

Original Research

Scientometric Analysis of Research Activity and Collaboration Patterns in Marine Pollution Literature

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Received: 18 September 2020

Accepted: 24 August 2021

Abstract

The current study aims to analyze the scholarly publications of researchers in marine pollution for 30 years (from 1989 to 2018). This study intends to identify the list of core journal publications, growth rate, the productivity of authors and institutions, proportion of Indian contribution, and various similar aspects at national and international levels in the field of marine pollution. The retrieved data were analyzed using the Microsoft-Excel package as per the objectives of the study, and the data has been presented as tables and graphs. The study was designed to assess and know the growth rate of the research literature output, author productivity, quantitative and qualitative indices, collaborative trends, citation patterns, key journal's list, and geographical distribution of publications at national and international levels in Marine pollution. The study shows an inconsistency in the Annual Growth Rate (AGR) of Marine pollution publications ranging from -35.63 to 23.69 between 1989 and 2018. The study also shows that the maximum Degree of Collaboration (DC) was identified in the years 2014 and 2018 (0.94) and the minimum DC identified in the year 1992 (0.60). The average of DC arrived as $C=0.85$, i.e., 85% of collaborative authors contributed. Collaboration Index (CI) of Marine pollution literature for the study period made clear that the number of authors per publication had increased from 3.32 (1989) to 5.40 (2018). The study results indicate that the overall growth rate calculated by various scientometric methods in marine pollution has been significantly growing in recent years at the international level. On the other hand, the growth rate of Marine pollution is moderate in India.

Keywords: Scientometrics, Marine Pollution, Citation Analysis, Degree of Collaboration, Doubling Time, Relative Growth Rate and Time Series Analysis.

Introduction

Scientometrics is the technique of measuring information using quantitative and qualitative indicators. It is analogous to Bibliometrics and Informatics; it uses mathematical and statistical techniques to evaluate and predict the advancement of science. Scientometrics may be defined as applying those quantitative methods that deal with the analysis of science viewed as an

information process. Tauge-Sutchiffe defined “scientrometrics as a study of the quantitative aspects of science as a discipline or economic activity” as part of the sociology of science and has application to science policy-making. It involves quantitative studies of scientific activities including, among others, publications and so overlaps bibliometrics to some extent.

The quantitative approach to characterize scientific activity emerged as a new strand of research within science and technology studies in the 1960s. Science becoming huge in terms of investment and skilled human resources requirement, competition for funding among different disciplines, peer review process being questioned as subjective helped push the new agenda of quantitative approach. This quantitative approach to measure scientific activity was coined as Scientometrics. It is a generic term for a system of knowledge that endeavors to study the scientific and technological system, using a variety of quantitative approaches within the area of Science and Technology Studies (Thanuskodi & Subramaniyan, 2013).

Marine Pollution

The pollution in the marine environment affects the safety of marine ecosystems and restricts the development of human society and the economy (Xiang, Wang, & Liu, 2017). Marine pollution has become a great danger to the marine environment, human physical condition, and other food sources. Marine waters are continuously contaminated by point and non-point sources (Thanuskodi & Venkatalakshmi, 2010). Pollution observed in the coastal atmosphere occurs mainly due to anthropogenic activities on the coast and land bordering the ocean environment. Scientometric analysis has received enough attention, and it has been broadly applied to appraise the research performance of the researchers and the progress of different subject areas of the science domain. Further, it could be observed that Scientometric analysis can detect upcoming research areas, research performance of individuals, research teams, and countries (Sudhakar, K. & Thanuskodi, 2018). Greater integration and research endeavor in marine pollution will assure ever-increasing contribution to new aspects of the environment and society. For this reason, it is necessary to study quantitatively and qualitatively the research output of Marine Pollution literature by applying Scientometric methods.

Significance of the Study

Evaluating the research attitude in the field of Marine pollution facilitates to appraise the academic research activities carried out by the scholars at the world level for a while. The current study intends to know the importance of documenting the research productivity with learning resources related to Marine pollution. However, many studies have been carried out to analyze the research publications in pollution; very few studies have been done in the subfield of marine pollution. Hence, the current study has been taken for the researcher's consideration to do Scientometric analysis in marine pollution from 1989 to 2018. Marine pollution is considered a universal problem and receives adequate research attention in this contemporary period.

The study's outcomes will give lessons to the upcoming scientific researchers for getting scholarly views to alert the human society from the hazards of Marine pollution. The study's outcomes also facilitate the concerned authorities to form better strategies in the growth of Marine pollution research. Thus, the current research provided an outline of the Marine pollution literature and aimed to record the prominent academic publications at national and international levels. The current study aims to analyze the scholarly publications of researchers

in marine pollution for 30 years (from 1989 to 2018). This study intends to identify the list of core journal publications, growth rate, the productivity of authors and institutions, the proportion of Indian contribution, and various similar aspects at national and international levels in the field of marine pollution.

Literature Review

Chaman Sab, Dharani Kumar and Biradar (2017) studied the publications on Oceanography from 2011-2015 using the Web of Science citation database. As a result, they found that the maximum number of articles, i.e., 7250, was published in 2015 in the world. They identified that the average citation per paper was 2.32. Globally the study helped to know the performance country-wise. During the period, 985 papers were published, 2286 citations were received in India & 33145 papers were published, and 175793 citations were received worldwide. Djalalinia (2015) conducted a scientometrics study on Obesity researches from 1990 to 2013 in Middle East countries. The search was made systematically from the Scopus database in health and biometrics disciplines for the publications related to obesity /overweight. A total of 4,15,126 papers were published during the period. In this study, the researchers assessed the trends of collaborative papers, scientific productivity, and citation. In publications, Turkey took first place(47.9%), Israel took second place(35.35%), and Iran took third place(26.27%).

Dhanya and Raja (2017) have made a scientometric study the industrial pollution from the Indian viewpoint. The study analyzed the research publications in the field indexed in the Web of Science (WoS) database. The Indian scientists on Industrial pollution released 805 publications during 2007-2016, which received 9699 citations. Environmental Earth Sciences and Journal of Environmental Biology were the second and third-ranking journals. The Relative growth rate was 0.16 (2016), and the doubling time was 4.58 (2016). The study furnished a clear picture of the scientific productivity of Indian scientists in the field of industrial pollution. Huai & Chai (2016) have performed a bibliometric study on water security research between 1998 and 2015, and the data required for the study was obtained in the Web of Science database. The study noted that the most promising subjects were environmental sciences and water resources and Zipf's law of publication distribution in all subjects was satisfied. The USA owned the maximum number of publications, whereas Canada had a more latent capacity. USA and UK dominated the collaborative network.

