International Journal on Emerging Technologies 11(2): 332-341(2020)

ISSN No. (Print): 0975-8364
ISSN No. (Online): 2249-3255

# Lotka's Law and the Pattern of Scientific Productivity in the Marine Pollution Research

**N. Rathika[1], S. Thanuskodi[2] and K. Sudhakar[3]**
[1]Ph.D. Research Scholar, Department of Library and Information Science, Alagappa University (Tamil Nadu), India.
[2]Professor & Head, Department of Library and Information Science, Alagappa University (Tamil Nadu), India.
[3]Ph.D. Research Scholar, Department of Library and Information Science, Alagappa University (Tamil Nadu), India.

(Corresponding author: S. Thanuskodi)
(Received 20 December 2019, Revised 08 February 2020, Accepted 14 February 2020)
(Published by Research Trend, Website: www.researchtrend.net)

**ABSTRACT: The 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 science domain. A greater integration and research endeavor in the field of Marine pollution will assure ever-increasing contribution to new aspects of environment and society. For this reason, it is necessary to study quantitatively as well as qualitatively the research output of Marine Pollution literature by applying Scientometric methods. A total of 14111 records were published between 1989 and 2018 on Marine Pollution and those records retrieved from the Scopus database. It was observed from the study the applicability of Lotka's law was tested with the Chi-Square test to evaluate the observed values with the expected values. The calculated Chi-Square value (1787.57) was higher than the table Chi-Square value i.e. 47.40 at a degree of freedom of 33 and level of significance at 0.05. Thus it was confirmed that Lotka's law did not fit the literature of Marine pollution. The study was identified that the square root of total authors was 193.13 i.e. 0.56% of the total contributions, which was much less than 50% (half of the literature on a subject); therefore the outcome not fulfilled the Price's square root law. The Bradford multiplier factor between the first zone and second zone was 18.67, the second zone and third zone was 22.55 and an average multiplier factor value was 20.61.**

**Keywords:** Scientometrics, Marin Pollution, Lotka's law, Price's square root law, Subject wise distribution, Language wise distribution.

## I. 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 for the evaluation and predicting the advancement of science. Scientometrics may be defined as the application of those quantitative methods which are dealing with the analysis of science viewed as an information process [1]. Scientometrics is a technique of assessing scientific productivity of an individual, institution, subject or nation. Scientific literature produced by these entities reflects their scientific activity. Hence scientometric analysis is being increasingly used to evaluate the research performance of researchers, research institutions and the research trends in various disciplines. Mathematical and statistical tools are used to conduct these studies. Though bibliometric and scientometric techniques are found to be more or less similar, the emphasis of scientometric studies are the quantitative aspects of generation, propagation and use of scientific information in order to contribute to understanding the mechanism of scientific research [2].

## II. MARINE POLLUTION

In this contemporary period, Marine pollution is considered as a universal problem and receives adequate research attention. The pollution in Marine environment is not only affecting the safety of marine ecosystems but also restricts the development of human society and economy (Xiang, Wang and Liu, 2017). Marine pollution has become a great danger to marine environment, human physical condition, and other food sources. Marine waters are continuously contaminated by both point and non-point sources. Pollution observed in the coastal atmosphere occurs mainly due to anthropogenic activities being conducted on the coast and on 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 science domain. Further, it could be observed that Scientometric analysis can employ in the detection of up-coming research areas, research performance of individuals, research teams and countries. A greater integration and research endeavor in the field of Marine pollution will assure ever-increasing contribution to new aspects of environment and society. For this reason, it is necessary to study quantitatively as well as qualitatively the research output of Marine Pollution literature by applying Scientometric methods.

## III. LOTKA'S LAW AUTHOR PRODUCTIVITY

The Lotka's law was tested using chi-square method in relation to a number of authors who contributed 'n' number of publications. It can be denoted by the following equation.

$$an = a1/n^2$$

whereas, n = 1, 2, 3

In other words, for every 100 authors making one contribution each, there would be 25 authors contributing two articles each ($100/2^2=25$) about 11 contributing three articles each $100/3^2 = 11.1$ and so on.

where 'an' is the number of authors contributing 'n' papers each and a1 is the number of authors contributing one paper each.

The chi-square can be calculated as $(O-E)^2/E$

O = observed number of authors with n publication

E = expected number of authors

## IV. PRICE'S SQUARE ROOT LAW

Price's Square Root law defines that half (50%) of the literature on any subject will be contributed by the square root of total number of authors publishing in that area. In order to validate whether the distribution status of the authors fulfil Price's Square root law, the following formula is used:

$$\mathrm{PSQ} = \sqrt{\mathrm{N}}$$

Where N = Number of authors

## V. BRADFORD'S LAW OF SCATTERING

Bradford's law was formulated in 1934 by Samuel C. Bradford with the aim of studying the distribution of scientific literature. Bradford's theory of distribution which states that "If Scientific periodicals are arranged in the order of decreasing productivity of articles on a given subject, they may be divided into a nucleus of periodicals more particularly devoted to the subject and several groups or zones containing the same number of articles as the nucleus where the number of periodicals in the nucleus and the succeeding zones will be as 1: n: n2" **(**Bradford, 1934). He applied the following formula for scattering phenomena.

$$\mathrm{F(x)} = \mathrm{a} + \mathrm{b}\ \mathrm{logx}$$

where F(x) is the cumulative number of references as contained in the first x most productive journal and 'a' and 'b' are constants.

## VI. REVIEW OF LITERATURE

Mingers and Yang (2017) made an attempt to evaluate the indicators in terms of accuracy, robustness, transparency and unbiasedness. The data for the study were collected from three sources for the years 2012 and 2013. The study revealed that even though the indicators appeared highly correlated in fact they lead to large differences in journal rankings [3]. Dhoble and Kumar (2017) made a scientometric analysis to study the authorship pattern and applicability of Lotka's law in the mustard research output in India. The study analysed 3588 papers collected from CAB Direct. The studied applied Chi-square test to validate the data. The study disclosed that collaboration of more number of authors per article dominates in publications activities in this research [4]. Thanuskodi (2011) the analysis covers mainly the number of articles, authorship pattern, subject, distribution of articles, average number of references per articles, forms of documents cited, year distribution of cited journals, et cetera. Findings of the studies point towards the merits and weakness of the journal which are helpful for its further development [5]. Kumar (2016) made an evaluated the author productivity in the field of artificial neural networks research in India during 1991-2014 using Science Citation Index-Expanded. There were 3411 articles contributed by 5654 single authors. Under the study, Lotka's law was tested using methodology suggested by Pao and Nicholls [6].

