AN ANALYSIS OF GLOBAL TREND ON 'ATOMIC ENERGY' RESEARCH PUBLICATIONS (1999-2018)

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The paper examines the research output of 'Atomic Energy' research of top ten countries in the world for 20 years i.e. 1999-2018 from the Scopus database. Out of a total 7967 research papers, the maximum 4699 of research papers were contributed by more than three authors and the highest, i.e. 696 (8.74%) contributions were published in the year 2002, followed by 616 (7.73%) publications in 2011. The maximum, i.e. 5405 (67.84%) of publications were 'Article' type record. The highest annual, compound annual and relative growth rate was noted in the year 2002 and 2000 each i.e. (360.93), (0.57) and (1.24) respectively. out of a total 64282 citations, the highest 5547 (8.63%) of citations were recorded on 359 publications in the year 2007, while the minimum, i.e. 191 (0.03%) citations were found in 2018. The average degree of author's collaborations, collaborative index and collaboration coefficient was (0.87), (3.21) and (0.61) recorded respectively. The maximum, i.e. 43 each record was contributed by Nakamura, T. and Nishitani, T. However, the maximum scientists were interested to publish their articles in the *Journal of Nuclear Science and Technology* source. The maximum, i.e. 1299 (5.56%) research papers include 'Nuclear Energy' keyword used by the authors. Japan Atomic Energy Agency has contributed the maximum, i.e. 1961 (19.57%) records during the period of study.

Keywords*:* Scientometrics, Atomic Energy, Collaboration Coefficient, Collaborative Index Relative Growth Rate.

INTRODUCTION

The field of Nuclear Physics is regularly progressing. To keep up this pattern, the theoretical improvements including various procedures of atomic splitting from one perspective and their applications by the utilization of powerful accelerators on the other perspective, need to go next to each other. In the present investigation, an endeavour has been made to ding out the examination inclines in this field. The energy that is discharged through an atomic response or radioactive rot procedure quite compelling is the procedure known as fission, which happens in an atomic reactor and produces energy as a rule as heat.

Scientometrics is a newly emerging field that analyses the quantitative characteristics of science, which means the application of quantitative

methods to the history of science, but now it is usually used for a variety of research perspectives in the study of science. That quantifiable aspect of science can be utilized to access the characteristics of science. The term 'Scientometrics' is a Russian term for the application of quantitative methods to measure the history of science. This term was introduced and came into prominence with the founding of the journal named 'Scientometrics' by T. Braunin 1977, originally published in Hungary and currently from Amsterdam (Ranganathan, 2016). According to Tague-Sutcliffe (1992), "Scientometrics as a study of the quantitative aspects of science as a discipline or economic activity. It is part of the sociology of science and has application to science policymaking. It involves quantitative studies of scientific activities including, among other, publication, and so overlaps bibliometrics to some extent."

SCOPE OF THE STUDY

The present study is restricted to only "Atomic Energy" research publication output of the top ten countries i.e. (i) Japan (ii) United States (iii) South Korea (iv) Austria (v) China (vi) France (vii) United Kingdom (viii) Canada (ix) Germany (x) Russian Federation. All the publications on the particular subject were indexed in the Scopus database during the period (1999-2018).

LITERATURE REVIEW

Bid and Mandal (2020) comparatively study the research output of India and China in nuclear science and technology from 2000 to 2019 using Web of Science database. The study reveals that China (16879) published more almost twice of India's publication (8637). The Bhabha Atomic Research Centre from India shares about 37% of the total output whereas Chinese Academy of Science shares almost 33% of the total output. Camara (2020) analyze a bibliometric study on publication outputs of nuclear science and technology from 1956-2020 in the Philippines. A total of 4,620 publications were reviewed those were written about the Philippine's nuclear science and technology using the INIS Database. The Philippines ranked 4th with the highest number of publications next to France. Obregon et. al (2019) reveal the bibliometric analysis of the nuclear energy research output (2008-2018). The results reveal that the U.S A. s the country with the top production rate, and the country with the highest h-index value. The Chinese Academy of Science was the top most producing institution and the peak body with publications under international set-up. Gupta and Dhawan (2018) performed a scientometric study on artificial intelligence research publications in India from 2007-2016. The maximum, i.e. 294 articles were contributed by Anna University, Chennai with 761 citations. The 'artificial intelligence' keyword was 9496 times used, while the authors prefer 'Applied soft computing journal' to publish their research papers. Singh et al. (2018) analysed the data of research work on nuclear physics using Web of Science database and found that India has contributed utmost, with highest cited publications and also has many leading institutes like BARC, etc

