LITERATURE ON OZONE (2000-2015): A BIBLIOMETRIC ANALYSIS

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ABSTRACT
This study is based on 1831 articles on ozone literature published during the years 2000-2015 and archived in Directory of Open Access Journals (DOAJ). Articles have been analysed to observe year wise growth pattern, authorship pattern, degree of collaboration, identification of core journals, subject wise average number of references and objects used per article etc. From the study it is found that there is positive growth on ozone literature and most of the articles are in engineering and technology discipline. Most of the articles are published by 1-5 author(s). Atmospheric Chemistry and Physics is the leading journal for publishing articles on ozone literature.

Key words: Bibliometrics, Ozone Literature, DOAJ

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1. INTRODUCTION
Bibliometrics is a major sub-discipline of quantitative research in LIS field. This is a tool traditionally used by the library and information science professionals for studying the communication process, information flows and others for better understanding and effective management and dissemination of information (Rajendiran & Parihar, 2007). Harrod’s Librarians’ Glossary and Reference Book defines Bibliometrics as “The application of mathematical and statistical methods to the study of the use made of books and other media within and between library systems” (Prytherch, 2005, p. 67). In this paper a bibliometrics study has been done to depict the open access publication pattern in the field of ozone literature.

2. OBJECTIVES OF THE STUDY
The objectives of this study are:

- To see year wise growth rate of ozone literature.
- To analyse authorship from various angles like year wise authorship pattern, single versus multiple authorship, degree of collaboration etc.
To know language wise distribution of ozone literature.
To identify core journals publishing ozone literature.
To observe subject wise distribution of ozone literature.
To access subject wise references and objects use pattern in ozone literature.

3. METHODOLOGY
For this study, data has been collected from Directory of Open Access Journals (DOAJ) database. ‘Ozone’ was the search term and has been searched against two criteria i.e. ‘title’ and ‘abstract’. Necessary data related to all the retrieved articles have been collected in Excel Sheet and duplicate record has been removed. Total 1831 articles have been found during the preferred time span. Then data has been tabulated and analysed to fulfil objectives of the study.

4. SCOPE AND LIMITATION
Articles published only in the period of 2000 to 2015 and available only in DOAJ database have been considered for the study. The searched term used was ‘ozone’; if any synonymous or related term of ‘ozone’ has been used in some articles then those are missing from the study.

5. LITERATURE REVIEW
Study of literature in any subject area is an integral part of LIS research. A good number of research articles are available on literature study. Bibliometrics study of laser literature was carried out by Rajendiran and Parihar (2007) to see growth pattern, authorship pattern, subject wise distribution of article etc. Macias-Chapula (2000) studied literature on Acquired Immune Deficiency Syndrome to find types of published documents, authorship pattern and subject content. A study was also carried out by Arunachalam and Gunasekaran (2002) on tuberculosis research in India and China and they identified institutions and cities active in research, core journals, and author collaboration. A study executed on literature on hepatitis (1984-2003) by Ramakrishnan and Babu (2007). They collected data from MEDLINE, CINAHL and IPA databases. Kannappanavar & Vijayakumar (2001) worked on authorship trend and solo versus team research in international monetary fund literature. Clarke (1964) studied on multiple authorship trends in scientific papers. Authorship trend and solo research in bibliometrics was also carried out by Kabir (1994). A work entitled “Bibliometric analysis of ‘fiber optics’ literature” was carried out by Rajendran, Babu and Gopalakrishnan (2005).

6. OZONE
“An allotropic form of oxygen, a bluish toxic gas, O₃, with a characteristic odour, produced from molecular oxygen by electrical discharge and in the upper atmosphere by ultraviolet light, and formerly supposed to have a tonic effect” (“Ozone,” 2007, p. 2065).