Tripathi and Sen (2016) together analyzed with the aim of preparing a list of core journals in the field of crop science research and to test whether the dataset follows Bradford law was well as Leimkuhler's formulation. The dataset containing 10,100 papers indexed in Indian Science Abstracts and CAB Abstracts relevant to six crops i.e. rice, wheat, barley, maize, sorghum and millets during the period from 1965 to 2010 were analysed [7]. Waltman (2016) carried out research to provide an in-depth review of the literature on citation impact indicators. The study provided focusing on bibliographic databases based on which indicators could be calculated, the selection of publications and citations to be included in the calculation of indicators, the normalization of indicators, the different counting methods that could be used to handle co-authored publications, and the topic of citation impact indicators for journals [8]. Ram and Paliwal (2014) assessed the application of Bradford's law of scattering to the Psoriasis literature through bibliometric analysis and the data for the study had been taken from PubMed for a period of 50 years (1960-2009) and it yielded 24031 citations. Journals had been listed based on rank [9]. Singh & Bebi (2014) assessed with the application of Bradford's law of scattering on the journals citations of 260 Ph.D. theses in social sciences submitted to the University of Delhi during the period 1995-2008. A total of 52,378 citations were found, the study focused on 9,997 journal references scattered over 934 journals [10]. Thanuskodi (2013) identified that the main intention for the use of libraries has been the academic interest of the students [11].

Pillai Sudhier (2013) intended to study the authorship distribution in physics literature and to examine the validity of Lotka's law of scientific publication productivity. A list of journal articles on various aspects of physics research cited in the doctoral theses of University of Kerala, Thiruvananthapuram, South India were compiled for the study [12]. Cobo *et al*., (2012) studied to present a new open-source software tool, SciMAT, to execute longitudinal science mapping. It provided different modules that help the analyst to carry out all the steps of the science mapping workflow [13]. Galyani-Moghaddam (2019) analysed the bibliographic data extracted from the Web of Science database to examine psychology publications in the database by authors affiliated with Iranian institutions (1970-2016) and to examine the co-authorship network in psychology publications by using social network analysis metrics at micro-level including the centrality indicators (degree, closeness, and betweenness) [14].

Costa and Caldeira (2018) made a study on bibliometric analysis of ocean literacy. Since the term "Ocean Literacy" (OL) was proposed in 2004 by a group of professionals dedicated to ocean sciences, marine education, and general education policies, its principles had spread worldwide [15]. Sudhakar and Thanuskodi (2018) have performed scientometric analysis of know the trends of marine pollution literature output. The outcome of study revealed that the maximum numbers of publications were in the year 2017. The relative growth rate (RGR) had decreased from 2009 to 2017 and the doubling time had increased from 2009 to 2017 in the span of 10 years [16]. According to Thanuskodi and Venkatalakshmi (2010) analyzed the performance of scientists in the field of ecology, working in various institutions in India, in terms of growth rate, areas of research concentration, author productivity, and authorship pattern [17].

## VII. OBJECTIVES OF THE STUDY

– To evaluate the progress of research productivity on Marine pollution research output at national and international levels during the period 1989-2018.

– To apply the scholar indices for measuring the contributions of authors, sources, institutions and countries in the Marine pollution literature.

– To assess the citation pattern and to make out the highly cited publications in the field of Marine pollution literature during the period 1989-2018.

– To recognize and list out the core journals in the field of Marine Pollution literature output by applying Bradford's Law of Scattering.
– To investigate the occurrence of keywords in the Marine pollution literature during the study period.
– To disclose the overall India contributions in the field of Marine pollution literature during the period 1989-2018.

## VIII. METHODOLOGY

The study aims to identify the growth of scientific output in the field of Marine Pollution for period of 30 years (from 1989 to 2018). The data required for the present study were retrieved from SCOPUS the multidisciplinary abstract and citation database. A total of 14,111 records were retrieved using the search term (TITLE-ABS-KEY ("pollution" OR "pollutions" OR "polluted" OR "pollutant" OR "pollutants" OR "pollute" OR "pollutes" AND "Marine")) AND PUBYEAR > 1988 AND PUBYEAR < 2019 from the database. The retrieved data were analyzed by using Microsoft-Excel package as per the objectives of the study and the data has been presented as tables and graphs. The study 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.

## IX. DATA ANALYSIS AND FINDINGS

The analysis and interpretation of data are presented on the following broad categories viz, Research productivity, Author's productivity and Citation analysis.

*A. Frequency Distribution of Publications*

**Table 1: Frequency distribution of publications on Marine Pollution Literature.**

| S. No. | Year | No. of Publications | % of 14111 | Cumulative Growth | Cumulative Percentage |
|---|---|---|---|---|---|
| 1. | 1989 | 87 | 0.62 | 87 | 0.62 |
| 2. | 1990 | 56 | 0.40 | 143 | 1.01 |
| 3. | 1991 | 133 | 0.94 | 276 | 1.96 |
| 4. | 1992 | 161 | 1.14 | 437 | 3.10 |
| 5. | 1993 | 158 | 1.12 | 595 | 4.22 |
| 6. | 1994 | 128 | 0.91 | 723 | 5.12 |
| 7. | 1995 | 186 | 1.32 | 909 | 6.44 |
| 8. | 1996 | 170 | 1.20 | 1079 | 7.65 |
| 9. | 1997 | 221 | 1.57 | 1300 | 9.21 |
| 10. | 1998 | 294 | 2.08 | 1594 | 11.30 |
| 11. | 1999 | 299 | 2.12 | 1893 | 13.42 |
| 12. | 2000 | 308 | 2.18 | 2201 | 15.60 |
| 13. | 2001 | 279 | 1.98 | 2480 | 17.57 |
| 14. | 2002 | 414 | 2.93 | 2894 | 20.51 |
| 15. | 2003 | 443 | 3.14 | 3337 | 23.65 |
| 16. | 2004 | 518 | 3.67 | 3855 | 27.32 |
| 17. | 2005 | 1135 | 8.04 | 4990 | 35.36 |
| 18. | 2006 | 519 | 3.68 | 5509 | 39.04 |
| 19. | 2007 | 427 | 3.03 | 5936 | 42.07 |
| 20. | 2008 | 463 | 3.28 | 6399 | 45.35 |
| 21. | 2009 | 519 | 3.68 | 6918 | 49.03 |
| 22. | 2010 | 666 | 4.72 | 7584 | 53.75 |
| 23. | 2011 | 737 | 5.22 | 8321 | 58.97 |
| 24. | 2012 | 607 | 4.30 | 8928 | 63.27 |
| 25. | 2013 | 639 | 4.53 | 9567 | 67.80 |
| 26. | 2014 | 706 | 5.00 | 10273 | 72.80 |
| 27. | 2015 | 811 | 5.75 | 11084 | 78.55 |
| 28. | 2016 | 846 | 6.00 | 11930 | 84.54 |
| 29. | 2017 | 975 | 6.91 | 12905 | 91.45 |
| 30. | 2018 | 1206 | 8.55 | 14111 | 100 |
| **Total** | | **14111** | **100** | | |
| **Average Number of Publications per year** | | | **470.36** | | |

