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A Bibliometric Study on Photosynthesis Research Output Based on Web of Science Database During 1989 to 2014

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***Abstract* - This study aims to research output of photosynthesis indexed in the Web of Science database during 1989-2014. About 53,839 bibliographical records were down loaded from Web of Science database during 1989-2014. It is observed that its relative growth rates contracted progressively from 0.302 at 1989 to 0.116 in the year of 2014. The whole study period sample mean relative growth rate is 0.10. Contrary to this, the Doubling Time for publication of all sources in Photosynthesis research output decreased from 2.29 years in 1989 to 5.97 years in 2014 during the study period, doubling time value is 25.11 years.**

Keywords: **Relative Growth Rate, Time Series Analysis, Collaborative Productivity, Prolific Authors, Degree of Collaboration, Photosynthesis**

I. INTRODUCTION

The term 'Bibliometrics' was first used by Alan Pritchard in 1969 to denote a new discipline where quantitative methods were employed to probe scientific communication process by measuring and analyzing various aspects of written documents. Bibliometrics is an emerging thrust area of research from different branches of human knowledge. Bibliometrics has become a standard tool of science policy and research management in the last decades. All significant compilations of science indicators heavily rely on publication and citation statistics and other, more sophisticated bibliometric techniques. Bibliometrics is a quantitative evaluation of publication patterns of all macro and micro communication along with their authorship by mathematical and statistical calculation.[Sengupta,1985] Bibliometrics can be applied to any subject area and to most of the problems concerned with written communication. It helps to monitor growth of literature and patterns of research. This paper studies the bibliometric analysis of the literature published in the Journal of Documentation.

II. RELEVANCE OF THE STUDY

It is necessary and useful to review the available literature in order to know the area that have invited the attention of the researcher so far, and the areas that seek the attention of the future researchers. Hence, a brief review of related literature and theories of the study under consideration is presented in this article. Karpagam [et al.,] (2011) has analyzed the growth pattern of Nanoscience and Nanotechnology literature in India during 1990-2009 (20 years), using Scopus international multidisciplinary bibliographical database. The study is identify the Indian contributions on the field of nanoscience and nanotechnology. The study measures the performance based on several parameters, country annual growth rate, authorship pattern, collaborative index, collaborative coefficient, modified collaborative coefficient, subject profile, etc. Manimekalai and Amsaveni (2012) analyzed the growth of research publications and the authorship pattern on Genetics and other related subject has been analyzed for the data taken from the articles listed in Web of Science covering the period 1998 to 2011. The records considered for the study is 871 and the pattern of productivity of various author categories are identified. The total of authors downloaded (4433) papers were divided into different categories, namely all authors, first authors, non-collaborative authors and co-authors. The collaborative publications have shown a systematic increase and the single author seemed to be in a decline in the proportion.

III. DATA AND METHODOLOGY

In order to get an idea about similar studies done in informetrics, an exhaustive literature search was carried out. For this the necessary data were collected from the Web of Science database using search term of "photosynthesis", collecting, organizing and analyzing of data were done on the basis of established informetrics/Scientometric methods. The downloaded data was transformed to MS-Excel format. The data was sorted to prepare tables and figures using MS-Excel software. This data has downloaded limits the during of 1989-2014 and the major topic of photosynthesis

IV. OBJECTIVES OF THE STUDY

1. To find out the Relation Growth Rates and Doubling Time for Photosynthesis research output during 1989 to 2014;
2. To find out single Vs multi authors, degree of collaboration of Photosynthesis research output;
3. To find out the continent wise contributed countries; and
4. To find out the Authorship Patterns on Photosynthesis Research Output

V. ANALYSIS AND INTERPRETATIONS

The researcher has chosen the years for analysis 1989 to 2014 (totally twenty six years); 53,839 records were downloaded from the web of knowledge database for this analysis on the subject of photosynthesis research productivity at worldwide. There are variations in the number of publications of articles during this sample period taken for the study. The below table value analysis reveals the year wise growth trend.

