

Scientometric Dimension of Research Productivity in Green Chemistry: A Global Perspective

C. Ranganathan

Assistant Professor, Department of Library and Information Science
Bharathidasan University, Tiruchirappalli, Tamil Nadu, India
E-Mail: cranganathan72@gmail.com

(Received 30 June 2018; Revised 20 July 2018; Accepted 12 August 2018; Available online 25 August 2018)

Abstract - The study deals with the Scientometric study on the publication of "Green Chemistry". The records are collected from Web of Science Databases for the period of 1991-2014. A total of 11503 publications were identified in Web of Science database. The study reveals that, most of the researchers preferred to publish their research results in journals; as such 77.8% of articles were published in journals. More numbers of articles were published in the year 2014. The authorship trend shows that, out of total 11503 publications published, 88.86% of the publication published under the joint author. Further this study also identified to analyses coverage growth rates, source wise, collaborative coefficient, co-authorship index and Geographical distribution of the literature and citation analysis is also noted

Keywords: Green Chemistry, Scientometrics Analyses, Citation, Collaborative Coefficient, co-authorship index

I. INTRODUCTION

As science has grown in extension and intension and the number of scientists, so obviously does the volume of literature generated by the scientific community (R. Maheswaran, 2018). Every day there is a huge proliferation of literature gushing out of the press continuously that poses problems to everybody to organize and preserve the published literature. The growth rate analysis of publication could yield some useful results regarding growth pattern of literature and scientific productivity of authors in that discipline. (Maheswaran, 2017) Scientometrics is an important field of information as it represents unique set of techniques for the monitoring and analysis of information resources and for the management of knowledge in science and organizational context. New areas of research are fast emerging and scientometric analysis of different disciplines is also gaining momentum. (Maheswaran, 2016) Green chemistry research is one such area which has grown exponentially over the recent years. The present study attempts to evaluate the research performance of scientists in the field of Green Chemistry in terms of their publication research output (R Maheswaran, R Balasubramani, 2016).

Green chemistry consists of chemicals and chemical processes designed to reduce or eliminate negative environmental impacts. (Jeyaraj, 2011) The use and production of these chemicals may involve reduced waste products, non-toxic components, and improved efficiency. Green chemistry is a highly effective approach to pollution prevention because it applies innovative scientific solutions to real-world environmental situations (Jeyaraj, 2012).

This study aims to examine the emergence of research areas, research groups and countries with a view to map the cognitive or intellectual structure of research. (Pratheepan, 2013) Further, this study corresponds to an appraisal of scientometric analysis of the pattern of publication, growth rate of publication, authorship, institutions, collaborative coefficient, co-authorship index, collaborative index and journals coverage of the scientists in the field of Green Chemistry. (Maheswaran, 2009)

II. OBJECTIVES OF THE STUDY

The major objectives are framed with the exclusive notion of the present study as mentioned below

1. To examine the growth of research productivity of Green Chemistry research during 1991-2014.
2. To identify the source wise distribution of publications in Green Chemistry.
3. To distinguish the leading prolific authors in green chemistry research
4. To reveal the nature of collaboration and co-authorship pattern, co-authorship index and determine the collaborative coefficient in Green Chemistry.
5. To assess the Institution wise research concentration on Green Chemistry research output.
6. To identify journal wise distribution of publications on Green Chemistry research output.
7. To identify the country wise research output performance in Green Chemistry with emphasis to Indian research output.
8. To identify the finding agencies support for Green Chemistry research.

III. COLLECTION OF DATA

The basic publication data used in this study is derived from the Expanded Version of Science Citation Index (SCI) database, available in Web of Science. The raw publications data along with their citations has been downloaded from the Web of Science in December 2014. Publications data for 24 years from 1991 to 2014 were used for analyzing the growth and impact of Green Chemistry research. The researcher has used the search string "Green Chemistry OR Chemistry, Green" for getting data from the Web of Science database. The researcher has downloaded the bibliographical data in the form of notepad files. Overall data retrieved by the researcher are 11529 records and

eliminated 26 duplicate records hence, the refined data consists only 11503 records taken for analyzing the present study.

