INTERNATIONAL JOURNAL OF
COASTAL, OFFSHORE & ENVIRONMENTAL ENGINEERING IJCOE Vol.10/No. 3/ Summer 2025 (53-61)

Available online at: www. Ijcoe.org

Evaluation of Ultra Border Analyzes of Researches Conducted In The Persian Gulf Sea Basin

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ARTICLE INFO

Article History:
Received: 22 MAY 2025
Accepted : 19 NOV 2025

Keywords:
Iran
Persian Gulf
Scopus
Evaluation
Marine sources

ABSTRACT

Given the significance of the Persian Gulf marine basin, research efforts must emphasize the protection and sustainable use of marine resources. Despite the unique importance and strategic position of the Persian Gulf in the region, and the numerous studies conducted across various scientific, economic, and social fields, the effectiveness of these investigations has never been evaluated. In fact, no quantitative or qualitative assessment has been carried out regarding these research efforts. Accordingly, the management of research activities across various scientific fields in this region becomes particularly important. Therefore, in this study, using data from the Scopus database, a quantitative perspective on the research conducted in the Persian Gulf is provided, along with an overview of the research topics over a defined period. With a particular focus on the themes related to marine science and engineering, conclusions will be drawn. A quantitative analysis of the research documentation reveals that Iran, followed by the United States, has produced the highest number of research outputs to date. Among Iranian research institutions, the University of Tehran and Amirkabir University of Technology rank at the top with the highest number of scientific publications. In this study, researchers' interest in biological sciences and geology is also evident. The Persian Gulf, due to its connection to open waters, can be a source of sustainable energy and new perspectives for research. However, only a small percentage of studies have been conducted in this area and in the field of engineering. A comparison of citation counts for the conducted studies also reveals a lack of attention to research in the fields of marine science and engineering, as well as computer science. The analysis of the results indicates that effective management in research planning can lead to more informed decision-making and more efficient outcomes.

1. Introduction

Oceans, containing over 97 percent of the Earth's water, cover approximately 71 percent of the planet's surface. As the largest ecosystem on Earth, the ocean plays a critical role in environmental sustainability. It regulates the planet's climate and weather systems. Oceans are the cradle of life and serve as key players in oxygen production and atmospheric carbon dioxide absorption, while also providing habitat for a vast array of living organisms. The utilization of oceans and seas holds immense global importance today in areas such as transportation, trade, food and pharmaceutical resources, mineral extraction, freshwater supply, tourism, and national security.

A vast expanse of Iran's territory—stretching over 5,700 kilometers—is bordered by the waters of the Caspian Sea, the Persian Gulf, and the Sea of Oman. The Persian Gulf is considered a strait extending from the Makran (Oman) Sea, sharing maritime boundaries with Iran, Saudi Arabia, Kuwait, Qatar, the United Arab Emirates, Bahrain, Oman, and Iraq (Figure 1).

The geographical location of the Persian Gulf is situated between 24° to 30°30′ north latitude and 48° to 56°25′ east longitude (see Figure 1). Today, the

boundaries of this gulf extend from the Strait of Hormuz in the east to the Arvandrud in Khuzestan, Iran, in the west.

The primary renown of the Persian Gulf is due to the immense oil and gas resources found in its sedimentary basins. However, this water body also holds special significance in geological, sedimentological, oceanographic, and many other scientific studies [1]. In light of this importance, conducting research in various fields and managing these studies is of strategic importance.

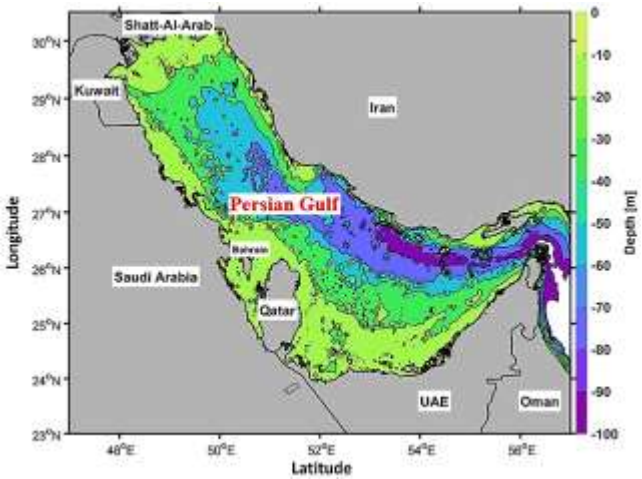

Figure 1- Geographical location of the Persian Gulf

The earliest investigations into the oceanographic characteristics of the Persian Gulf can be traced back to Iranian scholars, who conducted studies in the ancient the Persian Gulf. These studies were eventually compiled into a book known as Rahnâmik, Rahnâmag, or Rahnâmaj during the Sassanid era. With the advent of modern oceanography, the Persian Gulf has also become one of the principal focuses of oceanographers. Among the earliest studies in this field is the research conducted by James Murray in the 1880s [1].

