

SCIENTOMETRIC PROFILE OF RESEARCH ACTIVITIES ON GREEN ENERGY: AN INDIAN PERSPECTIVE

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ABSTRACT

The study examines Green Energy Research in India as revealed by the scholarly publication indexed in web of science (WoS) for a period of fifteen years from 1999 to 2013. It was seen that the analyses included research growth, author productivity, authorship pattern, Geographical distribution of the literature, citation analysis rank, global publications' share, citation impact, share of international collaborative papers and major collaborative partner countries and patterns of research communication in most productive journals. It also analyses the characteristics of most productive institutions, authors and high-cited papers.

KEYWORDS: Green Energy, Scientometric, Citation, India

INTRODUCTION

Green energy is closely associated with the concept of sustainable development introduced to the broad public in the report "Our Common Future" published in 1987 by the World Commission on Environment and Development chaired by Gro-Harlem Brundtland. The concept is defined in the report as: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The scientometric studies play a vital role in the process of information research. Scientometric studies have shown that all the pieces of published information do not have equal importance. Present study focuses attention on the growth of literature, authorship pattern, journal coverage, institutions involved in active research etc. Citation studies are recognized as an indicator of influence of published work on the scientific community. This study attempts to analysis the performance of Green Energy research output in terms of its content and coverage, growth rates, areas of research concentration, author productivity, and authorship pattern, journals and articles and other means of assisting the peer review procedure. Performance of research institutions in promotion of Green Energy research is also given due emphasis.

SCIENTOMETRICS

Scientometrics is "the study of the measurement of scientific and technological progress" (Garfield, 1979). Its origin is in the quantitative study of science policy research, or the science of science, which focuses on a wide variety of quantitative measurements, or indicators, of science at large.

OBJECTIVES OF THE STUDY

The main objective of this study is to examine the current status of Indian Green Energy, as reflected in the country research output during 1999–2013. The researcher has framed the following objectives for the purpose of present research.

- To examine the Year wise distribution of publications;
- To identify the Document wise distribution of publications output;
- To analyse the authorship pattern and examine the extent of research collaboration and ranking of authors based on publications output;
- To identify journal wise distribution of publications output;
- To assess the Institution wise research concentration;

METHODOLOGY

The present study aims at analysing the research output of Researchers in the field of Green Energy. The growth rates of output in terms of research productivity is analysed from 1999 to 2013. The authorship pattern and author productivity are examined to identify the pattern of research contribution in the field of Green Energy. The data has classified into Histcite Software. The data so retrieved were downloaded and later imported into a database management system for data cleaning and coding. In data cleaning, all duplicate records as well records pertaining to publication years not under the purview of our study, were eliminated.

DATA COLLECTION

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 May 2013. Publications data for 15 years from 1999 to 2013 were used for analyzing the growth and impact of Green Energy research.

DATA ANALYSIS

Growth of Publications and Citation Scores

The table 1 depicts the Green Energy research output in the Indian level. From the below table, we could clearly see that during the period 1999 - 2013 a total of 1105 publications were published. Table 1 shows that a chronological histogram of citations, demonstrating that citation frequency grew steadily from 1999; it reached a maximum GCS of 1439 in 2009 and LCS of 57 in 2009. The highest publication is 189 in 2012 with 170 Global Citation Scores followed by 166 papers in 2011 with 719 Global Citation Score and 123 papers in 2010 with 1241 Global Citation Scores. The lowest publication is 18 in 1999 with 83 Global Citation Scores. It shows that even minimum numbers of records were scored higher global citations. The study also reveals all these 1105 publications have 34493 cited references it shows that there is a healthy trend in citing reference is found among the Indian Scientists belongs to Green Energy.

