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Applicability of Lotka's Law to Pollution Control Research Publications During 2013-2017 Using Scopus Database

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ABSTRACT

This study aims to analyze the authorship contribution in the field of pollution control research publications during the selected five years from 2013 to 2017 from SCOPUS database. A total of 13825 research publications are identified and analyzed. The year 2017 contributed maximum of 3390 publications, Hao, J. was contributed highest of 53 (20.23%) research publications. During the study period maximum of 10470 (75.73%) research works are done by articles, and Chinese Academy of Sciences contributed 711 (5.14%) research publications with a top ranking institution in the field of pollution control research. China is top contributing countries with 4831 (34.94%) publications. This study identified that the author productivity does not fit in the Lotka's law application in the fields of pollution control research publications.

1. Introduction

Pollution is a problem of recent origin of our planet. It is the effect of undesirable changes in our surroundings that can lead to harmful effect on plants, animals and human beings. Human being has made greater damages to the ecology than any other natural phenomenon. During the past few decades the human have polluted air, water and land on a very large scale with a verity of pollutants generated by them[1]. Pollution may also be invisible, odorless and tasteless, but brutally capable of changing the entire atmosphere as the slow poison to the plants, animals and human beings. Some of the pollutions does not directly pollute the land, air, and water, but invariably reduce the lifetime of every human being.

The post-industrial revolution may offer the job to so many people, but through pollution, it deteriorates the health of the society. As Tiwari (2010) defines it as "the release of substances and energy as waste products of human activities, which result in changes, naturally harmful, within the natural environment"[2]. Pollution control is one of the major processes of reducing or eliminating the discharge of pollutants into the atmosphere. Various environmental agencies are synchronized to establish the limits for discharge of the pollutant into the air, water, and land. A wide variety of devices and systems have been developed to control solid wastes, air, and water pollutions.

2. Scientometrics: An Overview

Scientometric is a study to measure the performance of researchers as well as the research publications. The research activities contained major changes over the last few decades and emerged as established research in the discipline of "Library and Information Science" subsequently it becomes interdisciplinary. The scientometric study deals with quantitative research methods which are considered as most of the important aspect of research endeavor in the fast and developing information era. It could be attributed to the fact of identifying the pattern of publications like authorship pattern, citations contribution of countries, institutions and journals coverage, etc. Particularly, it has the potential to segregate the bibliographic segments of the research to give a clear report about any discipline[3]. Tague-Sutcliffe (1992)[4] defined as "*scientometrics is a study of quantitative aspects of scientific publications or economic activity.*" Bookstein (1995)[5] defined as "*Scientometrics is the science of measuring the science*."

3. Literature Review

Lakshmi Sankari and Chinnasamy[6] examined his study into Indian Journal of Biotechnology: A Scientometric Analysis during the period of 2004-2008 with a total number of 436 publications are identified and analyzed based on various parameters such as year-wise contribution, authorship productivity and geographical distributions of contribution, etc. Further, the applicability of Lotka's law has been tested and the values of n = 3.15. The numbers of contributions from Maharashtra at the National level and India at the International level is significant. **Pillai Sudhier[7]** analyzed the authorship pattern and applicability of Lotka's law into the physic scientific publications, and they identified journal articles are cited in the doctoral theses of University of Kerala. The study identified that 'straight count' of authorship was 1665 personal authors and 3,367 authors were using 'complete count'. They used his study to identify the Lotka's law application into K-S test and Chi - Square and it was confirmed that Lotka's law does not applicablein the field of physics literature. **Heigen Hsu, Oliver C.L. Hou, and Jiann-Min Yang[8]** have been studied the publications productivity of renowned "Pneumonology" related papers on SCI - expanded, SSCI and AHCI database. The result indicated that the publication productions were increasing tremendously. The publications are usually generated by multi-authors. Both complete and complete-normalized counting methods are used for the paper, and the distribution of contribution indexes of author productivity could not be held by Lotka's Law for the matter of co-authorship and interdisciplinary publishing.

