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E-WASTE RESEARCH OUTPUT: A SCIENTOMETRIC ANALYSIS

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Abstract: The current study examined the growth of research publications published between 2013 and 2022, using a sample of 4895 articles published in the field of e-waste. The most articles, 834 (17.04%), were published in 2022. For the provided study period, an article's RGR has gradually fallen from 0.78 in 2014 to 0.19 in 2022. The doubling time of article publishing gradually increases from 0.89 in 2014 to 3.73 in 2022. Huo, X. has contributed the most articles to research journals in China, with 79 (15.16%). China supplied the most papers, accounting for more than 1385 (33.78%) of total publications. Chinese Academy of Sciences has 317 articles (25.32%). Waste Management 225 (16.61%) publications took first place. Article 3451 scientific articles account for the vast majority of research output (70.50%).

Keywords: Scientometric Analysis, Bibliometric, Publication, Citation, Related citation index.

1.0 Introduction

E-waste is defined as unwanted electronic items that are no longer functional and are nearing or at the end of their "useful life." Ordinary electronic products include computers, televisions, VCRs, stereos, copiers, and fax machines. The issue of how to properly dispose of used and unwanted electronics is not a new one, Since the 1970s. However, much has changed since then, most notably the amount of devices that are being thrown away. We now have a term for this issue. After numerous words were proposed, including "digital garbage," a consensus developed around the simple term "e-waste."

02. Scientometrics Study

The term bibliometrics was coined by Alan Prichard (1969)2 to characterize the application of statistical and mathematical methods to literature and other forms of entertainment, the process of communication through writing, and the nature and development of a field. Van Raan (1997)3 Quantitative studies of science and technology, according to scientometric research. “According to Beck (1978), "scientometrics is defined as a statistical assessment and inter-comparison of scientific activity, productivity, and progress." Scientometrics, as defined by Bookstein (1995), is "the science of measuring science." Scientometrics is also accepted as a bibliometric evaluation for assessing technological advancement, societal significance, and the influence of scientific and technological applications." Ingwerson and Christensen (1997)6 defined it as "a recent extension of traditional bibliometric analysis, also to cover non-scholarly communities in which information is produced, communicated, and used."

03. Review of Literature

Manikandan M. Amsaveni N. (2015)[7] A Scientometric Measures In Cloud Computing: A Special Reference to Authors’ Productivity. The computer science department developing and uprising as thrill grips the world about connecting Networks and communications from different places of the world. In this study, we have made an attempt to measure the research output through a Scientometric analysis of Cloud computing to understand the

trends of research in terms of H-Index, Collaborative patterns, and Citations. The author of Buyya R. has 40 research publications, and total citations are is294, total global citations are 912, H- index is 12. The involvement of several writers is dominant, with double and three authors participating significantly, and the overall level of interaction is 0.86. NASA institutes have 304 (5.5%) research publications, a total of 497 citations, and a total of 12396 global citations.

Manimuthu A. (2015)[8] A bibliometric analysis of the cloud computing literature The popularity and rapid advancement of computing in the cloud in recent years have resulted in a huge number of publications presenting the collected information related to this area of study. While appraising science has a long history in many sectors, we find that substantial scientometric research on the subject of cloud computing is lacking. 29.360 was written by Buyya Raj Kumar of the University of Melbourne in Australia. From 2008 to 2013, the Scopus database comprises 15376 entries. This study employs scientometric methodologies to empirically evaluate the evolution and state of cloud computing research from above the clouds, based on a vast book reference (bibliographic) database. As a result, we can provide precise insights into publication patterns, research facts, and research productivity.

Praveena K. et al (2021)[10] examine the mapping of Artificial Intelligence Research Output: A Scientometric Study was investigated. The current study examines ongoing artificial intelligence research. At the end of November 2020, the data will be obtained from Web of Science. The research spans the years 1999 through 2019. During this time period, a total of 21643 papers on the subject of Artificial Intelligence were published. The collection is exported to HistCite, which returns a long list of 20743 articles and 341247 citations, as well as their local and global citation ratings (LCS and GCS). The Degree of Collaboration is discovered to be 0.83.

