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A SCIENTOMETRIC STUDY ON INDUSTRIAL POLLUTION IN INDIAN PERSPECTIVE (2007 to 2016)

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Abstract:

This study analyzed the research output in the field of industrial pollution in India. This was done by analyzing the publications indexed in the Web of Science (WoS) database. A total of 805 publications were released by the Indian scientists on Industrial pollution during 2007-2016 which received 9699citations.The-index is 43 and average citations per item 12.05.The study shows that Kumar A and Kumar R are the most productive authors from India in the present field of study. The most productive journal is Environmental Monitoring and Assessment and the highly published articles are seen in the year 2016.Relative Growth Rate is 0.16(2016) and Doubling Time is 4.58(2016).The study gives a clear picture of the scientific productivity of Indian scientists in the field of Industrial Pollution.

Keywords: Scientometric study, Industrial pollution, publication growth

Abbreviations: *TLCS-Total Local Citation Score, TGCS-Total Global Citation Score, TCR-Total Cited Reference, DT- Doubling time. RGR -Relative growth rate*

1.0 Introduction

Most of all parts of the world are affected in some way by industrial pollution and it includes the air, water, and chemical pollution caused by industries. Big cities with steel mills, power plants, heating plants, or railroad stations create the direct effects of industrial pollution. The smog, smell, and contamination of food or water are some direct effects[1].

Industry produces both traditional pollutants such as organic substances, sulfur dioxide, particulates, and nutrients, etc., and newly-recognized pollutants such as dioxin and other specific toxic substances. The pollutants are mainly in gas, water, and solid forms that can cause serious damage to the bio systems[2]. Scientometrics is an area which analyses scientific publications to explore the structure and growth of science. The Scientometrictechniques are used to analyze various quantitative or qualitative aspects of a publication. The history of science and technology, philosophy of science and sociology of scientific knowledge are the related fields of Scientometrics.[3]

2.0 Review of Literature

Raja, S, Balasubramani R[4](2011) analyzed the research output performance of Malaria research literature and identified the pattern of publication, authorship, citations and secondary journal coverage during 2003-2007.They found out that a total of 15685 papers were published by the scientists in the field of Malarial research and the average number of Publications produced per year was 20%. The highest number of publications 3731was produced in 2006and The most productive author is White N J with 136 papers dealing with malarial research.Sharokh, Ramin,Gharebaghi, Reza[5] and et al (2015) analyzed the scientific production on Diabetic retinopathy to draw an overall roadmap of future research strategic planning in that field. The study

concluded that earlier diagnosis and treatment of this devastating disease still has the highest global priority.YiF, P Yang[6,] and et al (2016)has identified the global research trends in Ebola research. This paper gives a clear picture of the current status of research and trends in studies about Ebola between 1977 and 2014. PozoA, Serrano, GM Aldridge[7]& et al (2017) has done the bibliometric and scientometric analysis of the Alzheimer's disease (AD).Their findings gave the need of the decision-making of research funding agencies in the near future.Najari , A, Yousefvand M[8](2013) studied the impact of journal indexing on the growth of scientific production of Iran. The result shows that Iran scientists contributed 1.5% of the world scientific production. They prefer English as the language to publish and according to their conclusion number of indexed journals with a number of articles , citations self-citations and H index of each country showed significant correlation.Muthumari, S, Raja S[9] (2016)presents bibliometric analysis of scholarly communication published in Defence Science Journal(DSJ) during the period 2005 to 2015.They analyzed different aspects like growth pattern, authorship pattern , prolific contributors, collaboration trend etc. They found out that 77.91% were scholarly articles and researchers from 26 different countries across the globe have contributed publications and India is on a top as largest contributing country with 77.73% during the study period.Vishnumaya R S, Nishy P[10]& et al(2016)attempts to analyze the growth and development of rare earth research in India based on the publication output as reflected in Web of Science (WoS) during 1987–2013. 1,88,877 papers are seen as global research output on rare earths and India secures a 7th position with 9457 papers. Recently developed three-dimensional performance indicators are used to rank the productivity of Indian institutions and authors in the field of rare earths research. These studies can help researchers to comprehend the magnitude of rare earths research in India and establish future research directions.

3.0 Statement of the Problem

The study analyzed the research output performance of researchers of India in Industrial pollution field. In the present educational and scientific field, publication plays an important role in analyzing the outreach of the subject. Therefore publication has an important role in society as well as our day to day activities for the betterment of the individuals. A collective effort will ensure that published findings are more representative of all the completed studies and can help maintain the integrity of scientific literature.

4.0 Scope of the Study

The study analyzes the various aspects related to the industrial pollution and to find out the research contribution of Indian scientists towards the topic. As Scientometric studies have a multidisciplinary nature it can be applied in various aspects such as items in journals, authors published the publications and papers published in conference proceedings published industrial pollution field from 2007to 2016.