IV. METHODOLOGY

The present study aims at analyzed the research output of Researchers in the field of Green Chemistry. The growth rate of output in terms of research productivity is analyzed from 1991 to 2014. The data has analyzed and classified into Histcite software. The data so retrieved were downloaded and later imported into a database management system for data cleaning and coding. Then the bibliographical details are converted to the form of MS – EXCEL format using the PHP (hyper text pre processor) scripting language text extracting based a delimiters Programme. Finally, the unique data are rearranged in MS – EXCEL format to eliminate duplication from the downloaded data and to analyzed the scattering of research in different dimensions. It is also analytical in nature in strengthening the empirical validity due to application of suitable statistical tools.

V. APPLICATION OF SCIENTOMETRICS INDICATORS

The following indicators have been used in the analysis of data

A. Collaborative Coefficient (CC)

The pattern of co-authorship among different countries have been examined by making use of Collaborative Coefficient (CC) suggested by Ajiferuke et al., (1988). The formula used for calculating CC is as follows. Where

$$CC = 1 - \left[\sum_{j=1}^k (1/j) F_j / N \right]$$

- F_j = the number of authored papers
- N = total number of research published; and
- K = the greatest number of authors per paper

According to Ajiferuke, CC tends to zero as single-authored papers dominate, and to 1-1/j as j-authored papers dominate. This implies that higher the value of CC, higher the probability of multi-authored papers.

B. Co-Authorship Index (CAI)

To study how the patterns of co-authorship have changed during a period use of Co- authorship index has been applied in this study. For calculating CAI the entire data set was divided into four blocks.

$$CAI = \{ (N_{ij}/N_{io}) / (N_{oj}/N_{oo}) \} * 100$$

- N_{ij} : Number of papers having j authors in block I
- N_{io} : Total Output of Block I
- N_{oj} : Number of papers having j authors for all blocks;
- N_{oo} : Total number of papers for all authors and all blocks

J=1, 2, 3, > 4

CAI = 100 implies that co-authorship in a particular block for a particular types of authorship corresponds to the world average, CAI>100 reflects higher than average co-authorship effort and CAI<100 lower than average co-authorship effort in a particular block for a particular type of authorship.

C. Collaborative Index (CI)

Collaborative Index can be obtained by the total number of authors divided by the total number of published articles.

$$\text{Collaborative Index} = \frac{\text{total number of authors}}{\text{total number of articles,}}$$

where, CI = the number of authors per paper

VI. DATA ANALYSIS AND DISCUSSION

The publication of research output is a measure to observe the performance at Global Level, of research output on Green chemistry is taken as a tool to evaluate the performance at various levels.

A. Pattern of Growth of Research Output and Citation Score

Table I views clearly that during the period 1991 - 2014 a total of 11503 publications were published at Global level. The highest publication is 1576 in 2014 with 5819 Global Citation Scores followed by 1424 papers in 2013 with 10178 Global Citation Score and 1251 papers in 2012 with 16806 Global Citation Scores. The lowest number of publications in the year 1990 record only forty nine publications due to the initial stage of Green Chemistry. It shows that even minimum numbers of records were scored higher global citations in the year 2010 in 879 papers with 22204 Global Citation Scores. It also calculated the average citations per paper in this table. These papers have together received an average of 21.91 citations per paper for the total papers. The highest average citation is 57.44 in 2002 with first rank position, followed by the citation 56.25 in 1993, 47.49 citations in 1992, 45.73 citations in 2001, and 41.41 citations in 1998 respectively.

B. Document Type Wise Distribution of Publications

It is clear from the analysis that the share of journal articles is the most prominent bibliographic form of publication and it occupies 77.8% (8952) of total publications along with 11061 TLCS and 170412 TGCS. The source of Review with research publication occupies 8.5% (985) with 4238 TLCS and 62617 TGSC and it stood in second position, meeting abstract with 602(5.23) contribution, Proceedings paper with 494 (4.29%) contributions, editorial material with 246(2.16%) contributions and news item with 117 (1.2 %) followed by remaining bibliographic forms.