4.0 Objectives of the Study:

- To examine the publication and growth rate of literature on the study of w-waste.
- To examine the RGR & doubling time.
- To identify the most productive authors and organizations.
- To investigate the distribution of publications around the country.
- To determine the form-wise distribution of articles.
- To study the highly cited paper on e-waste.

5.0 Research Methodology

The researcher gathered the necessary research material for the current study from the online edition of the Scopus database on e-waste from 2013 to 2022. (TITLE-ABS-KEY ("E-waste ") AND PUBYEAR > 2012 AND PUBYEAR 2023 AND PUBYEAR > 2012 AND PUBYEAR 2023 AND PUBYEAR > 2012 AND PUBYEAR 2023). The data was obtained in the Micro Soft Excel sheet on 16.12.2022 for the Scopus database.

6.0 Interpretations of Data and Analysis

6.1 Year-Wise Growth E-waste

Table 1 Year-Wise Growth E-waste

S.No	Year	Publications	%	Citations	%	CPP	RCI
1	2013	214	4.37	1460	1.76	6.82	0.40
2	2014	255	5.21	5314	6.41	20.84	1.23
3	2015	295	6.03	9326	11.25	31.61	1.87
4	2016	356	7.27	13783	16.62	38.72	2.29
5	2017	365	7.46	9528	11.49	26.10	1.54
6	2018	445	9.09	8591	10.36	19.31	1.14
7	2019	677	13.83	10292	12.41	15.20	0.90
8	2020	685	13.99	8960	10.80	13.08	0.77
9	2021	769	15.71	7747	9.34	10.07	0.59
10	2022	834	17.04	7932	9.56	9.51	0.56
	Total	4895	100.00	82933	100.00		

Table 1 depicts the rise of research publications published in the field of e-waste from 2013 to 2022, using a sample of 4895 articles. The most papers, 834 (17.04%), were published in the year 2022. In the year 2021, the second-highest number of articles contributed was 769 (15.71%). In the year 2020, 685 articles (13.99%) contributed the most. These three years are thought to be the most fruitful. In these two years, publication production climbed by 32.75%. In 2013, however, the bare minimum of 214 papers (4.37%) were published.

The high citations are with 13783(16.62%) research publications, the CPP is 16.62, and RCI is 2.29. Followed by 10292(12.41%) research publications, citations per paper is 15.20, & RCI is 0.90. The fewest citations are with 1460(1.76%) research publications, the CPP is 6.82, & the RCI is 0.40.

6.2 RGR & Doubling Time of the E-waste

Table 2 RGR & Doubling time of the E-waste

Sl.No	Year	Articles	Cumulative	W_1	W_2	RGR	Dt
1	2013	214	214		5.37		
2	2014	255	469	5.37	6.15	0.78	0.89
3	2015	295	764	6.15	6.64	0.49	1.43
4	2016	356	1120	6.64	7.02	0.38	1.82
5	2017	365	1485	7.02	7.30	0.28	2.47
6	2018	445	1930	7.30	7.57	0.26	2.66
7	2019	677	2607	7.57	7.87	0.30	2.31
8	2020	685	3292	7.87	8.10	0.23	2.98
9	2021	769	4061	8.10	8.31	0.21	3.32
10	2022	834	4895	8.31	8.50	0.19	3.73
	Total	4895					

Table 2 clearly shows the average relative growth rate and time to double the number of e-waste papers during the research period. During the investigation period, an article's RGR gradually decreased from 0.78 in 2014 to 0.19 in 2022. The doubling time for article publication gradually increases from 0.89 in 2014 to 3.73 in 2022. The above discussion can be summarized to show that the RGR of the article gradually declined. On the other hand, the article doubling time gradually rose.