Table 1: Shows Year Wise Distribution of Publication and Citation Scores

S.No	Year	No. of Papers	% of Papers	TLCS	TGCS
1	1999	18	1.6	4	83
2	2000	27	2.4	11	461
3	2001	27	2.4	13	1170
4	2002	22	2.0	14	329
5	2003	27	2.4	11	895
6	2004	38	3.4	19	964
7	2005	52	4.7	26	896
8	2006	46	4.2	26	767
9	2007	77	7.0	45	1295

Table 1: Contd.,

10	2008	88	8.0	34	1275
11	2009	116	10.5	57	1439
12	2010	123	11.1	49	1241
13	2011	166	15.0	41	719
14	2012	189	17.1	9	170
15	2013	89	8.1	1	13
Total		1105	100		

Document Wise Distribution of Publications

Table 2: Shows Document Wise Distribution of Publications

S.No	Document Type	Recs	Cum	%	%Cum	TLCS	TGCS
1	Article	1016	-	91.9	-	349	10076
2	Review	50	1066	4.5	96.47	8	1417
3	Article; Proceedings Paper	35	1101	3.2	99.63	3	220
4	Editorial Material	2	1103	0.2	99.81	0	1
5	Meeting Abstract	1	1104	0.1	99.90	0	0
6	Review; Book Chapter	1	1105	0.1	100	0	3
Total		1105		100		360	11717

A study of data in table 2 indicates the Document wise distribution of research output in Green Energy. This study has observed a total of 1105 publications in Green Energy during the period of fifteen years from 1999 to 2013. Out of various sources of publications in Green Chemistry, journal articles that appeared in the journals have shown a predominant contribution (91.9%) with Global citation score is 10076 and this source occupies the first position. The source of review comes second in order (4.5%) of sharing total research output in Green Energy during the period of analysis. The source of proceeding papers comes in the third position (3.2%) with respect to total output in Green Energy research during the study period.

Authorship Pattern

The authorship pattern in green energy literature reveals the following facts. The present study brings papers under analysis contributed by one author to ten authors. Table 3 indicates that the three author's papers rank first in order (27.76%), where as two authors papers obtain the second order of priority (25.70%) and four authors papers obtain the third order of priority (18.64%). The single author papers record the seventh order of priority (5.33%). The present study brings papers under analysis contributed by one author to ten authors. It is noticed that from four author papers to ten authors' papers, the trend in number of publications has reduced. It is noticed that from five authors to ten authors papers, the trend in number of publication has reduced.

Table 3: Shows Distribution of Authorship Pattern

Authorship Pattern	Publications	Cum. Output	%	Cum %
Single Author	59	59	5.33	5.33
Double Author	284	343	25.70	31.04
Three Authors	307	650	27.78	58.82
Four Authors	206	856	18.64	77.46
Five Authors	110	966	9.95	87.42
Six Authors	64	1030	5.79	93.21
Seven Authors	28	1058	2.53	95.74
Eight Authors	18	1076	1.62	97.37
Nine Authors	14	1090	1.26	98.64
Ten & above	15	1105	1.35	100
Total	1105		100	

Ranking of Authors Based on Publications

Table 4 indicates ranking of authors by number of publications. Authors “Rai SB” published highest number of articles for the study period with 29 records; next consecutive authors Kumar R. are published next highest number of articles for the study period with 23 records. Das Dhaving highest Global Citation Scores of 736 with just 6 publications followed by Mittal. Ahaving Global Citation Score of 389 with just 8 publications, while Kakani SL having lowest Global Citation Score of 7 with just 9 publications. Thus the most-cited authors are distinguished from the most-published ones. It is found from the analysis that Lotka’s law may not be applicable with regard to author productivity in proliferation of research in Green Energy as the research papers equally distributed by a large number of authors.