5.0 Methodology

In this study, needed data were downloaded from Web of Science database.Web of Science is an online subscription-based scientific citation indexing service originally produced by the Institute for Scientific Information, now maintained by ClarivateAnalytics, that provides a comprehensive citation search. The study evaluated papers published in the area of industrial pollution by the Indian researchers.The papers published in the period of study2007 to 2016are account 805.

6.0 Objective of the Study

The Objectives of this study are:

- To study the author wise document distribution as reflected in the web of science(WoS)
- To identify the core journals in the field of industrial pollution research.
- To examine and analyze the keyword wise distribution of publications.
- To study the relative growth rate and doubling time in the field of industrial pollution.
- To determine the institution wise distribution of documents
- To find out the institution with subdivision wise distribution of documents
- To find out the country wise distribution of publication around the world.

7.0 Data Collection

The publications of industrial pollution are mostly found in the variety of prime Journals, Notes, and Review, Editorial-materials, Meeting-abstracts, Bibliographic-items, and Discussions. Data collection was done through the Web of Science database.

8.0 Limitations of the Study

- The study undertaken is prescribed to 10years, i.e. 2007-2016
- In this study, we didn't include the citation analysis.
- The study mainly focuses on the research output of the researchers from India.

9.0 Analysis and Result

9.1 Author wise document

Productive authors are discussed in this table. The most productive authors are Kumar A and Kumar R with 13 records related to industrial pollution and all papers published in the area of research. Most of the authors preferred research journals for their publication.

Table 1: Author wise Document Distribution (Top 20)

S. No	Author	Records	%	TLCS	TLCS/t	TLCSx	TGCS	TGCS/t	TLCR	TLCSb	TLCSe
1	Kumar A	13	1.6	2	0.67	0	54	22.40	10	1	0
2	Kumar R	13	1.6	1	0.25	0	120	27.33	9	0	0
3	Rai PK	12	1.5	38	4.59	1	382	51.84	39	27	0
4	Singh AK	11	1.4	4	0.53	4	73	12.66	2	1	0
5	Gupta S	9	1.1	4	0.48	3	81	17.10	6	1	0
6	Kumar P	9	1.1	2	0.50	1	91	16.49	4	0	0
7	Kumar S	9	1.1	3	0.39	2	42	11.17	10	1	0
8	Singh A	9	1.1	4	0.60	2	459	69.58	5	1	0
9	Govil PK	8	1.0	30	3.51	24	417	51.81	5	6	14
10	Pervez S	8	1.0	15	1.81	5	75	11.19	14	3	0
11	Singh P	8	1.0	0	0.00	0	20	4.37	2	0	0
12	Singh R	8	1.0	3	0.42	3	44	8.21	8	1	0
13	Jayaprakash M	7	0.9	15	1.83	10	97	14.13	15	4	4
14	Nayak GN	7	0.9	6	1.07	0	73	15.92	13	3	0
15	Pandit GG	7	0.9	12	1.83	6	93	17.17	15	3	1
16	Krishna AK	6	0.7	22	2.40	18	266	31.99	2	3	9
17	Sahu SK	6	0.7	3	0.73	1	25	9.17	11	0	0
18	Sarkar SK	6	0.7	10	1.24	4	186	25.02	8	1	0
19	Sharma SK	6	0.7	4	1.43	2	49	23.29	8	0	0
20	Singh N	6	0.7	1	0.11	0	76	9.56	1	1	0