Suresh and Thanuskodi (2019) attempted to analyze the growth and development of ICAR-Indian Institute of Horticulture, Bangalore (ICAR-IIHR) research activity. Data for the study were retrieved from the Web of Science database for 30 years, from 1989 to 2018. Journal articles were the most published form of literature (90.13%), wherein the Indian Journal of Agricultural Sciences followed by Current Science were the top journals. The top collaborating country and institutions with ICAR-IIHR were the United States and Horticultural experiment Stations, respectively. The highly productive research areas were Agriculture and Plant Sciences. Vivekanandhan, Sivasamy & Prabhakar (2016) evaluated the output of the journal publications on Pollution control research during the period 2005-2014. The data was extracted from the Scopus database. A maximum of 51 publications was published by Hao.J, with 1816 citations and 1.39 as RCI. The researchers found that 90% (16139) of publications were English. Journals contributed the maximum publications, i.e., 73.01% and books contributed the minimum publications, i.e., 1.031%.

Kolle and Thyavanahalli (2016) have evaluated research works on air pollution published in 2005-2014, and records were collected from the Web of Science database. Most of the articles were published in journals devoted explicitly to research dissemination about air than multidisciplinary. The results of this study were useful to researchers and scientists in understanding trends in air pollution research during the year 2005-2014. Cherukodan and Mumthas (2019) examined the growth of scholarly articles produced by the University of Calicut for fifty-one years (1968-2018). A total number of 2158 scholarly articles were collected from the Scopus database. The scholarly articles in Social Sciences, Business, Management and Accounting, Arts and Humanities, Psychology, Economics, Econometrics, and Finance were very few (3.7%). The majority of articles (58%) were published during the last ten years (58%).

Sachithanatham and Raja (2015) analyzed the literature on Rabies research in India from 1950-2014. The source of this research is the PubMed database, and records (495) were downloaded and analyzed using the Bibexcel toolbox. The mean output of the rabies literature for the study period was 7.61. The doubling time was lowest (0.99) during 1960-64 and was highest (2.56) during 1995-99. The Journal of Association of Physicians of India (JAPI) published 46 articles. DC was 0 during 1955-59 and 0.93 during 2010-2014. The researchers have found the research productivity as low, and the government has encouraged the researchers in this field as the mortality rate is high due to rabies.

Chaurasia and Chavan (2014) performed a research output analysis of IIT Delhi between 2001 and 2010. The study has used various bibliometric measures, which help understand various aspects of the research. They have collected data from the WoS for various analyses. These analyses will help understand the growth, impact, and contribution of research carried by the respective organization's faculty. IIT Delhi has published 6109 scholarly outputs between 2001 and 2010; it has also been observed that articles are significant shareholders and reviews are very minimal compared to the total publication count. Engineering is spearheading the IIT Delhi research with 1890 publications, 30.9% of total publications.

Todeschini (2011) conducted a study to propose a new bibliometric index, the j-index, trying to preserve the advantages of the h-index and overcome its disadvantages. Using Principal Component Analysis (PCA), Hasse Diagram Technique (HDT), and multivariate comparisons among eighteen indices. The study highlighted the new index's interesting properties and showed relevant relationships among the indices. The researcher concluded that the j-index preserved the logic in which the h-index was defined, its efficiency, and robustness, but, at the same time, removed some of its drawbacks, such as degeneracy, resistance in increasing for h values, and insensitivity to the citation distribution.

Objectives of the Study

- To analyze the progress of research productivity on Marine pollution research output at national and international levels.
- To identify the Relative Growth Rate (RGR) and Doubling Time (DT) of Marine pollution literature.
- To know the collaborative pattern in the Marine pollution literature.
- To apply the scholar indices for measuring the contributions of authors, sources, institutions, and countries in the Marine pollution literature.

- To evaluate the citation pattern and make out the highly cited publications in marine pollution literature.

Methodology

There were very few publications on leather research before 1988; the beginning of the study period was chosen as 1989. Since the data collection work for the research was started in early 2019, the ending of the study period was fixed as 2018. Thus a period of 30 years from 1989 to 2018 was selected as the study period. The following search strategy was used in Scopus Database to retrieve the relevant data on leather research. The search string “Marine Pollution” was used in the title and abstract. In the publication year PUBYEAR >1989 AND PUBYEAR < 2018 was specified.

Relative Growth Rate (RGR)

The Relative Growth Rate (RGR) expresses growth in terms of a rate of increase in the size of publications per unit of time. The publications' growth was analyzed using RGR and DT (Mahapatra, 1985). The mean Relative Growth rate (R) over the specific period of the interval can be calculated from the following formula.

$$R(1 - 2) = \frac{W_2 - W_1}{T_2 - T_1}$$

Whereas,

R = Mean relative growth rate over the specific period of interval

W_1 = Log of the initial number of publications

W_2 = Log of the final number of publications after a specific period of interval

$T_2 - T_1$ = the unit difference between the initial and final times.

Doubling Time (DT)

The Doubling time is directly related to RGR. If the numbers of publications or pages of subject double during a given period, then the difference in the logarithms of numbers at the beginning and end of this period must be logarithms of number 2. If a natural logarithm is used, this difference has a value of 0.693. Thus, the formula can calculate the corresponding doubling time for each specific period of interval and both publications and pages.

$$\text{Doubling Time (DT)} = \frac{0.693}{R} \quad (3.4)$$

Where,

R = Relative Growth Rate

Time Series Analysis (TSA)

Time series is an ordered sequence of values of a variable at equally spaced time intervals. In other words, we can say that a time series is a sequence of data points, measured typically at successive times, spaced at (often uniform) time intervals. According to **Mooris Hamburg (1970)**, “A time series is a set of statistical observations arranged in chronological order”.

$$\text{Equation of Straight Line } Y_c = a + bx \quad (3.5)$$

Where,

Y = Trend value to be computed

X = Unit of time (Independent variable)

a = Constant to be calculated

b = Constant to be calculated

Degree of Collaboration (DC)

Degree of Collaboration calculates the proportion of co-author publications among total publications. In order to determine the degree of collaboration or the collaborative research pattern in quantitative terms, an indicator or the formula suggested by Subramanyam (1983) has been used.

$$C = \frac{N_m}{N_m + N_s} \quad (3.6)$$

Where,

C = Degree of collaboration in a discipline.