4. Objectives of the studies are

- To analyze the year wise growth

- To identify the top 10 author contributions
- To identified the bibliographic form
- To examine the top 10 institutions and countries contributions
- To analyze authorship pattern of the publications
- To test the Lotka's Law applications

5. Limitation

This study confined that only the publications are contributed in the field of Pollution Control Research from 2013 to 2017 for the data's are indexed in the SCOPUS database. This study analysis the lotka's law applications and few scientometric techniques are considered in the present study.

6. Methodology of Data Collection

This study analysis the publications on pollution control research data has been downloaded from SCOPUS database. The following search strategy has been used in the combined field of Title, Abstract & Keywords. (TITLE-ABS- KEY ("Pollution Control") AND PUBYEAR > 2012 AND PUBYEAR < 2018). During the selected five years from 2013 to 2018, a total number of 13825 data has been identified and extracted. The collected data has been classified by using simple MS-Excel spreadsheet.

7. Analysis and Interpretations

Year Wise Growth of Publications

S. No	Year	Publications	%	Cum.	Cum. %
1	2013	2395	17.32	2395	17.32
2	2014	2526	18.27	4921	35.59
3	2015	2688	19.44	7609	55.04
4	2016	2826	20.44	10435	75.48
5	2017	3390	24.52	13825	100.00
Total		**13825**	**100.00**		

Table – 1 Year-Wise Growth of publications

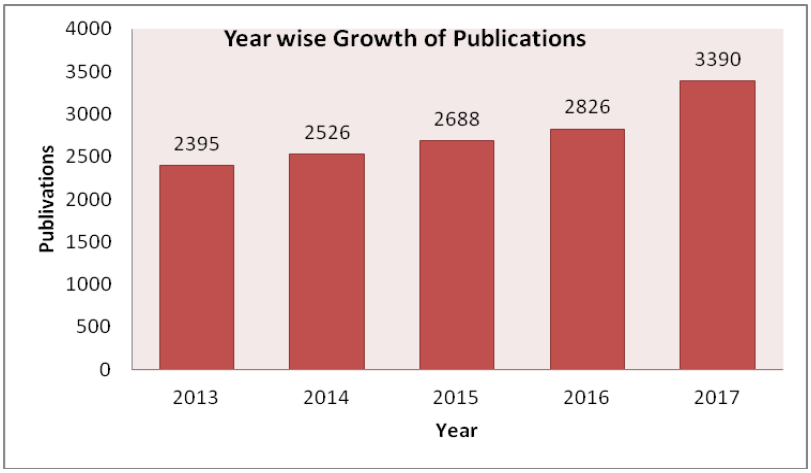

Figure - 1 Year-Wise Growth of Publications

Table-1 shows that year-wise growth of pollution control research publication during the selected five years study period. This five years study identified that publications growth are gradually increased from 2013 to 2017. The study identified the year 2013 with 2395 (17.32%) publications, 2014 with 2526 (18.27%), 2015 with 2688 (19.44%), 2016 with 2826 (20.44%) and 2017 with 3390 (24.52%) publications. During the study period, it is identified that the maximum of 3390 (24.54) publications are contributed in the year 2017.

Top 10 Author's Contributions

S No	Author	Publications	%	Rank
1	Hao, J.	53	20.23	1
2	Wang, S.	47	17.94	2
3	He, K.	26	9.92	3
4	Huang, G.H.	24	9.16	4
5	Huisingh, D.	22	8.40	5
6	Wu, Y.	20	7.63	6
7	Zeng, G.	19	7.25	7

8	Liu, H.	18	6.87	8
9	Strauss, A.	17	6.49	9
10	Duan, L.	16	6.11	10
Total		**262**	**100.00**	

Table – 2 Top 10 Author's Contributions

Table-2 shows that top 10 author's contributions in the field of pollution control researches are identified during the selected five years study period. It is identified from the table 2, the highest number of publications are Hao J with 53 (20.23%) into top rank. Followed by Wang S with 47 (17.94%) publications, He K with 26 (9.92%), etc. Top 10 authors have contributed 262 publications for the selected five years study period.