To evaluate the research productivity in the field of Marine pollution, the frequency distribution of publications was analyzed and interpreted. A total number of 14111 records were published between 1989 and 2018 on marine pollution and those records retrieved from the Scopus database which is a multidisciplinary abstract and citation database. As per the analysis of data, it was observed from Table 1 that the topmost productive year was 2018 with 1206 records (8.55%) followed by the year 2005 with 1135 records (8.04%). Similarly the least productive year was 1990 with 56 records (0.40%). It was also observed that out of all publications, from 2009 to 2018 (10 years) 54.65% publications were found; whereas from 1989 to 2008 (20 years) 45.35% publications were found.

According to Table 1 the frequency distribution of publications, it was also observed that the growth of productivity in Marine Pollution research was fluctuated up to the year 2014; afterwards there was a gradual increase from the year 2015 to 2018 (Cobo,2012) . Table 4.1 described that there was 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. It was found that the Average Number of Publications per year was 470.36 between the study period 1989 and 2018.

*B. Lotka's Law of Author Productivity*

Lotka's law was proposed by US mathematician and statistician Alfred J. Lotka in 1926 for analyzing the productivity of authors. Lotka's law is defined as "the number of authors making n contributions is about 1/na of those making one contribution, where 'a' is often nearly 2". Table 2 shows the author productivity of Marine Pollution Literature. The applicability of Lotka's law was tested with the Chi-Square test to evaluate the observed values with the expected values (Costa, 2018). The calculated Chi-Square value (1787.57) was higher than the table Chi-Square value i.e. 47.40 at a degree of freedom of 33 and level of significance at 0.05. Thus it was confirmed that Lotka's law did not fit the literature of Marine pollution.

*C. Lotka's Inverse Square Root Law of Author Productivity*

**Table 2: Lotka's Law of Author Productivity.**

| No. of Papers | No. of Observed authors with 'n' publications ($a_a$) or (O) | Observed percentage of authors $100^*a_a/a1$ | Expected No. of authors $a_a$-$a1/n^2$ or (E) | Expected percentage of authors predicted by Lotka $100/n^2$ | $(O-E)^2/E$ |
|---|---|---|---|---|---|
| 1 | 28766 | 100.00 | 28766 | 100.00 | 0 |
| 2 | 4795 | 16.67 | 7192 | 25.00 | 798.61 |
| 3 | 1696 | 5.90 | 3196 | 11.11 | 704.16 |
| 4 | 785 | 2.73 | 1798 | 6.25 | 570.63 |
| 5 | 430 | 1.49 | 1151 | 4.00 | 451.33 |
| 6 | 248 | 0.86 | 799 | 2.78 | 380.03 |
| 7 | 133 | 0.46 | 587 | 2.04 | 351.19 |
| 8 | 102 | 0.35 | 449 | 1.56 | 268.62 |
| 9 | 85 | 0.30 | 355 | 1.23 | 205.48 |
| 10 | 61 | 0.21 | 288 | 1.00 | 178.60 |
| 11 | 26 | 0.09 | 238 | 0.83 | 188.58 |
| 12 | 36 | 0.13 | 200 | 0.69 | 134.25 |
| 13 | 30 | 0.10 | 170 | 0.59 | 115.50 |
| 14 | 15 | 0.05 | 147 | 0.51 | 118.30 |
| 15 | 19 | 0.07 | 128 | 0.44 | 92.67 |
| 16 | 13 | 0.05 | 112 | 0.39 | 87.87 |
| 17 | 8 | 0.03 | 100 | 0.35 | 84.18 |
| 18 | 2 | 0.01 | 89 | 0.31 | 84.83 |
| 19 | 10 | 0.03 | 80 | 0.28 | 60.94 |
| 20 | 8 | 0.03 | 72 | 0.25 | 56.80 |
| 21 | 5 | 0.02 | 65 | 0.23 | 55.61 |
| 22 | 3 | 0.01 | 59 | 0.21 | 53.59 |
| 23 | 3 | 0.01 | 54 | 0.19 | 48.54 |
| 24 | 5 | 0.02 | 50 | 0.17 | 40.44 |
| 25 | 2 | 0.01 | 46 | 0.16 | 42.11 |
| 26 | 2 | 0.01 | 43 | 0.15 | 38.65 |
| 27 | 4 | 0.01 | 39 | 0.14 | 31.87 |
| 29 | 1 | 0.00 | 34 | 0.12 | 32.23 |
| 31 | 1 | 0.00 | 30 | 0.10 | 27.97 |
| 35 | 1 | 0.00 | 23 | 0.08 | 21.53 |
| 38 | 1 | 0.00 | 20 | 0.07 | 17.97 |
| 48 | 1 | 0.00 | 12 | 0.04 | 10.57 |
| 54 | 1 | 0.00 | 10 | 0.03 | 7.97 |
| 80 | 1 | 0.00 | 4 | 0.02 | 2.72 |
| | **37299** | | | **Chi-Square (χ2)** | **1787.57** |