“Allotrope of oxygen, m.p.-193⁰ C, b.p.-112⁰ C, blue in colour, present in upper atmosphere and absorbs u.v. radiation and hence protects earth’s surface from excess u.v. radiation. Holes can be caused in the ozone layers because of the radiation of ozone with species formed by, e.g. CFCs. Ozone is formed at ground level by interaction of nitrogen oxides, NOX, with hydrocarbons (from auto emissions). It is a respiratory irritant and can cause crop damage. Prepared by action of electric discharge on O₂ and can be separated from O₂ by fractionation. Has bent molecule, used for oxidation, sterilization and purification” (Sharpe, 2003, p. 293).
“A powerfully oxidizing allotropic form of the element oxygen. The ozone molecule contains three atoms (O₃), while the more common oxygen molecule has two atoms (O₂).

Ordinary oxygen is a colorless gas and condenses to a very pale blue liquid, whereas ozone gas is decidedly blue, and both liquid and solid ozone are an opaque blue-black color, similar to that of ink. Even at concentrations as low as 4%, the blue color of ozone gas mixed with air or other colorless gas in a tube in 1 in. (2.5 cm) or more in diameter and 4 ft (1.2m) or more long can be seen by looking length wise through the tube” (“Ozone,” 1987, p. 609).

7. BRIEF INFORMATION ABOUT DOAJ
DOAJ was launched in 2003 at Lund University, Sweden, with 300 open access journals. At present, it contains more than 10000 open access journals covering all areas of science, technology, medicine, social science and humanities. DOAJ is a membership organisation and membership is available in 3 main categories: Publisher, Ordinary Member and Sponsor. A DOAJ Membership is a clear statement of intent and proves a commitment to quality, peer-reviewed open access. DOAJ is a community-curated list of open access journals and aims to be the starting point for all information searches for quality, peer reviewed open access material. The main mission of DOAJ is to increase the visibility, accessibility, reputation, usage and impact of quality, peer-reviewed, open access scholarly research journals globally, regardless of discipline, geography or language. It will work with editors, publishers and journal owners to help them understand the value of best practice publishing and standards and apply those to their own operations. DOAJ also committed to being 100% independent and maintaining all of its services and metadata as free to use or reuse for everyone (“DOAJ,” 2018).

8. ANALYSES AND INTERPRETATIONS
8.1. Year Wise Distribution of Ozone Literature
Year wise distribution of ozone literature is presented in Table 1 that reveals that 13.43% of total literature is produced in the year 2015 followed by 12.73% and 10.05% are in the year 2014 and in 2012 respectively. Before the year 2007 the growth rate is less than 5% per year in respect of total literature. There is a positive growth rate from the year 2003 to 2015, but 2011 and 2013 – these two years are exceptional with in this thirteen years time span.

| S.No. | Years | No of Articles | Percentage |
|-------|-------|----------------|------------|
| 1     | 2000  | 41             | 2.24       |
| 2     | 2001  | 21             | 1.15       |
| 3     | 2002  | 20             | 1.09       |
| 4     | 2003  | 33             | 1.80       |
| 5     | 2004  | 58             | 3.17       |
| 6     | 2005  | 60             | 3.28       |
| 7     | 2006  | 72             | 3.93       |
| 8     | 2007  | 88             | 4.81       |
| 9     | 2008  | 113            | 6.17       |
| 10    | 2009  | 154            | 8.41       |
| 11    | 2010  | 172            | 9.39       |
| 12    | 2011  | 171            | 9.34       |
| 13    | 2012  | 184            | 10.05      |
| 14    | 2013  | 165            | 9.01       |
| 15    | 2014  | 233            | 12.73      |
| 16    | 2015  | 246            | 13.43      |
| Total |       | 1831           | 100.00     |
8.2. Authorship Pattern

The literature in any subject reflects the basic publishing pattern as well as characteristics of the authors themselves. In Table 2, number of authors has been categorized into seven classes in respect of concerned years. Out of 1831 articles 60.13% articles are contributed by 1-5 author(s) following 27.85% article by 6-10 authors. Article contributed by more than 30 authors are noticeable from the year 2007.