Marine research cruises in Iran do not have a long-established history; however, perhaps the most longstanding institution in this regard is the Iranian Fisheries Research Institute. Among this institute's objectives are the examination of fish stocks, experimental fishing and the testing of equipment and catch ratios, the development of fishing models, training, developmental programs for the fisheries industries, statistical programs, and assisting in the management of fishery resource exploitation [1].

After fisheries, the Hydrography Department of the National Cartography Organization has been actively engaged in mapping activities aimed at preparing hydrographic maps and nautical charts for this sea. Although other organizations and institutions—such as the Ports and Maritime Organization, coastal universities, and the research division of the Ministry of Energy—also conduct marine cruises in the country, these cruises are generally small-scale, local, and carried out with limited and specific objectives [1].

The Marine Geology Department of the Geological and Mineral Exploration Organization was officially established in 1372, and this department, by conducting marine surveys and equipping itself with the necessary tools, has carried out marine cruises to produce geological maps and atlases of Iran's coasts in its coastal waters [1].

One of the first organizations to conduct extensive and relatively comprehensive marine surveys in the Persian Gulf in collaboration with other countries was the Environmental Organization. These surveys were generally carried out to assess the latest physical, chemical, and biological conditions, as well as pollution and the ecosystem of the Persian Gulf and the Sea of Oman. In the years 1991 and 2001, regional marine surveys in the Persian Gulf and the Sea of Oman were conducted for the first time by the ROPME[1] member countries (Saudi Arabia, United Arab Emirates, Kuwait, Qatar, Bahrain, Oman, and the Islamic Republic of Iran) under the management of Iran (Environmental Protection Organization). Prior to these extensive surveys, similar research cruises were carried out in collaboration with experts from non-ROPME member countries (Sediments and Water of the Persian Gulf 1956). In this context, the research cruise "Mont Michel" was conducted in 1991 by American experts, and the research cruise "Omita Camaro" was carried out by Japanese experts in 1993 in this region [1].

The National Institute of Oceanography and Atmospheric Sciences has also conducted several research cruises in the northern and southern waters of the country. Many of these cruises have been confined to the coastal areas of the Persian Gulf or have been carried out with specific, limited objectives in certain fields. Notably, the Persian Gulf and Gulf of Oman Oceanographic Studies (PGGOOS) project—aimed at measuring the oceanographic and environmental characteristics of the Persian Gulf, the Strait of Hormuz, and the Sea of Oman—was conducted with comprehensive objectives over various seasons during an 18-month period starting in November 2012 [1].

In addition to these targeted and organized studies, numerous research investigations in various branches of marine sciences have been carried out by scholars at universities and research centers, with findings being published as articles in journals or presented at conferences both domestically and internationally.

Some of these studies are conducted in the form of review studies. These studies lack a specific structure. Each researcher plans it based on a specific goal. Some of these studies are discussed below.

[1] The Regional Organization for the Protection of the Marine Environment (ROPME) - https://ropme.org/

Mirkheshti et al. (2017), in a review study, examined the risks associated with offshore wind energy in the Persian Gulf. The study aimed to identify the relevant risks of offshore wind energy projects to determine which variables, through qualitative analysis by applying the impact and probability of each risk, have the greatest effect on the project [2].

In 2021, **Soleimani** conducted a Review on energy and renewable energy policies in Iran. Results showed that renewable energy technologies currently do not have a significant and adequate role in the energy supply of Iran [3].

Zhang et al. (2021) presented a review study on marine resources and economic development. The aim of this study was to analyze the current status of marine resources and achieve sustainable utilization of marine resources. It was found that, compared to the current state of research on land resources and economic development, there is significant lag both in theoretical development and in methodological innovation in marine resources and economic development. [4]

Wang et al. (2022) conducted a review study aimed at developing approaches for high-quality marine development and effective ocean governance. They concluded that research on the marine economy mainly centers on marine industries, with the marine circular economy representing the latest research frontier. Marine resources were identified as the foundation of the marine economy, and the implementation of a natural resource ownership system in marine domains was deemed necessary for more efficient resource utilization. [5]

Ocean literacy (OL) refers to the ability of citizens to understand and explain the concepts and phenomena related to the oceans, and leads them to positive behavioral change for the protection and sustainability of the oceans. **Cavas et al. (2023)** examined the research trends and content analysis of ocean literacy studies conducted between 2017 and 2021. They carefully selected seventy-nine articles from forty academic journals on ocean literacy indexed in WoS and Scopus, using predefined criteria. The findings of this study can contribute to the advancement of ocean literacy research, support informed investigations, and provide citizen input for policy development related to ocean literacy. [6]