6.3 Most Prolific Authors of the E-waste

Table-3 Most Prolific Authors of the E-waste

S.No	Authors	Country	Publications	%	Citations	%	H- Index	CPP	RCI
1	Huo, X.	China	79	15.16	2734	13.18	31	34.61	0.87
2	Li, J.	India	72	13.82	4254	20.50	37	59.08	1.48
3	Xu, X.	United States	72	13.82	2453	11.82	31	34.07	0.86
4	Mai, B.X.	Australia	55	10.56	2367	11.41	28	43.04	1.08
5	Xu, Z.	United Kingdom	53	10.17	1194	5.76	17	22.53	0.57
6	Sahajwalla, V	Canada	50	9.60	1100	5.30	21	22.00	0.55
7	Luo, X.J.	Japan	41	7.87	1121	5.40	22	27.34	0.69
8	Fobil, J.N.	Italy	36	6.91	595	2.87	13	16.53	0.42
9	Zeng, X.	South Korea	33	6.33	2562	12.35	25	77.64	1.95
10	Mai, B.	Brazil	30	5.76	2367	11.41	28	78.90	1.98
	Total		521	100.00	20747	100.00			

Table -3 displays the most prolific authors on the subject of e-waste, with Huo, X. contributing the most articles, i.e. 79(15.16%) research publications in China, followed by Li, J. with 72(13.82%) research publications the India, and Xu, X. with 72(13.82%) research publications in the United States. The highest number of citations is 4254(20.50%) research publications, and H-index is 37, the CPP is 59.08, and the RCI is 1.48. Followed by 2734(13.18%) research publications, the H-index is 31, citations per paper is 34.61, & the related citation index is 0.87. The fewest number of citations is 595(2.87%) research publications, the H-index is 13, the CPP is 16.53, and the RCI is 0.42.

6.4 Country-wise of E-waste

Table 4 Country-wise of E-waste

Sl.No	Country	Articles	%	Citations	%	H- Index	CPP	RCI
1	China	1385	33.78	33814	39.36	82	24.41	1.17
2	India	864	21.07	10400	12.11	51	12.04	0.57
3	United States	514	12.54	9605	11.18	49	18.69	0.89
4	Australia	274	6.68	7872	9.16	41	28.73	1.37
5	United Kingdom	249	6.07	6456	7.51	40	25.93	1.24
6	Canada	197	4.80	4587	5.34	35	23.28	1.11
7	Japan	166	4.05	3996	4.65	35	24.07	1.15
8	Italy	162	3.95	3216	3.74	28	19.85	0.95
9	South Korea	146	3.56	3303	3.84	33	22.62	1.08
10	Brazil	143	3.49	2661	3.10	27	18.61	0.89
	Total	4100	100.00	85910	100.00			

Table 4 depicts the geographical distribution of publications; of the 4100 articles, China contributed the most, accounting for more than 1385 (33.78%) of the total publication, followed by India 864 (21.07%), and the United States 514 (12.54%); these three countries contributed more than 67.39% of the world publications in the field of e-waste. Furthermore, research articles from Australia 274(6.68%), the United Kingdom 249(6.07%), Canada 197(4.80%), Japan 166(4.05%), Italy 162(3.96%), South Korea 146(3.56%), and Brazil 143(3.49%) are found.
The highest number of citations is 33814(39.36%) research publications, and H-index is 82, the CPP is 24.41, and the RCI is 1.17. Followed by 10400(12.11%) research publications, the H-index is 51, citations per paper is 12.04, & the related citation index is 0.57. The fewest number of citations in Brazil is 2661(3.10%) research publications, the H-index is 27, the CPP is 18.61, and the RCI is 0.89. However, Italy and other countries have made less of an impact on the subject. As a result, it can be inferred that China, India, and the United Kingdom are rising countries in the field of e-waste on a global scale.