| S.No. | Years | 1-5 Authors | 6-10 Authors | 11-15 Authors | 16-20 Authors | 20-25 Authors | 26-30 Authors | >30 Authors | Total |
|-------|-------|-------------|--------------|---------------|---------------|---------------|---------------|------------|-------|
| 1     | 2000  | 33          | 8            | 0             | 0             | 0             | 0             | 0          | 41    |
| 2     | 2001  | 21          | 0            | 0             | 0             | 0             | 0             | 0          | 21    |
| 3     | 2002  | 20          | 0            | 0             | 0             | 0             | 0             | 0          | 20    |
| 4     | 2003  | 27          | 5            | 1             | 0             | 0             | 0             | 0          | 33    |
| 5     | 2004  | 37          | 15           | 2             | 2             | 1             | 1             | 0          | 58    |
| 6     | 2005  | 39          | 14           | 2             | 2             | 1             | 2             | 0          | 60    |
| 7     | 2006  | 52          | 20           | 0             | 0             | 0             | 0             | 0          | 72    |
| 8     | 2007  | 53          | 25           | 7             | 0             | 0             | 2             | 1          | 88    |
| 9     | 2008  | 65          | 37           | 5             | 3             | 3             | 0             | 0          | 113   |
| 10    | 2009  | 85          | 51           | 9             | 2             | 5             | 1             | 1          | 154   |
| 11    | 2010  | 101         | 46           | 9             | 9             | 2             | 1             | 4          | 172   |
| 12    | 2011  | 106         | 45           | 11            | 4             | 3             | 2             | 0          | 171   |
| 13    | 2012  | 106         | 40           | 25            | 6             | 4             | 2             | 1          | 184   |
| 14    | 2013  | 85          | 60           | 11            | 2             | 2             | 2             | 3          | 165   |
| 15    | 2014  | 137         | 69           | 17            | 7             | 0             | 1             | 2          | 233   |
| 16    | 2015  | 134         | 75           | 22            | 7             | 3             | 1             | 4          | 246   |
| Total |       | 1101        | 510          | 121           | 44            | 24            | 15            | 16         | 1831  |
|       |       | 60.13%      | 27.85%       | 6.61%         | 2.41%         | 1.31%         | 0.82%         | 0.87%      | 100.00%

8.3. Single Authored Versus Multiple Authored Articles

| S.No. | Year | No of article | No of Article contributed by Single Author | Percentage | No of Article contributed by Multiple Authors | Percentage |
|-------|------|---------------|-------------------------------------------|-------------|---------------------------------------------|------------|
| 1     | 2000 | 41            | 5                                         | 12.20       | 36                                          | 87.80      |
| 2     | 2001 | 21            | 2                                         | 9.52        | 19                                          | 90.48      |
| 3     | 2002 | 20            | 5                                         | 25.00       | 15                                          | 75.00      |
| 4     | 2003 | 33            | 4                                         | 12.12       | 29                                          | 87.88      |
| 5     | 2004 | 58            | 6                                         | 10.34       | 52                                          | 89.66      |
| 6     | 2005 | 60            | 4                                         | 6.67        | 56                                          | 93.33      |
| 7     | 2006 | 72            | 13                                        | 18.06       | 59                                          | 81.94      |
| 8     | 2007 | 88            | 5                                         | 5.68        | 83                                          | 94.32      |
| 9     | 2008 | 113           | 2                                         | 1.77        | 111                                         | 98.23      |
| 10    | 2009 | 154           | 12                                        | 7.79        | 142                                         | 92.21      |
| 11    | 2010 | 172           | 5                                         | 2.91        | 167                                         | 97.09      |
| 12    | 2011 | 171           | 9                                         | 5.26        | 162                                         | 94.74      |
| 13    | 2012 | 184           | 6                                         | 3.26        | 178                                         | 96.74      |
| 14    | 2013 | 165           | 1                                         | 0.61        | 164                                         | 99.39      |
| 15    | 2014 | 233           | 9                                         | 3.86        | 224                                         | 96.14      |
| 16    | 2015 | 246           | 7                                         | 2.85        | 239                                         | 97.15      |
| Total |      | 1831          | 95                                        | 5.19        | 1736                                        | 94.81      |
In Table 3, single versus multiple authors’ contribution pattern has been presented. It is clear from the study that rate of multiple authors’ contribution is very high than single author’s contribution. From the year 2007 over 90% articles are from multiple authors and in 2013 single author’s contribution is very less (0.61%). Over all 94.81% article has been contributed by multiple authors.