N_m = Number of Multi-authored papers in the discipline published during a year.

N_s = Number of single-authored papers in the discipline published during the same year.

The degree of collaboration is determined using this formula.

Collaboration Index (CI)

Collaborative Index (**Lawani, 1980**) is a mean number of authors per joint paper. For this analysis, we have omitted the single-authored papers, which are always equal to 1. To determine the mean number of authors per jointly authored paper

$$CI = \frac{\sum_{j=1}^A j f_j}{N} \quad (3.7)$$

Where,

j = Number of Co-authored papers that appeared in a discipline;

N = Number of papers in the discipline over the same time interval;

Data Analysis and Findings

The analysis and interpretation of data are presented in the following broad categories: research productivity, author's productivity, and citation analysis.

Frequency Distribution of Publications

The frequency distribution of publications was analyzed and interpreted to evaluate the research productivity in marine pollution (figure 1). It was also observed that from 2009 to 2018 (10 years), 54.65% of publications were found, whereas from 1989 to 2008 (20 years), 45.35% of publications were found. According to Figure 1 the frequency distribution of publications, it was also observed that Figure 1 described that there was a gradual increase in every five-block years as follows: from the year 1989 to 1993 with 595 (4.22%) records followed by 1994-1998 with 999 (7.08%) records; 1999-2003 with 1743 (12.35%) records; 2004-2008 with 3062 (21.70%) records; 2009-2013 with 3168 (22.45%) records and 2014-2018 with 4544 (32.20%) records respectively.

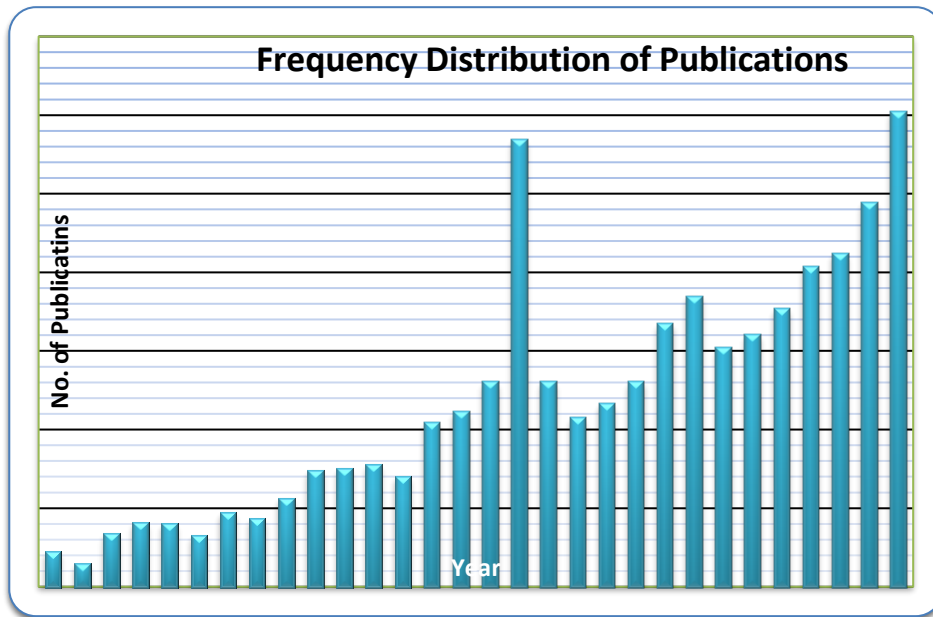


Figure 1: Frequency Distribution of Publication on Marine Pollution Literature 1989-2018

Annual Growth Rate and Exponential Growth Rate of Publications

Figure 2 represented an inconsistency in the Annual Growth Rate (AGR) of Marine Pollution publications ranging from -35.63 to 23.69 between 1989 and 2018. The highest AGR was found in 1991 (137.50), followed by 2005 (119.11). It was also found that 1990, 1993, 1994, 1996, 2001, 2006, 2007, and 2012 had a negative growth rate.

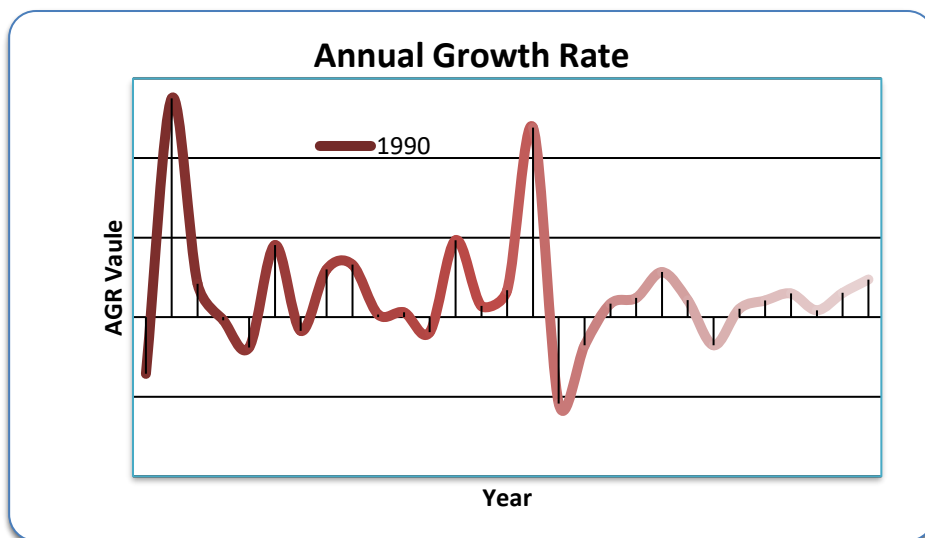


Figure 2: Annual Growth Rate of Marine Pollution Publications

Figure 3 concerned with the Exponential Growth Rate (EGR), it was identified that the highest EGR in the year 1991 (2.38) with 133 publications and followed by the year 2005 (2.19) with 1135 publications. The least EGR was reported in 2006 (0.46) with 519 publications. According to the analysis, the overall average EGR was 1.11.

