

## Citation Analysis of Environmental Science Research in India

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**Abstract:** There is a close relationship between population, development and the environment. The Environmental Science research is getting tremendous importance due to its adverse effects on society. The elements causing the environmental problem such as the growth of population and the developmental issues like the industrial revolution, land use pattern, use of fertilizer and pesticides in agriculture and the generation of nuclear power has elaborated with statistics. It seems to be the environmental problem is the major problem, and it is going to increase its seriousness in future. But all those factors providing a boost for research on the subject of environmental science. The growing literature creates the problem of filtration of the desired items based on the quality. The citation analysis is the effective and popular technique used to evaluate, assess, compare and to rank the document based on the quality. The citation is a metric used to evaluate and categorize the documents. The SCOPUS online database has retrieved 51382 records for the subject of environmental science research in India during 1999-2013. The citation related indicators, such as citation rate, records without citation, average citations per paper, top cited publications and their source titles, citation frequency, have presented in the research paper. The above indicators should be able to convey the used records, unused records, heavily used records and source titles. Application of Bradford's Law of Scattering has used to categorize the journals based on the citations. The list of core journals will be the output of the law. At the end of the research paper, the findings have listed. Assessment of the document based on the citations would provide maximum information at a minimum cost.

Keywords: (i) Citation Analysis (ii) Environmental Science Research (iii) India

**Introduction:** The environmental problem is the global challenging issue in the 21<sup>st</sup> century; it has linkage with other issues like population and development. The subject is an interdisciplinary in nature because, the population being a human branch, environment being a physical or natural branch and development is an outcome of the interaction of the above two. Increasing population required more goods and services, to create more goods and services, technological development is an essential factor. Excessive utilization and the consumption of resources is a part of the development. The development develops the problem of the depletion of resources; resulted ecological imbalance is also called environmental problem. While human populations remained small and human technology modest, their impact on the environment was localized. As population increased and technology improved and expanded, however, more significant and widespread problem arose. Rapid technological advances after the middle ages culminated in the industrial revolution, which involved the discovery, use, and exploitation of fossil fuels, as well as the extensive exploitation of the earth's mineral resources. With the Industrial Revolution, human began in the earnest to change the face of the Earth, the nature of its atmosphere, and the quality of its water. Today, unprecedented demands on the environment from a rapidly expanding human

population and advancing technology are causing a continuing and accelerating decline in the quality of the environment and its ability to sustain life.

### 1. Need for the study

**1.1 Population of India:** India is ranking at 2<sup>nd</sup> position in term of the population in the world after China. After the independence of India, the first census has conducted in the year 1951 and after 1951, it has continued at the interval of ten years, the latest census held in 2011. The annual average annual exponential growth rate shows that in 1951 it has observed 1.25 percent, in 1961, it has increased to 1.96 percent in 1971 further increased to 2.20 percent and in the year 1981; it has 2.22 percent. During the 20<sup>th</sup> century the growth of 2.22 percent has the highest and from the year 1991 it has started decreasing to 2.14 percent, in 2001 further decreased to 1.95 percent and according to the latest Census of India 2011, the growth rate indicates 1.64 percent. The statistics trends of the Indian population growth rate indicate the decreasing but actual population has increased, in the year 1951, the Indian population was 361,088,090 the absolute increase than the previous decade was 42,427,510 people in the year 1961 the population was 439,234,771 the addition in term of absolute was 78,146,681 people. In the year 1971, the population was 548,159,652 and the volume of absolute addition was 108,924,881

people. In the year 1981, the population was 683,329,097 and the absolute figure has added to 135,169,445 people. In the year 1991 Census figure was 846,387,888 and the absolute figure was 163,058,791 people. In the year 2001, the population was 1,027,015,247 and the absolute figure was 180,627,359 people. In this way, the population density of India after independence has increased decade by decade during 1951-2011.

**1.2 Industrial Growth in India:** Industrial growth is an important part of the development process of the country. It provides employment opportunities; demand for raw material and at the national level it helps to increase the Gross National Product. According to the Annual Survey of India 2000-2012, it has observed that during last 13 years, numbers of factories have increased more than 60 percent than the base year 2000. During the same period, fuel consumption has increased 400 percent, and the material consumption has increased by more than 660 percent.

