View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by DigitalCommons@University of Nebraska

University of Nebraska - Lincoln

DigitalCommons@University of Nebraska - Lincoln

Library Philosophy and Practice (e-journal)

Libraries at University of Nebraska-Lincoln

Winter 12-2-2019

Application of Bradford's Law of Scattering and obsolescence in the Literature of Chemistry: A study based on doctoral theses

MITHU ANJALI GAYAN
mithuanjaligayan@tripurauniv.in

Sanjay Kumar Singh
sksgu1@gmail.com

Follow this and additional works at: https://digitalcommons.unl.edu/libphilprac

 Part of the Library and Information Science Commons

GAYAN, MITHU ANJALI and Singh, Sanjay Kumar, "Application of Bradford's Law of Scattering and obsolescence in the Literature of Chemistry: A study based on doctoral theses" (2019). *Library Philosophy and Practice (e-journal)*. 3712.
https://digitalcommons.unl.edu/libphilprac/3712

Application of Bradford's Law of Scattering and obsolescence in the Literature of Chemistry: A study based on doctoral theses

Mithu Anjali Gayan,
Assistant Professor,
Department of Library and Information Science,
Tripura University,
Tripura, India
mithu.anjali@gmail.com,

Sanjay Kumar Singh
Professor and Head,
Department of Library and Information Science,
Gauhati University,
Assam, India
sksgu1@gmail.com

Abstract

The proposed study tries to investigate citation pattern of Chemistry theses submitted to Central library Tripura University. The study considered only those theses submitted to Shodhganga, the Indian ETD initiative. Hence data were collected from 20 theses constituting 6214 citations during 2007 to 2016. Bardford's law is used to find out the core journals in the field of Chemistry. The rank list of journals showed "Phytochemistry" is the most cited journal. The dataset of the study did not follow the Bradford's law. However, the dataset follow the Leimkuhler's model. Half life of Chemistry journals is found to be 12.6 years. The results revealed from the study will assist the researchers in the area of Chemistry in improved understanding the characteristics of the field; it will aid librarians in selection of documents and collection development of the library; it will help the policy makers in decision making.

Keywords: Citation Analysis, Bradford's law, Tripura University, PhD theses, Scimago, Obsolescence

Introduction

The exponential expansion of scientific literature, interdisciplinary nature of research and trend towards specialization has posed many problems both to the scientists and librarians. The extensive investigations and the abundance of literature being published and contributed to immense escalation of cost for the libraries, as the acquisition of published literature became an increasingly difficult task. To maintain a reasonable collection of periodicals, at least in broad fields, it is necessary for the librarians to know the characteristics of subject literature used by the users. Information is not only increasing exponentially but the growth rates also differ from one discipline to another. Citation analysis of theses helps in evaluating

research performance of departments and universities. Today most of the libraries are facing problems in Journal subscription cost, shrinking library budget, lack of space for library holdings, etc., which have resulted in number of user studies, being studied. The limited financial resources have caused a lot of problems to the librarian; so they are forced to look for an alternative system for collection development and provide quality document to the user community. That's where Citation Analysis proves to be one of the most essential and needful Study. This study recalls the nature of information used by the researchers and enables the librarian to plan and to provide better information services and better Collection development.

Objectives of the study

The key objectives of the study are

1. To identify the bibliographic forms of citations
2. To test the applicability of Bradford's law
3. To prepare the rank list of journals in Chemistry
4. To find out the form of journals cited

Literature Review

(Vickery, 1948) tested the Bradford's law of scatting of periodicals as he observed algebraic misunderstanding caused by Bradford and his collaborators. Vickery suggested that the zones should not just be restricted to 3. Later, he regarded the theoretical distribution of articles on a certain topic in scientific periodicals, as derived by Bradford[1]. (Leimkuhler, 1967) gave interpretation of verbal formulation of the Bradford's law. It was concluded that literature from different time periods may show different results in the same subject area. He suggested the relation $F(X) = \log (1+\beta x) \div \log (1+\beta)$, where β is related to the particular subject and entirety of communication[2]. (Brookes, 1968) explained that Bradford distribution and Zipf distribution are strongly related to each other. He revealed "a modified form of the Bradford distribution is required when Bradford-type collections of journals are merged into larger collections, when 'saturation' of the most productive journals occurs"[3]. (Kumar & Dora, 2011) 49 doctoral dissertations submitted during the period 2004 to 2009 at the Indian Institute of Management, Ahmadabad were examined by the researchers. It also disclosed that journals are the largely cited sources, and based on the pattern of citations, a local ranking list of journals was developed[4]. (Zafrunnisha, 2012) checked the validity of Bradford's law on Psychology doctoral theses literature. She carried out the study on 141

