



RESEARCH ARTICLE

Measuring the research productivity on environmental toxicology: A scientometric study

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Abstract

This paper attempts to highlight the growth and development of Environmental Toxicology literature and to make the quantitative and qualitative assessment by way of analyzing various facets of research output and Citations impact based on the Web of Science database. A total of 6,663 publications were published on Environmental Toxicology, which received 183279 Citations in 2022. There were 126 countries involved in the Environmental Toxicology research. The most productive countries are the USA, having the highest share of 3,051 publications and receiving 105322 Citations, followed by the People's Republic of China with 653 Citations with 13660 publications, Germany with 594 Citations for 21,315 publications, Canada with 575 Citations for 19,869 publications, England with 568 Citations for 24408 publications and so on. The most productive Institutions were the United States Environmental Protection Agency (USEPA) with 459 publications (17879 Citations), followed by USEPA with 65 publications (3822 Citations), and NIH National Institute of Environmental Health Sciences NIEHS 54 publications (3257 citations); it noted that 6 Institutes were registered more than 20 Publications and 25 Institutions were recorded more than 1000 Citations. The highly Cited journals are Environmental Toxicology and Chemistry with 10425 Citations for 577 Publications, Integrated Environmental Assessment and Management (IEAM) with 1436 Citations for 220 publications; Environmental Health Perspectives, with 1476 Citations for 162 publications; Environmental Health Perspectives, with 5332 Citations for 195 publications, and Toxicological Sciences with 729 Citations for 187 publications. The study found that 10 source titles were registered in more than 600 Citations, and most of the publications are published in high-impact journals. This paper also reveals the collaborating institutions, countries, authorship and publication pattern.

In the journal, Current Computer-aided Drug Design entitled "Quantitative Structure-activity Relationships of Aquatic Narcosis," Adhikari and Mishra explores the quantitative structure-activity relationships (QSAR) of aquatic narcosis and offer a comprehensive review of the field. Also, this article has a Local Citation Score of 2, a Global Citation Score of 11, a Local Citation Rank of 3. It has been cited 191 times, highlighting its influence and relevance in the area of drug design and environmental toxicology.

Also, in another journal, the International Journal of Environmental Health Research, entitled "Cellular Mechanisms of Cadmium-Induced Toxicity: A Review," Rani et al. explain the cellular mechanisms involved in cadmium-induced toxicity by providing an in-depth analysis of how cadmium affects biological systems Further this article has a local citation score (LCS) of 2, a Global Citation Score of 11, LCS of 3, and has been cited 191 times, highlighting its influence and relevance in the area of drug design and environmental toxicology.

Hence, it is identified that India ranks 17th position and has 157 publications in environmental toxicology that are covered by internationally reputed indexing sources

Keywords: Toxicology, Impact factor, Citations, Scientometrics, h- index

Novelty of the study:

The novelty of this study lies in its comprehensive approach to measuring research productivity in the field of environmental toxicology using scientometric methods. While environmental toxicology has become a developmental area of research, there has been a lack of systematic analysis that quantifies the trends, patterns, and impact of research output in this domain. Further, this study fills in the gap by applying scientometric techniques—such as citation analysis, co-authorship networks, and keyword analysis—to provide a clear, data-driven overview of the research landscape in environmental toxicology. The study also introduces innovative metrics to evaluate research productivity by highlighting influential authors, institutions, and journals, as well as identifying emerging research themes within the field. By offering insights into the global distribution of research and collaboration trends, the study provides valuable guidance for researchers, policymakers, and funding agencies looking to enhance research efforts and identify key areas for future investigation. Overall, the novelty lies in the application of scientometrics to offer an objective, evidence-based perspective on the evolution and current state of environmental toxicology research, helping to shape future research agendas and collaborations.