**Table 3: Lotka's Inverse Square Root Law of Author Productivity.**

| No. of Contribution X | No. of Contributors (Y) | Log X | Log Y | XY | $X^2$ |
|---|---|---|---|---|---|
| 1 | 28766 | 0.000 | 10.267 | 0 | 0 |
| 2 | 4795 | 0.693 | 8.475 | 5.875 | 0.480 |
| 3 | 1696 | 1.099 | 7.436 | 8.169 | 1.207 |
| 4 | 785 | 1.386 | 6.666 | 9.241 | 1.922 |
| 5 | 430 | 1.609 | 6.064 | 9.759 | 2.590 |
| 6 | 248 | 1.792 | 5.513 | 9.879 | 3.210 |
| 7 | 133 | 1.946 | 4.890 | 9.516 | 3.787 |
| 8 | 102 | 2.079 | 4.625 | 9.617 | 4.324 |
| 9 | 85 | 2.197 | 4.443 | 9.762 | 4.828 |
| 10 | 61 | 2.303 | 4.111 | 9.466 | 5.302 |
| 11 | 26 | 2.398 | 3.258 | 7.813 | 5.750 |
| 12 | 36 | 2.485 | 3.584 | 8.905 | 6.175 |
| 13 | 30 | 2.565 | 3.401 | 8.724 | 6.579 |
| 14 | 15 | 2.639 | 2.708 | 7.147 | 6.965 |
| 15 | 19 | 2.708 | 2.944 | 7.974 | 7.334 |
| 16 | 13 | 2.773 | 2.565 | 7.112 | 7.687 |
| 17 | 8 | 2.833 | 2.079 | 5.892 | 8.027 |
| 18 | 2 | 2.890 | 0.693 | 2.003 | 8.354 |
| 19 | 10 | 2.944 | 2.303 | 6.780 | 8.670 |
| 20 | 8 | 2.996 | 2.079 | 6.229 | 8.974 |

| No. of Contribution X | No. of Contributors (Y) | Log X | Log Y | XY | $X^2$ |
|---|---|---|---|---|---|
| 21 | 5 | 3.045 | 1.609 | 4.900 | 9.269 |
| 22 | 3 | 3.091 | 1.099 | 3.396 | 9.555 |
| 23 | 3 | 3.135 | 1.099 | 3.445 | 9.831 |
| 24 | 5 | 3.178 | 1.609 | 5.115 | 10.100 |
| 25 | 2 | 3.219 | 0.693 | 2.231 | 10.361 |
| 26 | 2 | 3.258 | 0.693 | 2.258 | 10.615 |
| 27 | 4 | 3.296 | 1.386 | 4.569 | 10.863 |
| 29 | 1 | 3.367 | 0.000 | 0.000 | 11.339 |
| 31 | 1 | 3.434 | 0.000 | 0.000 | 11.792 |
| 35 | 1 | 3.555 | 0.000 | 0.000 | 12.640 |
| 38 | 1 | 3.638 | 0.000 | 0.000 | 13.232 |
| 48 | 1 | 3.871 | 0.000 | 0.000 | 14.986 |
| 54 | 1 | 3.989 | 0.000 | 0.000 | 15.912 |
| 80 | 1 | 4.382 | 0.000 | 0.000 | 19.202 |
| | **37299** | **90.79** | **96.29** | **175.77** | **271.86** |

The formula of Lotka's law states that $y_x = c \ X \ x^{-n}$, whereby the expected number of authors (y) with a given number of publication (x) can be obtained by calculating the constant c and the exponent n. The calculation of n is given by the following formula:

$$n = \frac{N\Sigma\ XY - \Sigma X\ \Sigma Y}{N\Sigma\ X^2 - (\Sigma X)^2}$$

$$n = \frac{34 * \Sigma 175.77 - \Sigma 90.79 * \Sigma 9629}{34\Sigma\ 271.86^2 - (\Sigma 90.79)^2}$$

$$n = \frac{-2765.99}{1000.416} = -2.76$$

The values of n can be used to calculate c using the formula:

$$C = \Sigma \ \frac{1}{1/x^n} = 0.79$$

The calculation of the Critical Value (C.V.), using the formula:

$$\text{C.V.} = \frac{1.63}{\Sigma y + (\Sigma y/10)^{1/2})^{1/2}} = 0.008$$

The critical value using the Table is 0.008 and the maximum difference between the observed and expected accumulated frequencies is 0.15. Therefore it is clear that D value is greater than the critical value. Thus it was confirmed that Lotka's law did not fit the literature of Marine pollution literature.

*D. Price's Square Root Law of Author Productivity*

**Table 4: Price's Square Root Law of Author Productivity.**

| No. of Papers | Unique Author | | Total Contributions | |
|---|---|---|---|---|
| | No. | % | No. | % |
| 80 | 1 | 0.003 | 80 | 0.141 |
| 54 | 1 | 0.003 | 54 | 0.095 |
| 48 | 1 | 0.003 | 48 | 0.085 |
| 38 | 1 | 0.003 | 38 | 0.067 |
| 35 | 1 | 0.003 | 35 | 0.062 |
| 31 | 1 | 0.003 | 31 | 0.055 |
| 29 | 1 | 0.003 | 29 | 0.051 |
| 27 | 4 | 0.011 | 108 | 0.191 |
| 26 | 2 | 0.005 | 52 | 0.092 |
| 25 | 2 | 0.005 | 50 | 0.088 |
| 24 | 5 | 0.013 | 120 | 0.212 |
| 23 | 3 | 0.008 | 69 | 0.122 |
| 22 | 3 | 0.008 | 66 | 0.117 |
| 21 | 5 | 0.013 | 105 | 0.186 |
| 20 | 8 | 0.021 | 160 | 0.283 |
| 19 | 10 | 0.027 | 190 | 0.336 |
| 18 | 2 | 0.005 | 36 | 0.064 |
| 17 | 8 | 0.021 | 136 | 0.240 |
| 16 | 13 | 0.035 | 208 | 0.368 |
| 15 | 19 | 0.051 | 285 | 0.504 |
| 14 | 15 | 0.040 | 210 | 0.371 |
| 13 | 30 | 0.080 | 390 | 0.690 |
| 12 | 36 | 0.097 | 432 | 0.764 |
| **11** | **26 (193.13)** | **0.070 (0.531)** | **286 (3218)** | **0.506 (0.5689)** |
| 10 | 61 | 0.164 | 610 | 1.078 |
| 9 | 85 | 0.228 | 765 | 1.352 |
| 8 | 102 | 0.273 | 816 | 1.443 |
| 7 | 133 | 0.357 | 931 | 1.646 |
| 6 | 248 | 0.665 | 1488 | 2.631 |
| 5 | 430 | 1.153 | 2150 | 3.801 |
| 4 | 785 | 2.105 | 3140 | 5.551 |
| 3 | 1696 | 4.547 | 5088 | 8.995 |
| 2 | 4795 | 12.856 | 9590 | 16.955 |
| 1 | 28766 | 77.123 | 28766 | 50.857 |
| **Total** | **37299** | **100** | **56562** | **100** |