psychology theses. She divided the journals in to 4 groups identify the core journals. “Journal of Applied Psychology” was found to be the most cited journal. The data set did fit neither Bradford’s law nor Leimkuhler’s model[5]. (Wardikar & Gudadhe, 2013) tried to verify the application of Bradford's Law of Scattering on the references appended in Ph.D. theses at the universities in Maharashtra. From 138 theses 5467 references were collected. These references were dispersed in 798 periodicals. “Annals of Library Science” and “Documentation” both ranked first in the rank list of periodicals. The dataset did not fit the Bradford's distribution. Leimkuhler model was found valid for the dataset[6]. (K. P. Singh & Bebi, 2014) evaluated 260 PhD Social Science theses submitted during 1995 to 2008 to Delhi University by applying bibliometric techniques. It was revealed that 9,997 references were scattered in 934 journals. They found out Economic and Political Weekly is the most cited journal. Their study satisfied the Bradford’s law of scattering of journals. Most of citations were distributed in books unlike the Science subjects. India received highest numbers of citations followed by USA. The dataset fulfilled Bradford’s law of scattering[7]. (Bala and Singh, 2015) studied and analysed the citations appended in 17 theses submitted to Agronomy and Plant Breeding department, CCHAU, HISAR for the period of 2010-2014. Most of the citations came from co authored journal articles; “Indian Journal of Weed Science and Theoretical and Applied Genetics” resided the first position in both agronomy and plant breeding theses. Half life both the subjects were in between 12-14 years and Bradford’s law did not fit well for the dataset[8].

Methodology

For conducting the study theses submitted to central library, Tripura University in the field of Chemistry were considered. Theses submitted during 2007 to 2016 constitute the sample. The university was converted to central university in July 2007. So, for this study theses submitted for ten years from July 2007 to June 2016 were considered. For this time period a total of 20 chemistry theses were found in the library with 6214 citations. These citations appended at the end of these theses were analysed and interpreted in this study.

Type of documents cited per thesis citation wise distribution

The present study covers 20 theses and a total of 6214 citations with an average of 311 citations. Table 1 reports the list of documents preferred and average citation per thesis count. It is revealed that Journals are the most preferred type of documents with a total of 5581citations in 20 theses having the share of 89.81%. Books are the second highest cited

documents having received a total of 501citations in 20 theses with the share of 8.06%. Other sources such as Dictionary, Proceeding, Encyclopaedia, Patent and Websites are cited very few times having the share of less than 1% for each type of document. Miscellaneous sources account for 0.11% share of citations and it includes Atlas, Book of standards, Glossary, Magazine, Symposium, thesis and WHO report.

Table 1: Type of documents cited per thesis citation wise distribution

Sl. No.	Type	Frequency	Average citation /thesis	Percentage
1	Journal	5581	279	89.81
2	Book	501	25	8.06
3	Dictionary	15	1	0.24
4	Proceeding	14	1	0.23
5	Encyclopaedia	9	0	0.14
6	Patent	4	0	0.06
7	Website	3	0	0.05
8	Miscellaneous	7	0	0.11
9	Unidentified	10	1	0.16
10	Blank	70	4	1.13
Total		**6214**	**311**	**100.00**

BRADFORD'S LAW OF SCATTERING

S.C. Bradford coined the Bradford's Law of scattering and the idea of core journals in 1934. Bradford law of scattering describes that resources are scattered or spread in varying amount of journals in a particular subject[9]. L. Jones in 1933 performed a study in Science Museum Library, London. Bradford reported the law based on that study first in the ''Engineering'' journal and later in book titled ''Documentation'' in 1948. He defined the law as "If scientific journals are 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 the subject and several groups or zones containing the same articles as the nucleus, when the number of periodicals in the nucleus and succeeding zones will be as 1: n: n^2, where 'n' is a multiplier"[10.]