**1.3 Land Use Pattern in India:** Land has considered as an important natural resource, the land use pattern in India during 1998-2012 data shows that the geographical area of 328726 hectares remained same but as the population grows the utilization of land for various purposes has increased. According to Government of India, Ministry of Statistics and Program Implementation, the reporting area for land utilization statistics, 833 thousand hectares land has increased during 1998-2012. For the forest, 801 thousand hectares have increased whereas about 3000 hectares have added in the category of non-agriculture uses. About 315 thousand hectares of land decreased from the barren and un-cultured land, it means, the above land has converted for utilizing purpose and if we started consuming the land in this speed, the day will come we would not be able to convert any land for the utilization purpose.

**1.4 Consumption of fertilizers and pesticides for agriculture in India:** To provide food for the growing population, consumption of pesticides and fertilizers for agriculture has observed as one of the effective methods. According to RBI Report, in 1998-99, the consumption of fertilizer (Nitrogen, Phosphorus & Potassium) was 180.7 lakh tons, and 4,62,000 tons pesticides (technical grade material) have used for the agricultural crop production. In 2011-12 it has increased by 23 percent (277 lakh tons) fertilizers (NPK). The pesticide is concerned 4,38,000 tons of pesticides have used in 2008-09 (latest data).

**1.5 Nuclear power capacities and the requirement of India:** There are eight active atomic power stations in India, and one more has proposed to start at Jaitapur (Ramana, 2007). In 2000, India had power generation capacity of 2720 MW and in 2007 it increased to 3310 MW, which was less than three percent of total power. It has expected to generate the power of 14,600 MW in

2020 and further in 2050 proposed to supply 25 percent of the total power required for India. The above statement shows that there is a huge demand for the nuclear power in India. The nuclear power generation effect on (fresh & sea) water, aquatic life, flora & fauna through food chain will cost us by environmental degradation.

**2. Research Problem:** As society develops, increase the research, resulted in increasing literature which is known as 'Information Explosion.' The explosion scattered over thousands of periodicals and other sources. The factors such as, growing population, industrial revolution, land utilization pattern, consumption of fertilizer and pesticides and increasing nuclear power requirements have created the environmental problem and provided the platform for research. As a result, the publications in environmental science in India have observed as an increasing trend during 1999-2013 (except 2002). During the study period, 51382 records have published and about 60 percent of them have received 389064 citations. Rapidly growing literature creates the problem of appropriate selection of required literature for the libraries and also for the researchers. No library or an individual can afford to procure the entire collection for its potential readers due to the limited resources. But to filter it citation count (citation analysis) provides 'comparative importance of reading material' is the technique useful for the libraries. The information scattered in various source titles, the 'Bradford's Law of Scattering' is capable of identifying the core journals from the thousands of journals.

### 3. Objectives of the Research:

1. To present the year-wise citation rate (CR) during 1999-2013
2. To find out the records with and without citations
3. To present the Average Citations Per Paper (ACPP)
4. To present the top cited publications and their source titles
5. To analyze the citation frequency distribution
6. To apply the Bradford's Law of Scattering

**4. Research Methodology:** The data source: SCOPUS online database has used. The citation option has selected, downloaded and used for the analysis. The duration of 1999-2013 has considered for data collection, and the Micro Soft Excel has used as a tool.

**5. Literature Review:** Since last twenty-five years, no exhaustive study in environmental science research in India has performed. Karki (1990) has analyzed selected core areas of environmental science in India including citations. (Bertrand and Cote (2006) have analyzed Canadian research output in environmental science published during 1980-2004. They have presented the data on two levels, (i) global and (ii) country (Canada). At the

world level, the records, growth, ranking of top countries and ranking position of Canada in the world have presented. Bathrinarayan and Tamizhelvan (2013) Have performed as a scientometric study on Micro-Electro-Mechanical Systems (MEMS) as it is one of the promising technologies in the 21st century. They also covered authorship pattern, relative growth rate, doubling time, citation analysis. The scientometric study in material science by Kademani et al., (2013) has analyzed at a global level based on WoS data for the period of 2006 – 2010. The authors have covered, continent-wise and country-wise growth and distribution of publications and citations. The research has extended to the domain-wise distribution of publications and citations. They also have applied Bradford's Law in the paper. Scientometric analysis of Pakistan's S & T research output has presented by Gupta (2012) taking into consideration of the citations, highly productive institutions, authors, and highly cited papers. Joshiet al. (2010) have analyzed publications and the citations of global forest fungal research. They have included the citation pattern; the highly cited papers; the citation impact of different countries and the prolific institutions in the research. The scientometric study on laser research in India has performed by Garg and Padhi (2002) for the duration of 1974-1994. They have compared Indian research with the world research. The citation frequency, highly cited papers, highly productive institutions in India, prolific authors have identified in the study. Scientometric analysis of transport phenomenon literature has performed by Tsay and Lin, (2009). They have analyzed the growth of literature, and the citations and most cited journals, most cited articles have presented. The Institute level scientometric study in India in physics has performed by Gupta and Dhawan (2008), the Impact Factors, citations and collaborative research output of Highly Productive Institutes have analyzed. Kademani et al. (2005) have performed the scientometric study of Chemistry Division of BARC. The study has focused on, finding out year-wise; domain-wise