Agyeman and Bilson (2015) conducted a study of nuclear science and technology research

publications originating from Ghana and listed in the International Nuclear Information System (INIS) Database. The study was useful in evaluating research performance and also serveas a foundation for other African countries. Venkatesan and Thanuskodi (2014) analyzed the quantitative escalation of nuclear power publication during 1980-2013 and showed that Nuclear Power Generation papers gradually increased with an average of 134 records per year. Korea Atom Energy Research Institute ranked first with 31 papers and USA ranked 1st with 512 records, followed by Germany. Gupta (2013) analysed the research outcome of Bangladesh in S&T during 2001-10 using the Scopus Citation Database. An average publication annual growth rate of Bangladesh was 16.64 percent and It was concluded and suggested that Bangladesh needs to amplify its output and bring about upgradation in the quality of its research efforts. Upadhye et al. (2010) reveals that the publications of Nuclear Physics Division at Bhabha Atomic Research Centre. It was found that the most productive year was 2006, the average publications per year was 42.83. The publications were extended over 42 journals. There were more than 70 % mega-authored publications. Kademani et al. (2006) investigated the scientometric dimensions of thorium research in India (1970-2004). The average, i.e. 68.54 publication per year was recorded. The highest no. of publications was published by BARC. The maximum (47.81%) of the research papers were contributed in journals, followed by Conference (40.60%) publications while the leading journals preferred by the authors were the Journal of the Indian Chemical Society with 78 publications, followed by Indian Journal of Chemistry with 60 research papers. Kademani et al. (2006) carried out a study on "nuclear science and technology research in India (1970-2002). A total of 55313 research papers were published by Indian authors and the average 1676.15 publications were recorded per year. The maximum, i.e. 1327 publications were contributed in '*Pramana*' journal, followed by *Indian Journal of Pure and Applied Physics* with 1104 publications by the scientists. More than 60% of the publications were journales and rest (28.40%) of research papers were conferences and books type documents.

OBJECTIVES OF THE STUDY

The central objective of the study is to understand the performance of "Atomic Energy" research by the top 10 countries during the period (1999-2018). In specific, the study provide attention on the following objectives:

1. To study the year-wise distributions, annual, compound annual and relative growth rate of the publications.
2. To study the year wise citations of the publications and most productive authors.
3. To study the year wise authorship pattern, collaborative co-efficient and collaboration index
4. To study the trends in atomic energy research by identifying significant keywords.

METHODOLOGY

The primary data was collected by using the Scopus database which was maintained by

Elsevier. The study retrieved and downloaded for the last 20 years of research publications data of the world in "Atomic Energy" research publication from the particular database (http://www.scopus.com) from 1999 to 2018. The subsequent search sequence to be cast-off for gathering the data – ("TITLE-ABS-KEY" ("Atomic Energy") AND (LIMIT- TO (PUBYEAR, 2018 to 1999)) AND (LIMIT- TO (AFFILCOUNTRY, "Japan", "China", "United States", "South Korea", "Austria", "France", "Germany", "United Kingdom", "Canada", "Russian Federation") AND (LIMIT- TO (LANGUAGE, "English")). A total of 7967 records were available on the Scopus database for the particular time spam. These records along with full bibliographical descriptions like Authors details, Source information, Citation count, Year-wise distribution of all the records, Affiliation details, Document Type, etc. have been extracted from the particular database. The necessary data was downloaded on 07/Jan/2019 to conduct the study. The raw data of all the bibliographic details have been transferred to a spreadsheet and thus used relevant formulas and tools to evaluate the same.