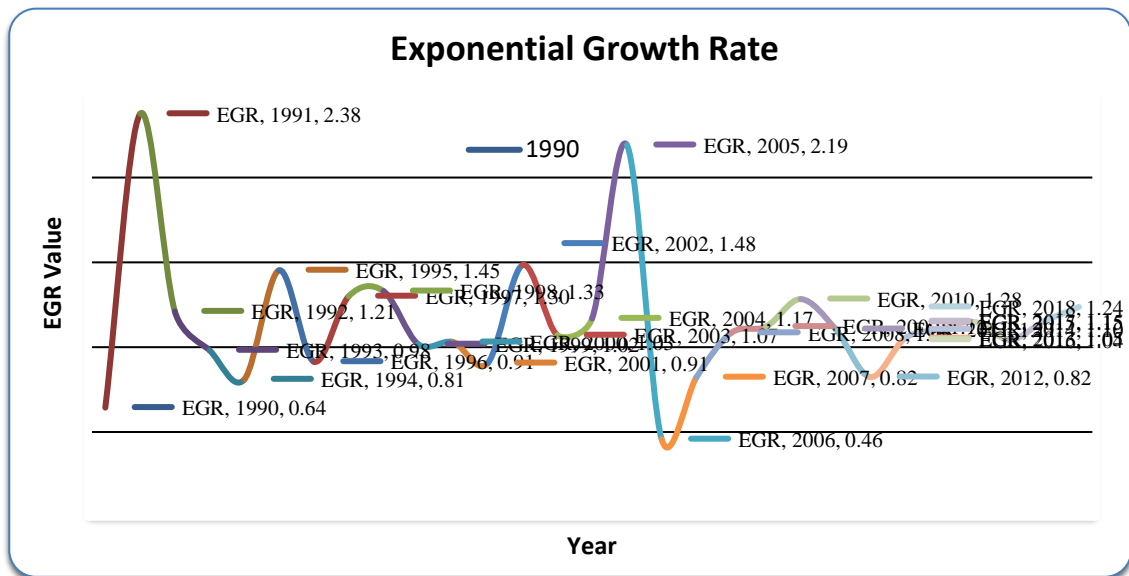


Figure 3: Exponential Growth Rate of Marine Pollution Publications

Relative Growth Rate and Doubling Time of Publications

Figure 4 represents the Relative Growth Rate (RGR) of Marine pollution literature for the study period. The highest RGR value was 0.86 in 1991, followed by 2005 with 0.78. Similarly, the lowest value was reported in 2006, with a value of -0.78.

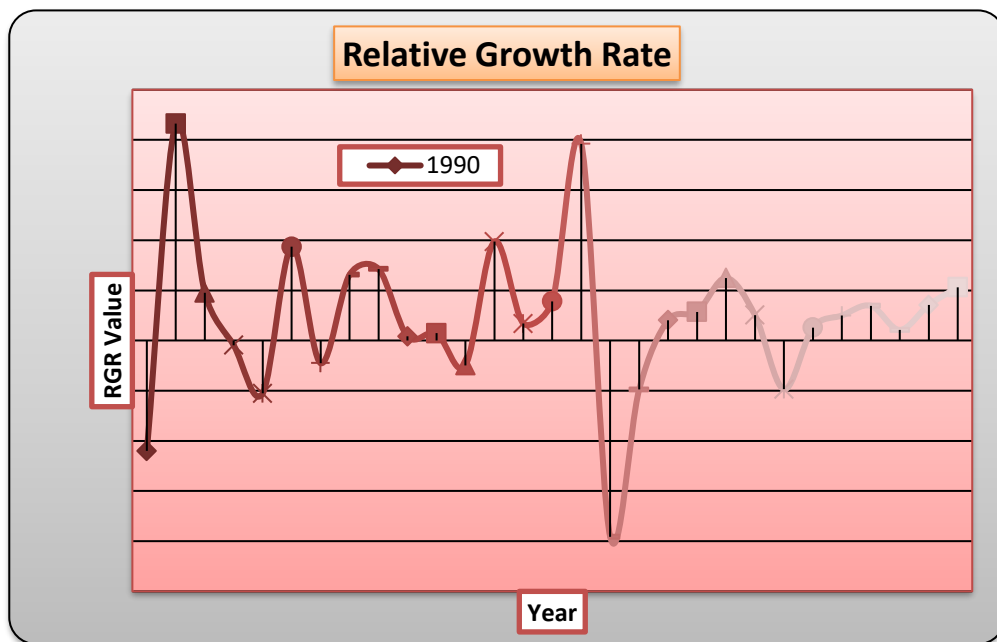


Figure 4: Relative Growth Rate of Marine Pollution Publications

Figure 5 is concerned with the Doubling Time (DT). Similarly, the lowest DT was reported in 1993 with -36.84. On the whole, it was known that there was also fluctuation in both Relative Growth Rate and Doubling Time during the study period.