publication productivity; domain-wise authorship and collaboration pattern; verified Lotka's Law and Bradford's Law. Gross and Gross (1927) have performed research to identify core scientific journals, based on citations in Chemistry. According to Mukherjee, (1976) information explosion scattered over thousands of periodicals and other sources. The Bradford's Law of Scattering' is capable of identifying the core journals, and he presented in his study. Moed (2010) has presented a paper on SNIP, it measures a journal's contextual citation impact, taking into account characteristics of its subject field, the frequency at which authors cite other papers in their reference lists, the rapidity of maturity of citation impact, and the extent to which the database used for the assessment covers the field's literature. The exhaustive study on citation related presented Colledge, Lisa et al. (2010) 'SJR and SNIP are the two new metrics discovered by the ELSEVIER Research Group is more effective for the measurement of journal quality, and it's topicality. The SJR considered the prestige i.e. the journal received citations, the measurement of citations based on quality, reputation, and the subject have a direct effect on citations, it gives to another journal including the self-citations. Garfield (2005) has sorted the top journals by some articles in 2004; most cited life science journals in 2004; top journals sorted by impact factor; most cited articles in ISI WoS 1945 July to 2005; citation frequency distribution 1900 – 2005; Journal Performance Index for Citation Impact. The article provides various methods and techniques to calculate journal impact factor.

**5. Analysis of Data:** The SCOPUS online database has retrieved 51,382 records, out of it 31,867 (57.98 percent) received 3,89,064 citations on environmental science research in India during 1999-2013. And the 19515 records (37.98 percent) have not cited. The Average Citation Per Paper (ACPP) 7.57 has measured. There is a possibility to mislead the actual numbers to compare or ranking; hence, instead of actual figures, hence the rates, percent, and average have presented.

**Table 1: Year-wise Records, Citations & Citation Related Indicators**

Year	Records	Citations	Cited R	NCR	PNC	CR	ACPP
1999	1446	12744	951	495	34.23	0.65	8.81
2000	1611	16297	1113	498	30.91	0.69	10.11
2001	1895	20282	1244	651	34.35	0.65	10.7
2002	1791	19831	1212	579	32.32	0.67	11.07
2003	2137	25197	1494	643	30.08	0.69	11.79
2004	2120	25041	1432	688	32.45	0.67	11.81
2005	2640	30284	1799	841	31.85	0.68	11.47
2006	2851	33900	1936	915	32.09	0.67	11.89
2007	3427	36233	2263	1164	33.96	0.66	10.57
2008	3694	35297	2517	1177	31.86	0.68	9.55

Year	Records	Citations	Cited R	NCR	PNC	CR	ACPP
2009	4624	42350	3172	1452	31.4	0.68	9.15
2010	5185	32779	3303	1882	36.29	0.63	6.32
2011	5616	28581	3462	2154	38.35	0.61	5.08
2012	5863	19725	3358	2505	42.72	0.57	3.36
2013	6482	10523	2611	3871	59.71	0.41	1.62
Total	51382	389064	31867	19515	37.98	0.62	7.57

Cited R = Cited Records

NCR = Not Cited Records

PNC = Percentage of Not Cited Records

CR = Citation Rate

**5.1 Citation Rate (CR):** The CR is one of the important indicators used to indicate the quality of the record. The average CR during 1999-2013 has observed the 0.62. The highest has observed 0.69 during 2000 and 2003, followed by 0.68 during 2005, 2008 and 2009. Followed by the 0.67 during 2002, 2004 and 2006. Further, it has reduced to 0.66 in 2007, 0.65 in 1999 and 2001 followed by 0.63 in 2010. During 1999-2010, the CR has observed above average and during 2011-2013 it has decreased to 0.61; 0.57 and 0.41 respectively and during 2011-2013, the CR has observed as below average.