Introduction

Environmental toxicology is the field of study in the environmental sciences that is concerned with the assessment of toxic substances in the environment. Although it is based on toxicology, environmental toxicology draws heavily on principles and techniques from other fields, including biochemistry, cell biology, developmental biology, and genetics. Among its primary interests are the assessment of toxic substances in the environment, the monitoring of environments for the presence of toxic substances, the effects of toxins on biotic and abiotic components of ecosystems, and the metabolism and biological and environmental fate of toxins. This paper analyses the awareness among the

Environmental toxicology uses the metric study that is the Scientometric study, which is the quantitative analysis used for measuring scientific and technological progress, productivity, and its impact and to compare the research productivity between years, authors, institutions, countries, and so on. The study uses an indexing technique in order to provide objective data that reflects the relevance and the impact of the study, which can be measured based on publication in journals, authorship pattern, collaborative institutions, country, etc, and a number of citations received based on the publications.

Objectives of The Study

- Aimed at examining the growth of research productivity in terms of publication outcome on environmental toxicology for the study period
- To reveal the most prolific authors and to analyze the authorship pattern proliferation of research.
- The study the country-wise publications in the fields of Environmental Toxicology

- To identify the Keyword distribution in the field of Environmental Toxicology research output and to confirm the Zip laws.
- Track out the research concentration and distribution in the chosen field has been mapped.
- To analyze the citation trends and the impact of research output in environmental toxicology

Methodology

The present study is to investigate the research performance of Environmental Toxicology scholarly publications. It aims to identify the distribution of research output on the basis of research papers contributed by Scientists. The study examines author productivity, keyword distribution, country-wise publications, the pattern of distribution, and h-index was also brought under the purview of the study, and it is also analytical in nature with suitable statistical tools applications in strengthening the experimental validity.

Source of Data Collection

There are various sources contributing to the research output of Environmental Toxicology research by overall scientists. For this study, the researcher has taken Secondary sources from an online database. The necessary data was collected from the database of Science Citation Index (SCI), Social Science Citation Index (SSCI), and Arts & Humanities Citation Index (ACHI), which is available via the Web of Science (WoS). The WoS is the search platform provided by Thomson Reuters (the former Thomson Scientific emerged from the Institute for Scientific Information (ISI) in Philadelphia). SCI and SSCI database is one of the very complete databases covering all aspects of science. The study period 1989 to 2022 is selected in the available database. The researcher has used the search string "Environmental Toxicology" in the address field for the study period of 1989 to 2022 were downloaded. A total of 6773 records were downloaded in the form of Notepad and used the Histcite, VOS viewer and MS Excel packages for tabulation.

Data Analysis and Interpretation

Year-wise Distribution of Publications:

During the study period from 1989 to 2022, 6773 records were documented, from that ten years were analyzed in Table 1(a) having record of 3834, and the records were downloaded from the web of knowledge database for this analysis on Environmental Toxicology research productivity. There are variations in the number of publications of articles during this sample period taken for study. Table 1(b) value analysis reveals that the year wise growth trend is gradually increased and allied subjects. It is also correlated with the trend of literature growth in other subjects that early researchers are studying carried out in the publications. The year 2022 has got the highest stake in Environmental Toxicology outcomes for the past 10 years, having 547 publications with 1141 global

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Conflict of interest: None.

Table 1 (a): Year-wise Distribution of Records

S. N	Publication year	Records	TLCS	TGCS	S. N	Publication year	Records	TLCS	TGCS
1	1989	8	6	33	18	2006	127	210	10259
2	1990	6	7	199	19	2007	166	392	13041
3	1991	45	22	1052	20	2008	205	537	16972
4	1992	50	105	3403	21	2009	200	431	12735
5	1993	51	40	2361	22	2010	217	365	12407
6	1994	87	110	3594	23	2011	219	386	11219
7	1995	100	115	3941	24	2012	232	442	11876
8	1996	101	122	4792	25	2013	240	418	11106
9	1997	96	93	2764	26	2014	279	348	10836
10	1998	99	132	5842	27	2015	280	339	9898
11	1999	85	110	5056	28	2016	310	496	9481
12	2000	114	131	7354	29	2017	365	422	9504
13	2001	109	160	5755	30	2018	357	343	8285
14	2002	135	100	5319	31	2019	424	254	7375
15	2003	126	220	8745	32	2020	488	117	7578
16	2004	118	242	7306	33	2021	544	130	3763
17	2005	133	226	11614	34	2022	547	34	1141

citation scores. It is reverse chronological. The 2021 and the year 2020 got publications 544 and 488, respectively, with the citation score of 3763 and 7578. It is also found that the citation score increased as to the age of the publications; the Year 2013 has got highest global citation score of 11106 for 240 publications, followed by the year 2014 with 10836 citations for the 279 articles (Figure 1).