Bibliographic Form Wise Publications

S. No	Bibliographic Form	Publications	%	Cum.	Cum.%
1	Article	10470	75.73	10470	75.73
2	Conference Paper	1843	13.33	12313	89.06
3	Review	691	5.00	13004	94.06
4	Note	342	2.47	13346	96.54
5	Book Chapter	205	1.48	13551	98.02
6	Editorial	90	0.65	13641	98.67
7	Short Survey	57	0.41	13698	99.08
8	Letter	53	0.38	13751	99.46
9	Book	47	0.34	13798	99.80
10	Conference Review	19	0.14	13817	99.94
11	Erratum	4	0.03	13821	99.97
12	Abstract Report	2	0.01	13823	99.99
13	Business Article	1	0.01	13824	99.99
14	Retracted	1	0.01	13825	100.00
Total		**13825**	**100.00**		

Table – 3 Bibliographic Forms

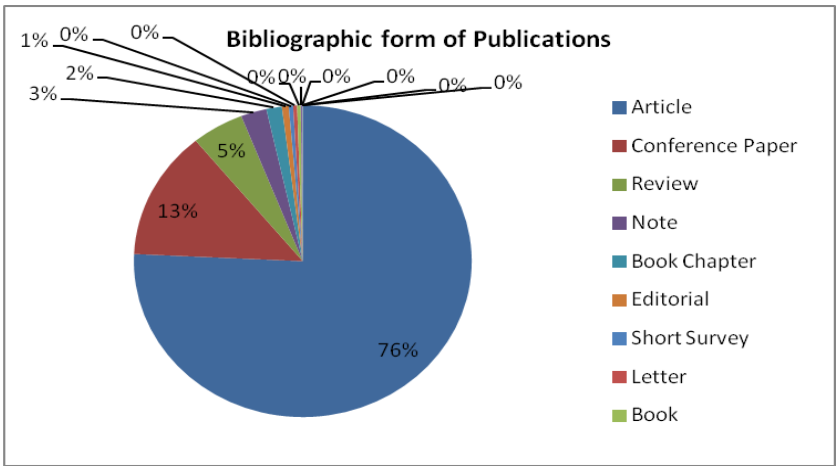

Figure - 2 Bibliographic forms of Publications

From the table–3 shows that bibliographic form wise pollution control research publications during the selected five years studies are identified 13825 publications. It is found that maximum of 1/3 of publication is contributed in articles 10470 (75.73%), followed by conference papers 1843 (13.33%), review 691(5%), note 342 (2.47%), etc. This study identified that articles and conference papers are contributed 12313 (89.06%) research publications.

Authorship Pattern

During the study period, it is identified by the authorship pattern of pollution control research from table 4. It is found that maximum of publications is contributed by three authors 2480 (17.94%), followed by four authors 2386 (17.26%), two authors 2132 (15.42%), five authors 1873(13.55%). Out of 13825 publications 1640(11.86%) contributions are a single author. This study found that 366(2.65%) publications are contributed more than ten authors.

S. No	No of Author's	Publications	%
1	Single	1640	11.86
2	Two	2132	15.42
3	Three	2480	17.94
4	Four	2386	17.26
5	Five	1873	13.55
6	Six	1263	9.14
7	Seven	734	5.31
8	Eight	490	3.54
9	Nine	282	2.04
10	Tem	179	1.29
11	More than Ten	366	2.65
Total		**13825**	**100.00**