TABLE I YEAR WISE DISTRIBUTION OF RESEARCH OUTPUT AND CITATION SCORE

S. No.	Publication Year	Recs	%	TLCS	TGCS	ACPP
1	1991	49	0.4	20	1664	33.95
2	1992	53	0.5	85	2517	47.49
3	1993	59	0.5	56	3319	56.25
4	1994	51	0.4	44	1732	33.96
5	1995	75	0.7	79	2468	32.90
6	1996	81	0.7	72	2806	34.64
7	1997	85	0.7	74	3344	39.34
8	1998	109	0.9	103	4514	41.41
9	1999	135	1.2	467	4016	29.74
10	2000	196	1.7	656	6057	30.90
11	2001	221	1.9	760	10107	45.73
12	2002	261	2.3	1389	14992	57.44
13	2003	328	2.9	666	11860	36.15
14	2004	363	3.2	877	13282	36.58
15	2005	473	4.1	1437	16984	35.90
16	2006	559	4.9	1522	19087	34.14
17	2007	636	5.5	1799	21193	33.32
18	2008	693	6.0	1745	19109	27.57
19	2009	842	7.3	1430	21102	25.06
20	2010	879	7.6	1452	22204	25.26
21	2011	1104	9.6	1154	16968	15.36
22	2012	1251	10.9	1206	16806	13.43
23	2013	1424	12.4	581	10178	7.14
24	2014	1576	13.7	133	5819	3.69
Total		11503	100	17807	252128	21.91

TABLE II DOCUMENT WISE DISTRIBUTION OF PUBLICATIONS

S. No.	Document Type	Recs	%	TLCS	TGCS
1	Article	8952	77.8	11061	170024
2	Review	985	8.6	4238	62617
3	Meeting Abstract	602	5.2	3	6
4	Article; Proceedings Paper	494	4.3	1408	13852
5	Editorial Material	246	2.1	922	3000
6	News Item	117	1.0	39	131
7	Review; Book Chapter	43	0.4	76	1497
8	Letter	24	0.2	43	568
9	Note	12	0.1	1	322
10	Correction	11	0.09	2	7
11	Biographical-Item	9	0.08	0	3
12	Book Review	4	0.03	9	27
13	Article; Book Chapter	3	0.02	5	73
14	Discussion	1	0.01	0	1
Total		11503	100	17807	252128

C. Ranking of Prolific Authors based on Publications

Table III reveals that top 25 prolific authors of the subject of Green Chemistry research belong to their highest productivity and given the rank according to their research output. The author Mallakpour S published the highest number of articles for the study period with 64 records; next author Anastas PT published the next highest number of articles for the study period with 60 records. Clark JH published 49 records. Warner JC published 44 records. It also shows that author Polshettiwar, V from USA has got the highest citations of 2073 with average cited per article as 109.10 and h-index of 17, which is followed by the Hayashi, S from Japan who has scored 1902 citations with 105.66 as average citation per article and the h-index of 16. Among the top 25 authors, author Varma RS has appended 294 cited references for its 39 publications which are followed by the authors Mallakpour S with 295 local cited references. There are only one author having more than 3000 global citations and three authors having more than 2000 global citations.

D. Pattern of Co-Authorship Index (CAI)

To study how the patterns of co-authorship have changed during a period the use of Co-authorship index has been applied in this study. For calculating CAI = 100 implies that co-authorship in a particular block for a particular types of authorship corresponds to the world average, CAI > 100 reflects higher than average co-authorship effort and CAI < 100 lower than average co-authorship effort in a particular block for a particular type of authorship. It is observed from the table-30 the Co-Authorship Index for single authors is declined from 219.73 in the year 1991 to 47.82 in the year 2014. On the other hand, the Co-Authorship Index for Multiple authors is enhanced from 84.98 in the year 1991 to 106.54 in the year 2014, which indicates the pattern of co-authorship is increasing among the contributions of the journal.

E. Collaborative Index in Green Chemistry Research

It can be observed that in the year 1991 had index value 2.90, and for 1992 the index value is 2.96, 1993 has an index value of 3.49; 1994 the index value is 2.96 and the trend continues. There are fluctuations in the number of Collaborative Index value during the study period. 4.44 is the highest index value observed in the year 2014. Results from the table shows, the trend in authorship pattern and collaborative measures. The 'Collaborative Index' for universal level is 3.54 which show the popularity towards collaborative research pattern than single author research in chosen field of Green Chemistry.