Regularity in measuring the number of titles in each of these zones was depicted by Bradford. On the basis of his observations he showed a common pattern in ratio of the title in each zone. The law says that a few core journals form the nucleolus for a substantial percentage

(1/3) of the articles, which is next followed by a second larger group of journals then followed by third group on a particular subject.

Decreasing Frequency of Journal Citations

The verbal and graphical theory of the Bradford's Law of Scattering is applied to the citations appended in Chemistry theses. Citations are arranged in the decreasing order of its frequency in table no 2. The data in table number 10 reports that a total of 5581 citations come from 903 journals. The top ranked journal consists of 325 citations followed by the second journal having received 247 citations and the third ranked journal received 188 citations. It is also revealed that 415 unique journals received 1 citation each. The table provides evidence that only a few journals received huge number of citations and a large chunk of journals receive a few citations each.

Table 2: Decreasing Frequency of Journal Citations

Sl. No.	Rank	No. of periodicals	Cumulative no of journals	No. of citations	Total	Cumulative citations
1	1	1	1	325	325	325
2	2	1	2	247	247	572
3	3	1	3	188	188	760
4	4	1	4	160	160	920
5	5	1	5	154	154	1074
6	6	1	6	150	150	1224
7	7	1	7	125	125	1349
8	8	1	8	105	105	1454
9	9	1	9	101	101	1555
10	10	1	10	77	77	1632
11	11	1	11	76	76	1708
12	12	1	12	72	72	1780
13	13	1	13	71	71	1851
14	14	1	14	69	69	1920
15	15	1	15	66	66	1986
16	16	2	17	57	114	2100
17	17	1	18	55	55	2155
18	18	1	19	53	53	2208
19	19	1	20	48	48	2256
20	20	1	21	47	47	2303
21	21	1	22	45	45	2348
22	22	1	23	44	44	2392
23	23	2	25	40	80	2472

24	24	1	26	35	35	2507
25	25	3	29	34	102	2609
26	26	1	30	33	33	2642
27	27	2	32	32	64	2706
28	28	1	33	30	30	2736
29	29	1	34	29	29	2765
30	30	2	36	28	56	2821
31	31	2	38	27	54	2875
32	32	6	44	25	150	3025
33	33	2	46	23	46	3071
34	34	1	47	22	22	3093
35	35	2	49	21	42	3135
36	36	3	52	19	57	3192
37	37	4	56	18	72	3264
38	38	4	60	17	68	3332
39	39	5	65	16	80	3412
40	40	4	69	15	60	3472
41	41	4	73	14	56	3528
42	42	7	80	13	91	3619
43	43	11	91	12	132	3751
44	44	2	93	11	22	3773
45	45	8	101	10	80	3853
46	46	8	109	9	72	3925
47	47	8	117	8	64	3989
48	48	12	129	7	84	4073
49	49	30	159	6	180	4253
50	50	30	189	5	150	4403
51	51	53	242	4	212	4615
52	52	59	301	3	177	4792
53	53	187	488	2	374	5166
54	54	415	903	1	415	5581

Bradford’s zone for Chemistry

Based on table 2, three Bradford zones of journals having equal number of citations are presented in table number11. In this case, each zone accounts for about 1860 citations. Table 3 depicts the data in three Bradford zones. The difference in the value of the multiplier is too high, almost three times. Hence, it is concluded that the dataset does not fit into Bradford’s law.

Table no 3: Bradford’s zone for Chemistry

Zone	No. of Periodicals	number of citations	Cumulative number of citations	Bradford multiplier
1	13	1851	1851	1
2	75	1864	3715	5.77
3	815	1866	5581	62.69

The three zones in the scattering of Bradford law of Chemistry display that in the first zone there are 13 journals with citations of 1851; in the second zone there are 75 journals with 1864 citations and in the third zone there are 815 journals with 1866 citations. The relationship of the each zone in the present table is explained with the following equations,

'F' denotes Finding, 'R' denotes Result and 'E' denotes excepted result

$F = 1.n:n_2$

R = 1:5.77:62.69

E = 1:5.77: 33.29

i.e. $\mathbf{1: 5.77: 62.69 \neq 1: n: n^2}$

Thus, it does not fit well into the law. Hence, to examine the verification of Bradford's Law of Scattering, Leimkuhler Model (Leimkuhler, 1967)[2] of distribution is employed. Leimkuhler model has been used many times in previous studies such as (Wardikar & Gudadhe, 2013)[6] (Kalita, 2016)[11] (Tripathi & Sen, 2016)[12] to study its applicability for calculating non cumulative rank frequency calculation.