Tavakoli et al. (2023) provided a review on the progress and research directions of ocean engineering over the past 50 years. They concluded that research has been conducted in six major research divisions (I) Ocean Hydrodynamics, (II) Risk Assessment and Safety, (III) Ocean Climate and Geophysics: Data and Models, (IV) Control and Automation in the Ocean, (V) Structural Engineering and Manufacturing for the Ocean, and (VI) Ocean Renewable Energy. They concluded that machine learning methods have attracted significant attention from researchers. They also identified the subfields of research within these areas and examined the continuity and quality of these studies. [7]

Halpin et al. (2004) presented an overview of interactions among oceanography, marine ecosystems, climatic and human disruptions along the eastern margins of the Pacific Ocean. They present an overview of the oceanographic processes that dominate the coastlines, and give examples of ecosystems and the effects that oceanography, human activities and their interaction have on the communities. [8]

Saleh and Ershadifar in 2024 investigated Decreasing Dissolved Oxygen in the Persian Gulf and the Gulf of Oman: Impacts and Strategies for Mitigation in a review study. They concluded, the Oxygen Minimum Zone (OMZ) in the Arabian Sea and the Gulf of Oman has intensified over the past few decades. Marine organisms of the near-bottom layer or surface sediments are most affected by the expansion and intensification of hypoxic and suboxic conditions. They proposed three categories of management actions to halt or reduce the effects of oxygen depletion in the Persian Gulf and the Sea of Oman: a) ecosystem-based mitigation measures for environmental restoration and protection, b) adaptation-based measures to restore and protect marine organisms and fisheries, c) implementation of monitoring programs and analysis of the information obtained. [9]

It can be seen that review studies can provide an overall perspective on a given topic. Review studies can enable the validation of the methods used and help identify research gaps related to the study topic. They can also determine the most effective approach to achieving results with minimal cost.

Despite the unique significance of the Persian Gulf environment in global oceanography and the country's reliance on this strategic waterway, a comprehensive depiction of the environmental characteristics of the Persian Gulf and the Sea of Oman, particularly the northern half belonging to the Islamic Republic of Iran, has yet to be provided [1]. Moreover, the effectiveness of these studies in various economic, social, and industrial sectors of the country has never been evaluated, and no quantitative or qualitative assessment of the research has been conducted. Therefore, managing research across various domains, including marine sciences, technical and engineering fields, military, economic, social sectors, and tourism, gains particular importance.

The present study provides a quantitative overview of the research conducted in the Persian Gulf over a defined period of time. While offering a general perspective, it places particular emphasis on marine studies. **The aim of this study** is to present a broad picture of the research conducted during this time frame and to highlight the existing gaps in the topics of studies carried out within this important geographic region.

2. Method and Theoretical Framework

Research topics in various fields, including oceanography, can be fundamental, applied, or developmental. The outcome of research enhances decision-making in various economic, military, or social domains, which consequently leads to improved decision-making in marine and atmospheric matters at different domestic and regional levels. Furthermore, the development and expansion of research will provide effective solutions for better utilization of marine resources and making products more economical. Therefore, in this study, regardless of the type of research, a quantitative comparison of the research efforts is presented.

For this purpose, data from the Scopus database has been used. This database is the largest repository of articles, books, and scientific journals. In this database, one can access relevant research in reputable publications, as well as utilize the analytical tools available within the platform.

A quantitative study was conducted in three stages within this database:

1- A search was performed without restrictions on the Article title, Abstract, and Keywords using the terms "Persian" and "Gulf." From the period 1856 to 2024, 10,910 results were obtained.

2- A search was conducted in the Article title using the terms "Persian" and "Gulf" and "Arabian Sea." From the period 1856 to 2024, 3,541 results were obtained.

3- A more targeted search was performed within the results from stage (2), focusing on fields such as energy, engineering, or research related to researchers and countries.

These results include all research titles in various formats within this marine environment. The use of mathematical tools within this system allows for categorizing these studies, enabling different analyses and comparisons, which lead to valuable conclusions.

3. Results and Discussion

The Chart showing the number of documents from stage1, by year, within the time range of 1856 to 2024 is provided in Chart 1.

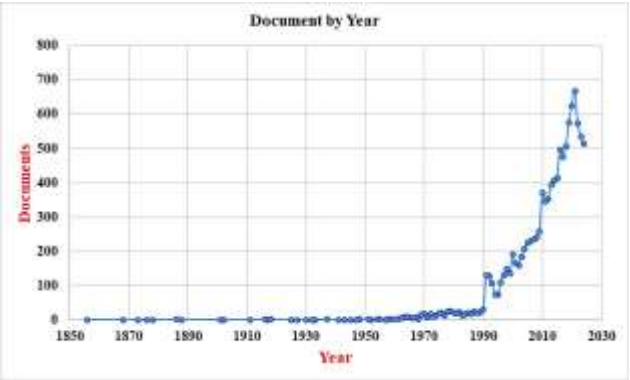

Chart 1- Chart showing the number of documents by year (Stage 1 Search)

This chart shows a growing trend in research from 1990 to 2021, with 667 results in 2021 representing the peak. After 2021, a decline in the number of studies has occurred, highlighting the need to investigate the reasons for this decrease and its impact on economic and social planning.