Formula used for CR =  $\frac{\text{Number of papers received at least one citation}}{\text{Number of papers published}}$

**5.2 Percentage of Not cited records (PNC):** Most of the ranking analysis has started from highest to lowest, the PNC starting from highest will be the starting with negative to positive, so the analysis of PNC has started with lowest to the highest. The lowest PNC 30.08 has observed in 2003, followed by PNC 30.91 in 2000, PNC 31.4 in 2009, PNC 31.85 in 2005, PNC 31.86 in 2008, PNC 32.09 in 2006, PNC 32.32 in 2009, PNC 32.45 in 2004, PNC 33.96 in 2007, PNC 34.23 in 1999, PNC 34.35 in 2001, PNC 36.29 in 2010, PNC 38.35 in 2010, PNC 42.72 in 2012 and the highest PNC observed 59.71 in 2013. It has observed that PNC goes on increasing from the past to present.

$$\text{PNC} = \frac{\text{Number of papers published} - \text{number of papers received at least one citation}}{\text{Total number of papers published}} * 100$$

**5.3 Average Citations Per Paper (ACPP):** provides more clarity regarding the quality of the literature as a group. The highest ACPP observed 11.89 in 2006; followed by 11.79 in 2003 and 11.47, in 2005. For rest of the years, the ACPP have arranged in decreasing order and presented as, the ACPP 11.07 has observed in 2002, the 10.07 in 2001, the 10.57 in 2007, the 10.11 in 2000, the 9.55 in 2008, the 9.15 in 2009, the 8.81 in 1999, the 6.32 in 2010. During the last three years of the study period 2011-2013 the ACPP has observed 5.08; 3.36 and 1.62 respectively, and for the entire period, it has 7.5 percent. From the above data, it has observed that for the years 1999-2009 the ACPP have above average and during 2010-2013 it has below average.

Formula used for ACPP =  $\frac{\text{citations}}{\text{Records}}$

**5.4 Highly Cited Publications:** The number of citations of a publication indicates the importance of that particular publication in the scientific community. The most cited 21 publications have listed in Table 2 with other relevant information. It contains the name of the author, year of publication, the source title, volume and issue number, the citations, and country.

**Table 2: List of top cited publications in environmental science in India received > 300 citations**

Sr. No.	Authors	Year	Source title	Vol.	Issue	Cited	Country
1	Mohan D., +(1)	2007	Journal of Hazardous Materials	142	1-2	926	ND
2	Lambin E.F., +(25)	2001	Global Environmental Change	11	4	893	UK
3	Parida A.K., +(1)	2005	Ecotoxicology and Environmental Safety	60	3	792	US
4	Gupta V.K., +(1)	2009	Journal of Environmental Management	90	8	769	US
5	Gogate P.R., +(1)	2004	Advances in Environmental Research	8	3-4	729	
6	Shanker A.K., +(3)	2005	Environment International	31	5	515	UK
7	Mohan D., +(1)	2006	Journal of Hazardous Materials	137	2	488	ND
8	Haritash A.K., +(1)	2009	Journal of Hazardous Materials	169	1-3	472	ND
9	Gogate P.R., +(1)	2004	Advances in Environmental Research	8	3-4	444	
10	Pandey S.	2006	Analytica Chimica Acta	556	1	439	ND
11	Achten W.M.J., +(6)	2008	Biomass and Bio-energy	32	12	428	UK

12	Ahluwalia S.S., +(1)	2007	Bioresource Technology	98	12	420	UK
13	Chowdhury U.K., +(1)	2000	Environmental Health Perspectives	108	5	402	US
14	Dinda S.	2004	Ecological Economics	49	4	397	ND
15	Shukla A., +(4)	2002	Journal of Hazardous Materials	95	1-2	373	ND
16	Selvam P., +(2)	2001	Industrial and Engineering Chemistry Research	40	15	348	
17	Madhavan Nampoothi K., +(2)	2010	Bio-resource Technology	101	22	339	UK
18	Gupta V.K., +(3)	2009	Critical Reviews in Environmental Science and Technology	39	10	334	UK
19	Widmer R., +(4)	2005	Environmental Impact Assessment Review	25	Sp. Iss.	331	US
20	Chakrabarti S., +(1)	2004	Journal of Hazardous Materials	112	3	324	ND
21	Sivaraj R., +(2)	2001	Waste Management	21	1	318	UK

ND = Netherlands, UK = United Kingdom, US = The United States, + ( ) indicates no. of additional authors