Leimkuhler model of Bradford's distribution is a size frequency measure and in this model at first the core journals with specific citations in the first zone is determined and then Bradford Multiplier is found out. Accordingly with its multiples the journals in the following zones are counted. Bradford's multiplier (K) for Leimkuhler distribution is counted with Egghe's formula (Egghe, 1986)[13].

Egghe's mathematical formula for calculation of the "Bradford multiplier" and the Leimkuhler model is used in this study.

Leimkuhler's model based on Bradford's verbal formulation is,

R0 = T (K-1)/(K_p-1),

To apply this formula, first we have to find out value of "K" with the following formula,

$K = (e^y Y_m)^{1/p}$ where, {e^y = 1.781 (Euler's No)}

Y_m = no of citations in the most productive journal i.e. Y_m = 325 (From table no. 2)

P =Bradford's group of no of zones of distribution i.e. P =3

By applying our data,

K = $(1.781 * 325)^{1/3}$

= $(578.825)^{1/3}$

K = 8.33

Now, let's find out number of journals in the Nucleus of each zone by using Leimkuhler developed model,

R_0 = T (K-1) / (K^p -1), [T = Total no of journals = 903 (from table 10)]

= 903***** **[**(8.33-1) / {$(8.33)^3$-1}]

= 903 * {7.33/ (578.009537-1)}

=903 * (7.33/ 577.009537)

=903 * 0.012703

= 11.471

So, for this dataset **R_0= 11.47**

That means in the Leimkuhler model of Bradford's distribution the core group contains 11.47 (≈11) journals.

Hence, the modified Bradford's distribution from Leimkuhler model can be written down as

= **R_0: R_0 *K: R_0 *K^2**

= 11.47: 11.47* 8.33: 11.47* $(8.33)^2$

= 11.47: 95.5451: 795.890

= 902.905783

% Error = {(903- 902.905783)/903}*100

= (0.094217/903)*100

= 0.000104337*100

= 0.010433

So, from the above equation % of error is found out to be 0.010% which is a very slight deviation. So we can acknowledge the acceptability of new modified Bradford's distribution given by the Leimkuhler model.

After application of Leimkuhler model we got three zones which are illustrated in table 12, the core zone which is Zone 1containing 12 journals with 31.89 % share of citations, Zone 2 containing 95 journals with 38.11 % and Zone 3 containing 796 journals with 29.99 % share of citations.

Table 12: Leimkuhler model Bradford's Distribution in 3 zones

Zone	**No of Journals**	**cumulative no of journals**	**Total Citations share**	**cumulative no of citations**	**% Share to total citations**
1	12	12	1780	1780	31.89
2	95	107	2127	3907	38.11
3	796	903	1674	5581	29.99
Total	**903**		**5581**		**100.00**