The number of research documents according to the research centers affiliated with the researchers is shown in Chart 2**Error! Reference source not found.** for the 15 centers with the highest number of documents.

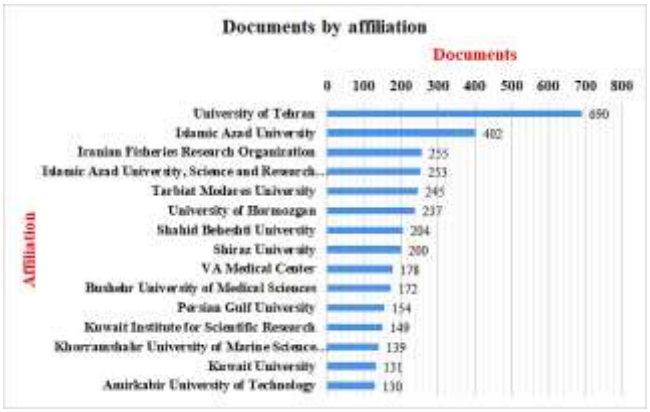

Chart 2- Comparison of research document counts for academic and research institutions (Stage 1 search)

Chart 2**Error! Reference source not found.** shows t hat the University of Tehran (Iran) is significantly leading research in the Persian Gulf domain. Investigating the reasons behind this difference, reviewing the outcomes of these studies, and discussing the application of these findings in industrial, economic, and tourism sectors is a relevant topic for further discussion.

compares the number of research documents for the top 10 researchers with the highest number of publications.

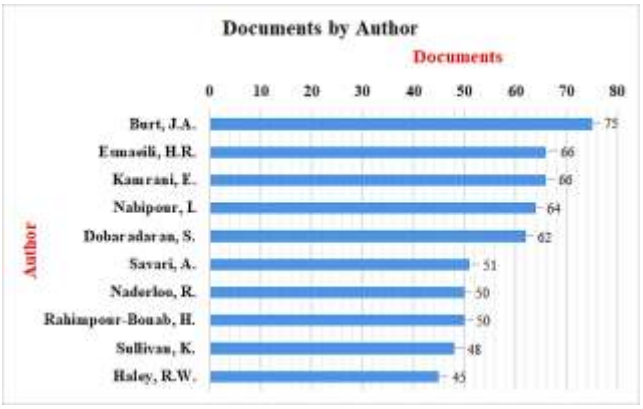

Chart 3- Comparison of research document counts for the top ten researchers (Stage 1 search)

Examining the perspectives of these researchers regarding the Persian Gulf marine area will yield valuable insights. It will not only highlight research gaps but also provide useful findings for management planning by reviewing the results of these studies.

John A. Burt, with 75 publications, leads this chart. He is a marine biologist at New York University Abu

Dhabi (NYUAD). This researcher uses the Persian Gulf, the hottest sea in the world, as a "natural laboratory." His studies focus on the responses of marine organisms to the unique environmental conditions of this water basin. He explores how marine organisms adapt and also provides insights into the potential impacts of future climate changes on the sea. He conducts research on corals, coral symbionts, reef fish, mangroves, and seagrasses in tropical ecosystems. Burt and his colleagues use science to support local policies, management, and conservation actions related to these areas.

The comparison of the number of research publications by country or territory regarding the Persian Gulf also provides valuable insights into the significance of the Persian Gulf (Chart 4).

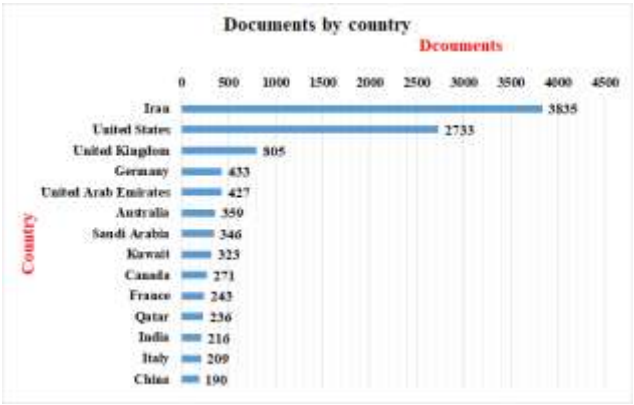

Chart 4- Number of Research Documents by Country (Stage 1 Search)

Chart 4 indicates the special attention given by the United States and the United Kingdom to the Persian Gulf. Examining the viewpoints of researchers from these countries in economic, military, and management programs is valuable.