SIGNIFICANCE OF THE STUDY

Scientometric study of the global trend on *'Atomic Energy'* research literature will provide an understanding of the research being carried out in the countries and helps identifying the major indicators in the discipline. From the beginning of the 20th century, librarians have the search problem of ever-expanding library collections to find a suitable place to accommodate them. The problem of ever-growing knowledge can never be controlled and not to be controlled but the required information or knowledge in demand must be well organized to reach the user within minimum time. The bibliometric study helps librarians to make vital decisions for selecting the most preferred journal for subscription in libraries within a limited budget allowance. Here, the bibliometric study is chosen to study the scientific growth of literature in the field of *'Atomic Energy'* in top ten countries.

DATA ANALYSIS

Year-wise Distribution, Annual Growth Rate (AGR) and Compound Annual Growth Rate (CAGR) of 'Atomic Energy' Publications

The table 1 depicts the year-wise distributions, annual and compound annual growth rate of the atomic energy research publications during the period (1999-2018), out of a total 7967 publications, 696 (8.74%) of research papers were published in 2002, followed by 616 (7.73%) of records were contributed in 2011 and in the year 2016 with 509 (6.39%), while the minimum, i.e. 125 (1.57%) of records were published in the beginning year of the study. It shows that year by year the publication on atomic energy research was increasing. On the observation of the particular table, it was also found that the AGR and CAGR were in fluctuating position. The maximum AGR was 360.93 recorded in 2002, followed by 146.40 annual growth was recorded in 2000 and AGR 72.40 was recorded in 2004, while the minimum annual growth, i.e. -68.25 was recorded in 2003, followed by -50.97 in 2001. The annual growth rate is a useful method to evaluate the yearly trends in research productivity (Kumar & Kaliyaperumal, 2015).

$$AGR = \frac{EndValue - FirstValue}{FirstValue} \times 100$$

Compound Annual Growth Rate helps frame the steady rate of return of a research output over a definite time spam. It assumes the research output or publications compounds over the period specified, and it helps compare research output with different returns across periods (Fuhrmann, 2014). The CAGR is calculated by taking the n^{th} root of the entire percentage of GR (growth rate), where *n* is the number of years in a certain period being considered. The maximum, i.e. CAGR 0.57 was recorded in 2000, followed by 0.47 in 2002 while the maximum decreasing CAGR, i.e. -0.21 was recorded for 2001 and 2003. The following formula has been used to evaluate the yearly trends of CAGR, the particular formula available on the website- https://www.investopedia.com/terms/c/cagr.asp).

$$CAGR = [(EndingValue / BeginningValue)^{1/n} - 1$$

Table 1: Year-wise distributions, Annual growth and compound annual growth rate of 'Atomic Energy' research publications

Year	No. of Publications	Annual Growth Rate	Compound Annual Growth Rate
1999	125	0	0
2000	308	146.40	0.57
2001	151	-50.97	-0.21
2002	696	360.93	0.47
2003	221	-68.25	-0.21
2004	381	72.40	0.09
2005	258	-32.28	-0.05
2006	415	60.85	0.06
2007	359	-13.49	-0.02
2008	427	18.94	0.02
2009	454	6.32	0.01
2010	474	4.41	0.004
2011	616	29.96	0.02
2012	433	-29.71	-0.02
2013	418	-3.46	-0.002
2014	452	8.13	0.005
2015	470	3.98	0.002
2016	509	8.30	0.004
2017	399	-21.61	-0.012
2018	401	0.50	0.0003
Total	**7967**		