TABLE I YEAR WISE DISTRIBUTION OF PHOTOSYNTHESIS RESEARCH PRODUCTIVITY DURING 1989 TO 2014

S.No.	Year	Records	%	Rank	TLCS	TGCS
1	1989	360	0.7	17	8694	16778
2	1990	487	0.9	16	6866	14134
3	1991	1479	2.7	15	24416	65664
4	1992	1552	2.9	14	23975	65909
5	1993	1560	2.9	14	21328	66226
6	1994	1585	2.9	14	22088	64049
7	1995	1782	3.3	11	23083	68589
8	1996	1899	3.5	13	23299	77178
9	1997	1854	3.4	12	21550	75321
10	1998	1821	3.4	12	20605	73586
11	1999	1764	3.3	11	20322	69718
12	2000	1774	3.3	11	18040	72155
13	2001	1786	3.3	11	19871	77224
14	2002	1878	3.5	10	20059	74809
15	2003	1970	3.7	9	18064	70171
16	2004	2042	3.8	8	18807	79690
17	2005	2159	4.0	7	17214	72754
18	2006	2140	4.0	7	14210	63444
19	2007	2360	4.4	6	14925	65250
20	2008	2481	4.6	5	14305	64537
21	2009	2636	4.9	4	13069	60108
22	2010	2651	4.9	4	10269	49802
23	2011	2662	4.9	4	7329	33778
24	2012	3378	6.3	3	6753	33814
25	2013	3664	6.8	2	3564	21882
26	2014	4115	7.6	1	811	8083
	Total	53839	100		413516	1504653

Note: TLCS – Total Local Citation Scores; TGCS – Total Global Citation Scores

The above table shows that the year wise distribution of research analysis, the year 2014 has highest number of publications 4115 (7.6%) with 811 of TLCS and 8083 of TGCS values and has secured the first position among the 26 years output in the Photosynthesis research at complete level.

The year 2013 has 3664 (6.8%) records and it stood in second position with 3564 of TLCS and 21882 of TGCS 2012 has 3378 (6.3%) publications and stood in the third position along with 6753 of TLCS and 33814 of TGCS.

Next to that 2011, 2010 and 2009 have 4.9 per cent of records; 2008 has 4.6 per cent of records; 2007 has 4.4 per cent of records; 2006 and 2005 have 4.0 per cent of records; 2004 has 3.8 per cent of records; 2003 has 3.7 per cent of records; 2002 and 1996 have 3.5 per cent of records; 1997 and 1998 have 3.4 per cent of records; 1995, 1999, 2000 and 2001 have 3.3 per cent of records; 1992, 1993 and 1994 have 2.9 per cent of records; 1991 has 2.7 per cent of records; and the remaining years 1990 and 1989 produced below one per cent of articles in photosynthesis research.

According to TLCS (Total Local Citation Scores) the following results were found from the above analysis: totally 413516 TLCS were measured; among those, 1991 has highest TLCS scores, 24,416 with first position for TLCS; 1992 has 23,975 with second position; and 1996 has 23,299 of TLCS values with third position.
Examined by TGCS (Total Global Citation Scores) the overall period has 1504653 citation scores. Among those twenty six years, 2004 has highest TGCS scores, 79,690 with first position; 2001 has 77,224 with second position; 1996 has 77,178 of TGCS values with third position.

It could be derived from the above analysis, that the most productive years are 2014, 2013 and 2012. The publication rate has increased from the value of 0.7 percent to 7.6 percent. It shows that growth rate increased more than seven times during 1989 to 2014. It is particularly identified that there is no relation between the productivity of publication between the citation scores. The years 1991, 1992 and 1996 have highest TLCS and 2004, 2001 and 1996 have TGCS scored measured.