Table 4: Shows Ranking of Authors Productivity

S.No	Author	Recs	%	Cum	TLCS	TLCS/t	TLCSx	TGCS	TGCS/t	TLCR
1	Rai SB	29	2.6	-	15	2.53	4	269	53.84	12
2	Kumar R	23	2.1	52	15	2.96	4	147	26.52	7
3	Kumar A	18	1.6	70	2	0.31	1	112	17.95	4
4	Maiti SK	15	1.4	85	6	1.20	0	106	21.62	6
5	Buddhudu S	14	1.3	99	4	0.49	0	165	20.33	4
6	Kanoria M	14	1.3	113	18	3.27	0	61	11.70	20
7	Rout GC	14	1.3	127	10	1.46	0	41	7.38	10
8	Singh A	12	1.1	139	10	3.00	4	71	17.32	8
9	Tyagi AK	12	1.1	161	1	0.33	0	45	11.92	1
10	Ajay	11	1.0	172	5	0.57	0	21	1.95	5
11	Karmakar B	11	1.0	183	19	2.81	1	162	28.61	19
12	Ahmed J	10	0.9	193	26	2.03	9	229	19.44	16
13	Chowdhury S	10	0.9	203	27	7.67	0	203	58.67	36
14	Rai DK	10	0.9	213	8	1.20	2	134	22.25	3
15	Shivhare US	10	0.9	223	21	1.61	7	201	17.35	16
16	Yadav GD	10	0.9	233	4	0.92	0	68	11.85	4
17	Behera SN	9	0.8	242	8	1.11	0	28	4.40	4
18	Ghosh S	9	0.8	251	0	0.00	0	22	4.21	2
19	Kakani SL	9	0.8	260	4	0.70	0	7	1.23	4
20	Mukhopadhyay S	9	0.8	269	7	1.03	5	41	6.99	2
21	Das S	8	0.7	277	1	0.11	0	104	17.69	1
22	Dwivedi Y	8	0.7	285	4	0.98	0	55	12.55	4
23	Kumar S	8	0.7	293	1	0.20	1	48	10.70	0
24	Mittal A	8	0.7	301	21	3.08	12	389	64.35	11
25	Saha P	8	0.7	309	26	7.25	1	196	55.33	19

Journal Wise Distribution of Publications

The study found that the total research output of the Green Energy for the study period (1999 – 2013) published in 86 journals. As the major portion of the research productivity (27.8%) covered by 25 journals that is coincide with the theory of Bradford’s Law of scattering of journals in research productivity. Top ten produced mostly 15% of the research output. The journal “JOURNAL OF LUMINESCENCE” topped with 23 publications with the Global Citation Score of 249; next “SPECTROCHIMICA ACTA PART A-MOLECULAR AND BIOMOLECULAR SPECTROSCOPY” has 22 publications with the Global Citation Score of 116 and “JOURNAL OF APPLIED PHYSICS” with 19 publications with the Global Citation Score of 175 respectively. “JOURNAL OF HAZARDOUS MATERIALS” has scored the highest Global Citation Score of 825 with 17 publications while “INDIAN JOURNAL OF PHYSICS AND PROCEEDINGS OF THE INDIAN ASSOCIATION FOR THE CULTIVATION OF SCIENCE” has scored a Global Citation Score of 2 with just 5 records.

Table 5: Distribution of Green Energy in Journal Publications

S.No	Journal	Recs	%	TLCS	TLCS/t	TGCS	TGCS/t	TLCR
1	Journal of Buminescence	23	2.1	11	2.24	249	47.03	10
2	Spectrochimica Acta Part A-Molecular and Biomolecular Spectroscopy	22	2.0	5	0.85	116	20.63	19
3	Journal of Applied Physics	19	1.7	0	0.00	175	34.80	3
4	Indian Journal of Animal Sciences	18	1.6	1	0.07	15	1.25	4
5	Physica B-Condensed Matter	18	1.6	15	3.04	106	18.47	9
6	Journal of Hazardous Materials	17	1.5	26	3.99	825	136.26	5
7	Materials Letters	14	1.3	3	1.17	126	20.17	2
8	Journal of Alloys and Compounds	12	1.1	4	0.53	266	46.37	2
9	Colloids and surfaces B-biointerfaces	11	1.0	6	2.42	66	21.25	8
10	Indian Journal of Pure & Applied Physics	11	1.0	2	0.27	22	3.54	2
11	Materials Chemistry and Physics	11	1.0	10	1.85	283	36.86	2
12	Asian Journal of Chemistry	10	0.9	0	0.00	0	0.00	5
13	Asian-Australasian Journal of Animal Sciences	10	0.9	6	0.56	52	4.66	1
14	Digest Journal of Nanomaterials and Biostructures	10	0.9	11	2.35	99	22.43	3
15	Journal of Chemical Physics	10	0.9	1	0.08	107	11.46	1
16	Journal of Thermal Stresses	10	0.9	10	1.86	77	10.59	14
17	Optical Materials	10	0.9	9	1.69	123	17.17	4
18	Journal of Food Science and Technology-Mysore	9	0.8	2	0.13	16	2.57	0
19	Journal of Physical Chemistry C	9	0.8	3	0.50	222	39.57	0
20	Physica C-Superconductivity and its Applications	9	0.8	4	0.42	17	2.19	4
21	Renewable & Sustainable Energy Reviews	9	0.8	1	0.20	247	60.05	1
22	Solid State Communications	9	0.8	6	1.16	64	11.75	3
23	Current Science	8	0.7	1	0.20	44	6.80	1
24	Energy Conversion and Management	8	0.7	2	0.17	143	12.15	3
25	International Journal of Hydrogen Energy	8	0.7	3	0.30	772	67.22	2