Relative Growth Rate

One important aspect of this discussion is the analysis of the growth rate of Environmental Toxicology research

output. This analysis aims to identify trends and prospects in the present research. The growth rate of Environmental Toxicology research literature is determined by calculating the relative growth rate of the publications.

It is observed that its relative growth rates have contracted progressively from 0.56 in 1989 to 0.12 in 2021. The whole study period sample mean relative growth rate is 0.14. Contrary to this, the doubling time for publication of all sources of environmental toxicology research output has decreased from 1.24 years in 1989 to 13.86 years in 2022. During the study period, the doubling time value is 4.39.

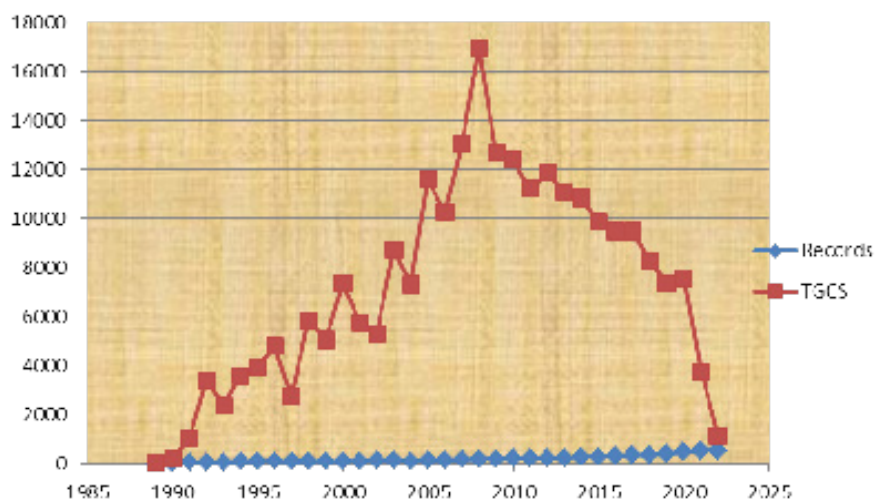


Figure 1: Year wise distribution

Table 1 (b): Relative Growth Rate

<i>Year</i>	<i>R. o/p</i>	<i>Cum. o/p</i>	<i>log e 1 p</i>	<i>log e 2 p</i>	<i>Rt(P)</i>	<i>Dt(P)</i>
1989	8	8	-	2.08	-	-
1990	6	14	2.08	2.64	0.56	1.24
1991	45	59	2.64	3.93	1.29	0.54
1992	50	109	3.93	4.55	0.62	1.12
1993	51	160	4.55	4.62	0.07	9.90
1994	87	247	4.62	4.93	0.31	2.24
1995	100	347	4.93	5.23	0.3	2.31
1996	101	448	5.23	5.30	0.07	9.90
1997	96	544	5.30	5.28	-0.02	-34.65
1998	99	643	5.28	5.27	-0.01	-69.30
1999	85	728	5.27	5.21	-0.06	-11.55
2000	114	842	5.21	5.29	0.08	8.66
2001	109	951	5.29	5.41	0.12	5.77
2002	135	1086	5.41	5.50	0.09	7.70
2003	126	1212	5.50	5.56	0.06	11.55
2004	118	1330	5.56	5.50	-0.06	-11.55
2005	133	1463	5.50	5.53	0.03	23.10
2006	127	1590	5.53	5.56	0.03	23.10
2007	166	1756	5.56	5.68	0.12	5.77
2008	205	1961	5.68	5.92	0.24	2.89
2009	200	2161	5.92	6.00	0.08	8.66
2010	217	2378	6.00	6.03	0.03	23.10
2011	219	2597	6.03	6.08	0.05	13.86
2012	232	2829	6.08	6.11	0.03	23.10
2013	240	3069	6.11	6.16	0.05	13.86
2014	279	3348	6.16	6.25	0.09	7.70
2015	280	3628	6.25	6.33	0.08	8.66
2016	310	3938	6.33	6.38	0.05	13.86
2017	365	4303	6.38	6.51	0.13	5.33
2018	357	4660	6.51	6.58	0.07	9.90
2019	424	5084	6.58	6.66	0.08	8.66
2020	488	5572	6.66	6.82	0.16	4.33
2021	544	6116	6.82	6.94	0.12	5.77
2022	547	6663	6.94	6.99	0.05	13.86
	6663	13326			4.91 (0.14)	149.39 (4.39)