The analysis of growth rate in Photosynthesis research output is one of the important aspects of discussion. This analysis aims to identify the trends and growth of prospects in the present research. However, increase in the literature of Photosynthesis has made it extremely difficult for scientists to keep in touch with the recent advances in their fields. The growth rate of research literature on Photosynthesis is determined by calculating the relative growth rates and doubling time of the publications. In the research design, the details of this model have been explained.

TABLE II RELATIVE GROWTH RATE AND DOUBLING TIME OF THE RESEARCH OUTPUT IN PHOTOSYNTHESIS

Year	R. o/p	Cum. o/p	$log_e 1^p$	$log_e 2^p$	Rt(P)	Dt(P)
1989	360	360	-	5.886	-	-
1990	487	847	5.886	6.188	0.302	2.295
1991	1479	2326	6.188	7.299	1.111	0.624
1992	1552	3878	7.299	7.347	0.048	14.438
1993	1560	5438	7.347	7.352	0.005	138.600
1994	1585	7023	7.352	7.368	0.016	43.313
1995	1782	8805	7.368	7.485	0.117	5.923
1996	1899	10704	7.485	7.549	0.064	10.828
1997	1854	12558	7.549	7.525	0.024	-28.875
1998	1821	14379	7.525	7.507	0.018	-38.500
1999	1764	16143	7.507	7.475	0.032	-21.656
2000	1774	17917	7.475	7.481	0.006	115.500
2001	1786	19703	7.481	7.488	0.007	99.000
2002	1878	21581	7.488	7.538	0.05	13.860
2003	1970	23551	7.538	7.586	0.048	14.438
2004	2042	25593	7.586	7.622	0.036	19.250
2005	2159	27752	7.622	7.677	0.055	12.600
2006	2140	29892	7.677	7.669	0.008	-86.625
2007	2360	32252	7.669	7.766	0.097	7.144
2008	2481	34733	7.766	7.816	0.05	13.860
2009	2636	37369	7.816	7.877	0.061	11.361
2010	2651	40020	7.877	7.883	0.006	115.500
2011	2662	42682	7.883	7.887	0.004	173.250
2012	3378	46060	7.887	8.125	0.238	2.912
2013	3664	49724	8.125	8.206	0.081	8.556
2014	4115	53839	8.206	8.322	0.116	5.974
Total					2.60 (0.10)	653.57 (25.11)

The above table 5 shows that the data of relative growth rate and doubling time for total research output on Photosynthesis. It is observed that its relative growth rates contracted progressively from 0.302 at 1989 to 0.116 in the year of 2014. The whole study period sample mean relative growth rate is 0.10. Contrary to this, the Doubling Time for publication of all sources in Photosynthesis research output decreased from 2.29 years in 1989 to 5.97 years in 2014. During the study period, doubling time value is 25.11 years. Relative growth rate has shown declining trend, which means the rate of increase is low in terms of segment, and this has been highlighted by doubling time for publications, which is more than the relative growth rate. Hence the second and third hypotheses (The relative growth rate of total scientific publications shows a declining trend and the doubling time for publications reflects an increasing trend. There is an extensive level of increase in the growth of Photosynthesis research output, indicating the progressive

of research performance noted in thesis has been substantiated.

A study of the above data indicates the degree of collaboration in the research output on Photosynthesis. The below table reveals the single Vs. multi-authored paper on Photosynthesis research productivity.