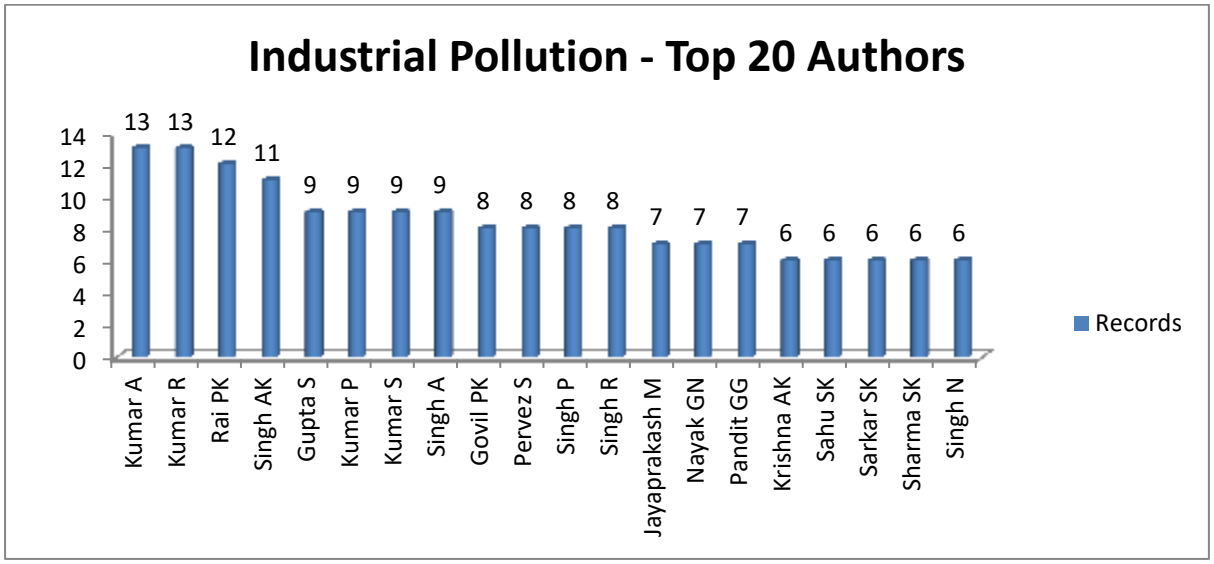

Figure 1 Journal wise Distribution

Most productive journals where the industrial pollution articles are published were discussed in this table. The most productive Journal is Environmental Monitoring and Assessment with 106 articles dealing with industrial pollution and 12.8% articles are published in this journal. Environmental earth sciences and Journal of Environmental Biology were the 2nd and 3rd ranking journals were most published journals are present.

Table 2: Journal wise Distribution of Publications

S. No	Journal	Records	Percent	TLCS	TLCS/t	TGCS	TGCS/t	TLCR
1	Environmental monitoring and assessment	103	12.8	107	14.52	1419	214.02	67
2	Environmental earth sciences	24	3.0	9	1.88	180	45.23	36
3	Journal of environmental biology	19	2.4	9	1.06	135	18.30	6
4	Aerosol and air quality research	18	2.2	27	3.89	248	44.06	32
5	Atmospheric pollution research	17	2.1	12	3.43	111	40.09	24
6	Atmospheric environment	14	1.7	8	1.94	215	42.32	14
7	Journal of hazardous materials	14	1.7	46	5.85	573	75.22	4
8	Bulletin of environmental contamination and toxicology	13	1.6	5	0.77	60	16.63	12
9	international journal of environmental science and technology	12	1.5	1	0.14	153	33.27	14
10	environmental science and pollution research	11	1.4	2	0.75	88	27.38	4
11	research journal of chemistry and environment	10	1.2	0	0.00	22	3.79	2
12	atmospheric research	9	1.1	11	1.56	204	34.52	7
13	current science	9	1.1	0	0.00	8	2.51	3
14	ecotoxicology and environmental safety	9	1.1	2	0.39	194	59.14	5
15	international journal of environmental research	9	1.1	11	1.46	102	13.10	5
16	science of the total environment	9	1.1	2	1.25	91	21.24	3
17	Arabian journal of geosciences	8	1.0	1	0.50	45	18.75	14
18	environmental geology	8	1.0	26	2.89	162	18.13	1
19	journal of cleaner production	8	1.0	0	0.00	74	26.92	1
20	desalination and water treatment	7	0.9	0	0.00	17	8.54	1

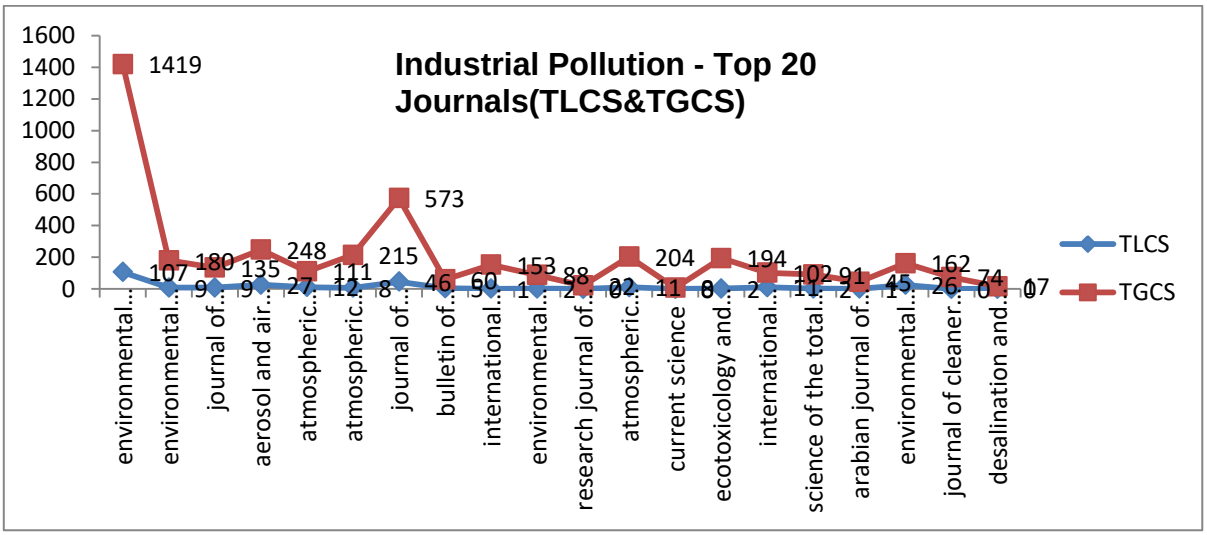

Figure 2

9.2 Keyword wise Distribution of Publications

Key word wise Distribution of Publications is discussed in Table 3. The high-frequency keywords help us to understand the various searching aspects of industrial pollution in the present study. The high frequency keyword is India(37.8%),Industrial(21.1%),Heavy(14.5%),Pollution(13.7%) respectively. Analysis of the keywords appeared either on the title or assigned by the indexer or the author himself will help in knowing in which direction the knowledge grows.