Prolific Authors

Among 24509 authors, the environmental toxicology research outcome, which is documented in different forms of scholarly communications indeed in the web of science, has been tabulated and analyzed as shown in Table 2. It is interpreted that there were 24509 authors who totally contributed to the Environmental Toxicology research and allied subjects in which Brooks BW who has got the highest number of contributions 32 with 1100 citation having

h-index of 18, followed by Ankley GT with 29 and Judson RS with 29 publications respectively. It is also inferred that the authors with less number of publications have more citations. Accordingly, Judson RS who scored 3069 global citations with 29 publications. Author De voogt P having 30 publications with no citations and no h-index. The research is proliferated in different subject areas. Hence, the core contributors to the Environmental Toxicology research are minimal (Figure 2).

Table 2: Prolific authors

S. No	Author	Author Affiliations	Records	Citations	H-index
	Brooks BW	University of South Bohemia Ceske Budejovice	32	1,100	18
	De Voogt P	Assoc Retired Environm Scientists	30	0	0
	Ankley GT	EPA United States Environmental Protection Agency	29	1200	19
	Judson RS	United States Environmental Protection Agency	29	3069	26
	Hartung T	The Cyprus Institute	27	1545	19
	Martyniuk CJ	University of Michigan System	22	471	14
	Escher BI	Eberhard Karls University of Tübingen	20	997	13
	Huang RL	NIH National Center for Advancing Translational Sciences (NCATS)	20	1033	16
	Hundsen TB	United States Environmental Protection Agency	20	1615	15
	Rusyn I	Texas A&M University College Station	20	739	16

Journal-wise Distribution of Publications

It is found from the analysis that there were 1439 journals published, the total research outcome of Environmental Toxicology research for the study period. The top 20 journals are tabulated which reveals that Environmental Toxicology and Chemistry 577 publications and 220 citations for the study period. The top 20 journals got 12053 citations, followed by 1790 global citations, respectively. Journal Environmental Health Perspectives with 195 publications having 22972 global citations. The top 20 journals contributed nearly around 50% of publication output. It is noteworthy to mention that journals that published less number of articles have got more citations. The journal Environmental Health Perspectives got a higher citation

of 22972 global citation score and 916 local citation score, higher than that of second ranked journal Toxicological Sciences. Accordingly, the journal Toxicological Sciences got 12076 global citations for 187 publications. Journal Environmental Science and Technology has only 88 publications, but the impact factor (11.357) is very high compared to all other journals, which have more records and citation scores (Figure 3 and Table 3).

Keyword Frequency

Plotting word frequencies illustrates Zipf's law (Table 4). This is a phenomenological law related to rank data frequencies, primarily of the linguistic corpora. It says that the most frequent word will occur approximately twice as often as the second most frequent word, which will occur