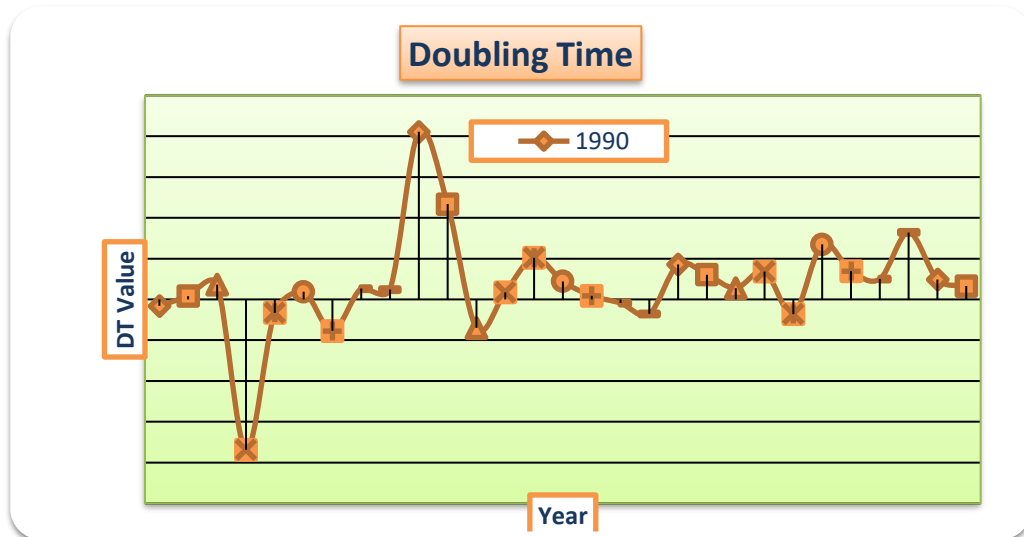


Figure 5: Doubling Time of Marine Pollution Publications

Time Series Analysis: The Future Growth of Publications

Straight Line equation $Y_c = a + bX$

Since $\Sigma X = 0$

$$a = \Sigma Y/N = 14111/30 = 470.37$$

$$b = \Sigma XY/\Sigma X^2 = 70462.5/2247.5 = 31.35$$

$$\text{Estimated literature in 2025} = 470.37 + (31.35 \cdot (2025 - 2003)) = 1160$$

$$\text{Estimated literature in 2030} = 470.37 + (31.35 \cdot (2030 - 2003)) = 1317$$

$$\text{Estimated literature in 2040} = 470.37 + (31.35 \cdot (2040 - 2003)) = 1630$$

$$\text{Estimated literature in 2050} = 470.37 + (31.35 \cdot (2050 - 2003)) = 1944$$

It was observed from Figure 6 on Time series is an ordered sequence of values of a variable at equally spaced time intervals. In other words, we can say that a time series is a sequence of data points, measured typically at successive times, spaced at (often uniform) time intervals. According to Mooris Hamburg (1970), "A time series is a set of statistical observations arranged in chronological order". However, it increased in the forthcoming years viz: 2030 with 1317 publications; 2040 with 1630 and 2050 with 1944 publications. Therefore, it was visibly understood that the growth of the marine pollution literature publications might increase as per the projected upcoming years.

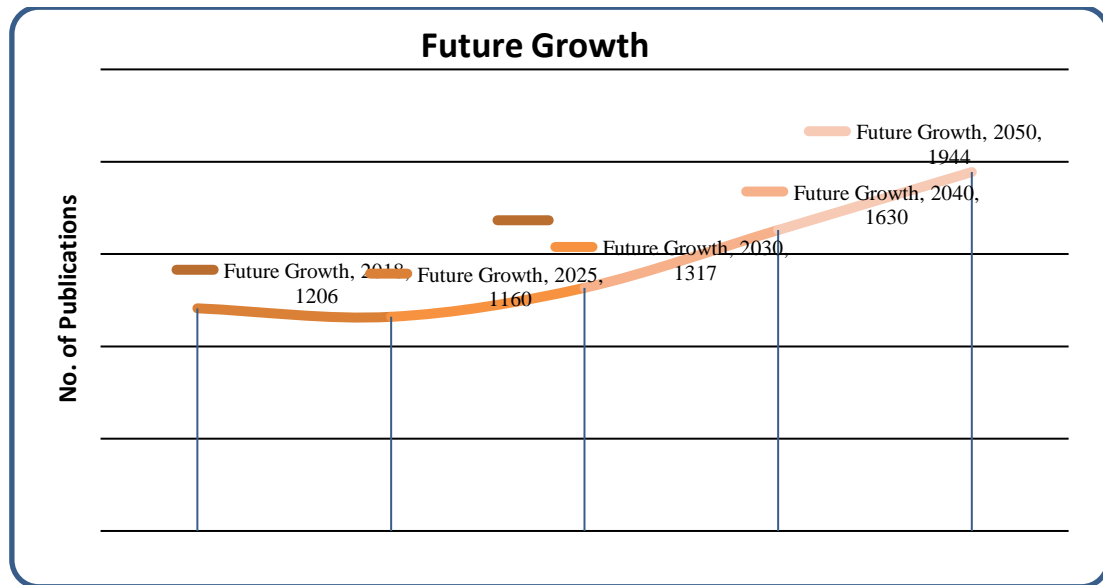


Figure 6: Future Growth of Marine Pollution Publications

Authorship Pattern

The Authorship Pattern in Marine Pollution literature varies from single-authored publications to a maximum of forty authored publications during the study period 1989-2018. As per the analysis of the table, the highest number of research output by three authored was 18.39% with 2595 contributions, followed by double authored contributions was 16.60% (2342), and single-authored contributions were 13.80% (1947). At this point, the biggest cluster had been formed by publications with single-authored to six authored. It was also inferred that 40 authors contributed to only one publication. It shows that collaborative research is governed by individual research in the field of study.

Figure 7 shows that the contributions made as Single Vs. Multiple authors Publications fluctuated in the study period. The highest percentage of single-authored contributions was identified in 2005 with 288 publications, and the highest percentage of multi-authored contributions was identified in 2018 with 1136 publications. It was visibly indicated that the multi authorship pattern with 12008 (85.10%) publications was predominant than the single authorship pattern with 1947 (13.80%) publications. It was known that collaborative authorship was the primary kind of authorship pattern in marine pollution literature.

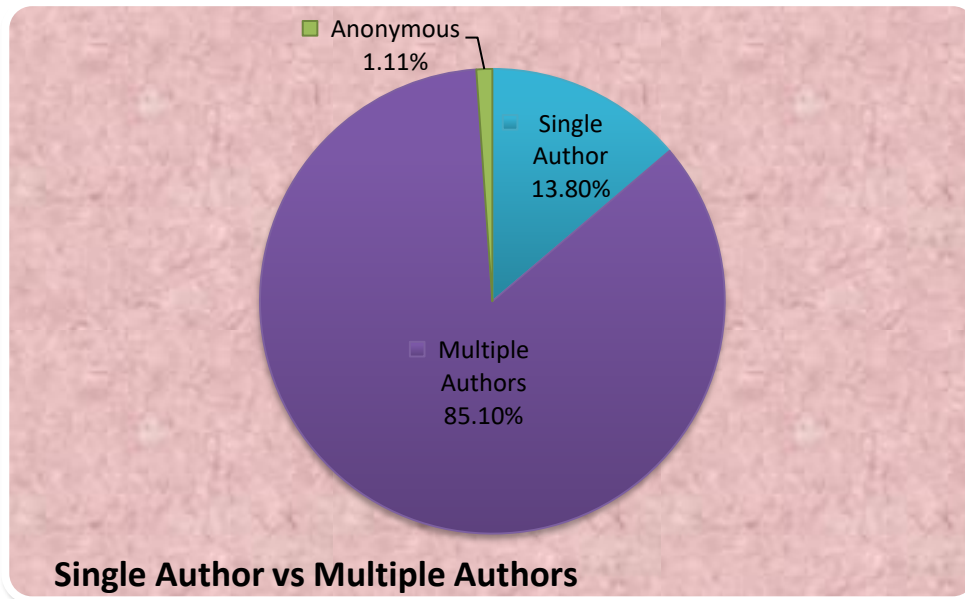


Figure 7: Single Author vs. Multiple Authors Contributions

Degree of Collaboration (DC)