Table – 4 Authorship Pattern

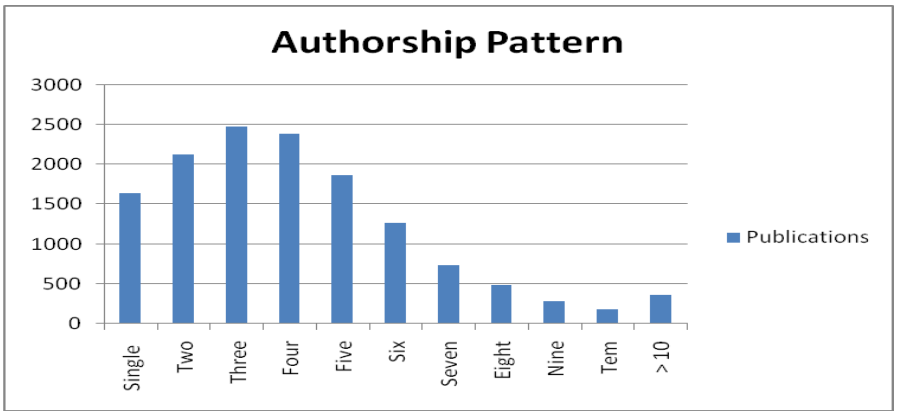

Figure - 3 Authorship Pattern

Lotska's Law

Lotka's Law is one of the three major bibliometric laws. The main focused on the distribution of publication activity of various authors in a given field of scientific publications. It explains the frequency of publications by authors in a particular field of study. It states that the number of authors making n contributions is about $1/n^2$ of those making one, and the proportion of all contributors that make a single contribution is in the region of 60 percent. This means that out of all the authors in a given field, 60 percent will have just one publication; 15 percent will have two publications ($1/2^2$ times 60); 7 percent will have three publications ($1/3^2$ times 60), and so on.[10].

$$y = C \times X^{-n}$$

Here,

x is the number of publications (1,2, etc.,)

n is an exponent that is constant for a given set of data

y is the expected percentage of authors with frequency x of publications

Authors Productivity

Sl. No	Publications	#Authors	%
1	1	29953	83.19353
2	2	3485	9.67948
3	3	909	2.524719
4	4	447	1.241529
5	5	287	0.797134
6	6	165	0.458282
7	7	139	0.386068
8	8	79	0.21942
9	9	62	0.172203
10	10	52	0.144428
11	11	33	0.091656
12	12	50	0.138873
13	13	39	0.108321
14	14	35	0.097211
15	15	19	0.052772
16	16	15	0.041662
17	17	21	0.058327
18	18	20	0.055549
19	19	14	0.038885
20	20	11	0.030552
21	21	10	0.027775
22	22	7	0.019442
23	23	7	0.019442
24	24	8	0.02222
25	25	6	0.016665
26	26	5	0.013887
27	27	13	0.036107
28	28	4	0.01111
29	29	7	0.019442
30	30	6	0.016665
31	31	3	0.008332
32	32	5	0.013887
33	33	2	0.005555
34	34	3	0.008332

35	35	7	0.019442
36	36	2	0.005555
37	37	2	0.005555
38	38	4	0.01111
39	39	1	0.002777
40	40	4	0.01111
41	41	4	0.01111
42	42	1	0.002777
43	43	3	0.008332
44	44	1	0.002777
45	46	1	0.002777
46	47	1	0.002777
47	48	2	0.005555
48	49	2	0.005555
49	50	3	0.008332
Others	31	45	0.124986
Total Authors		**36004**	

Table - 5 Author Productivity

From table 5 it is identified from the selected five years study period, a total number of 13825 publications are contributed in 36004 authors. Out of that maximum of 29953 (83.19%), authors are contributed by the single publication. Followed by 3485 (9.68%) authors are contributed by two publications, 909 (2.53%) authors are contributed by three publications. Top three (single, two, three) category of authors are contributed 95.4% contributions.