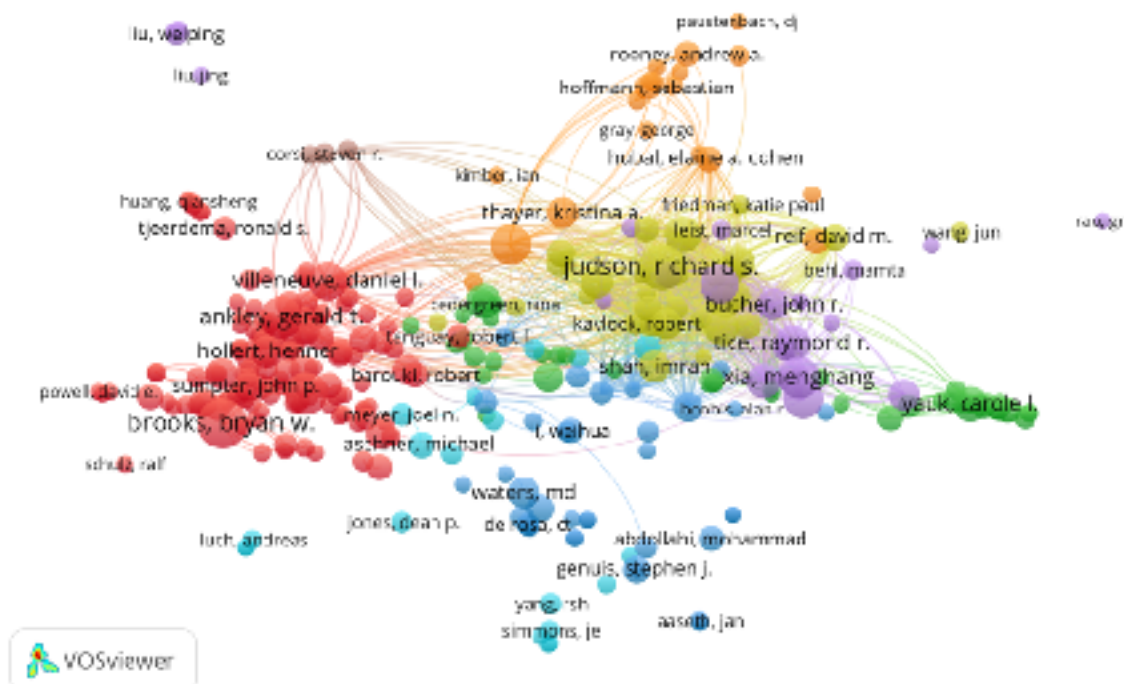


Figure 2: Prolific Authors

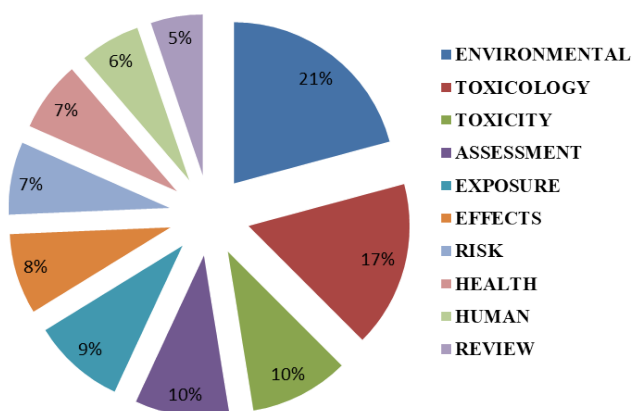
Table 4: Ranking of word occurrence in Zipf's law

S.No	Word	Publication (F)	Percentage	Rank (R)	Log F	Log R	Log C
1	ENVIRONMENTAL	1385	20.4	1	3.14	0	3.14
2	TOXICOLOGY	1110	16.4	2	3.05	0.30	3.35
3	TOXICITY	662	9.8	3	2.82	0.48	3.3
4	ASSESSMENT	630	9.3	4	2.80	0.60	3.4
5	EXPOSURE	618	9.1	5	2.79	0.70	3.49
6	EFFECTS	539	8	6	2.73	0.78	3.51
7	RISK	486	7.2	7	2.69	0.85	3.54
8	HEALTH	470	6.9	8	2.67	0.90	3.57
9	HUMAN	404	6	9	2.61	0.95	3.56
10	REVIEW	348	5.1	10	2.54	1.00	3.54
Total		6652			27.84	6.56	34.4

documented in journal articles related to the subjects for editorial materials, book reviews, reviews, news items, meeting abstracts, particularly reprints, and corrections. Hence, the present study also intends to have the distribution of forms of scholarly communications in Toxicology research as published in different forms across the globe, which are indexed in the source database (Table 5).