Relative Growth Rate and Doubling Time of 'Atomic Energy' research Publication

The table 2 illustrates the relative growth rate and doubling time of atomic energy publications (1999-2018). The author has applied the RGR model developed by (Mahapatra, 1985) to analyse the growth rate of the publications. The highest RGR 1.24 was recorded in the year 2000, followed by 0.78 was recorded in 2002, while the minimum, i.e. RGR 0.05 recorded in the year 2017 and 2018 each. The following formula was used to examine the relative growth rate of the publications. The mathematical demonstration of the mean RGR of the records over certain time spam is derived from the following formula:

$$RGR = \frac{W2 - W1}{T2 - T1}$$

RGR = Growth Rate over the specific period of the interval

W1 = Log_e (natural log of the initial number of contributions)

W2 = Log_e (natural log of the final number of contributions)

T1 = the unit of initial time

T2 = the unit of the final time

Doubling time is to observe the growth rate of research articles published. There is direct equality that exists among the RGR and Dt. If the number of research papers of a subject doubles throughout the time of the study, then the variation

Table 2: Relative Growth Rate and Doubling Time of 'Atomic Energy' research publications

Year	No. of Publications	Cumulative Sum	W1	W2	Relative Growth Rate	Doubling time
1999	125	125	0	4.83	0	0
2000	308	433	4.83	6.07	1.24	0.56
2001	151	584	6.07	6.37	0.30	2.31
2002	696	1280	6.37	7.15	0.78	0.88
2003	221	1501	7.15	7.31	0.16	4.23
2004	381	1882	7.31	7.54	0.23	3.01
2005	258	2140	7.54	7.67	0.13	5.39
2006	415	2555	7.67	7.85	0.18	3.94
2007	359	2914	7.85	7.98	0.13	5.44
2008	427	3341	7.98	8.11	0.13	5.17
2009	454	3795	8.11	8.24	0.13	5.27
2010	474	4269	8.24	8.36	0.12	5.82
2011	616	4885	8.36	8.49	0.13	5.17
2012	433	5318	8.49	8.58	0.09	7.80
2013	418	5736	8.58	8.65	0.07	9.30
2014	452	6188	8.67	8.73	0.06	11.48
2015	470	6658	8.73	8.80	0.07	9.42
2016	509	7167	8.8	8.88	0.08	8.97
2017	399	7566	8.88	8.93	0.05	13.48
2018	401	7967	8.93	8.98	0.05	13.06

between the logarithm of the numbers at the starting and the end of the time spam must be number 2. "If one uses a natural logarithm this difference has a value of 0.693." The highest 13.48 doubling time was recorded in 2017, followed by 2018 with 13.06 Dt. was recorded. The following formula used to analysis the doubling time.

$$DoublingTime(Dt) = \frac{0.693}{R}$$

Document wise distribution of Publications

The table 3 depicts the document wise distribution of atomic energy research publications from 1999 to 2018. During the particular period, a total of 7967 research papers were contributed by the top ten countries' authors, out of the total publications, the maximum, i.e. 5405 (67.84%) of publications were recorded as an 'Article' type contribution, followed by 1991 (24.99%) of publications were 'Conference papers' type contributions, while 273 (3.43%) of publications were 'Review' type contributions. The whole data about document wise dispersal of publications has been given in the table 3.

Year wise distribution of Citations on 'Atomic Energy' research publications

The table 4 shows the year-wise distribution of citations on the publications of atomic energy research from the particular time span. A total of 64282 citations were recorded for 7967 publications. The maximum, i.e. 5547 (8.63%) of citations were recorded for 359 research papers in the year 2007, followed by 5042 (7.84%) of citations were recorded for 415 publications in the year 2006 while the minimum, i.e. 191 (0.30%) of citations were recorded for 401 research papers in 2018. The overall data about the year-wise distribution of citations have been given in the table 4.