Based on the data presented in Table 2, D. Mohan, and C.U. Pittman Junior have jointly received the highest number of citations (926) for their publication 'Arsenic removal from water/wastewater using adsorbents' published in Journal of Hazardous Materials Vol. 142 (1-2), 2007. The second highest receiving record has observed causes of land use and land cover change: moving beyond the myths by E.F. Lumbin along with other 25 co-authors published in Global Environmental Change Vol. 11 (4), 2001, it has received 893 citations. Authors A.K. Parida, and A.B. Das have published, Salt tolerance and salinity effects on plants: A review received 792 citations published in Ecotoxicology and Environmental Safety Vol. 60 (3), 2005 ranked at the third position. Followed by V.K. Gupta and Suhas with 769 citations for their record, Application of low-cost adsorbents for dye removal – A review, published in Journal of Environmental Management Vol. 90 (8), 2009. The P.R. Gogate and A.B. Pandit have contributed, A review of imperative technologies for wastewater treatment I; in the journal, Advances in Environmental Research Vol. 8 (3-4), 2004, ranking at fifth position with 729 citations. The Environmental International Vol. 31 (5), 2005 has contained an article, Chromium toxicity in plants by A.K. Shanker and others received 515 citations, ranked at sixth position. Followed by Removal and recovery of metal ions from acid mine drainage using lignite a low-cost sorbent appeared in Journal of Hazardous Management 137 (3), 2006 holding the seventh rank with 488 citations. The A.K. Haritash and C.P. Kaushik have ranked at the eighth position with 472 citations for their article, bio-degradation of aspects of polycyclic aromatic hydrocarbons: a review, in Journal of Hazardous Materials Vol. 169 (1-3), 2009. The P.R. Gogate and A.B. Pandit have re-appeared at the ninth rank for their article, imperative technologies for wastewater treatment II published

in Advances in Environmental Research Vol. 8 (3-4) with 444 citations. Followed by S. Pandey with 439 citations for his article, analytical applications of room-temperature ionic liquids published in Analytica Chimica Acta Vol. 556 (1), 2006 at the tenth ranking position. The W.M.J. Achten and others have published an article, Jatropa bio-diesel production, and use, in 2008 by Biomass and Bio-energy Vol. 32 (12) for which they have received 428 citations and holding the eleventh ranking position. Followed by S.S. Ahluwalia and D. Goyal for their article, Microbial and plant derived biomass for removal of heavy metals from wastewater published in Bio-resource Technology Vol. 98 (12), 2007 received the 320 citations. At the thirteenth rank, U.K. Chowdhury and others have contributed, groundwater arsenic contamination in Bangladesh and West Bengal; India published in Environmental Health Perspectives Vol. 108 (5), 2000 with 402 citations. Environmental Kuznets curve hypothesis: A survey has contributed by S. Dinda in Ecological Economics Vol. 50 (3-4), 2004 received 397 citations and holding the 14<sup>th</sup> ranking position. A. Shukla and others have contributed, the role of sawdust in the removal of unwanted materials from the water published by Journal of Hazardous Materials Vol. 95 (1-2), 2002, received 373 citations and holding the 15<sup>th</sup> rank. The 16<sup>th</sup> position has held by P. Selvam and others for their article, recent advances in processing and characterization of periodic mesoporous MCM-41 silicate molecular sieves published in Industrial and Engineering Chemistry Research Vol. 40 (15), 2001 and received 348 citations. Nampoothiri K. Madhavan, N.R. Nair, and R.P. John have jointly contributed an overview of the recent developments in polylactide research, and they have received 339 citations published in Bio-resource Technology Vol. 101 (22), 2010. Followed by V.K. Gupta and others (ranking at the 19<sup>th</sup> position) have contributed, low-cost

adsorbents: growing approach to wastewater treatment a review published in Critical Review in Environmental Science and Technology Vol. 39 (10), 2009 received 334 citations. Widmer, R. et al. have contributed, global perspective on e-waste published in Environmental Impact Assess Review Vol. 25 (5) 2005 and holding anineteenth ranking position with 331 citations. S. Chakraborty and his co-authors have contributed, Photocatalytic degradation of model textile dyes in wastewater using ZnO as semiconductor catalyst Published in Journal of Hazardous Materials Vol. 112 (3), 2004. They have received 324 citations and ranking at the twentieth position. At the 21<sup>st</sup> position, R. Sivaraj and others have received 318 citations for their work, orange peel as an adsorbent in the removal of acid violet 17 from aqueous solution, published in Waste Management Vol. 21 (1), 2001.

From Table 2 it has observed that out of 21 top publications, three authors have appeared twice on the table. The author of the top most cited publication, D. Mohan has also held the seventh rank on the list. V.K. Gupta has appeared twice; at fourth and eighteenth rank. In the most cited publications, P.R. Gogate holds the fifth and ninth rank. The year wise distribution of top cited publications has, in 2000 one publication, in 2001 three publications, in 2002, one publication, in 2004 four publications, in 2005 three publications, in 2006 and 2007 two publications each, in 2008 one publication, in 2009 three publications and

2010 one publication. It has also observed the effect of co-authorship on number of citations in top cited publications. The two publications among top by a single author, nine publications contributed by two authors, three publications of three authors, two publications of four and five authors, one by fourteen authors and other by twenty-six authors. The highest citation publication has observed the two authored publication, published in 2007.