Table 3: Key word wise Distribution of Publications

S. No	Word wise	Records	Percent	TLCS	TGCS
1	INDIA	304	37.8	258	3651
2	INDUSTRIAL	170	21.1	144	2147
3	HEAVY	117	14.5	115	2347
4	POLLUTION	110	13.7	55	1043
5	METAL	100	12.4	74	1584
6	WATER	96	11.9	46	976
7	ASSESSMENT	95	11.8	77	1608
8	USING	91	11.3	53	939
9	METALS	78	9.7	86	1541
10	QUALITY	69	8.6	32	435
11	SEDIMENTS	63	7.8	70	982
12	RIVER	62	7.7	50	855
13	AIR	59	7.3	27	374
14	URBAN	56	7.0	62	848
15	AREA	49	6.1	47	824
16	GROUNDWATER	48	6.0	24	443

17	CONTAMINATION	45	5.6	57	776
18	COAST	41	5.1	38	441
19	DELHI	40	5.0	47	455
20	ENVIRONMENTAL	38	4.7	18	526

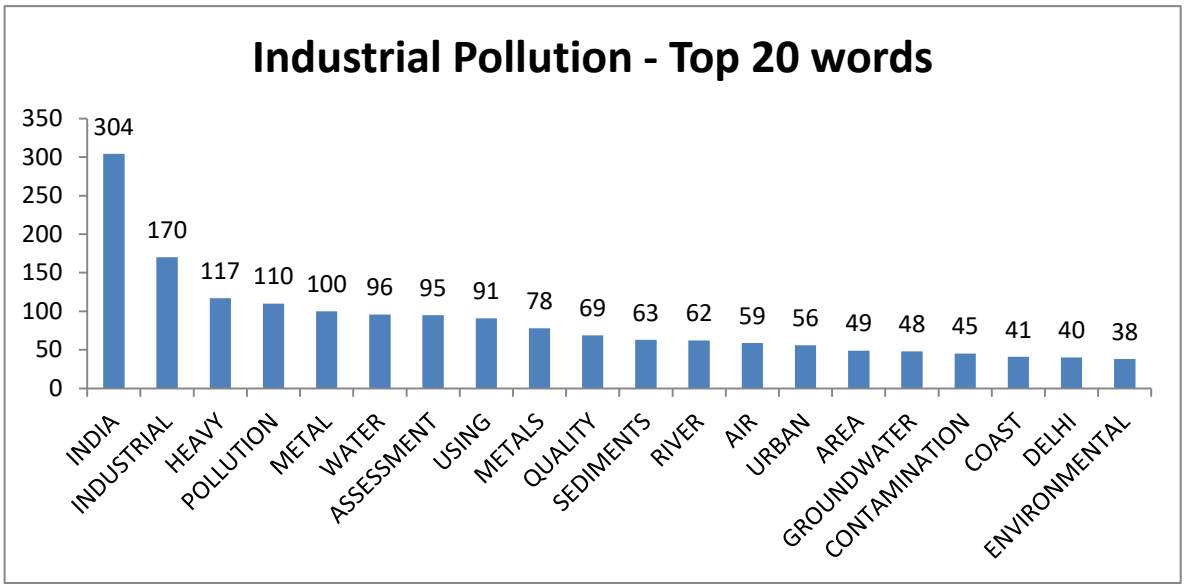

Figure 3

9.3 Year Wise Distribution of Documents

This table shows the year wise increase of research productivity in the field of industrial pollution. From the table, we can identify that a tremendous growth in this field. In the year 2016a total of113documents were published in industrial pollution from India. The average number of publications produced per year was 80.5.The highest number of publications is produced in 2015,2013,2014 respectively. We can identify that the research productivity of industrial pollution is least in the year 2007.