8.4. Degree of Collaboration

K. Subramanyam (as cited in Kannappanavar & Vijayakumar, 2001) suggested a formula to measure the degree of collaboration in quantitative terms, that formula has been used here to find out the degree of collaboration and result has been given in Table 4. The formula is given below:

\[ C = \frac{N_m}{N_m + N_s} \]

Where,

- \( C \) = Degree of collaboration in a discipline
- \( N_m \) = Number of multiple authored papers
- \( N_s \) = Number of single authored papers

From Table 4 it is found that in the year 2002 the value of degree of collaboration is less (0.75) and in 2013 the value is very high (0.99) than any other concerned years. A positive trend of collaboration has been found here and the average value of degree of collaboration is 0.95 which indicate a higher degree of collaborative research in ozone.

| S.No. | Year | No of Article contributed by Single Author | No of Article contributed by Multiple Authors | Degree of Collaboration |
|-------|------|-------------------------------------------|---------------------------------------------|-------------------------|
| 1     | 2000 | 5                                         | 36                                          | 0.88                    |
| 2     | 2001 | 2                                         | 19                                          | 0.90                    |
| 3     | 2002 | 5                                         | 15                                          | 0.75                    |
| 4     | 2003 | 4                                         | 29                                          | 0.88                    |
| 5     | 2004 | 6                                         | 52                                          | 0.90                    |
| 6     | 2005 | 4                                         | 56                                          | 0.93                    |
| 7     | 2006 | 13                                        | 59                                          | 0.82                    |
| 8     | 2007 | 5                                         | 83                                          | 0.94                    |
| 9     | 2008 | 2                                         | 111                                         | 0.98                    |
| 10    | 2009 | 12                                        | 142                                         | 0.92                    |
| 11    | 2010 | 5                                         | 167                                         | 0.97                    |
| 12    | 2011 | 9                                         | 162                                         | 0.95                    |
| 13    | 2012 | 6                                         | 178                                         | 0.97                    |
| 14    | 2013 | 1                                         | 164                                         | 0.99                    |
| 15    | 2014 | 9                                         | 224                                         | 0.96                    |
| 16    | 2015 | 7                                         | 239                                         | 0.97                    |
| Average | 95 | 1736                                       |                                             | 0.95                    |

8.5. Distribution of Articles According to Country Wise Authors’ Contribution

In Table 5, total authors contributed for 1736 articles have been categorized into two categories that are author(s) from a single country and authors form more than one country responsible for an article. It is found from the table that 8.12% articles have been written by the collaboration of authors from multiple countries. It also found from the table that within the parameter of author(s) from a single country Brazil is the leading country producing...
13.16% articles followed by Russian Federation (9.86%), Cuba (7.85%), Italy (6.01%) and India (5.79%) respectively.

| Authors’ contribution for an article | Country        | No of article | Percentage |
|--------------------------------------|----------------|---------------|------------|
| Author(s) from single country        | Brazil         | 241           | 13.16      |
|                                      | Russian Federation | 175       | 9.86       |
|                                      | Cuba           | 146           | 7.85       |
|                                      | Italy          | 110           | 6.01       |
|                                      | India          | 106           | 5.79       |
|                                      | China          | 79            | 4.29       |
|                                      | USA            | 64            | 3.47       |
|                                      | Chile          | 57            | 3.11       |
|                                      | Poland         | 41            | 2.24       |
|                                      | Mexico         | 35            | 1.91       |
|                                      | Japan          | 32            | 1.74       |
|                                      | Others         | 596           | 32.45      |
| Authors from more than one country   | 149            | 8.12          |
| Total                                | 1831           | 100.00        |

### Table 5 Country wise distribution of authors

8.6. Language Wise Distribution of Articles

Language wise distribution of articles has been depicted in Table 6. It is seen from the Table that 63.24% articles published in English language whereas 11.80%, 5.84% and 5.41% articles published in Portuguese, Spanish and Russian language respectively.