Among the 21 top cited publications, five have published by Journal of Hazardous Materials (highest cited publication has observed in the above journal), followed by Advances in Environmental Research and Bio-resource Technology with two publications each. The remaining publications have observed indifferent source titles. In the top cited publications, seven publications from each have published from the Netherlands and the United Kingdom. From the Bradford's Law of Scattering fifteen source titles have identified as core journals in one hand and highly cited 21 publications on other. It has also observed that only two source titles of core journals have included in highly cited publications as (1) Journal of Hazardous Materials (appeared five times) and (2) Bio-resource Technology (appeared twice).

**5.5 Citation Frequency Distribution:** The year-wise number of records received citations on the interval scale of measurement.

**Table 3: Citation Frequency Distribution in Environmental Science in India**

Citations	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	99-13	%
> 900	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0.001
>850 <899	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.001
>800 <849	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>750 <799	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	2	0.003
>700 <749	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0.001
>650 <699	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>600 <649	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>550 <599	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>500 <549	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0.001
>450 <499	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	2	0.003
>400 <449	0	1	0	0	0	1	0	1	1	1	0	0	0	0	0	5	0.009
>350 <399	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	2	0.003
>300 <349	0	0	2	0	0	1	1	0	0	0	1	1	0	0	0	6	0.01
>250 <299	1	0	1	1	2	2	1	1	2	0	1	0	0	1	0	13	0.02
>200 <249	1	2	4	3	7	6	6	4	2	2	3	0	1	0	0	41	0.07
>150 <199	3	2	4	9	4	7	5	12	7	7	2	1	2	0	0	65	0.12
>100 <149	6	17	18	16	14	13	14	20	22	13	15	8	3	1	0	180	0.35
>76 <99	9	17	14	13	19	10	23	34	32	26	26	13	8	2	0	246	0.47
> 51 <75	29	42	41	44	63	60	67	74	75	64	73	43	17	7	5	704	1.37
> 26 <50	82	94	114	113	174	157	200	226	238	267	305	226	135	68	15	2414	4.69
>15 <25	110	119	154	161	222	193	248	271	312	335	417	364	320	189	52	3467	6.74

Citations	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	99-13	%
>10 <14	106	133	135	118	178	151	177	208	277	350	422	361	428	269	109	3422	6.65
>5 <9	210	200	223	266	252	252	321	358	454	513	669	751	855	809	297	6430	12.51
>2 <4	245	294	325	279	329	350	450	422	482	555	752	902	1004	1180	1170	8739	17
1	149	192	208	188	230	227	284	304	358	384	484	633	689	832	963	6125	11.92
0	495	498	651	579	643	688	841	915	1164	1177	1452	1882	2154	2505	3871	19515	37.98
Total	1446	1611	1895	1791	2137	2120	2640	2851	3427	3694	4624	5185	5616	5863	6482	51382	100

In the category of zero (0) citation means not cited records, have found 19515 (37.98 percent) highest among all the categories. The 6125 (11.98 percent) records have received one citation each; the 8739 (17 percent) records have received the citations between the range of 2-4 citations, in the above category the highest number of citations have received. In the range of citations 5-9, the 6430 (12.51 percent) records have observed, followed by 3422 (6.65 percent) records received the citation between the ranges of 10-14. For the range of the citations 15-25, the 3467 (6.74 percent) records have found. For the range of 26-50 citations 2414 (4.69 percent) records have categorized. The next category of 51-75 citations has observed 704 records (1.37 percent). A unique (the only) category of 24 numbers has created round off the figure i.e. 76-99 citations and in this category 246 (0.47 percent) records have observed.