Calculation of N for the Pollution Control Research Publications

The author productivity corresponds not to the number of articles published by an author but to its logarithm; it seems that a multiplicative, rather than simply additive, model provides a better fit to this measure or counting method. The exponent n is often fixed at 2, in which case the law is known as the inverse square law of scientific productivity. However, given that the exponent n predicts the relative number of authors at each productivity level it would seem to calculate it.

x	y	X = (logx)	Y = (logy)	XY	XX
1	29953	0.0000	4.4764	0.0000	0.0000
2	3485	0.3010	3.5422	1.0663	0.0906
3	909	0.4771	2.9586	1.4116	0.2276
4	447	0.6021	2.6503	1.5956	0.3625
5	287	0.6990	2.4579	1.7180	0.4886
6	165	0.7782	2.2175	1.7255	0.6055
7	139	0.8451	2.1430	1.8111	0.7142
8	79	0.9031	1.8976	1.7137	0.8156
9	62	0.9542	1.7924	1.7104	0.9106
10	52	1.0000	1.7160	1.7160	1.0000
11	33	1.0414	1.5185	1.5814	1.0845
12	50	1.0792	1.6990	1.8335	1.1646
13	39	1.1139	1.5911	1.7724	1.2409
14	35	1.1461	1.5441	1.7697	1.3136
15	19	1.1761	1.2788	1.5039	1.3832
16	15	1.2041	1.1761	1.4162	1.4499
17	21	1.2304	1.3222	1.6269	1.5140
18	20	1.2553	1.3010	1.6331	1.5757
19	14	1.2788	1.1461	1.4656	1.6352
20	11	1.3010	1.0414	1.3549	1.6927
21	10	1.3222	1.0000	1.3222	1.7483
22	7	1.3424	0.8451	1.1345	1.8021
23	7	1.3617	0.8451	1.1508	1.8543
24	8	1.3802	0.9031	1.2465	1.9050
25	6	1.3979	0.7782	1.0878	1.9542
26	5	1.4150	0.6990	0.9890	2.0021
27	13	1.4314	1.1139	1.5945	2.0488
28	4	1.4472	0.6021	0.8713	2.0943
29	7	1.4624	0.8451	1.2359	2.1386
30	6	1.4771	0.7782	1.1494	2.1819
31	3	1.4914	0.4771	0.7116	2.2242
32	5	1.5051	0.6990	1.0521	2.2655
33	2	1.5185	0.3010	0.4571	2.3059
34	3	1.5315	0.4771	0.7307	2.3454
35	7	1.5441	0.8451	1.3049	2.3841

36	2	1.5563	0.3010	0.4685	2.4221
37	2	1.5682	0.3010	0.4721	2.4593
38	4	1.5798	0.6021	0.9511	2.4957
39	1	1.5911	0.0000	0.0000	2.5315
40	4	1.6021	0.6021	0.9645	2.5666
41	4	1.6128	0.6021	0.9710	2.6011
42	1	1.6232	0.0000	0.0000	2.6349
43	3	1.6335	0.4771	0.7794	2.6682
44	1	1.6435	0.0000	0.0000	2.7009
46	1	1.6628	0.0000	0.0000	2.7648
47	1	1.6721	0.0000	0.0000	2.7959
48	2	1.6812	0.3010	0.5061	2.8266
49	2	1.6902	0.3010	0.5088	2.8568
50	3	1.6990	0.4771	0.8106	2.8865
Total		**62.8299**	**54.6437**	**52.8960**	**87.7350**

Table - 6 Calculation of n for the K-S Test

$$n = \frac{N\sum XY - \sum X \sum Y}{N\sum X^2 - (\sum X)^2}$$

Where,

N is the number of data pairs considered

X is the logarithm of x (x=number of articles)

Y is the logarithm of y (y=number of authors)

$$\mathbf{n} = \frac{((50*52.896) - (62.8299*54.643))}{((50*87.7350) - (62.8299)^2)} = \mathbf{-1.7954}$$

Kolmogorov-Smirnov Test

The constant C is calculated using the below formula,

$$C = \frac{1}{\sum(1/x^n)}, \text{ Here } C = 1 / \sum(1/x^n) = 1/1.8325 = \mathbf{0.5457}$$