F. Collaborative Co-efficient (CC) of Authorship Pattern

To analyze the pattern of co-authorship for the contributions from various countries, the Collaborative Coefficient (CC) has been calculated for each country and results are presented in Table-6. The Collaborative Coefficient for USA

has been calculated as stated above and the calculated result is 0.38. It is observed that although the overall productivity on Green Chemistry by American authors ranks the first position, but the collaborative coefficient has been calculated at 0.38, which is below 0.50. This reveals that the sharing among the authors is not in grater probability. The highest collaborative coefficient has been calculated for South Korea (0.49) followed by People R China, Spain and Taiwan with 0.48 and remaining country followed by India, Iran, Australia, Austria and Belgium with 0.47.

TABLE III RANKING OF PROLIFIC AUTHORS BASED ON PUBLICATIONS

S. No.	Author	Recs	Percent	TLC S	TGC S	TLC R	h-index
1	Mallakpor S	64	0.6	259	956	285	19
2	Anastas PT	60	0.5	1115	2640	126	20
3	Clark JH	49	0.4	589	3043	154	26
4	Warner JC	44	0.4	74	208	20	8
5	Varma RS	39	0.3	511	2804	294	26
6	Tu SJ	35	0.3	80	663	69	13
7	Zhang Y	34	0.3	28	404	31	12
8	Kirchhoff MM	32	0.3	568	1322	18	7
9	Mizuno N	31	0.3	157	1718	148	22
10	Wang L	31	0.3	24	803	25	12
11	Yadav GD	31	0.3	53	333	53	10
12	Yamaguchi K	31	0.3	172	1873	150	23
13	Heravi MM	30	0.3	74	847	63	15
14	Hutchison JE	28	0.2	93	219	29	9
15	Poliakoff M	27	0.2	328	1156	55	14
16	Tundo P	27	0.2	260	1065	102	12
17	Han BX	26	0.2	52	637	59	14
18	Liu Y	24	0.2	8	382	48	12
19	Azizi N	23	0.2	61	323	65	10
20	Luque R	23	0.2	79	645	74	16
21	Singh S	23	0.2	33	271	47	8
22	Garcia H	22	0.2	93	1756	81	18
23	Kidwai M	22	0.2	33	140	32	8
24	Kumar S	22	0.2	42	250	37	9
25	Li CJ	22	0.2	201	1233	59	15
	Total	800	7	4987	25691	2124	358

TABLE IV PATTERN OF CO-AUTHORSHIP INDEX

Year	Single Authors		Multiple Authors		Total
	No. of Output	CAI	No. of Output	CAI	
1991	12	219.7396	37	84.9813	49(0.43)
1992	8	135.437	45	95.55521	53(0.43)
1993	6	91.24779	53	101.0978	59(0.51)
1994	12	211.1223	39	86.06214	51(0.44)
1995	14	167.4904	61	91.53481	75(0.65)
1996	16	177.2385	65	90.31213	81(0.70)
1997	19	200.5662	66	87.38618	85(0.74)
1998	20	164.6367	89	91.89275	109(0.95)
1999	49	325.6757	86	71.69393	135(1.17)
2000	57	260.9407	139	79.81352	196(1.70)
2001	52	211.1223	169	86.06214	221(1.92)
2002	65	223.458	196	84.5149	261(2.27)
2003	54	147.7213	274	94.01442	328(2.85)
2004	64	158.1963	299	92.70055	363(3.16)
2005	68	128.9944	405	96.36329	473(4.11)
2006	78	125.2004	481	96.83916	559(4.86)
2007	74	104.3993	562	99.4482	636(5.53)
2008	88	113.939	605	98.25165	693(6.02)
2009	101	107.6298	741	99.04301	842(7.32)
2010	61	62.26788	818	104.7327	879(7.64)
2011	104	84.52542	1000	101.9409	1104(9.60)
2012	91	65.26903	1160	104.3562	1251(10.88)
2013	85	53.55895	1339	105.825	1424(12.38)
2014	84	47.82403	1492	106.5443	1576(13.70)
Total	1282		10221		11503

G. Journal wise Distribution of Publications (Journals: 1505)

In this analysis 78 percentage of the preferred documents by Green Chemistry research scientists have journals publishing their investigations. In this analytical period, scientists have produced 8952 articles scattered over 1505 journals during 1991 to 2014. It is identified from the below table-7 the out of 1505 journals, "Green Chemistry" has published the highest number of articles 355 (4 %); 1870 TLCS, 12340 TGCS and 869 TLRC scaled. It dominates in first place of research output in the field of Green Chemistry. The journal of "Tetrahedron Letters" has 262 (2.93 %); 434 TLCS with 5206 TGCS and the 348 TLRC measured and occupies the second position. The journal of "Chemistry-A European Journal" has 162 (1.81 %) in third rank; 266 TLCS and 6119 TGCS with 174 TLRC are scaled and it stands in the third position of the publication output in Green Chemistry.

