacturing framework for marine hoses that will reduce the failure of marine composite tubulars along the longitudinal lines, aligning to the manufacturing die piece. Full-scale testing of marine bonded hoses to investigate parameters such as delamination and metal-to-composite interfaces (MCI) is recommended. It is also recommended that more experimental work on full-scale marine hoses be conducted. Additionally, there should be more collaboration between the industry and academia on marine hose research. This will help to promote knowledge transfer in the subject area and improve research trends.

6. Concluding Remarks

Currently, there is still high global dependence on fossil fuels, which require lighter sustainable materials for energy production, such as marine hoses. The deluge of publications that are released each year could obscure much of the knowledge gained from research on marine hoses. Consequently, it is important to examine the bibliographic output of marine hose research. In this study, a scientometric review of research trends for marine hoses with visualization mapping was presented. The study expatiated an understanding of marine hoses from meta-analysis and bibliometric review using data retrieved from academic databases. This paper detailed the findings from the scientometric review on research trends conducted on marine hoses, which shows the progress made in the development of marine hoses. This research also presented the application of state-of-the-art tools for scientific literature reviews. Section 1 introduced the research on marine hoses and the application of a scientific literature review in this industry and related areas. In Section 2, the methodology for the detailed meta-science analysis was presented. It also showed how it was conducted with comprehensive steps taken with a focus on the publication data obtained from source databases. The research design included the use of recent scholarly articles from two academic databases, SCOPUS and Web of Science (WoS). Both databases cover high-impact journal papers and conference papers in the subject area. Despite this, some sorting was carried out as it was noticed that some related articles on marine composites were captured and evaluated by considering the state-of-the-art on marine hoses. In Section 3 of this meta-science analysis and scientometric review, the results and discussion were presented. The results were based on findings from these data retrieval and text-mining tools, while Section 4 presented thematic areas with some implications of the research trends with future areas. Section 5 presented the conclusions drawn from this study.

The following are the research's key highlights:

- The research on marine hoses for the offshore marine industry is the first subject of this scientometric review.
- Secondly, a thorough meta-science study of marine hoses was performed using academic databases.
- Thirdly, using the available literature, the assessment of the marine hose research was examined.
- Fourthly, to visualize the outcomes, a thorough analysis of the data was conducted utilizing cutting-edge techniques using tools such as Voyant tools for the word cloud.
- Lastly, the examination of the research pattern was based on the outcome of this scientometric analysis on marine hoses, which also showed progress on the developments made.

The findings from this study reflect that there are currently more publications on marine hoses. These publication fields from the data gathered include general research, engineering, and science. An important finding from the research trend is the increased research on the reinforcements for marine hoses, as conducted in more recent studies [68,74,75,88,216–220]. Additionally, based on the publication categories, journal articles, review articles, conference papers, and notes are among the publication categories. There are various authors from each of these universities, and various sponsors or donors have funded some of the articles. A more in-depth examination of the funding agencies' effects is provided in the following subsection. As hoses are still being developed for various applications such as the marine industry, the affiliations have a range of publication types, which include collections of documents, and some only have one publication. Additionally, it was noted that the papers from these prestigious affiliations were additionally published in high-impact periodicals. The authors of the papers from these highest affiliations are among individuals with a wealth of research experience on marine hoses. This thorough meta-science examination of the topic also revealed recent developments, geographical activity by countries, authorship histories, partnerships, funding organizations, affiliations, co-occurrences, and potential research subjects. According to the study trends, it was discovered that the USA has the most publications in the field of maritime hoses and associated fields. The study

showed other countries that had publications, but there were fewer co-occurrences with other associations outside the cluster. In addition, the meta-analysis offers research funders a useful analysis of the advancement of the field and the impact of their financial support on research projects. The outcomes also display authorship, co-authorship, citations, affiliations, and keywords related to the study on the “marine hose”. Therefore, to sustainably advance the research trend, more funding sources and collaborations on marine hoses are required. Additionally, this study demonstrates the impact of affiliations and the accurate documentation of financial acknowledgements on research databases and repositories. Lastly, this study demonstrates the techno-economic benefits that are derived from marine hoses as its research trend sets future paths for both academia and business.

Supplementary Materials: The supplementary data used in the study can be downloaded at: <https://data.mendeley.com/drafts/sv792pk7c3> (accessed on 4 October 2022); with the following details: Amaechi, C.V. (2022), “Supplementary Data on Scientometrics of Marine Hose”, *Mendeley Data*, V2, doi: 10.17632/sv792pk7c3.2. Also, for the word clouds using Voyant tools, the following URL suffices: <https://voyant-tools.org/?corpus=9f569e9097a7c565cf86c2df9cf42474> (accessed on 4 October 2022).

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Data Availability Statement: The raw/processed data required to reproduce these findings are to be shared as supplementary data. The data also forms part of an ongoing study.

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