To verify that the observed distribution of author productivity fits the estimated distribution, Pao (1985)[11] suggested applying the non-parametric Kolmogorov-Smirnov (K-S) goodness-of-fit test. To this end, the maximum difference between the real and the estimated accumulated frequencies was calculated, and these values are compared with the critical value (c.v.) obtained from the following equation.

$$\text{Critical Value CV} = \frac{1.63}{(\sum yx + (\sum yx/10)^{1/2})^{1/2}} = \frac{1.63}{(54056+(54056/10)^{1/2})^{1/2}} = \frac{1.63}{232.6545}$$

$$= \mathbf{0.007006}$$

KOLMOGOROV-SMIRNOV TEST

Paper's x	Author's y	Observed D	Cum. D	Cum. Y	$1/(x^n)$	$Fe=c(1/x^n)$	Cum. fe	Dif.
1	29953	0.8319	0.8319	29953	1.0000	0.5457	0.5457	0.2862
2	3485	0.0968	0.9287	33438	0.2881	0.1572	0.7029	0.2258
3	909	0.0252	0.9540	34347	0.1391	0.0759	0.7788	0.1752
4	447	0.0124	0.9664	34794	0.0830	0.0453	0.8241	0.1423
5	287	0.0080	0.9744	35081	0.0556	0.0303	0.8544	0.1199
6	165	0.0046	0.9789	35246	0.0401	0.0219	0.8763	0.1026
7	139	0.0039	0.9828	35385	0.0304	0.0166	0.8929	0.0899
8	79	0.0022	0.9850	35464	0.0239	0.0130	0.9059	0.0791
9	62	0.0017	0.9867	35526	0.0194	0.0106	0.9165	0.0702
10	52	0.0014	0.9882	35578	0.0160	0.0087	0.9252	0.0629

11	33	0.0009	0.9891	35611	0.0135	0.0074	0.9326	0.0565
12	50	0.0014	0.9905	35661	0.0115	0.0063	0.9389	0.0516
13	39	0.0011	0.9916	35700	0.0100	0.0055	0.9444	0.0472
14	35	0.0010	0.9925	35735	0.0088	0.0048	0.9491	0.0434
15	19	0.0005	0.9931	35754	0.0077	0.0042	0.9534	0.0397
16	15	0.0004	0.9935	35769	0.0069	0.0038	0.9571	0.0363
17	21	0.0006	0.9941	35790	0.0062	0.0034	0.9605	0.0336
18	20	0.0006	0.9946	35810	0.0056	0.0030	0.9635	0.0311
19	14	0.0004	0.9950	35824	0.0051	0.0028	0.9663	0.0287
20	11	0.0003	0.9953	35835	0.0046	0.0025	0.9688	0.0265
21	10	0.0003	0.9956	35845	0.0042	0.0023	0.9711	0.0245
22	7	0.0002	0.9958	35852	0.0039	0.0021	0.9732	0.0225
23	7	0.0002	0.9960	35859	0.0036	0.0020	0.9752	0.0208
24	8	0.0002	0.9962	35867	0.0033	0.0018	0.9770	0.0192
25	6	0.0002	0.9964	35873	0.0031	0.0017	0.9787	0.0177
26	5	0.0001	0.9965	35878	0.0029	0.0016	0.9803	0.0162
27	13	0.0004	0.9969	35891	0.0027	0.0015	0.9817	0.0151
28	4	0.0001	0.9970	35895	0.0025	0.0014	0.9831	0.0138
29	7	0.0002	0.9972	35902	0.0024	0.0013	0.9844	0.0127
30	6	0.0002	0.9973	35908	0.0022	0.0012	0.9856	0.0117
31	3	0.0001	0.9974	35911	0.0021	0.0011	0.9868	0.0106
32	5	0.0001	0.9976	35916	0.0020	0.0011	0.9879	0.0097
33	2	0.0001	0.9976	35918	0.0019	0.0010	0.9889	0.0087
34	3	0.0001	0.9977	35921	0.0018	0.0010	0.9899	0.0078
35	7	0.0002	0.9979	35928	0.0017	0.0009	0.9908	0.0071
36	2	0.0001	0.9979	35930	0.0016	0.0009	0.9917	0.0063
37	2	0.0001	0.9980	35932	0.0015	0.0008	0.9925	0.0055
38	4	0.0001	0.9981	35936	0.0015	0.0008	0.9933	0.0048
39	1	0.0000	0.9981	35937	0.0014	0.0008	0.9940	0.0041
40	4	0.0001	0.9983	35941	0.0013	0.0007	0.9948	0.0035
41	4	0.0001	0.9984	35945	0.0013	0.0007	0.9955	0.0029
42	1	0.0000	0.9984	35946	0.0012	0.0007	0.9961	0.0023
43	3	0.0001	0.9985	35949	0.0012	0.0006	0.9968	0.0017
44	1	0.0000	0.9985	35950	0.0011	0.0006	0.9974	0.0011
46	1	0.0000	0.9985	35951	0.0010	0.0006	0.9979	0.0006
47	1	0.0000	0.9986	35952	0.0010	0.0005	0.9985	0.0001
48	2	0.0001	0.9986	35954	0.0010	0.0005	0.9990	0.0004
49	2	0.0001	0.9987	35956	0.0009	0.0005	0.9995	0.0008
50	3	0.0001	0.9988	35959	0.0009	0.0005	1.0000	0.0012
				$\sum(1/x^n)$	1.8325		**D Max**	0.2862
			C =	$1/\sum(1/x^n)$	**1/1.8325**			