Institution Wise Distribution of Publications

In general, institutions which are specifically meant for research activities would contribute a greater level of research publications and it is not up to the mark of desired level of expectations in other institutions. The below given table 6 analysis indicates Institution-wise research productivity. It is noted that 860 institutions were contributed 1105 of the total research productivity. It is noted that Central Green Energy Research Institute contributed the highest number of research publications (116) at the same time it ranks first in terms of Global Citation Score 2031.

Table 6: Institution Wise Distribution of Publications

S.No	Institution	Recs	Percent	TLCS	TGCS
1	Indian Inst Technol	116	10.5	38	2031
2	Banaras Hindu Univ	49	4.4	29	428
3	Indian Inst Sci	36	3.3	9	826
4	Bhabha Atom Res Ctr	34	3.1	5	140
5	Sri VenkateswaraUniv	33	3.0	10	277
6	Univ Delhi	27	2.4	7	224
7	CSIR	22	2.0	7	324
8	Saha Inst Nucl Phys	22	2.0	7	288
9	Indian Assoc Cultivat Sci	20	1.8	3	326
10	Univ Calcutta	20	1.8	18	80

Table 6: Contd.,

11	NatlPhys Lab	18	1.6	3	102
12	Anna Univ	17	1.5	3	585
13	NatlInstTechnol	17	1.5	9	161
14	GovindBallabh Pant Univ Agr & Technol	16	1.4	7	36
15	Univ Pune	16	1.4	4	87
16	Indian Vet Res Inst	15	1.4	1	35
17	Cent Glass & Ceram Res Inst	13	1.2	19	236
18	Jawaharlal Nehru Ctr Adv Sci Res	13	1.2	2	209
19	Narasinha Dutt Coll	13	1.2	6	84
20	Guru Nanak Dev Univ	12	1.1	25	179

FINDINGS

- The findings of Indian research productivity in Green Energy has the highest publication as 189 in the year 2012 with 170 Global Citation Scores followed by 166 papers in 2011 with 719 Global Citation Score and 88 papers in 2008 with 1275 Global Citation Scores. The lowest publication is 18 in 1999 with 83 Global Citation Scores.
- It is found that analysis contributed by one author to ten authors. It is noticed that from four author papers to ten authors' papers, the trend in number of publications has reduced. It is noticed that from five authors to ten authors papers, the trend in number of publication has reduced.
- The authorship pattern of Indian research productivity on Green Energy has identified that majority of papers are multi-authored. It is found from the analysis that Lotka's law may not be applicable with regard to author productivity in proliferation of research in Green Energy as the research papers equally distributed by a large number of authors.
- The findings of the Authors "Rai SB" published highest number of articles for the study period with 29 records, next consecutive authors Kumar R. are published next highest number of articles for the study period with 23 records. Das Dhaving highest Global Citation Scores of 736 with just 6 publications followed by Mittal. Ahaving Global Citation Score of 389 with just 8 publications, while Kakani SL having lowest Global Citation Score of 7 with just 9 publications. Thus the most-cited authors are distinguished from the most-published ones.
- The study found that the total research output of the Green Energy for the study period (1999 – 2013) published in 86 journals. As the major portion of the research productivity (27.8%) covered by 25 journals that is coincide with the theory of Bradford's Law of scattering of journals in research productivity.

CONCLUSIONS

It concluded quantitatively the contributions made by the Indian researchers during 1999-2013 as reflected in Web of Science database. During 15 years period (1999 –2013) Indian contributions in terms of number of publications is significant. A comparison of Indian output in relation to the world output may help in understanding the contribution in a better angle. Though the records available in the Web of Science database reveal a small number, it is important that the Web of Science covers only the peer-reviewed journals. If a broader coverage database is available, it may provide a reasonable number of papers. Researcher suggest for tracking citation record of papers so that the impact of publications in Green Energy may be visible.

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