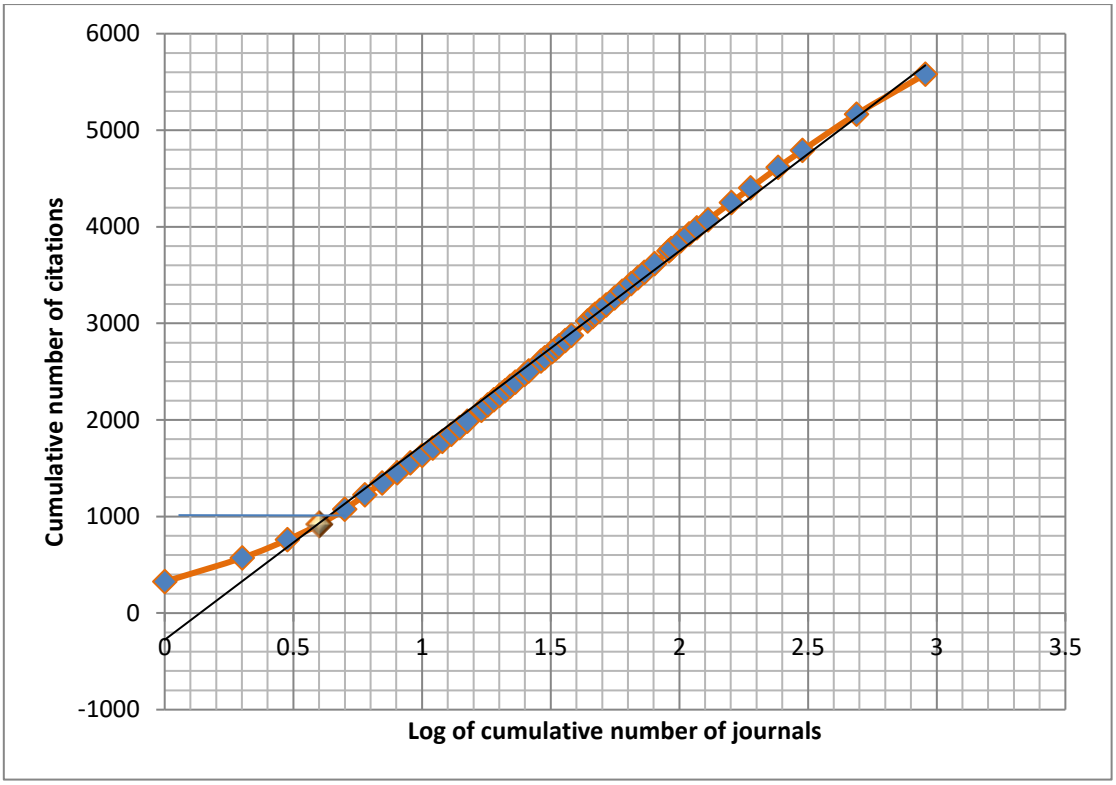

Figure 1: Graphical formulation of Bradford's distribution

Figure 1 gives a graphical formulation of the Bradford's law, when we put the log of cumulative no of journals in the X axis and cumulative no of citations in Y axis. In the graph we see there is a step rise initially which contains the core group of journals then it becomes linear and sloping part of the graph starts towards the end. So, the graph in figure 5 satisfies the criteria of Bradford's distribution graph given by Brookes (Brookes, 1969)[14].

Rank list of journals in Chemistry

A rank list of journals is prepared based on number of citations received. The rank list of journals is presented in table number 4. It is found that out of total 5581 journal citations, "Phytochemistry" received highest 325(5.82%) number of citations and stands in the first position in the rank list. "Phytochemistry" is published from Netherlands by Elsevier BV and it belongs to the Scimago subject area of Biochemistry, Genetics and Molecular Biology. "Inorganic Chemistry" journal stands on second position with 247 (4.43%) citations. It is published by "American Chemical Society" from United States of America and it belongs to the Scimago area of Chemistry. Journal of American Chemical Society stands on the third rank having received 188 citations with a share of 3.37%. It is published by "American Chemical Society" from United States of America and it belongs to the Scimago area of Biochemistry, Genetics and Molecular Biology. "Journal of natural products" published by

"American Chemical Society" from USA occupies the fourth rank with 160 (2.87%) citations. This journal is indexed under the Biochemistry, Genetics and Molecular Biology in Scimago. "Inorganica Chimica Acta" published by Elsevier BV, Netherlands with 154 (2.67%) citations has occupied the fifth position under the Scimago area of Chemistry. The ranking of other journals of this department can be seen from the table 12.