Language-wise Distribution of Publications

Language-wise distribution of records on Environmental Toxicology research outcomes is organized in the table below. It is evident that the analyzed data were scattered in 20 languages, which carried the publications on Environmental Toxicology in the Web of Science as the source database for the study period. It is also evident that the database which given much coverage in English, the publication in the English language is dominant and significant, with 6644 records which are followed by French (35), German (28), Spanish (21), Portuguese (6), Hungarian and Turkish (1) and so on (Table 6).

**Figure 4:** Keyword Analysis**Table 5:** Document-wise distribution

S. No	Document Type	Records	Percent	TLCS	TGCS
1	Article	4389	64.8	4360	115778
2	Review	1336	19.7	2278	104656
3	Article; Proceedings Paper	443	6.5	466	18215
4	Editorial Material	249	3.7	429	4481
5	Editorial Material; Book Chapter	78	1.2	0	3
6	Article: Early Access	77	1.1	0	34
7	Meeting Abstract	68	1	0	5
8	Review: Book Chapter	28	0.4	55	2438
9	Letter	21	0.3	2	65
10	Review: Early Access	20	0.3	0	10
11	Book Review	12	0.2	0	3
12	News Item	11	0.2	2	123
13	Reprint	11	0.2	1	39
14	Article; Book Chapter	10	0.1	6	101
15	Note	6	0.1	6	251
16	Biographical-Item	5	0.1	0	7
17	Correction	3	0	0	11
18	Correction, Addition	2	0	0	0
19	Article; Data Paper	1	0	0	385
20	Discussion	1	0	0	43
21	Editorial Material: Early Access	1	0	0	0
22	Hardware Review; Book Chapter	1	0	0	0
23	Review; Retracted Publication	1	0	0	12