Table 3: Document wise distribution of publications

Type of Documents	No. of Publications	% of Publications
Article	5405	67.84
Conference Paper	1991	24.99
Review	273	3.43
Book Chapter	190	2.38
Article in Press	37	0.46
Book	31	0.39
Editorial	13	0.16
Letter	9	0.11
Note	7	0.09
Short Survey	6	0.08
Erratum	5	0.06
Total	**7967**	**100.00**

Table 4: Year wise distribution of Citations on 'Atomic Energy' research publications

Year	No. of Publications	No. Citations	% of Citation
1999	125	2044	3.18
2000	308	4044	6.29
2001	151	4056	6.31
2002	696	4252	6.61
2003	221	2757	4.29
2004	381	4429	6.89
2005	258	3045	4.74
2006	415	5042	7.84
2007	359	5547	8.63
2008	427	3574	5.56
2009	454	4946	7.69
2010	474	2688	4.18
2011	616	4334	6.74
2012	433	2991	4.65
2013	418	3350	5.21
2014	452	2553	3.97
2015	470	2131	3.32
2016	509	1645	2.56
2017	399	663	1.03
2018	401	191	0.30
Total	**7967**	**64282**	**100.00**

Author's Degree of Collaboration

The table 5 illustrates the Degree of Collaborations of atomic energy research publications (1999-2018). The Degree of Collaboration gives the proportion of multiple-authored publications, as for calculation of the strength of collaboration in a discipline. The Degree of Collaboration can be interpreted as a degree, i.e., lies between "0 and 1." Single authored research papers give 0, while 1 for maximal collaboration. To examine the degree of author collaboration in quantitative terms, Subramanyam (1983) given the formula. Out of a total of 7967 publications, 968 research papers were contributed by single-authored while 6899 research papers were published by multiple-authored publications. The average or mean degree of author's collaboration was 0.87 recorded during the period of study. After the analysis, it has been found that the degree of author collaboration was clearly shown its dominance on multiple author contributions.

$$DC = \frac{Nm}{Nm + Ns}$$

Table 5: Author's Degree of Collaboration

Year	Single Authored Publications (Ns)	Multiple Authored Publications (Nm)	Nm + Ns	Degree of Collaboration (DC)
1999	22	103	125	0.82
2000	43	265	308	0.86
2001	25	126	151	0.83
2002	69	627	696	0.90
2003	35	186	221	0.84
2004	36	345	381	0.91
2005	50	208	258	0.81
2006	58	257	415	0.62
2007	45	314	359	0.87
2008	58	369	427	0.86
2009	59	395	454	0.87
2010	54	420	474	0.89
2011	62	554	616	0.90
2012	75	358	433	0.83
2013	55	363	418	0.87
2014	36	416	452	0.92
2015	61	409	470	0.87
2016	50	459	509	0.90
2017	38	361	399	0.90
2018	37	364	401	0.91
Total	**968**	**6899**	**7967**	**Avg.0.87**

Year wise Authorship Pattern, Collaboration Index and Collaborative Coefficient

The table 6 illustrates the year wise authorship pattern, collaborative coefficient and collaboration index on the atomic energy research contributions from particular time spam. Out of the total 7967 research papers, the maximum 4699 publications were contributed by more than three authored, followed by three authored with 1207 publications and 1093 research papers were contributed by two authors, while only 968 publications were contributed by a single author.

Collaborative Index is a measure of an average of contributors in each record. It is not easily interpretable as a degree. It also gives non-zero weight to single-authored publications, which indicates no collaboration. The maximum CI was 3.33 recorded in the year 2002 and 2008 each, followed by 3.32 recorded in 2014. The average CI was 3.21 recorded from the particular time span of the study. "The Collaboration Index (CI) counted by the following formula suggested by the (Lawani, 1980)":

$$CI = \frac{\sum_{j=1}^{A} jfj}{N}$$

Where,

j = the number authors in an article i.e. 1, 2, 3, more than 3.