TABLE V COLLABORATIVE INDEX IN GREEN CHEMISTRY RESEARCH

Year	No. of articles	No. of authors	CI
1991	49	142	2.90
1992	53	157	2.96
1993	59	206	3.49
1994	51	151	2.96
1995	75	252	3.36
1996	81	240	2.96
1997	85	267	3.14
1998	109	320	2.94
1999	135	385	2.85
2000	196	593	3.03
2001	221	754	3.41
2002	261	803	3.08
2003	328	1376	4.20
2004	363	1291	3.56
2005	473	1712	3.62
2006	559	2054	3.67
2007	636	2353	3.70
2008	693	2698	3.89
2009	842	3282	3.90
2010	879	3741	4.26
2011	1104	4611	4.18
2012	1251	5278	4.22
2013	1424	6107	4.29
2014	1576	6994	4.44
Total	11503	45767	3.54

H. Country wise Research output on Green Chemistry

Totally 112 countries have contributed 11503 of publications with 20227 TLCS and 302544 global citation scores earned and shared publications of total output. The USA has the highest productivity and highest local and global citation scores measured and it stands first rank among 112 countries. USA has 2245 (19.52%) of output with 5231 Local citation and 79518 global citation scores measured. Next productivity country of Peoples R China has the highest publications 1300 (11.30%) of articles and it stands second

position with 1311 Local citation scores and 25757 global citation scores measured.

TABLE VI COLLABORATIVE COEFFICIENT (CC) OF AUTHORSHIP PATTERN

	Country	Single authors	More than one authors	Total	Collaborative Coefficient (CC)
1	USA	517	1728	2245	0.38
2	Peoples R China	47	1253	1300	0.48
3	India	54	857	911	0.47
4	Japan	94	465	559	0.41
5	Germany	62	492	554	0.44
6	France	45	435	480	0.45
7	England	98	368	466	0.39
8	Italy	36	375	411	0.45
9	Iran	21	383	404	0.47
10	Spain	14	346	360	0.48
11	Canada	35	307	342	0.44
12	Brazil	18	271	289	0.46
13	Australia	13	223	236	0.47
14	South Korea	3	193	196	0.49
15	Netherlands	17	142	159	0.44
16	Switzerland	26	119	145	0.41
17	Russia	17	117	134	0.43
18	Poland	30	98	128	0.38
19	Sweden	9	110	119	0.46
20	Portugal	13	96	109	0.44
21	Austria	5	101	106	0.47
22	Belgium	5	95	100	0.47
23	Turkey	13	85	98	0.43
24	Taiwan	3	84	87	0.48
25	Scotland	20	52	72	0.36
	Other countries	67	1426	1493	0.47
	Total	1282	10221	11503	0.44

TABLE VII JOURNAL WISE DISTRIBUTIONS OF PUBLICATIONS

S. No.	Journal	Recs	%	TLCS	TGCS	TLCR	Rank
1	Green Chemistry	355	3.96	1870	12340	869	1
2	Tetrahedron Letters	262	2.93	434	5206	348	2
3	Chemistry-A European Journal	162	1.81	266	6119	174	3
4	Journal of Chemical Education	158	1.76	382	946	372	4
5	RSC Advances	146	1.63	34	731	266	5
6	Advanced Synthesis & Catalysis	133	1.48	237	3723	215	6
7	Angewandte Chemie-International Edition	128	1.43	357	8185	103	7
8	SYNLETT	122	1.36	136	1825	109	8
9	Inorganic Chemistry	113	1.26	41	3008	31	9