Table 4: Rank list of the core journals in Chemistry

Sl. No.	Rank	Journal	Frequency of citations	Percentage of citations	Country	Publisher	Scimago subject area
1	1	Phytochemistry	325	5.82	Netherlands	Elsevier BV	Biochemistry, Genetics and Molecular Biology
2	2	Inorganic Chemistry	247	4.43	United States	American Chemical Society	Chemistry
3	3	Journal of the American Chemical Society	188	3.37	United States	American Chemical Society	Biochemistry, Genetics and Molecular Biology
4	4	Journal of Natural Products	160	2.87	United States	American Chemical Society	Biochemistry, Genetics and Molecular Biology
5	5	Inorganica Chimica Acta	154	2.76	Netherlands	Elsevier BV	Chemistry
6	6	Langmuir	150	2.69	United States	American Chemical Society	Materials Science
7	7	Tetrahedron Letters	125	2.24	United Kingdom	Elsevier Ltd.	Biochemistry, Genetics and Molecular Biology
8	8	Chemical and Pharmaceutical Bulletin	105	1.88	Japan	Pharmaceutical Society of Japan	Pharmacology, Toxicology and Pharmaceutics Drug Discovery
9	9	Polyhedron	101	1.81	United Kingdom	Elsevier Ltd.	Chemistry
10	10	Angewandte Chemie International Edition in English	77	1.38	Germany,	Wiley-VCH	UK
11	11	Chemical Reviews	76	1.36	United States	American Chemical Society	Chemistry
12	12	Coordination Chemistry Reviews	72	1.29	Netherlands	Elsevier BV	Chemistry

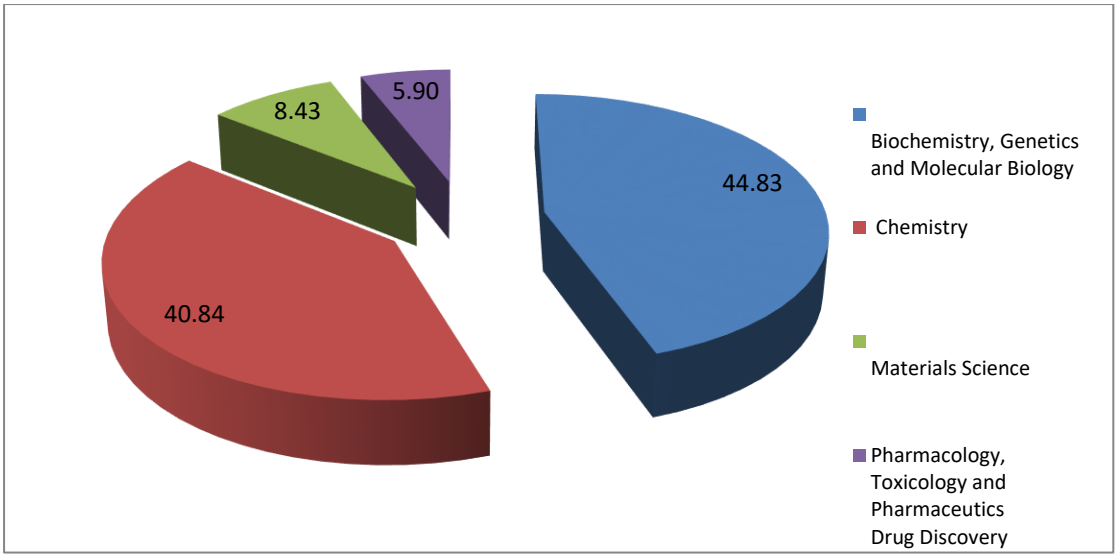

Figure 2: Scimago subject areas of Zone 1 i.e. core journals

Scimago subject areas of core journals

Figure 2 illustrates the subject wise distributions of core journals. It is found that out of all core journals 44.83% share of citations belong to Biochemistry, Genetics and Molecular Biology followed by 40.84% belong to Chemistry; 8.43% share belong to Material science and 5.90% belong to Pharmacology, Toxicology and Pharmaceutics Drug discovery (http://www.scimagojr.com)[16].

Half-life or Obsolescence of journal Literature in Chemistry

As per (Sen, 1999)[15] the half-life period will be integral number consisting of whole years plus a fraction of a year. It can be represented as T= Y + y ---------- (1)

Here Y is the number of whole years and y is the fraction of a year which can be calculated by the formula (a-b)/(c-b) ---------- (2)

Here, "a" is the 50 per cent of the references; "b" is the cumulative number of references of the subcritical year and "c" is the cumulative number of references of the critical year. Critical year is the year in which 50 per cent of the citations are reached counted from the base year. Subcritical year is the year previous to critical year. Putting the value of y in Eqn. (1), we get the formula for half-life period. **T= Y + (a-b)/(c-b)**. Half life is used to find out number of years taken to receive the half of the total citations. It helps in finding out within how much time particular literature gets obsolete.