Table 4: Year wise distribution of Documents

S. No	Publication Year	Records	Percent	TLCS	TGCS
1	2007	51	6.3	68	1231
2	2008	75	9.3	100	1579
3	2009	69	8.6	68	1513
4	2010	69	8.6	62	1244
5	2011	71	8.8	46	1361
6	2012	75	9.3	37	748
7	2013	100	12.4	15	724
8	2014	80	9.9	10	605
9	2015	102	12.7	11	478
10	2016	113	14.0	3	216

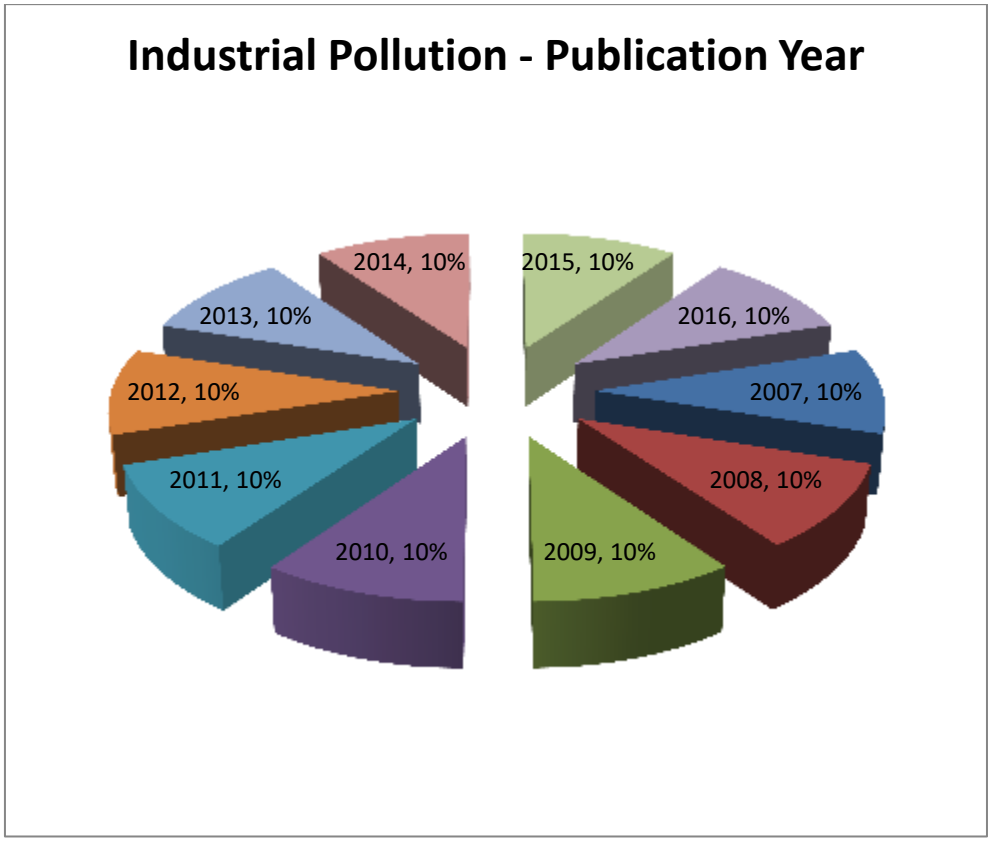

Figure 4

9.4 Relative Growth Rate and Doubling Time

The relative growth rate and doubling time of publications were discussed and presented in Table 5.The table gives indicates that the value of average RGR of publications which decreased from 3.93 in 2007 to 0.15 in 2016. At the same time, the values of doubling time (Dt) of publications increased from 0.18 (2007) to4.58 (2016).

Table 5: Relative Growth Rate and Doubling Time

Year	No. of Records	Cumulative	W1	W2	RGR	Doubling Time
2007	51	51	0.00	3.93	3.93	0.18
2008	75	126	3.93	4.84	0.90	0.77
2009	69	195	4.84	5.27	0.44	1.59
2010	69	264	5.27	5.58	0.30	2.29
2011	71	335	5.58	5.81	0.24	2.91
2012	75	410	5.81	6.02	0.20	3.43
2013	100	510	6.02	6.23	0.22	3.18
2014	80	590	6.23	6.38	0.15	4.76
2015	102	692	6.38	6.54	0.16	4.35
2016	113	805	6.54	6.69	0.15	4.58