10	Chemsuschem	112	1.25	128	2095	169	10
11	European Journal of Organic Chemistry	109	1.22	105	1720	130	11
12	Tetrahedron	107	1.19	151	2234	215	12
13	Pure and Applied Chemistry	102	1.14	255	1916	162	13
14	Journal of the American Chemical Society	99	1.10	172	6261	95	14
15	Synthetic Communications	98	1.09	53	702	105	15
16	Journal of Industrial and Engineering Chemistry	70	0.78	17	518	39	16
17	Synthesis-Stuttgart	69	0.77	60	1010	79	17
18	Green Chemistry Letters and Reviews	64	0.71	34	291	127	18
19	Journal of Organic Chemistry	63	0.70	160	2314	73	19
20	Journal of Molecular Catalysis A-Chemical	61	0.68	94	1679	109	20
21	ACS Sustainable Chemistry & Engineering	60	0.67	21	275	139	21
22	Chemical Communications	59	0.66	141	2862	82	22
23	Current Organic Chemistry	59	0.66	37	389	165	22
24	European Journal of Inorganic Chemistry	59	0.66	17	641	37	22
25	Quimica Nova	59	0.66	118	320	205	22
Total		2829	31.56	5320	67310	4418	319

TABLE VIII COUNTRY WISE RESEARCH OUTPUT OF GREEN CHEMISTRY

S. No.	Country	Recs	%	TLCS	TGCS	CR	NA	h-index
1	USA	2245	19.52	5231	79518	115784	10982	125
2	Peoples R China	1300	11.30	1311	25757	70582	7391	70
3	India	911	7.92	1064	15610	53187	3986	53
4	Japan	559	4.86	1232	19507	33092	2649	72
5	Germany	554	4.82	938	18154	39720	3190	63
6	France	480	4.17	745	14364	33577	2918	58
7	England	466	4.05	2650	21450	33751	3106	75
8	Italy	411	3.57	999	11266	27848	2451	50
9	Iran	404	3.51	709	6198	22345	1808	36
10	Spain	360	3.13	575	9907	26374	2167	46
11	Canada	342	2.97	711	8956	20733	1716	44
12	Brazil	289	2.51	468	4784	16109	1714	32
13	Australia	236	2.05	357	6000	12515	1138	40
14	South Korea	196	1.70	89	3330	10204	954	28
15	Netherlands	159	1.38	427	6405	10185	1250	43
16	Switzerland	145	1.26	170	3815	7486	611	30
17	Russia	134	1.16	90	1873	7298	621	22
18	Poland	128	1.11	273	2840	8661	546	30
19	Sweden	119	1.03	117	3887	6687	637	26
20	Portugal	109	0.95	221	3203	8948	636	26
21	Austria	106	0.92	174	2579	6737	594	25
22	Belgium	100	0.87	77	2318	5087	625	23
23	Turkey	98	0.85	59	1514	4454	381	16
24	Taiwan	87	0.76	74	1608	4877	395	21
25	Denmark	78	0.68	76	2565	4670	495	27

VII. MAJOR FINDINGS

Based on the analysis undertaken the present study, the following findings are drawn.

- The findings of research productivity in Green Chemistry has the highest publication as 1576 in the year 2014 with 5819 Global Citation Scores followed by 1424 papers in 2013 with 10178 Global Citation Score and 1251 papers in 2012 with 16806 Global Citation Scores. The overall growth of publication of Green Chemistry research output brings out the research paper published trend in increasing trend.
- The findings of authorship pattern of research output bring out the facts that the majority of the articles are contributed by multiple authors. Especially three authors' contribution is the highest among the other collaborative productivity. It indicates that the single authored work is less than that of the multiple authored contributions.
- The findings of top twenty five prolific authors by number of publications bring out the facts that the Author Mallakpour, S from Iran has published 64 research publications with the individual global citation scores of 956 with h-index of 19, Among the top 25 authors, Polshettiwar, V from USA has got the highest citations of 2073 with average cited per article as 110.11 and h-index of 17.
- The findings of Journal articles (8952) scattered over 1505 journals, the journal "Green Chemistry" has published the highest number of articles 355 (4 %);

1870 TLCS, 12340 TGCS and 869 TLCR scaled and it dominates in first place of research output, followed by “Tetrahedron Letters” has 262 (2.93 %); 434 TLCS with 5206 TGCS and the 348 TLCR measured and occupies the second position of the publication output in Green Chemistry.