TABLE III SINGLE VS. MULTI-AUTHOR AND DEGREE OF COLLABORATION OF PHOTOSYNTHESIS RESEARCH OUTPUT

Year	Single authors		Multi authored		Total	Degrees of Collaboration
	No of output	%	No. of output	%		
1989	75	1.57	285	0.58	360	0.79
1990	67	1.40	420	0.85	487	0.86
1991	219	4.59	1260	2.56	1479	0.85
1992	248	5.20	1304	2.65	1552	0.84
1993	209	4.38	1351	2.74	1560	0.87
1994	206	4.32	1379	2.80	1585	0.87
1995	229	9.26	1553	3.15	1782	0.78
1996	233	4.88	1666	3.38	1899	0.88
1997	197	4.13	1657	3.36	1854	0.89
1998	190	3.98	1631	3.31	1821	0.90
1999	168	3.52	1596	3.24	1764	0.90
2000	183	3.83	1591	3.23	1774	0.90
2001	147	3.08	1639	3.33	1786	0.92
2002	195	4.09	1683	3.42	1878	0.90
2003	201	4.21	1769	3.59	1970	0.90
2004	176	3.69	1866	3.79	2042	0.91
2005	165	3.46	1994	4.05	2159	0.92
2006	153	3.21	1987	4.03	2140	0.93
2007	155	3.25	2205	4.47	2360	0.93
2008	153	3.21	2328	4.72	2481	0.94
2009	158	3.31	2478	5.03	2636	0.94
2010	159	3.33	2492	5.06	2651	0.94
2011	176	3.69	2486	5.04	2662	0.93
2012	163	3.42	3215	6.52	3378	0.95
2013	169	3.54	3495	7.09	3664	0.95
2014	166	3.48	3949	8.01	**4115**	0.96
Total	4560	8.47	49279	91.53	53839	0.915

The overall period Photosynthesis productivity has 8.47% of articles produced by single authors and 91.53% of articles were produced by collaborative authors. The collaborative value is 79 in 1989 and it raised 0.96 in 2014. The degree of collaboration value is 0.915. (i.e.) 91% articles were produced by the collaborative work. The table value showed that 91% of articles were produced by collaborative mode. This analysis strongly mentioned that the collaborative work has dominated for producing articles in Photosynthesis research in world. In recent years, the scientists/researchers target communal participation in research problem solving activities.

It has resulted in the dilapidated single author papers and thereby an increase in multiple author papers. It is seen clearly from the above that the degree of collaboration in producing research output on Photosynthesis research has shown an increasing trend during the study period since it is a new discipline. The study shows, the result of the degree of collaboration C = 0.91. i.e., 91 percent of collaborative authors' articles were published during the sample study periods.

This analysis covers the scientist's research output on Photosynthesis research publications at various continents along with their associated countries level. There are seven

continents. The researcher has taken only six continents (there is no publication from the continent of Antarctica) contribution to the publications of this area. So for this part of analysis, the researcher has selected continents of Asia, Europe, Africa, North America, South America, Australia or Oceania. Some articles are not found in the country. So those were seen as unknown variable for this analysis.

TABLE IV CONTINENT WISE RESEARCH OUTPUT OF PHOTOSYNTHESIS DURING 1989-2014

S. No.	Continent	R. o/p	%	TLCS	TGCS	No. of countries	H - index	CR
1	North America	16230	30.15	126468	507796	19	498	753894
2	Europe	18640	34.62	170453	606508	46	763	843694
3	Asia	12342	22.92	62550	216898	39	649	505042
4	Australia	3395	6.31	38909	115055	9	206	177214
5	South America	2143	3.98	10833	39421	16	234	100303
6	Africa	1089	2.02	4303	18975	37	144	50251
	Total	53839	100	413516	1504653	166	2494	2430398

The above table indicates that the continent wise distribution of 53839 researchers output on Photosynthesis research literature during 1989 to 2014 from 166 different countries. The North America continent stood in the first place with the highest publication of 3719 (41.15%) outputs from 8 countries with 110407 TCS. European continent occupies the second position with 3471 publications (38.41%) from 36 countries with 110416 TCS. Asian continent contributes 3242 (35.87%) with 69473 TCS values from 29 countries. Australian continent has produced 236 (2.61%) among the seven continents along with 6958 TCS from 2 countries. South American continent has produced 185 publications (2.05%) during the study period along with 2223 TCS from 9 countries. African continent contributes 132 (1.46%) with 4852 TCS values from 21 countries. And some articles have not shown their country. So, they are mentioned here as unknown category, from unknown 371 (4.11%) publications. Sometimes one single article belongs to two or more countries of the continent due to the collaborative publications, so that here the total value is different from the sample data. The highest research productivity is from the North American continent and the lowest research productivity is from Africa. Europe and Africa continents were having equal contributing countries. Hence the fourth (There is a significant variation in the growth and deliberation of research output on Photosynthesis research among the selected continents and countries) hypothesis is proved.