6.5 Institutions of the E-waste

Table 5 Institutions of the E-waste

S.No	Name of the Institutions	Publications	%	Citations	%	H-Index	CPP	RCI
1	Chinese Academy of Sciences	317	25.32	8904	24.09	52	28.09	0.95
2	Guangzhou Institute of Geochemistry	164	13.10	5559	15.04	42	33.90	1.15
3	University of Chinese Academy of Sciences	145	11.58	4075	11.02	38	28.10	0.95
4	Ministry of Education China	131	10.46	2985	8.07	30	22.79	0.77
5	Jinan University	104	8.31	2631	7.12	29	25.30	0.86
6	Tsinghua University	102	8.15	5263	14.24	41	51.60	1.75
7	Shantou University Medical College	79	6.31	2838	7.68	33	35.92	1.22
8	Shanghai Jiao Tong University	79	6.31	1820	4.92	24	23.04	0.78
9	UNSW Sydney	67	5.35	1431	3.87	24	21.36	0.72
10	The Chinese Academy of Sciences' Research Centre for Eco-Environmental Sciences	64	5.11	1460	3.95	21	22.81	0.77
	Total	1252	100.00	36966	100.00			

Table -5 summarises the research publications by the top ten global research institutes on e-waste. They published 1252 publications in international journals over the course of the ten-year study. The Chinese Academy of Sciences supplied 317 (25.32%) publications, followed by the Guangzhou Institute of Geochemistry, which gave almost 164 (13.10%) articles, and the University of Chinese Academy of Sciences, which contributed 145 (11.58%) articles. The Chinese Academy of Sciences has the fewest research publications of the Research Centre for Eco-Environmental Sciences, with 64 (5.11%).
The highest is the Chinese Academy of Sciences 8904(24.09%) research publications, the H-index is 52 the CPP is 28.09, and the RCI is 0.95. Followed by the Guangzhou Institute of Geochemistry 5559(05.04%) research publications, the H-index is 42, the citation per paper is 33.90, & the related citation index is 1.15. The fewest number of citations is the UNSW Sydney of 1431(3.87%) research publications, the H-index is 24, the CPP is 21.36, and the RCI is 0.77.

6.6 Most Productive Journals of the E-waste

Table 6 Most Productive Journals of the E-waste

Sl.No	Journal	Articles	%	Citations	%	H-Index	CPP	RCI
1	Waste Management	225	16.61	6955	17.61	45	30.91	1.06
2	Science Of The Total Environment	183	13.51	5596	14.17	40	30.58	1.05
3	Environmental Science And Pollution Research	173	12.77	3434	8.70	33	19.85	0.68
4	Journal Of Cleaner Production	135	9.96	5081	12.87	42	37.64	1.29
5	Resources Conservation And Recycling	133	9.82	4386	11.11	38	32.98	1.13
6	Chemosphere	120	8.86	2940	7.45	28	24.50	0.84
7	Journal Of Hazardous Materials	118	8.71	3183	8.06	32	26.97	0.93
8	Environmental Pollution	107	7.90	3329	8.43	36	31.11	1.07
9	Environmental Science And Technology	85	6.27	3806	9.64	37	44.78	1.54
10	Sustainability Switzerland	76	5.61	774	1.96	16	10.18	0.35
	Total	1355	100.00	39484	100.00			

The most productive journals on e-waste are shown in Table -6. It found that on the top of the list with the publication of Waste Management 225(16.61%) publications securing the first rank. Accordingly, the Science of the Total Environment occupied the second rank with a publication of 183(13.51%) research publications. Environmental Science and Pollution Research ranked third with 173 (12.77%). These three publications appear to be the most productive in the topic of e-waste. The remaining productivity journals are likewise listed in the table above. In Switzerland, the lowest number of scientific papers is 76 (5.61%).