Figure 8 dealt with Degree of Collaboration (DC) in Marine pollution literature. The maximum DC was identified in 2014 and 2018 (0.94), and the minimum was identified in 1992 (0.60). Therefore, the degree of collaboration depicted the extent of collaborations among the authors. The average of DC arrived as $C=0.85$, i.e., 85% of collaborative authors contributed. Figure 8 also described that the mean in DC was progressively increased in every five-block years as follows: from the year 1989 to 1993 with mean in DC of 0.67 followed by 1994-1998 with 0.71; 1999-2003 with 0.82; 2004-2008 with 0.85; 2009-2013 with 0.88 and 2014-2018 with 0.93 respectively.

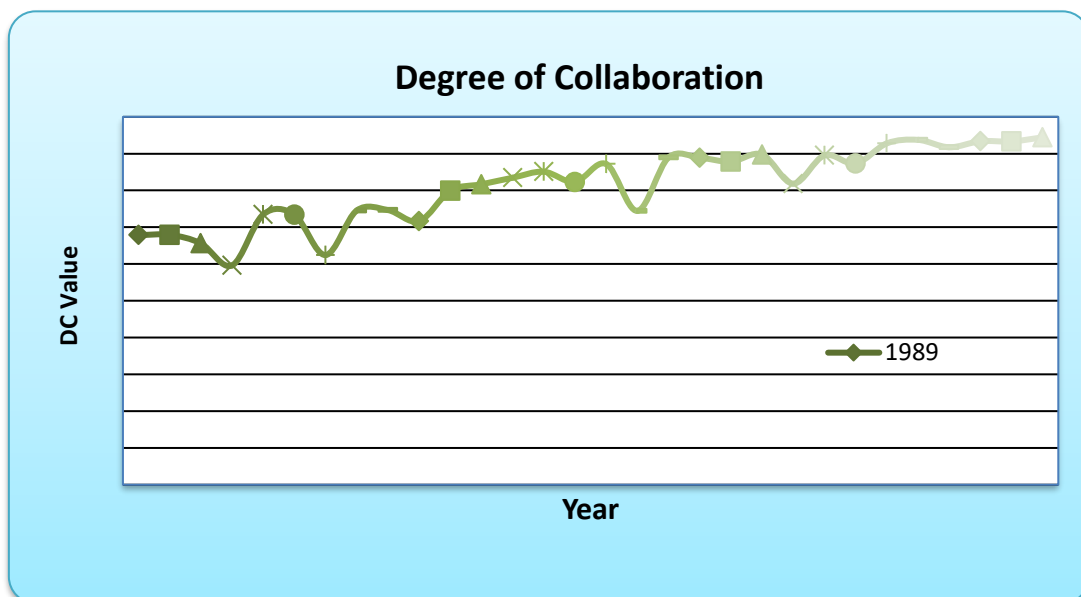


Figure 8: Year-wise Distribution of Degree of Collaboration

Collaboration Index (CI)

Figure 9, concerned with the Collaboration Index (CI) of marine pollution literature for the study period, made clear that the number of authors per publication had increased from 3.32 (1989) to 5.40 (2018). The highest CI was found as 5.40 (2018), and the lowest CI was found as 2.99 (1991). It was also found that the average number of authors per paper was from 3 to 5. Figure 9 expressed that the mean in CI was gradually increased every five-block years.



Figure 9: Year-wise Distribution of Collaboration Index

Co-Authorship Index

Figure 10 represents the Co-Authorship Index (CAI) of Marine Pollution literature. It was noted that the value of Co-authorship Index in the case of single authorship declined from 224.92 in the year 1989 to 40.26 in the year 2018. The CAI for both two authorship and three authorship patterns declined from 145.44 to 63.45 and from 100 to 86.12 during the study period. Similarly, The CAI for four, five, and more than five authorship patterns increased from 72.34 to 91.95; 56.84 to 127.81, and 20.81 to 170.80, respectively.