The type of research and the study area are also other aspects of the current review, shown in Chart 5

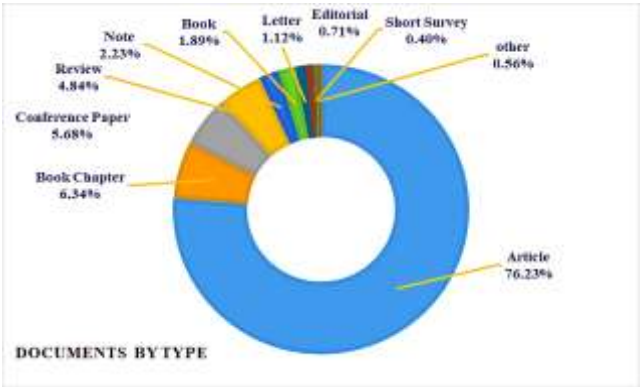

Chart 5- Research Documents by type (Stage 1 Search)

A large portion of the documents are articles, indicating that the research titles can form a wide range. Examining the impact of these studies on industry, the economy, and social life can be a subject of discussion.

A quantitative comparison of research areas presents the interests of the researchers.

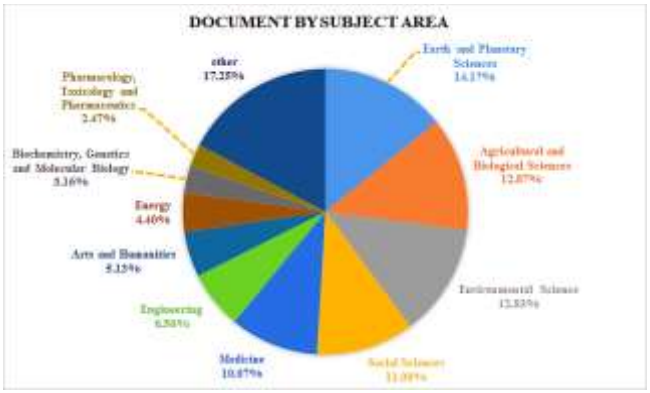

Chart 6- Comparison of research document by subject area (Stage 1 search).

Chart 6 indicates that considerable research attention has been directed toward Earth and space sciences, followed by agricultural and biological sciences. However, despite the Persian Gulf being an oceanic basin and a significant energy resource, related scientific research remains substantially underrepresented.

The following key findings can be highlighted:

- A noticeable decline in the number of publications since 2021
- Iran's leading position in terms of the number of publications
- The University of Tehran (Iran)ranking highest among Iranian universities in publication count
- Significant research interest in the Persian Gulf region by the United States and the United Kingdom
- The prominent focus and contributions of John A. Burt, a marine biologist at New York University Abu Dhabi (NYUAD), to research on the marine domain of the Persian Gulf

For a more detailed analysis, the second search stage, focused on "*Article title*", was examined, followed by a third stage involving a closer inspection of the results from the second stage.

The search in the "*Article title*" section revealed 3541 research titles. In this type of search, the title of the paper provides a concise summary of its content. Every word is carefully selected to convey the maximum amount of information in the smallest possible package, enabling optimal "findability" in article databases, journals, and internet search engines.

In the results, changes in the number of research documents over the years under review can be observed (Chart 7):

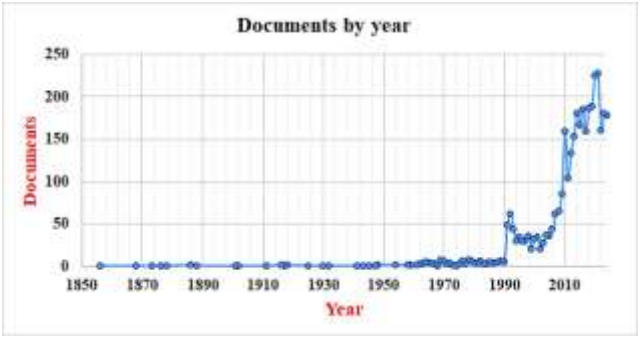

Chart 7- Number of research documents by year (stage 2 search)

At this stage, the research focus on the water basin of the Persian Gulf from 1990 to 2021 shows an upward trend, with a decline in the number of documents after 2021, as indicated by this chart. Additionally, the highest number of documents, 228 research titles, is recorded in 2021.

The following chart shows the number of documents by country for the 15 countries with the highest number of documents.