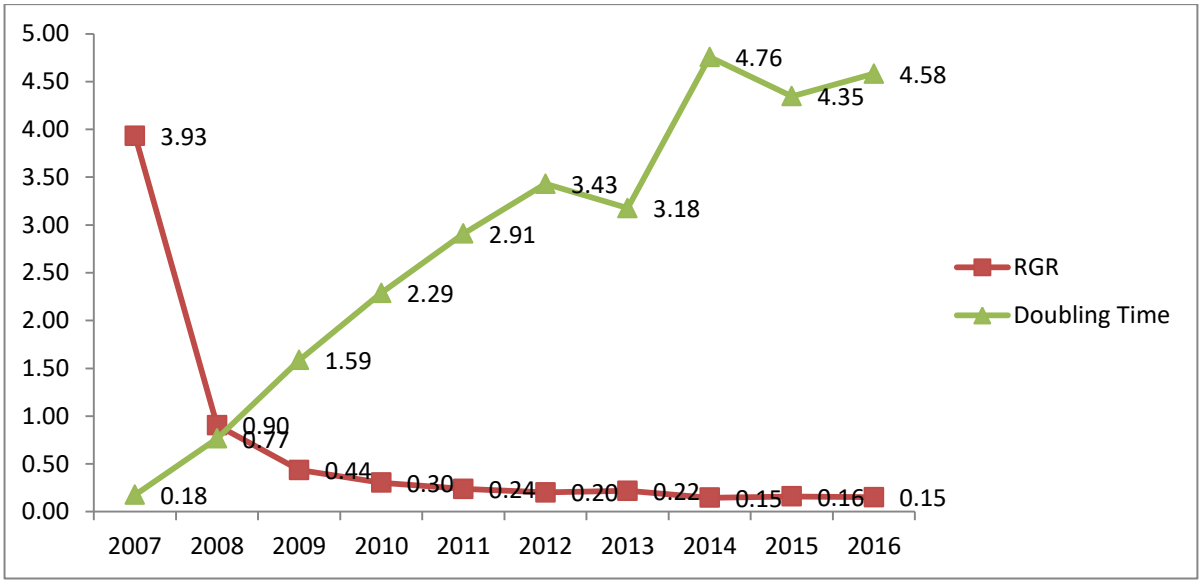

Figure 5

9.5 Document Type Distribution

Table 6 shows the document type distribution.It shows that most of the researchers are interested in publishing their documents in the form of research articles.In the present study, Articles covers the most preferred type ie 89.7% following by the review 8%, Conference papers 2% respectively.

Table 6 : Document Type Distribution

S. No	Document Type	Records	Percent	TLCS	TGCS
1	Article	722	89.7	396	7356
2	Review	64	8.0	23	2259
3	Article; Proceedings Paper	16	2.0	1	70
4	Editorial Material	1	0.1	0	2
5	Letter	1	0.1	0	1
6	Review; Retracted Publication	1	0.1	0	11

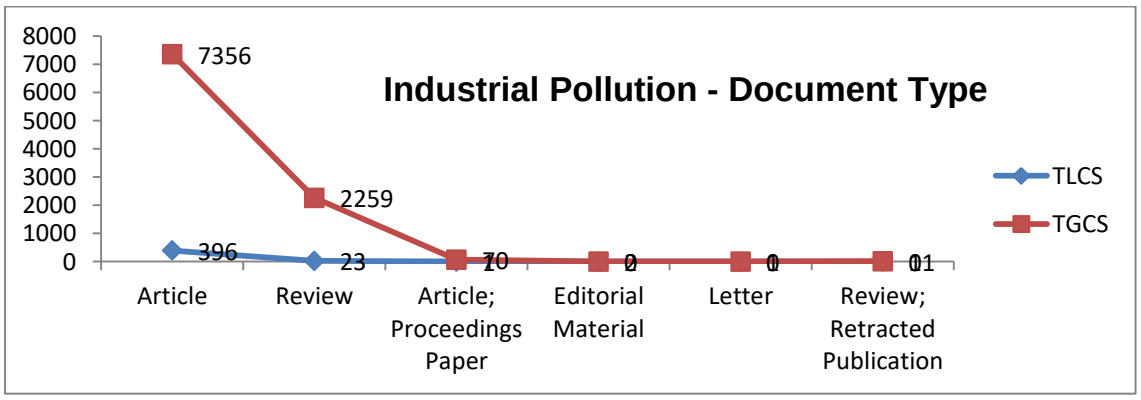

Figure 6

9.6 Institution Wise Distribution of Documents

There were 746 institutions involved in research activity in the field of industrial pollution Table 7 provides publication productivity of top 20 institutions. Indian Institute of Technology topped the list with 70 publications (8.7 %, TLCS 45, TGCS 1103) followed by National Environment Engineering Research Institute with 28(3.5%)publications, respectively.

Table 7: Institution Wise distribution of documents

S. No	Institution	Records	Percent	TLCS	TGCS
1	Indian InstTechnol	70	8.7	45	1103
2	NatlEnvironmEngn Res Inst	28	3.5	5	207
3	CSIR	27	3.4	20	406
4	Jawaharlal Nehru Univ	25	3.1	31	274
5	NatlGeophys Res Inst	20	2.5	29	411
6	AnnamalaiUniv	18	2.2	8	114
7	Univ Calcutta	18	2.2	14	208
8	Bhabha Atom Res Ctr	17	2.1	14	154
9	Anna Univ	16	2.0	15	194
10	Univ Madras	14	1.7	24	210
11	Univ Delhi	13	1.6	9	100
12	Aligarh Muslim Univ	12	1.5	4	262
13	Banaras Hindu Univ	12	1.5	16	328
14	Mizoram Univ	12	1.5	29	281
15	Indian Inst Trop Meteorol	11	1.4	7	112
16	NatlInstOceanog	11	1.4	14	192
17	NatlInstTechnol	11	1.4	3	120
18	PtRavishankarShuklaUniv	11	1.4	14	134
19	Indian Sch Mines	9	1.1	3	199
20	Goa Univ	8	1.0	6	76

9.7 Institution With Subdivision Wise Distribution

This table shows the various sub division departments that involved in the research productivity in the given field. It shows that Dept of Civil Engineering , Indian Institute of Technology placed in the first with 25 records and that covers 3.1% of the total records. Top 20 departments are discussed in the table and this table helps us to identify the department wise increase of productivity.