Totally 166 countries contributed from various continents. Among those USA contributed 15691 (29.14%) of articles and being in first rank position of publication level in photosynthesis research. Followed by Germany produced 6012 (11.17%) of articles, China produced 5019 (9.32%) of articles in photosynthesis research during the sample period.

TABLE V MOST PRODUCTIVITY COUNTRIES OF PHOTOSYNTHESIS DURING 1989-2014

S.No	Country	No. of output	%
1	USA	15691	29.14
2	GERMANY	6012	11.17
3	PEOPLES R CHINA	5019	9.32
4	JAPAN	4312	8.01
5	ENGLAND	3273	6.08
6	AUSTRALIA	3129	5.81
7	FRANCE	3078	5.72
8	CANADA	2917	5.42
9	SPAIN	2396	4.45
10	ITALY	1901	3.53
11	**INDIA**	**1895**	**3.52**
12	NETHERLANDS	1655	3.07
13	RUSSIA	1406	2.61
14	SWEDEN	1384	2.57
15	BRAZIL	1198	2.23

India stood in the eleventh position in photosynthesis research publications. The researcher has taken the Indian productivity of photosynthesis for further analysis. It is vital to analyze the author's productivity. The author's efficiency is determined by the scientists in a specific field. The analysis of the author's productivity examines the prevailing trend in understanding the research process in any discipline of science.

The research has used this analysis for identifying the author's status of contributing style. From the previous table analysis derived the result for collaborative team which has produced more number of articles in Photosynthesis research during the time span. Here this table analysis may be used to find the type of collaborative authorship, which has contributed highest number of articles in Photosynthesis research productivity. Totally 1895 articles were produced by 7091 authors.

The above table indicates the sample articles produced by the authorship pattern during 1989 to 2015. The researcher has categorized the authorship pattern as single authored, two authored, three authored, four authored, five authored, six authored, seven authored, eight authored, nine authored, ten and above authored productivity by year wise.

TABLE VI AUTHORSHIP PATTERNS ON PHOTOSYNTHESIS RESEARCH OUTPUT

Articles	**1 Authored**	**2 Authored**	**3 Authored**	**4 Authored**	**5 Authored**	**6 Authored**	**7 Authored**	**8 Authored**	**9 Authored**	**10 & above Authored**	**Total**
1989	2	6	4	0	1	0	0	0	0	0	13
1990	1	10	10	2	2	0	1	0	0	0	26
1991	1	16	11	7	1	0	0	0	0	0	36
1992	2	23	13	6	1	1	2	0	0	0	48
1993	2	21	19	3	1	0	0	0	0	0	46
1994	6	15	20	5	2	0	0	0	0	1	49
1995	6	20	13	6	4	3	1	0	0	0	53
1996	5	17	16	6	3	7	0	0	0	0	54
1997	4	23	14	8	3	0	0	0	0	0	52
1998	3	17	19	11	4	0	2	0	0	0	56
1999	6	26	15	5	4	4	1	0	0	0	61
2000	3	15	12	4	2	3	2	0	0	0	41
2001	3	12	18	5	2	0	0	0	1	0	41
2002	3	14	12	9	4	3	1	0	0	1	47
2003	5	21	10	5	3	0	2	1	0	0	47
2004	2	23	19	11	2	2	1	0	1	1	61
2005	4	21	10	13	10	3	2	1	0	0	64
2006	3	13	11	16	4	6	3	3	0	0	59
2007	5	16	27	18	6	5	5	3	0	1	86
2008	1	18	16	23	11	5	3	2	1	4	84
2009	1	15	25	18	6	5	3	1	0	4	78
2010	5	10	23	22	15	6	4	2	0	3	91
2011	2	25	29	23	17	15	2	3	4	4	124
2012	5	21	25	25	20	15	6	1	2	3	123
2013	1	22	31	34	15	8	7	3	3	5	129
2014	3	26	32	35	20	11	11	5	2	8	153
2015	2	25	28	33	36	11	14	9	8	7	173
Total	86 (4.54)	491 (25.9)	482 (25.4)	353 (18.6)	199 (10.5)	113 (5.96)	73 (3.9)	34 (1.79)	22 (1.16)	42 (2.2)	1895