Table - 7 K-S Test for Pollution Control Research Publications

During the study based on the data contribution in Table-7 the calculated values of n and C are 1.7954 and 0.5457 correspondingly. To verify the values of the observed and expected frequency distribution of the author's productivity of DMax is fit or not in the threshold value from the data to the non-parametric Kolmogorov-Smirnov Test. To this end, we used the data from Table 7 (Dmax), obtained as the absolute value of the difference between observed and expectation value.

From table-7 it was identified that the greatest value of Dmax is 0.2862 compared with the Critical Value (CV) is **0.007006**. The Maximum Difference (DMax) between the observed value and expected accumulated frequency is 0.2862, which is greater than the critical value 0.007006. So that this study identified Lotka's law is not fit in the field of pollution control research publications during the study period.

8. Major Findings

- A total number of 13825research publications are identified, and the maximum of 3390 (24.54) publications are contributed in the year 2017.
- The highest number of publications are contributed by Hao J with 53 (20.23%) into top ranking authors, and maximum of publications are contributed in articles 10470 (75.73%) publications.
- It is identified from the study three authors are contributed a maximum of 2480 (17.94%) publications.

- The Lotka's Law study identified that the greatest value of Dmax is 0.2862 compared with the Critical Value (CV) is **0.007006**. The Maximum Difference (DMax) between the observed value and expected accumulated frequency is 0.2862, which is greater than the critical value of 0.007006. So it is confirmed this study that Lotka's law application is not fit in the field of pollution control research publications during the study period.

9. Conclusion

In the recent era environments are mainly affected by pollution. During the five year study identified that pollution control research has been increased gradually, the maximum of the publications are contributed by multi-authors, and lotka's law author productivity didn't match during the study period. Pollution control study is essential in the world to identify the recent trends into the researchers. Due to the dynamic industrial revolution and fast-growing economy, our environment gets polluted. Due to the growth of industrialization, the pollution also spread around the world. It can be controlled for the long happy life of every living human beings, plants and animals on the earth. Due to controlling the pollution this study suggest that avoid unnecessary or wasteful packaging of products into polythene cover, reuses the carry bags, don't burn any waste especially plastics for the smoke may contain polluting gases and plan to more plant trees to our surrounding.

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