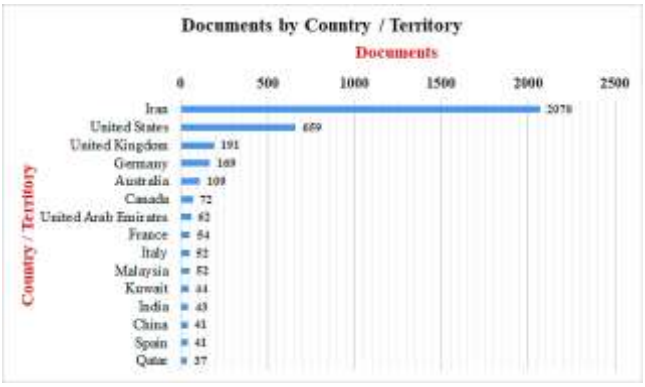

Chart 8- Number of research documents per country (stage 2 search)

This chart highlights the significance of the Persian Gulf region for various countries. Iran has shown the greatest attention to this marine area, followed by the United States and the United Kingdom, as seen in stage 1.

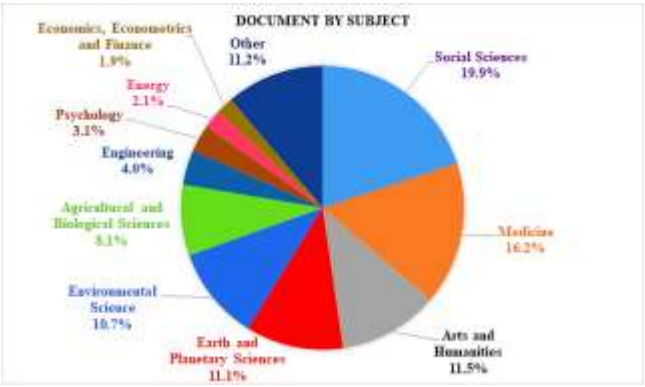

Chart 9- Comparing documents based on the study area of the United States (Search Stage 3)

In a more detailed analysis (Chart 9), among the 659 documents from the United States, social sciences titles accounted for 19.9%, showing the highest interest, while economic and financial titles, with 1.9%, showed the least interest (Chart 9).

Among the 3541 documents obtained, a comparison of research centers affiliated with the researchers for the top 15 centers with the most data can also provide valuable insights (Chart 10).

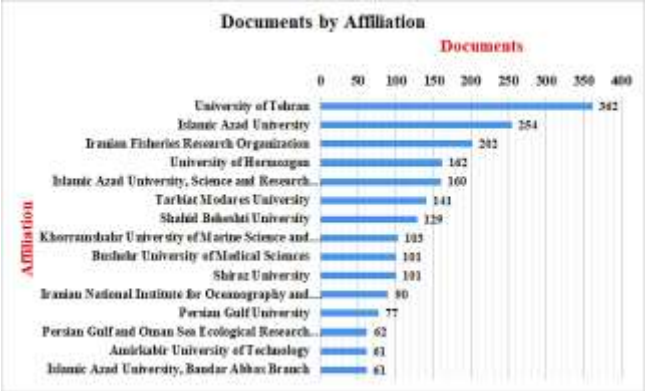

Chart 10- Comparison of the number of research documents for each research institution (Stage 2 of the search).

Examining the researchers' interests can help identify the areas of focus as well as potential research gaps. Therefore, a more detailed comparison of the number of documents by researchers has been made (Chart 11), where the number of documents by the top 15 researchers (with the most documents) is compared.

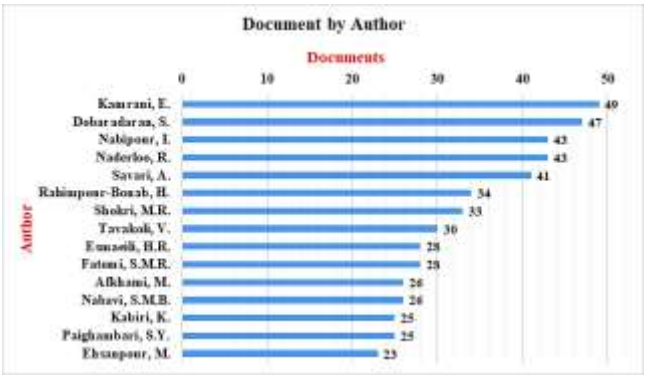

Chart 11- Comparison of the number of documents for the 15 researchers with the most publications (Stage 2 of the search).

In this comparison, Kamrani, a researcher at Hormozgan University (Iran), is at the top with 49 research results, focusing on fisheries and aquaculture. Kabiri, a researcher at the National Institute of Oceanography and Atmospheric Science, works in the field of remote sensing. Other researchers in this chart have conducted studies in the areas of biological sciences and geology. It appears that various disciplines within basic sciences, engineering, and energy topics are of relatively low interest. Therefore, a thematic analysis of the research documents could be valuable (Chart 12).