Totally 1895 articles were produced by different types authorship pattern during 1989 to 2015; among those 86 (4.54%) articles are single authored, 491 (25.9%) articles are two authored team, 482 (25.4%) articles are three authored team, 353 (18.6%) articles are four authored team; 199 (10.5%) articles are five authored team, 113 (5.96 %) articles are six authored team, 73 (3.9%) articles are seven authored team, 34 (1.79%) articles are eight authored team, 22 (1.16%) articles are nine authored team, 42 (2.2%) articles are ten and above authored team. It could be identified that the two authored production is higher than that of other teams.

According to year wise analysis the result has shown here the years' 1989 to 2015; during 1989 totally 13 articles were produced; three authored articles production is higher than that of other teams. 26 articles were produced during 1990; among those, two and three authored production is equally highest; 36 articles were produced during 1991; among those, two authored production is highest; 48 articles were produced during 1992; among those, two authored production is highest; 46 articles were produced during 1993; among those, two authored production is highest; 49 articles were produced during 1994; among those, three authored production is highest; 53 articles were produced during 1995; among those, two authored production is highest; 54 articles were produced during 1996; among those, two authored production is highest; 52 articles were produced during 1997; among those, two authored production is highest; 56 articles were produced during 1998; among those, three authored production is highest; 61 articles were produced during 1999; among those, two authored production is highest; 41 articles were produced during 2000; among those, two authored production is highest; 41 articles were produced during 2001; among those, three authored production is highest; 47 articles were produced during 2002; among those, two authored production is highest; 47 articles were produced during 2003; among those, two authored production is highest; 61 articles were produced during 2004; among those, two authored production is highest; 64 articles were produced during 2005; among those, two authored production is highest; 59 articles were produced during 2006; among those, two authored production is highest; 86 articles were produced during 2007; among those, three authored production is highest; 84 articles were produced during 2008; among those, four authored production is highest; 78 articles were produced during 2009; among those, three authored production is highest; 91 articles were produced during 2010; among those, three authored production is highest; 124 articles were produced during 2011; among those, three authored production is highest; 123 articles were produced during 2012; among those, three and four authored production is equally highest; 129 articles were produced during 2013; among those, four authored production is highest; 153 articles were produced during 2014; among those, four authored production is highest; and 173 articles were produced during 2015; among those, two authored production is highest in photosynthesis research. It could be concluded from this analysis that two authored team has highest productivity on photosynthesis research during the sample period. Next to that three authored team contributed the highest.

VI.CONCLUSION

The researcher has derived the result from this photosynthesis research analysis, the last two years of 2013,2014 has highest publication; 167 countries were contributed 53839 articles from different continents; totally 215107 authors were contributed during study period; the mean relative growth rate of 0.10. whereas the mean for doubling time 25.11 years. It is found that the collaboration three authored team has produced more number 11587 (highest) of articles; countries wise contribution on photosynthesis research output shows that USA, Germany and China contributed more number of articles among the 166 countries of photosynthesis research, it shows that the team work could be leads in photosynthesis research output during the study period.

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