The highest citation is Waste Management 6955(17.61%) research publications, the H-index is 45, the CPP is 30.91, and the RCI is 1.06. Followed by the Science of the Total Environment 5596(14.17%) research publications, the H-index is 40, citation per paper is 30.58, & the related citation index is 1.05. The fewest number of citations is Sustainability Switzerland 774(1.96%) research publications, the H-index is 16, the CPP is 10.18, and the RCI is 0.35.

6.7 Type of Document wise Distribution of E-waste

Table-7 Type of Document wise distribution of E-waste

S.No	Document Type	No. of Articles	%	Cumulative	%
1	Article	3451	70.50	3451	5.27
2	Conference Paper	612	12.50	4063	6.21
3	Review	426	8.70	4489	6.86
4	Book Chapter	284	5.80	4773	7.29
5	Conference Review	35	0.72	4808	7.35

6	Editorial	19	0.39	4827	7.37
7	Note	19	0.39	4846	7.40
8	Book	16	0.33	4862	7.43
9	Letter	15	0.31	4877	7.45
10	Erratum	9	0.18	4886	7.46
11	Short Survey	4	0.08	4890	7.47
12	Data Paper	2	0.04	4892	7.47
13	Retracted	2	0.04	4894	7.48
14	Undefined	1	0.02	4895	7.48
	Total	4895	100.00	65453	100.00

Table 7 shows the bibliographical form-wise distribution of documents, and it is clear that the vast majority of research output is available in the form of Article 3451(70.50%), with a significant amount of publications also available in the form of research Conference Papers 612(12.50%). A significant number of publications 426(8.70%) and 284(5.80%) were brought in the form of reviews and book chapters, respectively. However, only a small percentage of publications are in the form of conference reviews 35(0.72%), editorials 19(0.39%), notes 19(0.39%), books 16(0.33%), letters 15(0.31%), and erratum 9(0.18%). The short survey and data paper was withdrawn and undefined, with 4(0.08%), 2(0.04%), 2(0.04%), and 1(0.02%) being retracted and undefined, respectively. According to the preceding discussion, the vast majority of research articles are the type of articles, conference papers, reviews, and book chapters.

7.0 Major Findings

- Using a sample of 4895 articles, the current study assessed the growth of studies published on the subject of e-waste from 2013 to 2022. The most papers, 834 (17.04%), were published in the year 2022. In the year 2021, the second-highest number of articles contributed was 769 (15.71%).
- During the provided study period, the RGR of an item has gradually fallen from 0.78 in 2014 to 0.19 in 2022. The doubling time for article publication gradually increases from 0.89 in 2014 to 3.73 in 2022.
- Huo, X. has contributed the most papers, 79(15.16%) research publications in China, followed by Li, J. with 72(13.82%) research publications in India, and Xu, X. with 72(13.82%) research publications in the United States.
- During the period, China provided the most articles, accounting for more than 1385 (33.78%) of total publishing), followed by India 864 (21.07%), and the United States 514 (12.54%) research publications.
- During this period, the Chinese Academy of Sciences supplied 317 (25.32%) publications, followed by the Guangzhou Institute of Geochemistry, which produced roughly 164 (13.10%) articles, and the University of Chinese Academy of Sciences, which contributed 145 (11.58%).
- The Waste Management 225(16.61%) publications securing the first rank. Accordingly, the Science of the Total Environment occupied the second rank with a publication of 183(13.51%) research publications. Environmental Science and Pollution Research 173(12.77%) secured the third rank.
- During the bulk of the research output is available in the form of Article 3451(70.50%), and a significant quantity of publications are also published in the form of research Conference Paper 612(12.50%) research publications.

8.0 Conclusion:

There are various costs and benefits to electronic waste. The advantages to the community will significantly surpass the costs. Reusing electronics increases the accessibility of rare natural resources for future generations, while also limiting potentially hazardous compounds from entering the ecological system. Finally, recycling electronic waste minimizes the carbon footprint and pollution. These are significant advantages that will benefit the ecosystem and future generations significantly**.**

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