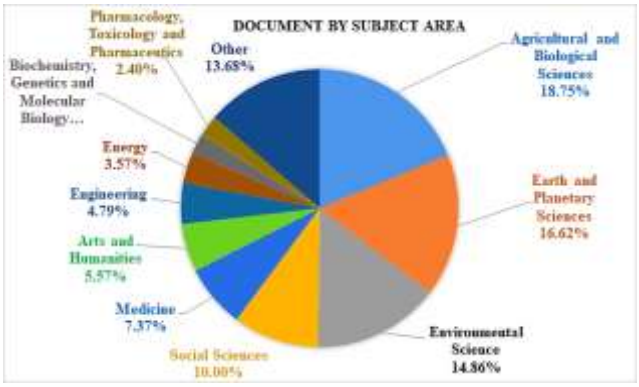

Chart 12- Comparison of documents based on subject area (Stage 2 of the Search)

Disregarding the "Other" category (13.7%), which includes fields such as computer science, psychology, materials science, physics and astronomy, chemistry, and mathematics, this chart shows that the highest attention from researchers (18.7%) is directed toward agriculture and biological sciences. This can be considered natural due to the biodiversity of organisms in the islands and waters of the region. Following that, earth and planetary sciences attract the attention of researchers (16.6%).

In this field, the evolution of the Earth and planets is addressed, from the Earth's interior to the atmosphere, along with their physical and chemical processes. Given that the Persian Gulf is a vital water basin, economic hub, and strategic area, and considering that water is a renewable energy source, the relatively small share of documents related to energy (3.6%) and engineering sciences (4.8%) warrants further investigation.

The "Other" category in this Chart 12 encompasses fields such as computer science, psychology, material science, physics and astronomy, chemistry, mathematics, and others, each contributing a negligible share individually. On the other hand, fluid dynamics is a significant topic in the fields of physics and even engineering. Therefore, the lack of interest among researchers from the physics and engineering disciplines in this area warrants further investigation.

In search 2, out of the 3541 research documents, 199 are related to the energy sector, which accounts for 3.6%. Among these, the University of Tehran (Iran) holds the largest share with 42 documents (Chart 13).

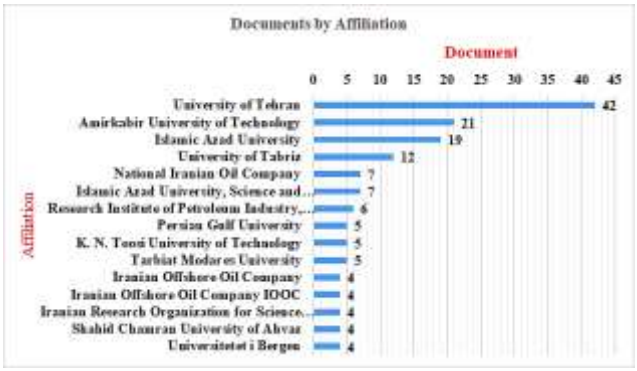

Chart 13- Comparison of the number of research documents on energy for each research center (Stage 3 of the search)

In these 199 documents, energy in the Persian Gulf region has been examined in various ways. A more detailed review of the titles reveals that 15 documents are related to numerical modeling, 10 documents to wave energy, and 3 documents to wind energy.

It is also observed that out of the 3541 research documents, 267 are related to the field of engineering, accounting for 4.8%. In this regard, the University of Tehran (Iran)ranks first, slightly ahead of Amirkabir University and Khajeh Nasir Toosi University (Iran), (Chart 14).

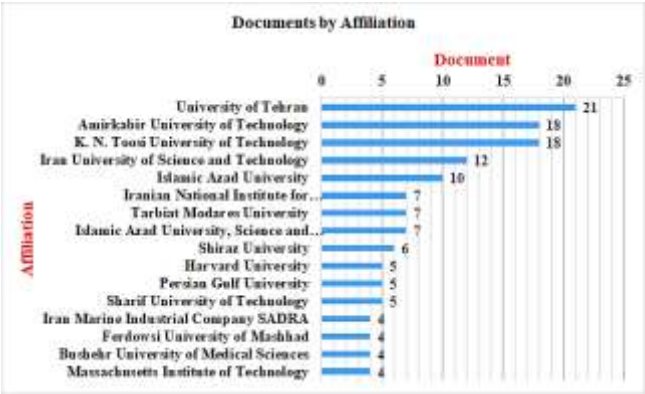

Chart 14- Comparison of the number of research documents on engineering topics for each research institution (Stage 3 of the search).

Given the geographical, climatic, and social conditions of the Persian Gulf basin, there are various topics for research, and different engineering disciplines can address them, which has already occurred. The compiled statistics do not show a particular focus on a specific subject within the field of engineering.