| S.No. | Language | No of article | Percentage |
|-------|----------|---------------|------------|
| 1     | English  | 1158          | 63.24      |
| 2     | Portuguese | 216        | 11.80      |
| 3     | Spanish  | 107           | 5.84       |
| 4     | Russian  | 99            | 5.41       |
| 5     | Italian  | 55            | 3.00       |
| 6     | Chinese  | 32            | 1.75       |
| 7     | Persian  | 27            | 1.47       |
| 8     | Serbian  | 24            | 1.32       |
| 9     | Thai     | 22            | 1.20       |
| 10    | Turkish  | 18            | 0.98       |
| 11    | Others   | 73            | 3.99       |
| Total | 1831     | 100.00        |

8.7. Ranking of Core Journals

There are total 1831 number of articles has been taken for the study and they are scattered in different journals. Only top 12 ranking journals have been highlighted in Table 7 and as shown from the table that 611 articles (33.37%) published in ‘Atmospheric Chemistry and Physics’, 339 articles (21.79%) in ‘Atmospheric Measurement Technique’, 179 articles (9.78%) in ‘Annals of Geophysics’ and so on.
8.8. Subject Wise Distribution of Articles

Though there is an increasing trend of research articles from its single disciplinary area to multi disciplinary area, an attempt has been made to categorise articles into seven broad disciplines. The highest, 31.08% of articles have been found under the discipline engineering and technology, followed by 24.19% in chemistry, 12.78% in physics and 10.48% in earth and environment sciences and so on.

8.9. Subject Wise Reference Distribution

It reveals from Table 9 that in chemistry 51 numbers of references have been used per article. Average number of references used per article in agriculture, earth and environmental

| S.No. | Subject                          | Average no of references used per article (in round figure) | Rank |
|-------|---------------------------------|------------------------------------------------------------|------|
| 1     | Chemistry                       | 51                                                         | 1    |
| 2     | Agriculture                     | 37                                                         | 2    |
| 3     | Earth and Environmental Sciences | 36                                                         | 3    |
| 4     | Biosciences                     | 31                                                         | 4    |
| 5     | Medicine                        | 30                                                         | 5    |
| 6     | Physics                         | 27                                                         | 6    |
| 7     | Engineering and Technology      | 25                                                         | 7    |
| 8     | Others                          | 28                                                         | -    |

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sciences, bioscience, medicine, physics and engineering and technology are 37, 36, 31, 30, 27, and 25 respectively.

8.10. Subject Wise Objects Distribution
Generally the content of any scholarly communication, particularly in science may be broadly categorising in five groups according to its nature i.e. elements for bibliographic information, textual content, objects, numerical contents and references. Objects include tables, maps, figures, diagrams, photographs etc. In Table 10 subject wise average number of objects used per article has been presented. Here rank 1 position goes to chemistry (9 objects per article) and rank 7 position for medicine having 4 objects per article.

Table 10 Subject wise number of objects used in articles

| S.No. | Subject                        | Average no of objects used (in round figure) | Rank |
|-------|--------------------------------|---------------------------------------------|------|
| 1     | Chemistry                      | 9                                           | 1    |
| 2     | Engineering and Technology     | 8                                           | 2    |
| 3     | Physics                        | 7                                           | 3    |
| 4     | Earth and Environmental Sciences | 7                                         | 3    |
| 5     | Agriculture                    | 5                                           | 5    |
| 6     | Biosciences                    | 5                                           | 5    |
| 7     | Medicine                       | 4                                           | 7    |
| 8     | Others                         | 3                                           | -    |

9. FINDINGS
The major findings of this study are given below:
- There is a positive growth trend of ozone literature.
- 60.13% articles are contributed by the collaboration of 1-5 author(s).
- Only 5.19% articles from single authorship.
- Average degree of author collaboration is also very high 0.95.
- 8.12% articles are written by the collaboration of authors from more than single country.
- The journal entitled ‘Atmospheric Chemistry and Physics‘ is the top most leading journal for publishing ozone literature.
- Most of the articles (31.08%) are related to the discipline engineering and technology.
- In Chemistry, average number of references (51) and average number of objects (9) used per article is higher than any other disciplines.

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