Table 8: Institution with Subdivision wise Distribution

S. No	Institution with Subdivision	Records	Percent	TLCS	TGCS
1	Indian InstTechnol, Dept Civil Engn	25	3.1	17	493
2	Jawaharlal Nehru Univ, SchEnvironmSci	21	2.6	31	269

3	PtRavishankarShuklaUniv, Sch Studies Chem	11	1.4	14	134
4	Indian InstTechnol, DeptChemEngn	9	1.1	4	129
5	AnnamalaiUniv, Dept Earth Sci	8	1.0	5	43
6	CSIR, NatlGeophys Res Inst	8	1.0	7	137
7	NatlEnvironmEngn Res Inst, Nagpur 440020	8	1.0	2	55
8	Univ Calcutta, Dept Marine Sci	8	1.0	10	188
9	Banaras Hindu Univ, Dept Bot	7	0.9	14	272
10	Goa Univ, Dept Marine Sci	7	0.9	6	73
11	GovindBallabh Pant UnivAgr&Technol, DeptEnvironmSci	7	0.9	9	81
12	NatlGeophys Res Inst, Hyderabad 500007	7	0.9	15	182
13	Indian Inst Trop Meteorol, Pune 411008	6	0.7	4	65
14	NatlEnvironmEngn Res Inst, Air Pollut Control Div	6	0.7	0	47
15	Univ Madras, DeptApplGeol	6	0.7	15	95
16	AnnamalaiUniv, DeptPhys	5	0.6	4	46
17	AnnamalaiUniv, Fac Marine Sci	5	0.6	0	23
18	Bhabha Atom Res Ctr, Environm Monitoring & Assessment Sect	5	0.6	1	10
19	Cochin UnivSci&Technol, Sch Marine Sci	5	0.6	2	11
20	HanyangUniv, Dept Civil &EnvironmEngn	5	0.6	1	5

9.8 Country Wise Distribution of Publication Around the World

This table shows the country wise publication output of research productivity in the given field around the world. India placed in the topmost position with 803(99.8%) records and the USA in the second position with 31(3.9%).It can be identified that India is the most productive country in the field of industrial pollution.

Table: 9 Country wise distribution of publication

S. No	Country	Records	Percent	TLCS	TGCS
1	India	803	99.8	419	9686
2	USA	31	3.9	14	346
3	South Korea	12	1.5	2	97
4	Germany	10	1.2	6	157
5	Malaysia	9	1.1	2	74
6	Peoples R China	9	1.1	2	49
7	Japan	8	1.0	4	299
8	Saudi Arabia	7	0.9	1	94
9	Italy	6	0.7	2	147
10	Mexico	6	0.7	8	64

11	UK	6	0.7	3	214
12	Taiwan	5	0.6	2	93
13	Iran	4	0.5	1	131
14	Sweden	4	0.5	0	47
15	Australia	3	0.4	1	15
16	Brazil	3	0.4	7	127
17	France	3	0.4	0	17
18	Nigeria	3	0.4	1	64
19	Norway	3	0.4	3	53
20	Portugal	3	0.4	1	259

9.9 Cited reference wise documents distribution

The most cited reference is APHA AWWA WPCF, 1998, STAND METH EX WAT WA with 25 papers dealing with industrial pollution. 3.1 % of all papers published in this research field. The cited reference of the seminal publication on industrial pollution has given Table 10, appeared on rank 2 HAKANSON L, 1980, WATER RES, V14, P975, DOI 10.1016/0043-1354(80)90143-8 and Muller G., 1969, GEOJOURNAL, V2, P108 respectively. It was clearly depicted in the below table.

Table 10: Cited reference wise documents distribution

S. No	Author / Year / Journal	Records	Percent
1	APHA AWWA WPCF, 1998, STAND METH EX WAT WA	25	3.1
2	HAKANSON L, 1980, WATER RES, V14, P975, DOI 10.1016/0043-1354(80)90143-8	24	3.0
3	Muller G., 1969, GEOJOURNAL, V2, P108	24	3.0
4	TUREKIAN KK, 1961, GEOL SOC AM BULL, V72, P175, DOI 10.1130/0016-7606(1961)72[175:DOTEIS]2.0.CO;2	23	2.9
5	TOMLINSON DL, 1980, HELGOLANDER MEERESUN, V33, P566, DOI 10.1007/BF02414780	19	2.4
6	MULLER G, 1979, UMSCHAU, V79, P778	18	2.2
7	TAYLOR SR, 1995, REV GEOPHYS, V33, P241, DOI 10.1029/95RG00262	18	2.2
8	WEDEPOHL KH, 1995, GEOCHIM COSMOCHIM AC, V59, P1217	18	2.2
9	GAUDETTE HE, 1974, J SEDIMENT PETROL, V44, P249	17	2.1
10	LOWRY OH, 1951, J BIOL CHEM, V193, P265	17	2.1
11	DOCKERY DW, 1993, NEW ENGL J MED, V329, P1753, DOI 10.1056/NEJM199312093292401	16	2.0
12	Sutherland RA, 2000, ENVIRON GEOL, V39, P611	16	2.0
13	NRIAGU JO, 1988, NATURE, V333, P134, DOI 10.1038/333134a0	15	1.9
14	Jonathan MP, 2004, ENVIRON GEOL, V45, P466, DOI 10.1007/s00254-003-0898-7	14	1.7
15	Rubio B, 2000, MAR POLLUT BULL, V40, P968, DOI 10.1016/S0025-326X(00)00039-4	14	1.7