According to Price's square root law "half of the literature on a subject will be contributed by the square root of the total number of authors publishing in that area". Table 4 shows the applicability of Price's square root law to assess the author productivity in the Marine pollution literature. It was found that 77.12% (28766) of the unique authors contributed 50.86% of total contributions. Alternatively 22.88% (8533) of the total authors contributed with 49.14% of total contributions.

N = 37299

PSQ = √ N=193.13

It was identified that the square root of total authors was 193.13 i.e. 0.56% of the total contributions, which was much less than 50% (half of the literature on a subject); therefore the outcome has not fulfilled the Prices square root law.

*E. Bradford's Distribution of Journals*

**Table 5: Bradford's Distribution of Journals.**

| S. No. | No. of Journals | No. of Articles | Total no. of Articles | Cumulative Articles |
|---|---|---|---|---|
| 1. | 1 | 2616 | 2616 | 2616 |
| 2. | 1 | 408 | 408 | 3024 |
| 3. | **1 (3)** | **384** | **384** | **3408 (3296)** |
| 4. | 1 | 327 | 327 | 3735 |
| 5. | 1 | 316 | 316 | 4051 |
| 6. | 1 | 229 | 229 | 4280 |
| 7. | 1 | 195 | 195 | 4475 |
| 8. | 1 | 156 | 156 | 4631 |
| 9. | 1 | 117 | 117 | 4748 |
| 10. | 1 | 116 | 116 | 4864 |
| 11. | 1 | 108 | 108 | 4972 |
| 12. | 1 | 77 | 77 | 5049 |
| 13. | 1 | 76 | 76 | 5125 |
| 14. | 1 | 72 | 72 | 5197 |
| 15. | 1 | 71 | 71 | 5268 |
| 16. | 1 | 70 | 70 | 5338 |
| 17. | 1 | 67 | 67 | 5405 |
| 18. | 2 | 65 | 130 | 5535 |
| 19. | 1 | 59 | 59 | 5594 |
| 20. | 1 | 54 | 54 | 5648 |
| 21. | 1 | 51 | 51 | 5699 |
| 22. | 1 | 48 | 48 | 5747 |
| 23. | 1 | 46 | 46 | 5793 |
| 24. | 1 | 43 | 43 | 5836 |
| 25. | 2 | 39 | 78 | 5914 |
| 26. | 2 | 38 | 76 | 5990 |
| 27. | 1 | 35 | 35 | 6025 |
| 28. | 1 | 34 | 34 | 6059 |
| 29. | 2 | 33 | 66 | 6125 |
| 30. | 1 | 32 | 32 | 6157 |
| 31. | 2 | 31 | 62 | 6219 |
| 32. | 1 | 29 | 29 | 6248 |
| 33. | 4 | 28 | 112 | 6360 |
| 34. | 2 | 27 | 54 | 6414 |
| 35. | 1 | 25 | 25 | 6439 |
| 36. | 2 | 24 | 48 | 6487 |
| 37. | 2 | 23 | 46 | 6533 |
| 38. | 3 | 22 | 66 | 6599 |
| 39. | 3 | 21 | 63 | 6662 |
| 40. | 1 | 20 | 20 | 6682 |
| 41. | **4 (56)** | **19** | **76** | **6758 (3350)** |
| 42. | 1 | 18 | 18 | 6776 |
| 43. | 2 | 17 | 34 | 6810 |
| 44. | 3 | 16 | 48 | 6858 |
| 45. | 7 | 15 | 105 | 6963 |
| 46. | 6 | 14 | 84 | 7047 |
| 47. | 7 | 13 | 91 | 7138 |
| 48. | 11 | 12 | 132 | 7270 |
| 49. | 16 | 11 | 176 | 7446 |
| 50. | 8 | 10 | 80 | 7526 |
| 51. | 12 | 9 | 108 | 7634 |
| 52. | 14 | 8 | 112 | 7746 |
| 53. | 20 | 7 | 140 | 7886 |
| 54. | **19** | 6 | 114 | 8000 |
| 55. | 47 | 5 | 235 | 8235 |
| 56. | 48 | 4 | 192 | 8427 |
| 57. | 102 | 3 | 306 | 8733 |
| 58. | 215 | 2 | 430 | 9163 |
| 59. | **725 (1263)** | **1** | **725** | **9888 (3130)** |
| **Total** | **1322** | **6422** | **9888** | |

Bradford's Law of Scattering is a law of diminishing returns and scattering. Bradford formulated the law in 1948 and claimed that for a given subject area "there are a few very productive periodicals, a larger number of more moderate producers, and a still larger number of constantly diminishing productivity". It describes that number of core journals will supply the nucleus of articles on a given topic which accounts for a substantial percentage (1/3) of the articles, to be followed by a second larger group of journals that account for another third, while a much larger group of journals picked up the last third. Table 5 indicated that 3 journals with 0.23% covering 3408 (34.47%) articles were identified as core journals (Waltman, 2016). The second small number of 56 journals with 4.24% covering 3350 (33.88%) articles and the third largest numbers of journals 1263 with 95.54% covering 3130 (31.65%) articles.

*F. Bradford's Distribution of Journals in Zones*

Table 6 showed Bradford's distribution of sources in zones in the Marine Pollution literature for study period. As per the analysis of the table, the first zone contains 3 core journals, second zone contains 56 journals and third zone contains 1263 journals. According to Bradford's journal distribution, the relationship between the zones was 1: n: $n^2$. From this table, it was observed that there was a difference in the Bradford's journal distribution, the relationship between the zones was found to be 3:56:1263.

The Bradford multiplier factor between the first zone and second zone was 18.67, the second zone and third zone was 22.55 and an average multiplier factor value was 20.61.