Table 3 indicates that between the range of 0 to 25 citations, five different groups have made as, a group of records received 0 citations, one citation, 2-4 citations, 5-9, 10-14, 15-25 as a number of citation increased the number of units in a group increase. But even then the numbers of records have observed continuously decreasing as the analysis move to wider ranges. Hence, for analysis purpose, a group of 25 citations has used up to the 75 citations and a single group of 24 citations has made i.e. 76-99. After that the ranges have taken for 50 citations consistently up to > 900 citations, because the highest number of citations have received (for a record) in the range of >900, so the last category has created for analysis of the records receive > 900 citations. Accordingly, the following categories and the citations have analyzed. In the category of ranges of citations between 100-149 has found 182 (0.35 percent) records. In the category of ranges between 150-199 citations have observed 63 (0.12 percent) records, followed by the category of the ranges 200-249 citations, 41 (0.07 percent) records have found. For the range of 250-299 the 13 records (0.02 percent) have observed. Followed by the next five categories of 300-349 citations, 350-399 citations, 400-449 citations, 450-499 citations, 500-549 citations, and for the above five categories, the total 16 records have found. Between the ranges of 550 to > 900 citations, eight categories, and four records have found them. The top most categories for receiving the citations have the range of >2 to <4, it has measured 17.31 percent; followed by the

categories of the records which received the citations between the range of >5 <9, counts 12.98 percent.

It has observed that about 48 percent of the cited records have received the citations in the ranges of 1-4. About 49 percent of cited records have received the citations in the ranges of 5-50 and rest is about 1 percent records have received 51 > 900 citations.

**5.6 Application of Bradford's Law:** Journals act as well established and effective communication media for the exchange of ideas and transmission of current information. Most of the new discoveries and the ideas first appear in journals. As a result selection, preservation and organization of the journals in the library are the professional activity. Ever increasing subscription rates of the journals and an increasing number of journals creates the problem to the library professionals to provide appropriate reading material to the clientele. Copy Right Act protects the author's intellectual property and restricts from copying. Generally, to handle this type of situation, the Bradford's law provide a guideline to the library professionals and also to the subject experts in determining the number and list of core journals in any given field.

**Bradford's Law of Scattering:** This has first observed by Samuel Clement Bradford in 1934 in his article 'sources of information.' He formulated the law known as 'Law of Scattering' based on a bibliography on geophysics. He has covered 326 journals for the study, in the first zone identified nine journals for 429 articles, 59 journals categorized in the second zone contained 499 articles and third zone identified with 258 journals contained 404 articles. Bradford stated that nine journals contained one-third of articles, five times 9 to produce next one-third articles and five times 9 or 225 journals for last one-third articles. The statement is statistically not accurate, but this law is common for identifying core journals for any subject. In Bradford's example, he has used to construct the law, "If scientific journals have arranged in order of decreasing productivity of articles on a given subject, they may be divided into a nucleus of periodicals more particularly devoted to subject and several groups or zones containing the same number of articles as the nucleus, when the zones will be 1:n:n2 . . ."

**Table 4: Distribution of Journals as per Bradford's Law on environmental science in India**

Zone	No. of Journals (observed)	No. of Journals (expected)	No. of Records
A	15	15	15139
B	66	60	14666
C	947	264	14340
Total	1028	339	44145

Based on the citations, 1028 journals have found in the SCOPUS database published the records in environmental science in India. All those journals have contained 44145 articles. All the journals have arranged based on the volume of articles (H-L). The Number of articles has divided into three equal groups. Selected the journals contained the first group of (1/3rd) articles and called as zone A. The above list has minimum number journals contained a maximum number of articles in environmental science in India published during 1999-2013. The above list of the 15 journals contained 15139 articles, has called a core collection of environmental science in India. The next 1/3<sup>rd</sup> number of articles have measured from the list of (1028-15) 1013 journals. The above group of journal measuring 66 contained 14666 articles categorized in zone B. The last group of (1013-66) 947 journals contained about 1/3rd (14349) articles have categorized in zone C.

#### Core journals of environmental science in India:

The list of journals contained in zone A (15) measuring one-third number of total records (14570). The seven important indicators for each journal has given in the table such as articles, SJR,

h-index, SNIP, IPP and the country of the publication.

The output of Bradford's Law of Scattering has presented in Table 5. The highest number of articles (1870) have contained by the journal, Pollution Research. The other indicators of the above journal have observed, SJR 0.117; h-index 18; SNIP 0.121 and IPP has 0.49, and it has published from India. Followed by Indian Journal of Environmental Protection, contained 1757 articles; its SJR 0.204, h-index 12; SNIP 0.285 and IPP has 0.123. At the third position, Ecology, Environment, and Conservation have listed with 1565 articles, having SJR 0.141; h-index 9, SNIP 0.184 and IPP has 0.053. At the fourth position, Colourage has with 1247 articles, SJR 0.191 and 15 has the h-index. At the fifth position, Journal of Environmental Biology contained 1154 articles, having SJR 0.342 with 24 h-index; SNIP 0.921, and IPP has observed 0.840. At the sixth position, Journal of Hazardous Materials contained 1020 articles having 1.868 SJR with h-index 127; SNIP 2.411 and IPP has 4.786. The above journal has published from Netherlands.