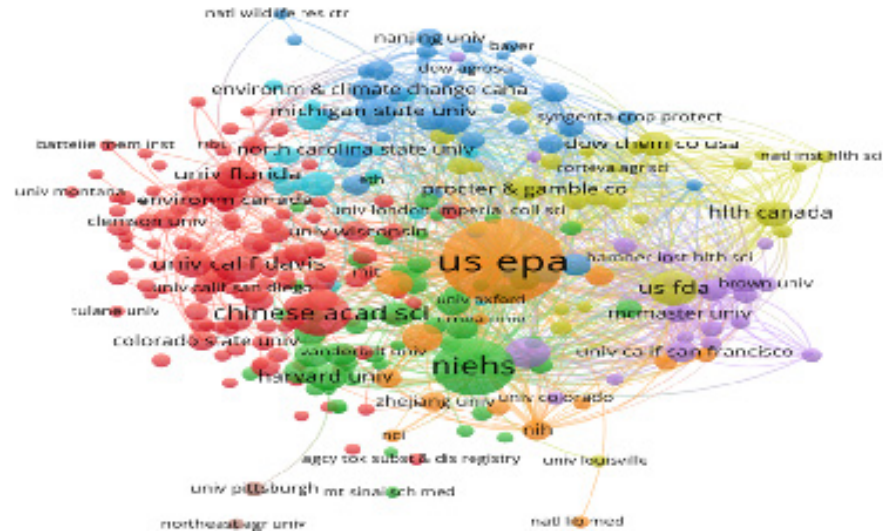


Figure 5: Institution-wise distribution of publications

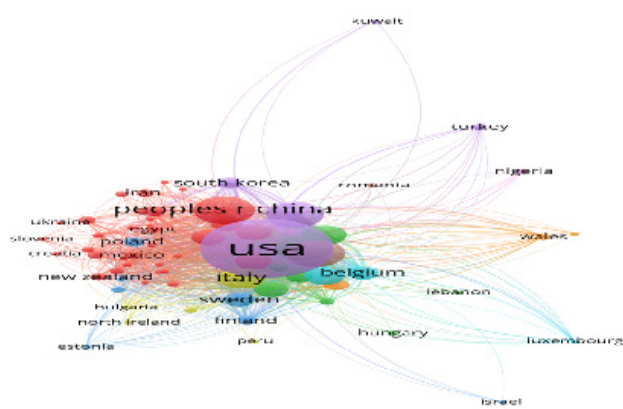


Figure 6: Most productive countries

Highly Contributed Institutions

The researcher also analyzed the contribution of different universities and research organizations/institutions on Environmental Toxicology and allied subjects. Accordingly, the distribution of publications culled out for the study period is being made. It is evident that the Environmental Protection Agency, Washington, the National Institute of Environmental Health Sciences, and the Chinese Academy of Science are the top four institutions that contributed to Environmental Toxicology research, which were published and indexed in the source database for the study period. Environmental Protection Agency has produced 404 publications having 23056 global citation scores, the National Institute of Environmental Health Sciences with 200

Table 6: Language-wise distribution of publications (14)

S.No	Language	Records	TLCS	TGCS
1	English	6644	7570	246098
2	French	35	8	98
3	German	28	21	146
4	Spanish	21	2	137
5	Chinese	14	1	49
6	Polish	8	0	16
7	Japanese	7	1	12
8	Portuguese	6	1	79
9	Hungarian	5	1	11
10	Italian	2	0	1
11	Czech	1	0	1
12	Greek	1	0	0
13	Norwegian	1	0	0
14	Turkish	1	0	12

Table 7: Institution-wise distribution of publications (6578)

S.No	Institution	Records	TLCS	TGCS
1	United States Environmental Protection Agency, Washington	404	2091	23056
2	National Institute of Environmental Health Sciences, USA	200	752	10797
3	Chinese Academy of Sciences, China	121	66	3307
4	University of California, Davis, California	84	129	4158
5	Food and Drug Administration, USA	83	311	4228
6	University of North Carolina at Chapel Hill, USA	71	153	2685
7	University of Florida, USA	65	125	2638
8	Michigan State University, Michigan	60	64	2114
9	United States Geological Survey, USA	57	116	1414
10	Unknown	126	10	441

publications having global citations of 10797 to its credits, followed by the Chinese Academy of Sciences with 121 publications on Environmental Toxicology Science which scored 4158 global citations. It is also found that the top 50 organizations/ institutions spread across the entire continent that contributed to Environmental Toxicology research. It is also inferred that some of the research organizations that published less number of publications have scored more numbers of global citations, as like University of Rochester scored 7923 with 34 publications; the Technical University of Denmark, Denmark scored 2271 global citations with 34 publications and the University California Berkeley had 5414 global citations with 48 publications (Figure 5 and Table 7).

Most Productive Countries

The geographical distribution of research outcomes carried out by the various organizations was also studied. In this context, the researcher has tabulated the origin of the country of the publications as the source database. It is found that there are more than 113 countries that represent all the five continents that contributed to the research in Environmental Toxicology and related studies. Out of these nations, contributed research is being analyzed USA stands

Table 8: Most Productive Countries

S.No	Country	Records	TLCS	TGCS
1	USA	2892	5231	126981
2	Peoples R China	652	319	14432
3	UK	634	1116	30139
4	Canada	573	817	21678
5	Germany	560	765	22142
6	Italy	342	522	12971
7	France	332	349	9534
8	Netherlands	276	465	10293
9	Brazil	234	105	4818
10	Australia	225	222	8512
11	Switzerland	196	303	9021
12	Spain	194	210	10118
13	Sweden	175	296	9365
14	Japan	171	140	4502
15	Belgium	159	278	5751
16	India	157	93	5674
17	Norway	121	165	3312
18	Denmark	115	168	5277
19	South Korea	99	121	4363