Bradford's distribution = 3 : 3 × 20.61 : 3 × $(20.61)^2$ = 1 : $n : n^2$

i.e. 3 : 61.83 : 1274.31 = 1339.14

Percentage of error = $\frac{1339.14 \times 1322}{1322} \times 100 = 1.29\%$

Obviously the result indicated that the percentage of error (1.29%) was negligible; hence Bradford's law fits into the journal distributions.

From Table 7 Document type wise distribution of publications of Marine pollution literature was observed. As per the analysis, there were 16 types of documents categorized. The document type "Article" was the highly preferred document type by the researchers which received 9888 (70.07%) publications with 246102 citations among all type of documents. The document type "Conference Paper" received 3193 (22.63%) publications with 22266 citations and the document type "Review" received 444 (3.15%) publications with 23390 citations (Thanuskodi, 2013). Hence, 96% of entire publications were occupied by the above three document types. On the other hand, the document type "Review" had received with the highest CPP value of 52.68, followed by document type "Article" with the value of 24.89 and "Short Survey" with the value of 20.69 respectively.

**Table 6: Bradford's Distribution of Sources in Zones.**

| Zone | No. of Journals | % of 1322 | No. of Articles | % of 9888 | Bradford Multiplier |
|---|---|---|---|---|---|
| 1 | 3 | 0.23 | 3408 | 34.47 | |
| 2 | 56 | 4.24 | 3350 | 33.88 | 18.67 |
| 3 | 1263 | 95.54 | 3130 | 31.65 | 22.55 |
| | **1322** | **100** | **9888** | **100** | **20.61** |

*G. Document Type wise Distribution of Publications*

**Table 7: Document Type wise Distribution of Publications.**

| S. No. | Document Type | No. of Contributions | % of 14111 | No. of Citations | % of 295380 | CPP |
|---|---|---|---|---|---|---|
| 1. | Article | 9888 | 70.07 | 246102 | 83.317 | 24.89 |
| 2. | Conference Paper | 3193 | 22.63 | 22266 | 7.538 | 6.97 |
| 3. | Review | 444 | 3.15 | 23390 | 7.919 | 52.68 |
| 4. | Book Chapter | 242 | 1.71 | 988 | 0.334 | 4.08 |
| 5. | Short Survey | 78 | 0.55 | 1614 | 0.546 | 20.69 |
| 6. | Editorial | 61 | 0.43 | 184 | 0.062 | 3.02 |
| 7. | Book | 54 | 0.38 | 589 | 0.199 | 10.91 |
| 8. | Note | 48 | 0.34 | 161 | 0.055 | 3.35 |
| 9. | Conference Review | 44 | 0.31 | 2 | 0.001 | 0.05 |
| 10. | Erratum | 22 | 0.16 | 6 | 0.002 | 0.27 |
| 11. | Letter | 18 | 0.13 | 45 | 0.015 | 2.50 |
| 12. | Article in Press | 10 | 0.07 | 24 | 0.008 | 2.40 |
| 13. | Business Article | 4 | 0.03 | 0 | 0.000 | 0.00 |
| 14. | Report | 2 | 0.01 | 7 | 0.002 | 3.50 |
| 15. | Retracted | 2 | 0.01 | 2 | 0.001 | 1.00 |
| 16. | Abstract Report | 1 | 0.01 | 0 | 0.000 | 0.00 |
| | **Total** | **14111** | **100** | **295380** | **100** | **20.93** |

*H. Language-wise Distribution of Publications*

Table 8 illustrated the Language-wise distribution of Marine pollution literature. It was identified that contributions were made in 17 languages at global level. It was noted that English language was the predominant language of communication which received 13742 (97.385%) publications with 294481 citations. After that, the Chinese language received 137 (0.971%) publications with 287 citations and French language received 64 (0.454%) publications with 145 citations(Singh, 2014). In addition, the language English had received with highest CPP value of 21.43, followed by Romanian with the value of 13.00 and Turkish with the value of 7.00 respectively.

Table 9 exemplified that the Subject-wise distribution of publications of Marine Pollution literature during the study period. Based on the analysis, 26 major subjects were categorized. Among these categories, the subject "Environmental Science" received the maximum number of publications 9257 (33.135%), followed by the subjects "Earth and Planetary Sciences" 5432 (19.444%) publications and "Agricultural and Biological Sciences" 4633 (16.584%) publications respectively. It was identified that 12 subject categories were received with below 1% of publications.

**Table 8: Language-wise Distribution of Publications.**

| S. No. | Language | No. of Contributions | % of 14111 | No. of Citations | % of 295380 | CPP |
|---|---|---|---|---|---|---|
| 1. | English | 13742 | 97.385 | 294481 | 99.696 | 21.43 |
| 2. | Chinese | 137 | 0.971 | 287 | 0.097 | 2.09 |
| 3. | French | 64 | 0.454 | 145 | 0.049 | 2.27 |
| 4. | Russian | 45 | 0.319 | 78 | 0.026 | 1.73 |
| 5. | Spanish | 34 | 0.241 | 235 | 0.080 | 6.91 |
| 6. | German | 17 | 0.120 | 14 | 0.005 | 0.82 |
| 7. | Korean | 17 | 0.120 | 48 | 0.016 | 2.82 |
| 8. | Croatian | 13 | 0.092 | 6 | 0.002 | 0.46 |
| 9. | Japanese | 13 | 0.092 | 11 | 0.004 | 0.85 |
| 10. | Italian | 9 | 0.064 | 9 | 0.003 | 1.00 |
| 11. | Turkish | 6 | 0.043 | 42 | 0.014 | 7.00 |
| 12. | Persian | 4 | 0.028 | 5 | 0.002 | 1.25 |
| 13. | Bosnian | 3 | 0.021 | 2 | 0.001 | 0.67 |
| 14. | Serbian | 3 | 0.021 | 1 | 0.000 | 0.33 |
| 15. | Portuguese | 2 | 0.014 | 3 | 0.001 | 1.50 |
| 16. | Hungarian | 1 | 0.007 | 0 | 0.000 | 0.00 |
| 17. | Romanian | 1 | 0.007 | 13 | 0.004 | 13.00 |
| **Total** | | **14111** | **100** | **295380** | **100** | **20.93** |