**Table 5 List of Core Journals, Articles, SJR, h-index, SNIP, IPP and the Country**

Sr.No	Source Title	Articles	SJR	h-index	SNIP	IPP	Country
1.	Pollution Research	1870	0.117	18	0.121	0.049	India
2.	Indian Journal of Environmental Protection	1757	0.204	12	0.285	0.123	India
3.	Ecology, Environment and Conservation	1565	0.141	9	0.184	0.053	India
4.	Colourage	1247	0.191	15	-----	-----	India
5.	Journal of Environmental Biology	1154	0.342	24	0.921	0.840	India
6.	Journal of Hazardous Materials	1020	1.868	127	2.411	4.786	N. lands
7.	Oriental Journal of Chemistry	980	0.261	9	0.508	0.463	India
8.	Environmental Monitoring and Assessment	930	0.533	31	1.328	1.727	N. lands
9.	Pestology	879	0.112	9	0.51	0.013	India
10.	Asian Journal of Microbiology, Bio-technology and Environmental Sciences	670	0.128	11	0.139	0.115	US
11.	Indian Journal of Fibre and Textile Research	650	0.673	20	1.340	0.947	India
12.	Bulletin of Environmental Contamination and Toxicology	631	0.544	45	0.783	1.239	US
13.	Bioresource Technology	611	2.472	152	2.463	5.627	U.K.
14.	Zoos' Print Journal	606	-----	9	-----	-----	India
15.	Journal of Industrial Pollution Control	569	0.151	9	0.269	0.080	India
	Total number of publications	14570					

The rest of the journals have published > 500 < 1000 articles as, Oriental Journal of Chemistry has published 980 articles; its SJR has 0.261; h-index has 9; SNIP has 0.508, and IPP has measured 0.463 ranking at seventh position. At the eighth position, Environmental

Monitoring and Assessment has contained 930 articles with 0.533 SJR; 31 h-index; SNIP 1.328 and 1.727 IPP. At the Ninth Rank Pestology contained 879 articles, the SJR has 0.112; h-index has 9; SNIP 0.51; with 0.013 IPP. At the tenth position, Asian Journal of



Microbiology, Biotechnology, and Environmental Sciences has published 670 articles having 0.128 SJR; 11 h-index; SNIP has 0.139; and 0.115 IPP. At the eleventh position, Indian Journal of Fiber and Textile Research contain 650 articles having 0.673 SJR; 20 h-index; 1.340 SNIP and having 0.947 IPP. At the twelfth ranking Bulletin of Environmental Contamination and Toxicology has with 631 articles having 0.544 SJR; 45 h-index; 0.783 SNIP and 1.239 IPP. Bio-resource Technology ranking at the thirteenth position with 611 articles; SJR 2.472 (highest in core journals); h-index measuring 152 (highest in core) and also 5.627 IPP (highest). Zoos' Print Journal has to rank at the fourteenth position with 606 articles with h-index of nine. At the fifteenth rank, Journal of Industrial Pollution Control has published 569 articles, with SJR 0.151 having h-index of nine. The SNIP has 0.269, and the IPP value has 0.08.

The Bradford's Law of Scattering has its own important, as stated by many scientists it is not accurate, but this has method accepted in the world to discover the core collection of any subject. It has cost beneficial, provide perfect collection at minimum cost.

#### Findings:

- Out of total 51382 records 31867 (62.02 percent) records have received 389064 citations
- The Average Citations Per Paper (ACPP) has measured 7.57 during the study period

- The highest ACPP 11.89 has observed in 2006
- The lowest ACPP has recorded 1.62 in 2013
- During 2010-2013 the ACPP has observed as below average
- Out of 51382 records 19515 (37.98 percent) records have not received any citation
- The highest Citation Rate (CR) 0.69 has observed in 2000 and 2003
- The lowest CR 0.41 has observed in 2013
- The Average CR during 1999-2013 has found 0.62
- The minimum Percentage of Not Cited Records (PNC) 30.08 has observed in 2003
- The Highest PNC 59.71 has found in 2013
- Highest citation received (> 300 citations) to 21 records
- **No any relationship has observed between top authors and highest citations**
- About 30 percent records have received the citations between the range of 1-4
- About 30 percent records have received the citations between the range of 5-50
- About 2 percent records have received the citations between the range of 51-926
- The top most SJR among core journals was 2.472, top most h-index 152, top most SNIP 2.463 and top most IPP 5.627 having by 'Bio-resource Technology' of UK

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