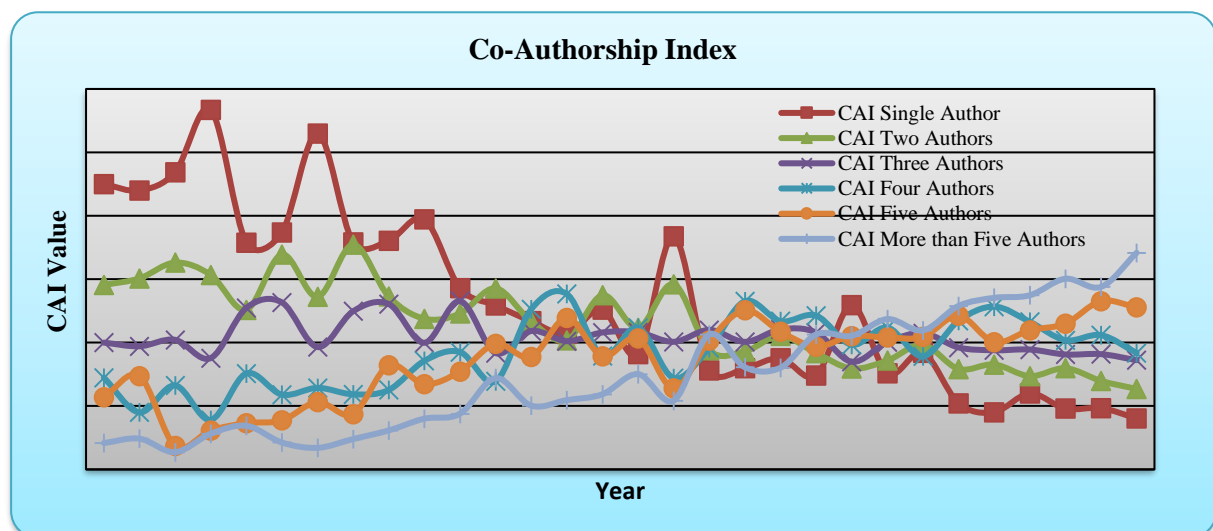


Figure 10: Year-wise Distribution of Co-Authorship Index

Prolific Authors Vs. Number of Publications

Figure 11 is concerned with Prolific Authors Vs. Number of Publications. Unique authors (37299) contributed 56562 times in the publications on marine pollution literature for the study period 1989-2018. For the ranking of authors, only 50 authors were considered and listed in the table. It was noted that Tanabe, S., affiliated to Centre for Marine Environmental Studies, Ehime University from Japan, became a topper amongst all the authors. He had published 80 publications (0.14%) which was the highest contribution. Lam, P.S.K. from Hong Kong became second toppers with 54 publications (0.09%) and Shim, W.J. from South Korea became third toppers with 48 publications (0.08%). It was also noted that from the first rank to the seventh rank, the authors belonged to Asian countries.

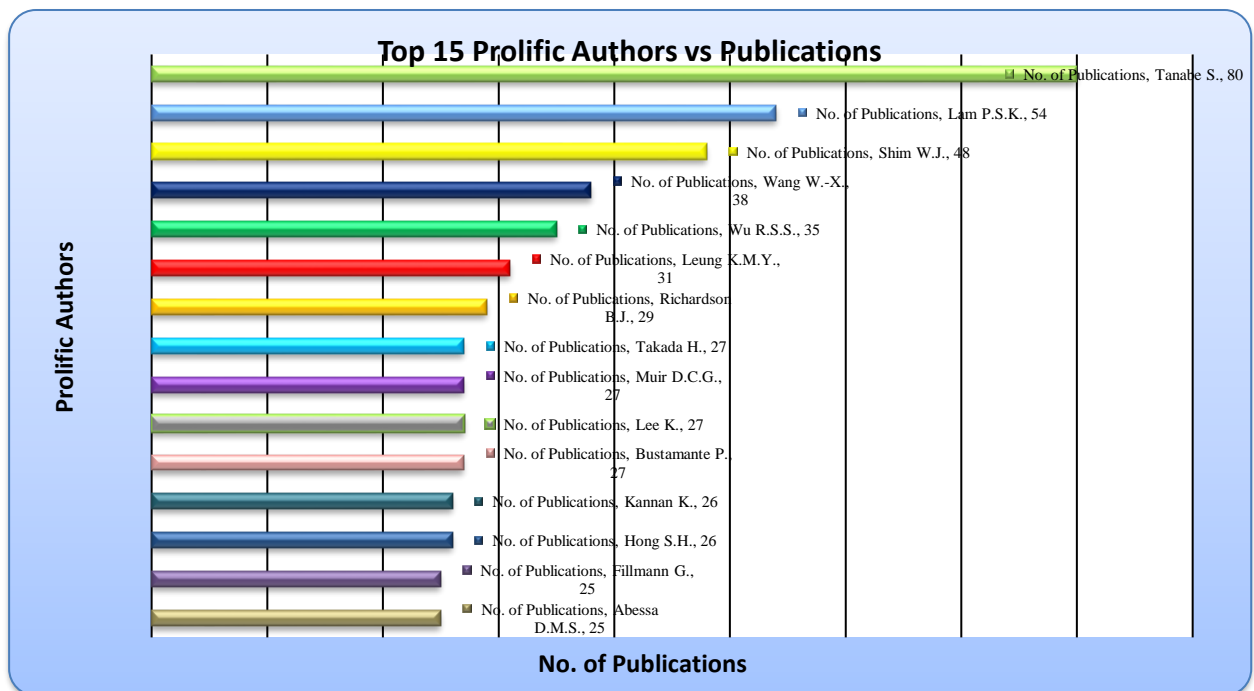


Figure 11: Top 15 Prolific Authors vs Number of Publications

Prolific Authors Publications Vs. Citation per Paper (CPP)

Table 1 illustrated Prolific Authors Publications Vs. Citation per Paper (CPP) of marine pollution literature globally. It was found that Thompson R.C. from the UK ranked first with the CPP value of 264.21, followed by Galloway T.S., also from the UK with 178.65, and Kannan K. from the USA with 104.38 respectively. It was noted that Snow N. from the USA got the least rank with a CPP value of 0.13 in the table.

Table 1

Top 10 Prolific Authors Publications Vs Citation per Paper

| Sl. No. | Prolific Author | Country | Number of Publications | Total Citations | Citation per Paper |
|---------|-----------------|-------------|------------------------|-----------------|--------------------|
| 1 | Tanabe S. | Japan | 80 | 4202 | 52.53 |
| 2 | Lam P.S.K. | Hong Kong | 54 | 3066 | 56.78 |
| 3 | Shim W.J. | South Korea | 48 | 1626 | 33.88 |
| 4 | Wang W.-X. | China | 38 | 1747 | 45.97 |
| 5 | Wu R.S.S. | Hong Kong | 35 | 1126 | 32.17 |
| 6 | Leung K.M.Y. | Hong Kong | 31 | 1126 | 36.32 |
| 7 | Richardson B.J. | Hong Kong | 29 | 1789 | 61.69 |
| 8 | Bustamante P. | France | 27 | 898 | 33.26 |
| 9 | Lee K. | Canada | 27 | 587 | 21.74 |
| 10 | Muir D.C.G. | Canada | 27 | 2125 | 78.70 |

Prolific Authors Vs. h-index

The h-index has been used to quantify the scientific productivity of researchers based on their cited publications. Figure 12 pointed out the Prolific Authors vs. h-index, g-index, and hg-index in marine pollution. It was found that the prolific authors Tanabe, S. from Japan and Lam, P.S.K. from Hong Kong occupied the first two positions.