Despite the fact that the waters of the Persian Gulf have the potential to be a source of renewable energy, only a small percentage of research has been conducted in this area.

Another important perspective is the result of examining and comparing the number of citations by researchers to a specific topic or research title. The result of this comparison highlights the research areas that attract the most attention. The top ten research titles with the highest number of citations are as follows:

1. Microplastics in different tissues of fish and prawn from the Musa Estuary, the Persian Gulf, 2018, with 506 citations.
2. Health of UK servicemen who served in the Persian Gulf War, 1999, with 490 citations.
3. War syndromes and their evaluation: from the US Civil War to the Persian Gulf War, 1996, with 336 citations
4. Submarine lithification of Holocene carbonate sediments in the Persian Gulf, 1969, with 306 citations.
5. Shoreline reconstructions for the Persian Gulf since the last glacial maximum, 1996, with 303 citations.
6. Mortality among US veterans of the Persian Gulf War, 1996, with 296 citations.
7. Investigating a probable relationship between microplastics and potentially toxic elements in fish muscles from northeast of the Persian Gulf, 2018, with 290 citations.
8. Microplastics contamination in molluscs from the northern part of the Persian Gulf, 2018, with 276 citations.
9.I solation and characterization of crude-oil-degrading bacteria from the Persian Gulf and the Caspian Sea, 2012, with 243 citations.
10. The circulation of the Persian Gulf: a numerical study, 2006, with 241 citations.

The comparison shows that biological research has received the highest number of citations, while numerical and physical studies have received the fewest citations. Additionally, research in the fields of industry, engineering, and computer science has not played a role in this comparison.

Therefore, given the role of industry and basic sciences in advancing the scientific level of the country, and to align the country's progress with global advancements, more attention must be given to research in the fields of marine science and engineering, particularly in computer science (both hardware and software) within the Persian Gulf marine basin. This, in turn, requires specific planning and investment.

In this way, various topics can be viewed in an overview, research titles can be examined and analyzed, and research gaps in different research areas can be identified.

4. Conclusions

This study aims to provide a comprehensive and quantitative overview of the research conducted in the oceanic domain of the Persian Gulf over the period from 1856 to 2024. The most significant outcome of this study is the identification of gaps in research topics. To achieve this, the characteristics of 10,910 research papers registered in the Scopus database were examined.

Chart 1 and Chart 7 demonstrate that the highest level of research attention to the Persian Gulf region occurred in 2021, followed by a declining trend in subsequent years.

Among the Persian Gulf littoral countries, Iran has shown the greatest attention to issues related to this region, followed by the United States with the highest number of research publications in this field (Chart 4 and Chart 8).

Likewise, among academic and research institutions, the University of Tehran (Iran) ranks highest in terms of the number of research publications (Chart 2 and Chart 10).

Researchers' interests can also reveal important insights; as shown in Chart 3, John A. Burt, a marine biologist at New York University Abu Dhabi (NYUAD), has produced the highest number of research publications. A more detailed analysis of the titles (Chart 11) shows that Kamrani, a researcher at the University of Hormozgan specializing in fisheries and aquatic organisms, has produced the highest number of publications. An analysis of the research specializations in Chart 11 indicates that the Persian Gulf has primarily attracted the attention of experts in biological and geological sciences.

This study indicates that various disciplines within the basic sciences, such as ocean physics and chemistry, as well as engineering, have received relatively limited attention. In the second search, a total of 3,541 documents were identified, of which 267 were related to engineering and 199 to the energy sector. A more detailed analysis of the 199 energy-related titles revealed that 15 focused on numerical modeling, 10 on wave energy, and 3 on wind energy.

Despite the fact that the waters of the Persian Gulf could serve as a renewable energy source, a small percentage of research has been conducted in this area. On the other hand, a comparison of citation counts reveals a lack of attention to research in marine sciences and engineering, as well as computer science. The reasons for the low level of interest in these areas can be attributed to the need for research outcomes, research facilities, and specialized human resources.

Given the importance of the Persian Gulf marine basin, research must emphasize the protection and sustainable use of marine resources. Therefore, in addition to quantitative assessments, content analysis of articles and research documents can be considered one of the most essential actions.

Focusing research planning within a centralized institution or organization can create opportunities for the broader application of research outcomes. Additionally, establishing an internal, multidisciplinary database in the field of marine sciences can facilitate researchers' access to various research data and information, as well as analytical tools and criteria. This database can significantly contribute to guiding research priorities, advancing studies, and achieving educational goals. The use of a centralized database can lead to more informed decision-making and more efficient outcomes.

In this regard, in addition to training specialized personnel, focusing research planning within a centralized institution or organization, and facilitating researchers' access to data, research information, and analytical tools, will play a vital role in guiding research priorities and advancing studies toward practical and applicable outcomes.

Acknowledgment (Optional)

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