Table 5: Distribution of Chemistry journal citations in reverse chronological order

Sl. No.	Year	Age of Citation	No. of citations	Cumulative Citations	Percentage of Citations	cumulative Percentage
1	2016	0	0	0		0
2	2015	1	41	41	0.73	0.73
3	2014	2	135	176	2.42	3.15
4	2013	3	219	395	3.92	7.08
5	2012	4	199	594	3.57	10.64
6	2011	5	252	846	4.52	15.16
7	2010	6	267	1113	4.78	19.94
8	2009	7	266	1379	4.77	24.71
9	2008	8	248	1627	4.44	29.15
10	2007	9	234	1861	4.19	33.35
11	2006	10	236	2097	4.23	37.57
12	2005	11	273	2370	4.89	42.47
13	**2004**	**Y=12**	**282**	**b=2652**	**5.05**	**47.52**
14	2003	13	226	**c=2878**	4.05	51.57
15	2002	14	212	3090	3.8	55.37
16	2001	15	164	3254	2.94	58.3
17	2000	16	174	3428	3.12	61.42
18	1999	17	130	3558	2.33	63.75
19	1998	18	162	3720	2.9	66.65
20	1997	19	128	3848	2.29	68.95
21	1996	20	161	4009	2.88	71.83
22	>1996	more than 20	1563	5572	28.01	99.84
23	blank		9		0.16	100.00

Value of Y = 12 [table 5]

a = 5581/2 = 2790.5 (say 2791); b= 2652; c= 2878

y = (2791-2652) ÷ (2878-2652)

= 139 ÷226 = 0.615

Half-life T= Y + y = 12+0.615 = 12.615

The half-life period of Chemistry journals has been calculated as 12.6 years. Table 5 unveils that 10.64 per cent of the journal citations are 4 years old. More than 29.15% of the journal citations are 8 years old and 51.57 % citations are 13 years old.5

Format wise distribution of journals

There are two broader medium of scholarly communication namely print medium and electronic medium. Some publishers publish their journals in electronic medium, some in only print format and publish in both formats. Table 6 and figure 3 provide an account of print vs. non print journals based on the frequency of citations.

Table 6: Format wise distribution of journals

Sl. No.	Format	Sources	Citations	Percentage
1	Electronic	94	2113	47.99
2	Both	94	2285	51.90
3	Unidentified	1	5	0.11
Total		**189**	**4403**	**100.00**

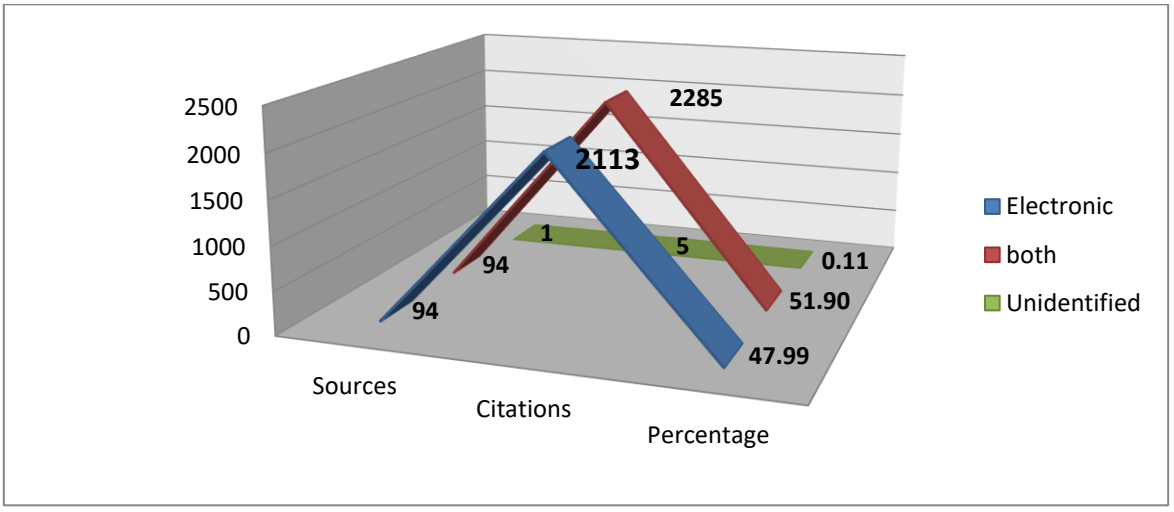

Figure 3: Format wise based on 50 top ranked journals

It is found from the above table and figure that highest 2285 number of citations with a share of 51.90% comes from 94 sources published both in electronic as well as print medium followed by 2133 number of citations with a share of 47.99% comes from 94 only electronic sources. No citation is found from only print source. So, there is a clear indication that researchers prefer electronic journals over print.