5. The findings of country wise distribution analysis reveal the following fact that the USA with 2245 (19.52%) publications occupies the first place followed by China with 1300(11.30) records of research publications respectively. India occupies the 3rd position in the world in terms of publication. The country of USA with 79518 Global citations score got the first followed by Peoples R China secured second rank in terms of GCS with 25757. India occupies 3rd position with total publication of 911 records and Global citation score (15610) wise occupied in the 6th position.
6. The findings of Co-Authorship Index for single authors reveal that it has declined from 219.73 in the year 1991 to 47.82 in the year 2014. On the other hand, the Co-Authorship Index for Multiple authors is enhanced from 84.98 in the year 1991 to 106.54 in the year 2014, which indicates the pattern of co-authorship is increasing among the contributions of the journal.
7. The findings of Collaborative Index for universal level is 3.54 which show the popularity towards collaborative research pattern than single author research in chosen field of Green Chemistry.
8. The findings of overall productivity on Green Chemistry by American authors ranks the first position, the collaborative coefficient has been calculated at 0.38, which is below 0.50. The highest collaborative coefficient has been calculated for South Korea (0.49) followed by People R China, Spain and Taiwan with 0.48 and remaining country followed by India, Iran, Australia, Austria and Belgium with 0.47.

REFERENCES

- [1] Gupta. B.M. (2010). Mapping of science technology output of Brazil during 1997-2007. *Annals of Library and Information Studies*. 57(2). 150-165.

- [2] Ranganathan C & Balasubramani R. (2013). Mapping of Green Chemistry Research in India: A Scientometric Analysis. *Journal of Advances in Library and Information Science*, 2(4). 221-229.
- [3] Ranganathan. C. (2014). Mapping of Oceanography Research Productivity in India: A Scientometric Analysis. *Library Philosophy and Practice*. 12-23-2014. Paper 1205. Link: <http://digitalcommons.unl.edu/libphilprac/1205>.
- [4] Ranganathan C. (2014). Performance of Research Productivity on Digital Architecture based on Web of Science Database: a Scientometric analysis. *International Journal of Library and Information Studies*. 4(2), 140-151.
- [5] Ranganathan. C (2014). Growth and Development of Research Activities on Digital Architecture: A Scientometric Analysis. *Pearl: a Journal of Library and Information Science*. 8(4). 185-194.
- [6] Ranganathan C. (2014). Indian Scientists Contribution of Green Chemistry Research: A Scientometric Profile. *Library Progress (International)*. 34(2).113-128.
- [7] Gupta, HarKaur & AvinashKshitig. (2012). Dementia research in India: A scientometric analysis of research output during 2002-11. *Annals of Library and Information Studies*, 59(4). 280-288.
- [8] Jeyaraj, W. J. (2012). Scientometric Analysis of Library and Information Science Research Output in Asian Countries. *Indian Journal of Information Sources and Services*, 2(2), 55-60.
- [9] Jeyaraj, W. J., (2011). The Scientometric Evaluation of Research Output on Computer Communication, 1(1), 50-55.
- [10] Maheswaran, R. (2009). Bibliometric phenomenon of Tamil Publications in Sri Lanka in 2005. *Journal of the University Librarians Association of Sri Lanka*, 11(0). <https://doi.org/10.4038/jula.v11i0.321>
- [11] Maheswaran, R. (2016). Mapping of Agriculture Research Output in Sri Lanka : A Scientometric Analysis. *Indian Journal of Information Sources and Services*, 6(1), 43-46.
- [12] Maheswaran, R. (2017). Visualizing The Citation Patterns Of Quantum Cryptography Research Publications : A Study Using Citenet Explorer. *International Journal of Information Retrieval and Management*, 5(10), 7-9.
- [13] Pratheepan, T. (2013). Evaluating Scientific Contribution of the Sri Lankan Scientists in the Field of Environmental Science Based on the Science Citation Index Expanded (SCIE). *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.2253226>
- [14] R. Maheswaran. (2018). Yoga Research Output : A Scientometric study. *Indian Journal of Information Science and Services*, 12, 31-39.
- [15] R Maheswaran, R Balasubramani, S. K. (2016). SAARC Citation Index: A Proposal for the Tool and Measurement of Scholarly Communication. In *University Librarians' Association of Sri Lanka ICULA 2016* (pp. 85-89).
- [16] Srinivasa S. Ragavan, Surulinathi. M. Balasubramani, R & Neelakandan. B. Mapping of Harvard Business Review Publications. *SMART Journal of Business Management Studies*, 6(1). 59-66.