*I. Subject-wise Distribution of Publications*

**Table 9: Subject-wise Distribution of Publications.**

| S. No. | Subject | No. of Publications | % of 27937 |
|---|---|---|---|
| 1. | Environmental Science | 9257 | 33.135 |
| 2. | Earth and Planetary Sciences | 5432 | 19.444 |
| 3. | Agricultural and Biological Sciences | 4633 | 16.584 |
| 4. | Engineering | 2812 | 10.066 |
| 5. | Chemistry | 1111 | 3.977 |
| 6. | Social Sciences | 642 | 2.298 |
| 7. | Computer Science | 561 | 2.008 |
| 8. | Pharmacology, Toxicology and Pharmaceutics | 549 | 1.965 |
| 9. | Energy | 487 | 1.743 |
| 10. | Physics and Astronomy | 403 | 1.443 |
| 11. | Materials Science | 352 | 1.260 |
| 12. | Chemical Engineering | 340 | 1.217 |
| 13. | Biochemistry, Genetics and Molecular Biology | 285 | 1.020 |
| 14. | Medicine | 280 | 1.002 |
| 15. | Mathematics | 230 | 0.823 |
| 16. | Immunology and Microbiology | 149 | 0.533 |
| 17. | Economics, Econometrics and Finance | 108 | 0.387 |
| 18. | Decision Sciences | 93 | 0.333 |
| 19. | Multidisciplinary | 85 | 0.304 |
| 20. | Business, Management and Accounting | 64 | 0.229 |
| 21. | Arts and Humanities | 33 | 0.118 |
| 22. | Health Professions | 14 | 0.050 |
| 23. | Veterinary | 7 | 0.025 |
| 24. | Neuroscience | 5 | 0.018 |
| 25. | Nursing | 2 | 0.007 |
| 26. | Psychology | 2 | 0.007 |
| 27. | Undefined | 1 | 0.004 |
| **Total** | | **27937** | **100** |

*J. Continent wise Distribution of Publications*

Table 10 showed the Continent wise distribution of publications in Marine pollution literature. It was observed that the continent Europe held first position with a share of 5323 (37.72%) publications and 126754 citations among all the continents. The continent Asia held second position with a share of 3397 (24.07%) publications and 61468 citations. Similarly, North America held third position with a share of 3373 (23.90%) publications and 71719 citations (Mingers, 2017). It was noted that Africa occupied the least position that contributed a share of 379 (2.69 %) publications and 5744 citations in the table.

*K. Continent wise Distribution of h-indices*

Table 11 indicated the Continent wise distribution of h-indices of marine pollution literature. The h-index value for the continent Europe was 128, for North America 111 and for Asia 97 respectively. The g-index, hg-index, e-index, R-index, f-index and A-index values for the continent Europe were 193, 157.18, 115.98, 172.73, 0.82 and 233.09 respectively. Similarly, the values for the continent North America were 173, 138.57, 108.01, 154.88, 0.95 and 216.11 respectively and for the continent Asia were 148, 119.82, 90.94, 132.96, 0.88 and 182.26 respectively.

*L. BRICS Countries Distribution of Publications*

Table 12 illustrated the Brazil Russia India China and South Africa (BRICS) countries distribution of publications in the Marine Pollution literature for the period from 1989 to 2018 Sudhakar, 2018). Among the BRICS countries, China was at top position, received 1215 contributions with 16792 citations and the h-index value of 61. India was at second top position, received 395 contributions with 5761 citations and the h-index value of 36. Brazil was at third top position, received 367 contributions with 8000 citations and the h-index value of 46.

**Table 10: Continent wise Distribution of Publications.**

| S. No. | Continent Name | No. of Contributions | % of 14111 | Total Citations | % of 295380 | h-index | g-index | Rank |
|---|---|---|---|---|---|---|---|---|
| 1. | Europe | 5323 | 37.72 | 126754 | 42.91 | 128 | 193 | 1 |
| 2. | Asia | 3397 | 24.07 | 61468 | 20.81 | 97 | 148 | 2 |
| 3. | North America | 3373 | 23.90 | 71719 | 24.28 | 111 | 173 | 3 |
| 4. | South America | 568 | 4.03 | 11686 | 3.96 | 52 | 78 | 4 |
| 5. | Oceania | 549 | 3.89 | 16556 | 5.60 | 61 | 105 | 5 |
| 6. | Africa | 379 | 2.69 | 5744 | 1.94 | 38 | 60 | 6 |
| Undefined | | 522 | 3.70 | 1453 | 0.49 | 18 | 34 | |
| **Total** | | **14111** | **100** | **295380** | **100** | **171** | **256** | |

**Table 11: Continent wise Distribution of h-indices.**

| S. No. | Continent Name | h-index | g-index | hg-index | e-index | R-index | f-index | A-index |
|---|---|---|---|---|---|---|---|---|
| 1. | Europe | 128 | 193 | 157.18 | 115.98 | 172.73 | 0.82 | 233.09 |
| 3. | North America | 111 | 173 | 138.57 | 108.01 | 154.88 | 0.95 | 216.11 |
| 2. | Asia | 97 | 148 | 119.82 | 90.94 | 132.96 | 0.88 | 182.26 |
| 5. | Oceania | 61 | 105 | 80.03 | 71.45 | 93.95 | 1.37 | 144.69 |
| 4. | South America | 52 | 78 | 63.69 | 46.96 | 70.06 | 0.82 | 94.40 |
| 6. | Africa | 38 | 60 | 47.75 | 38.43 | 54.05 | 1.02 | 76.87 |
| Undefined | | 18 | 34 | 24.74 | 25.44 | 31.16 | 2.00 | 53.94 |
| **Total** | | **171** | **256** | **209.23** | **153.69** | **229.92** | **0.81** | **309.13** |

**Table 12: BRICS Countries Distribution of Publications.**

| Rank | Country Name | No. of Contributions | % of 2313 | Total Citations | % of 33606 | h-index |
|---|---|---|---|---|---|---|
| 1 | China | 1215 | 52.53 | 16792 | 49.97 | 61 |
| 2 | India | 395 | 17.08 | 5761 | 17.14 | 36 |
| 3 | Brazil | 367 | 15.87 | 8000 | 23.81 | 46 |
| 4 | Russian Federation | 253 | 10.94 | 1499 | 4.46 | 19 |
| 5 | South Africa | 83 | 3.59 | 1554 | 4.62 | 19 |
| **Total** | | **2313** | | **33606** | | |

## X. RECOMMENDATIONS

– As per the findings of this study the document type “Articles” were highly preferred by the researchers for their publication and citations. Hence, it is suggested that the researchers may focus to publish their Marine pollution research outcome in journals for wider attraction.