Conclusion

Citation analysis still remains one of the most important tools to assess the usefulness of library holdings for postgraduate students' research activities (Becker & Chiware, 2015)[16]. The quantitative analysis of Chemistry literature has put forward some interesting facts. The study has tried to bring in to light some features of Chemistry literature. It is found that Chemistry researchers depend on highly on journal articles for pursuing their research. The rank list of journals showed “Phytochemistry” is the most cited journal. The dataset of the study did not follow the Bradford’s law. However, the dataset follow the Leimkuhler’s model. The outcomes found from the study will assist the researchers in the area of Chemistry in improved understanding the characteristics of the field; it will aid librarians in selection of documents and collection development of the library; it will help the policy makers in decision making.

References

1. Vickery B C, Bradford's law of scattering, *Journal of Documentation*. 4 (3) (1948) 198-203, https://doi.org/10.1108/eb026133
2. Leimkuhler F F, Bradford distribution, *Journal of Documentation.* 23 (3) (1967) 197-207.
3. Brookes B C, The derivation and application of the bradford-zipf distribution, *Journal of Documentation.* 24(4) (1968) 247-265. http://dx.doi.org/10.1108/eb026457
4. Kumar H A and Dora M, Citation analysis of doctoral dissertations at IIMA, *Library Collections, Acquisitions, & Technical Services*, 35(1) (2011) 32-39 10.1080/14649055.2011.10766290
5. Zafrunnisha N, Bradford’s zones and productivity of journals in psychology doctoral theses, *Annals of Library and Information Studies*, *59*(1) (2012) 39–52.
6. Wardikar V G V and Gudadhe, Application of Bradford’s Law of Scattering to the Literature of Library & Information Science: A Study of Doctoral Theses Citations Submitted to the Universities of Maharashtra, India. *Library Philosophy and Practice*, 1054. (2013).http://digitalcommons.unl.edu/libphilprac/1054
7. Singh K P and Bebi, Library herald: A bibliometric study (2003–2012), *Library Herald*, *52*(1) (2014) 19. https://doi.org/10.5958/j.0976-2469.52.1.002

8. Bala S and Singh J, Citation analysis of ph.d. theses in agronomy and plant breeding submitted at CCHAU, Hisar during 2010-2014: a comparative study,*Information Studie*, 21(4) (2015) 205-220 DOI: 10.5958/0976-1934.2015.00016.6
9. Bradford S C, Documentation, (London; Crosby Lockwood and Sons), 1948.
10. Bradford S C, Sources of Information on Specific Subjects, *Engineering* 137(3550) (1934) 85-86.
11. Kalita D, Citation Analysis of Science, *COLLNET Journal of Scientometrics and Information Management*, *10*(2) (2016) 237–254. https://doi.org/10.1080/09737766.2016.1213967
12. Tripathi H K and Sen B K, Crop science literature and Bradford law, *Annals of Library and Information Studies*, *63*(2) (2016) 85–90.
13. Egghe L, Dual of Bradford's law, *Journal of American Society of Information Science and Technology*, 37 (4) (1986) 173-89.
14. Sen BK, Symbols and formulas for a bibliometric concept. *Journal Documentation*, **55**(3) (1999) 325-334. doi: 10.1108/EUM0000000007149
15. Deborah A B and Chiware E, Citation Analysis of Masters' Theses and Doctoral Dissertations: Balancing Library Collections with Students' Research Information Needs, *The Journal of Academic Librarianship.* 41(5) (2015) 613-620. https://doi.org/10.1016/j.acalib.2015.06.022
16. Brookes B C , Bradfords law and bibliography of science. *Nature*, 232 (1969) 955.
17. Schimago Journal and Country Rank, http://www.scimagojr.com/ (Accessed on 01.06. 2019)