Table 9: Highly Cited Papers

S.N.	Title of the paper	Journal name	Author	Affiliation	Citations
1	Nanotoxicology: An Emerging Discipline Evolving From Studies Of Ultrafine Particles	Environmental Health Perspectives	Oberdorster, G	University Rochester Usa	5345
2	Nanomaterials And Nanoparticles: Sources And Toxicity	Biointerphases	Buzea, Cristina	Queen's University, Canada	1923
3	Hormones And Endocrine-Disrupting Chemicals: Low-Dose Effects And Nonmonotonic Dose Responses	Endocrine Reviews	Vandenberg, Laura N	Tufts University, Usa	1892
4	Nanomaterials In The Environment: Behavior, Fate, Bioavailability, And Effects	Environmental Toxicology And Chemistry	Klaine, Stephen J	Clemson University, Usa	1886
5	A Toxicologic Review Of Quantum Dots: Toxicity Depends On Physicochemical And Environmental Factors	Environmental Health Perspectives	Hardman, R	Duke University, Usa	1645
6	The E-Screen Assay As A Tool To Identify Estrogens - An Update On Estrogenic Environmental Pollutants	Environmental Health Perspectives	Soto, Am	Tufts University, Usa	1490
7	Polychlorinated-Biphenyls (Pcbs) - Environmental-Impact, Biochemical And Toxic Responses, And Implications For Risk Assessment	Critical Reviews In Toxicology	Safe, Sh	Texas A&M University, Usa	1429
8	Molecular Biomarkers Of Oxidative Stress In Aquatic Organisms In Relation To Toxic Environmental Pollutants	Ecotoxicology And Environmental Safety	Valavanidis, Athanasios	University Athens, Greece	1182
9	Environmental Transformations Of Silver Nanoparticles: Impact On Stability And Toxicity	Environmental Science & Technology	Levard, Clement	Stanford University, Usa	1071
10	Phthalates: Toxicology And Exposure	International Journal Of Hygiene And Environmental Health	Heudorf, Ursel	University Of Giessen, Germany	1014

in first position with 2892 publications having 126981 global citations as a significant contributor, which is double the second contribution from the People's Republic of China, the United Kingdom, Canada, and Germany are the other top five nations followed by USA and China with 652, 634, 573 and 560 publications respectively. It is quite surprising to know that India stands in 16th position, having 157 publications in Environmental Toxicology covered by internationally reputed indexing sources (Figure 6 and Table 8).

Highly Cited Papers

Below table reveals the top ten highly cited papers for the study period in the field of Environmental Toxicology. The article "NANOTOXICOLOGY: AN EMERGING DISCIPLINE EVOLVING FROM STUDIES OF ULTRAFINE PARTICLES," authored by OBERDORSTER, G belongs to the University Rochester, USA, has highest citation of 5345 in the journal ENVIRONMENTAL HEALTH PERSPECTIVES followed by "NANOMATERIALS AND NANOPARTICLES: SOURCES AND TOXICITY" authored by BUZEA, CRISTINA from Queens University, Canada with 1923 citations in the Journal Biointerphases (Table 9).

Conclusion

The literature on this topic, "Environmental Toxicology," has been analyzed using scientometric methods. It identified the major facets (countries, organizations, authors journals, and keywords) and studied their collaboration linkages among them. It will help the decision-makers to identify the areas of strength and areas that need to be funded for future research. It will also inform and improve decision-making in a study of poisonous substances treating Environmental toxicology and scholars researching this area. The study found that 6774 publications are published in Environmental Toxicology. It was also found that 24509 authors contributed to the field of Environmental Toxicology, and they referred to 317126 publications as references, and 247636 citations are cited within the collection. The study also found that 19 Countries contributed more than 100 publications, and 10 Countries recorded more than 500 Citations. As expected, the United States (2892) is at the top of the list of countries and recorded 126981 Global Citation Scores, followed by Germany (560) with 22142 Citations. As the field is multidisciplinary, Co-Authors, Co Journals, and major contributory organizations are a few. The reputation of any Scientist can be measured on the basis of its publication output. It is the responsibility of the Library and Information Science community to study the research trend of the

subject areas of research through scientometric analysis and help them to do further research in their field.

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