– It was noted that 158 publications of total published documents were anonymous. Hence it is suggested that the publishers include author’s details such as name, affiliation, etc in their publications.

– Compared to global output, the growth rate of Marine pollution literature in India was very low (2.79%). Thus the researchers associated with Government and private research institutions and universities should pay more attention in Marine pollution research. At the same time, the Government of India should allocate necessary funds and research environment to compete with global research progress.

– Comparative study on Marine pollution records indexed in various databases like Scopus, PubMed and Web of Science may be considered.

– The scientometric measures such as Bibliographic Coupling and Co-citation in the field of Marine Pollution literature may be used for citation analysis.

– Relative study of Marine pollution research between developed and developing countries may be studied.

– Research on different Marine pollution such as ship pollution, nutrient pollution, atmospheric pollution, plastic pollution literature, etc. can be conducted.

## XI. CONCLUSION

The present study was conducted with the aim of evaluating the growth of Marine Pollution literature output with scientometric approach published from 1989 and 2018 and indexed in the Scopus multidisciplinary online database. The applicability of Lotka's law was tested with the Chi-Square test to evaluate the observed values with the expected values. The calculated Chi-Square value (1787.57) was higher than the table Chi-Square value i.e. 47.40 at a degree of freedom of 33 and level of significance at 0.05. Thus it was confirmed that Lotka's law did not fit the literature of Marine pollution. There were 2219 source titles/journals contributed to the Marine pollution research. The Marine Pollution Bulletin published by Elsevier Limited, UK at top position with 2961 (20.98%) publications. It was followed by the 2005 International Oil Spill Conference, IOSC 2005 published by American Petroleum Institute, USA with 662 (4.69%) publications. It was noted that English language was the predominant language of communication which received 13742 (97.385%) publications with 294481 citations. The results of the study indicate that the overall growth rate calculated by various scientometric methods in the field of Marine pollution is significantly growing in the recent years at international level. On the other hand, the growth rate of Marine pollution is moderate level in India.

## ACKNOWLEDGMENT

This article has been written with the financial support of RUSA – Phase 2.0 grant sanctioned vide Letter No. F.24-51/2014-U, Policy (TNMulti-Gen), Dept. of Edn. Govt. of India, Date 09.10.2018.

## REFERENCES

[1]. Nalimov, V. V., & Mulchenko, B. M. (1969). Scientometrics. *Studies of science as a process of information. Moscow, Russia: Science*.

[2]. Bornmann, L., & Haunschild, R. (2017). Does evaluative scientometrics lose its main focus on scientific quality by the new orientation towards societal impact?. *Scientometrics*, *110*(2), 937-943.

[3]. Mingers, J., & Yang, L. (2017). Evaluating journal quality: A review of journal citation indicators and ranking in business and management. *European Journal of Operational Research*, *257*(1), 323-337.

[4]. Dhoble, S., & Kumar, S. (2017). Applicability of Lotka's law in mustard research publications in India – a scientometric study. *SSARSC International Journal of Library, Information Networks and Knowledge*, *2*(1), 1-10.

[5]. Thanuskodi, S. (2011). Bibliometric analysis of DESIDOC journal of library & information technology. *Library and information science in developing countries: Contemporary issues*, 303-312.

[6]. Kumar, S. (2016). An evaluation of author productivity in artificial neural networks research in India during 1991-2014. *Annals of Library and Information Studies*, *63*(2), 126-131.

[7]. Tripathi, H. K., & Sen, B. K. (2016). Crop science literature and Bradford law. *Annals of Library and Information Studies*, *63*(2), 85-90.

[8]. Waltman, L. (2016). A review of the literature on citation impact indicators. *Journal of Informetrics*, *10*(2), 365-391.

[9]. Ram, S., & Paliwal, N. (2014). Assessment of Bradford Law's of Scattering to Psoriasis literature through bibliometric snapshot. *DESIDOC Journal of Library & Information Technolog*y, *34*(1), 46-56.

[10]. Singh, K. P., & Bebi (2014). Application of Bradford's Law on journal citations: A study of Ph.D. theses in social sciences of University of Delhi. *Annals of Library and Information Studies*, *61*(2), 112-120.

[11]. Thanuskodi, S. (2013). Students' attitudes towards library facilities and information resources of university libraries in tamil nadu: A survey. *Challenges of academic library management in developing countries*, 1-15.

[12]. Pillai Sudhier, K. G. (2013). Lotka's law and pattern of author productivity in the area of physics research. *DESIDOC Journal of Library & Information Technology*, *33*(6), 457-464.

[13]. Cobo, M. J., Lopez-Herrera, A. G., Herrera-Viedma, E., & Herrera, F. (2012). SciMAT: A new science mapping analysis software tool. *Journal of the American Society for Information Science and Technology*, *63*(8), 1609-1630.

[14]. Galyani-Moghaddam, G. (2019). Visualization of collaboration in psychology: a case study of Iran. *Annals of Library and Information Studies (ALIS)*, *66*(1), 7-15.

[15]. Costa, S., & Caldeira, R. (2018). Bibliometric analysis of ocean literacy: An underrated term in the scientific literature. *Marine Policy*, *87*, 149–157.

[16]. Sudhakar, K., & Thanuskodi, S. (2018). Marine Pollution Bulletin: A Scientometric Analysis. *Library Philosophy and Practice (e-journal)*. *2043*. http://digitalcommons.unl.edu/libphilprac/2043/

[17]. Thanuskodi, S., & Venkatalakshmi, V. (2010). The growth and development of research on ecology in India: A bibliometric Study. *Library Philosophy and Practice*, *2010*(MAY), 1–10. Retrieved from http://digitalcommons.unl.edu/libphilprac/359

**How to cite this article:** Rathika, N., Thanuskodi, S. and Sudhakar, K. (2020). Lotka's Law and the Pattern of Scientific Productivity in the Marine Pollution Research. *International Journal on Emerging Technologies*, *11*(2): 332–341.