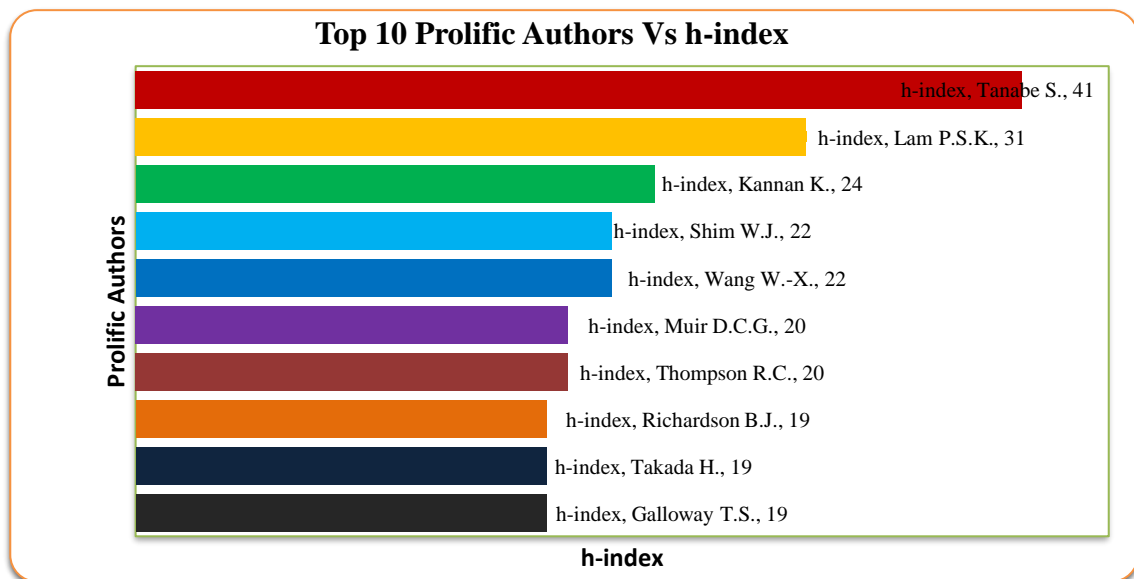


Figure 12: Prolific Authors vs. h-index

Discussion

It was observed that the topmost productive year was 2018 with 1206 records (8.55%) followed by the year 2005 with 1135 records (8.04%) in marine pollution research. Similarly, the least productive year was 1990, with 56 records (0.40%). Compared to the research fields of oceanography (Chaman Sab et al., 2017) and industrial pollution (Dhanya & Raja, 2017). The highest RGR value was 0.86 in 1991 and followed by the year 2005 with the value of 0.78. It was identified that the highest DT in 1999 with the value of 41.09 and followed by the year

2000 with the value of 23.37. It was known that there was a fluctuation in Relative Growth Rate and Doubling Time during the study period, which is greater than the water security research, the relative growth rate (RGR) was linear, and the average citation for Indian articles was 241.08 (Huai & Chai, 2016).

The Future Growth of Publications of Marine pollution literature output decreased from 2018 with 1206 publications to 2025 with 1160 publications. However, it increased in the forthcoming years viz: 2030 with 1317 publications; 2040 with 1630 publications and 2050 with 1944 publications, wherein the Indian Journal of Agricultural Sciences followed by Current Science were the top journals. The top collaborating country and institutions with ICAR-IIHR were the United States and Horticultural Experiment Stations, respectively. The highly productive research areas were Agriculture and Plant Sciences (Suresh & Thanuskodi 2019). The compound annual growth rate was 9.49, which is better than pollution control research was 3.26 (Vivekanandhan et al., 2016). The Authorship patterns in Marine pollution literature vary from single-authored publications to a maximum of forty authored publications during the study period 1989-2018. Compared to the research field of air pollution (Kolle & Thyavanahalli, 2016).

The average of DC arrived as $C=0.85$, i.e., 85% of collaborative authors contributed and compared to the Journal of Association of Physicians of India (JAPI), published 46 articles and stood in the first place. DC was 0 during 1955-59 and 0.93 during 2010-2014. The researchers have found the research productivity as low, and the government has encouraged the researchers in this field as the mortality rate is high due to rabies (Sachithanatham & Raja, 2015). It was also identified that the mean in DC was gradually increased every five-block years, were in the growth of scholarly articles produced by the University of Calicut for fifty-one years (1968-2018). There were very few publications of scholarly articles in Social Sciences, Business, Management and Accounting, Arts and Humanities, Psychology, Economics, Econometrics, and Finance (Cherukodan & Mumthas, 2019). It has also been observed that articles are significant shareholders and reviews are minimal compared to the total publication count. Engineering is spearheading the IIT Delhi research with 1890 publications, 30.9% of total publications (Chaurasia & Chavan, 2014). The study conducted by Todeschini (2011) a new bibliometric index, the j-index, tried to preserve the advantages of the h-index and overcome its disadvantages.

Due to the current increase in marine pollution due to rapid industrial discharge and wastewater discharge, the scientific community must better understand increasing carbon dioxide (CO₂) and other greenhouse gas (GHG) emissions from human activities. To aid the scientists working in this emerging field, we have attempted a scientometric study in the marine field concerning its pollution. Although the field is comparatively new, our analysis does provide information about prospective research areas in the following years. Finally, our analysis provides information about future research and emerging trends explored in the coming years.

Conclusion

The present study evaluated the growth of Marine Pollution literature output with a scientometric approach published from 1989 and 2018 and indexed in the Scopus multidisciplinary online database. The researcher conducted the study comprehensively to recognize the growth rate, author's productivity, journal's productivity, citation analysis, and

structure by publications, geographical distributions, and India's research output. The study results revealed that the growth of marine pollution literature fluctuated until 2014; afterward, there was a gradual increase from 2015 to 2018. It was predicted that the number of scientific publications related to Marine pollution research still multiplies in the future.

The present scientometric study in marine pollution research was carried out from 1989-2018. Similar studies can be carried out for different study periods. The current research was confined to the publications included under the Scopus database. Further research can be carried out using other bibliographic databases like Web of Science or Google Scholar. In addition, a comparative study of research output by various databases can be carried out. The research organizations are encouraged to sign more MOUs with leading research institutions and universities to support collaborative research. The research institutions motivate the researchers to publish more by providing incentives and awards and training the young researchers in Research methodology, and preparing papers for publications in journals.

Acknowledgment

This article has been written with the financial support of UGC STRIDE Component -I grant sanctioned vide Letter No. F. 2-5/2019 (STRIDE-I), Dt.03.12.2019

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