16	Govil PK, 2001, ENVIRON GEOL, V41, P461, DOI 10.1007/s002540100415	13	1.6
17	LORING DH, 1992, EARTH-SCI REV, V32, P235, DOI 10.1016/0012-8252(92)90001-A	13	1.6
18	Singh KP, 2005, ANAL CHIM ACTA, V538, P355, DOI 10.1016/j.aca.2005.02.006	13	1.6
19	TESSIER A, 1979, ANAL CHEM, V51, P844, DOI 10.1021/ac50043a017	13	1.6
20	Vega M, 1998, WATER RES, V32, P3581, DOI 10.1016/S0043-1354(98)00138-9	13	1.6

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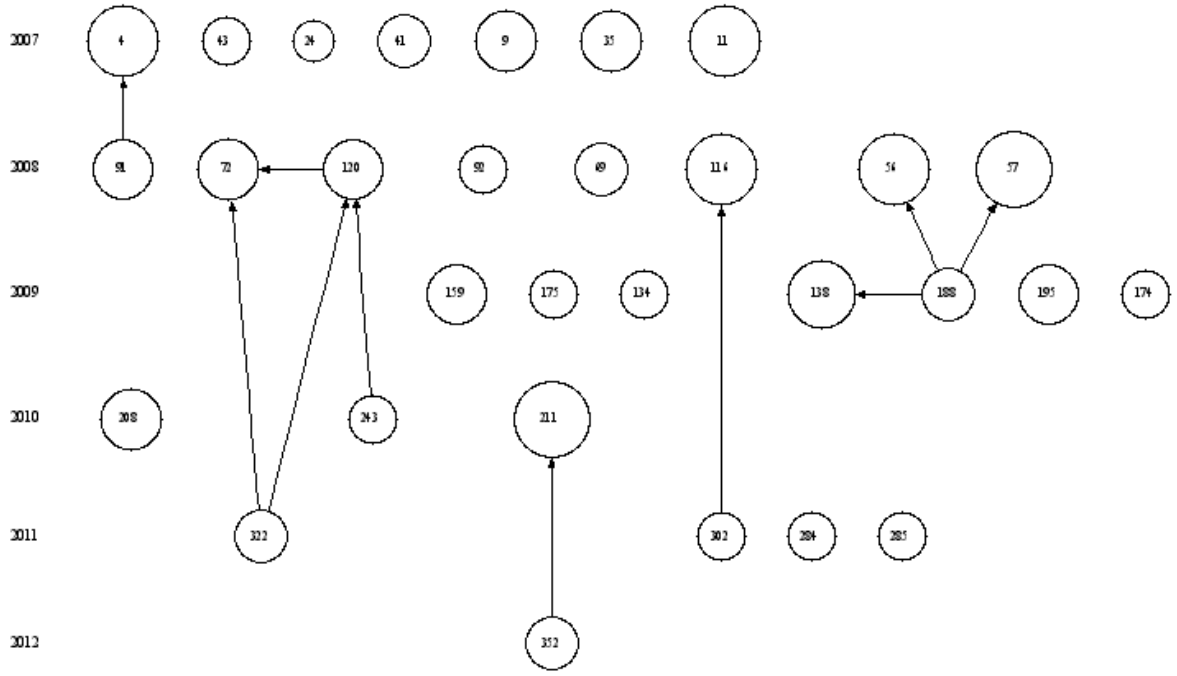

Figure 7

10.0 Conclusion

This paper has investigated 805 publications on industrial pollution and cited within the web of science database in the period 2007 to 2016. The most productive authors are Kumar A and Kumar R with 13 records related to industrial pollution and all papers published in the area of research. Most of the research findings are published in the form of scientific articles.The most productive Journal is Environmental Monitoring and Assessment with 106 articles dealing with industrial pollution and 12.8% articles are published in this journal. Environmental earth sciences and Journal of Environmental Biology were the 2nd and 3rd ranking journals were most published journals are present.The most published articles are seen in the year 2016.The relative growth rate is 0.15(2016) and Doubling time is4.58(2016).The study has given the outline of the research output of Indian researchers in the field of Industrial Pollution.

11.0 Reference

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