fj = the number of j authored articles

N = the total number of articles published, and

A = the total number of authors per articles

Collaborative Coefficient was suggested by (Ajiferuke et al., 1988) and used by (Karki and Garg, 1997). It was intended to remove the shortcomings pertaining to Collaborative Index and Degree of Collaboration. The Collaborative Coefficient always lies between "0 and 1." CC = 0 when the number of solo authors dominates. Collaborative coefficient distinguishes between single-authored, two authored, three authored, and more than three authored. CC doesn't give the value "1" for maximal collaboration except in the circumstance where the number of authors is immeasurable. The average CC 0.61 recorded

Table 6: Year-wise authorship pattern, Collaboration Index and Collaborative Coefficient

Year	Single Authors	Joint Authors	Three Authors	More than Three Authors	Total	CI	CC
1999	22	24	14	65	125	2.98	0.56
2000	43	39	56	170	308	3.15	0.6
2001	25	22	23	81	151	3.06	0.58
2002	69	86	85	456	696	3.33	0.63
2003	35	37	34	115	221	3.04	0.58
2004	36	55	50	240	381	3.3	0.63
2005	50	40	38	130	258	2.96	0.55
2006	58	54	62	241	415	3.17	0.6
2007	45	51	59	204	359	3.18	0.61
2008	58	56	79	234	427	3.15	0.6
2009	59	62	80	253	454	3.16	0.6
2010	54	67	70	283	474	3.23	0.62
2011	62	82	100	372	616	3.27	0.63
2012	75	56	57	245	433	3.09	0.58
2013	55	46	67	250	418	3.22	0.61
2014	36	60	80	276	452	3.32	0.64
2015	61	78	58	273	470	3.16	0.6
2016	50	77	71	311	509	3.26	0.63
2017	38	54	62	245	399	3.29	0.63
2018	37	47	62	255	401	3.33	0.64
Total	**968**	**1093**	**1207**	**4699**	**7967**	**3.21**	**0.61**

during the period of study. The Collaboration Coefficient (CC) is counted by using the following formula:

$$CC = 1 - \frac{\sum_{j=1}^{A} \left(\frac{1}{j}\right) fj}{N}$$

Where,

j = the number authors in an article i.e. 1, 2, 3, more than 3.

fj = the number of j authored articles

N = the total number of articles published, and

A = the total number of authors per articles

Profile of the Top 10 Most Productive Authors in 'Atomic Energy' research

The table 7 depicts the profile of the top 10 most productive authors with their contribution to atomic research publications during the period (1999-2018). The maximum publications were contributed by Nakamura, T. and Nishitani, T. with 43 publications each, followed by 42 publications contributed by He, M. and Jiang, S., Yamamoto, A. and Kunitomi, K., Ochiai, K.with 41 and 39 each publications werecontributed respectively. 37 each publications were contributed by Okuno, K. and Zhang, T., while Konno, C. contributed 36 research papers during the period of study.

Profile of the Top 10 Most Productive Journals in 'Atomic Energy' research

The table 8 shows the top ten most productive journals in atomic energy research publications from the particular time spam of study. The highest productive journal (with 2688 (43.89%))

Table 7: Profile of the top 10 most productive authors in 'Atomic Energy' research

Author Name	Affiliation Name	No. of Publications	h-index	Total Citations
Nakamura, T.	Kyoto University, Department of Physics and Astronomy, Kyoto, Japan	43	42	8674
Nishitani, T.	National Institutes of Natural Sciences - National Institute for Fusion Science, Toki, Japan	43	32	4393
He, M.	China Institute of Atomic Energy, Beijing, China	42	11	489
Jiang, S.	China Institute of Atomic Energy, Beijing, China	41	11	416
Yamamoto, A.	Nagoya University, Nagoya, Japan	41	20	1880
Kunitomi, K.	Japan Atomic Energy Agency, Kashiwa, Japan	39	16	1221
Ochiai, K.	National Institutes for Quantum and Radiological Science and Technology, Aomori Prefecture, Japan	39	16	926
Okuno, K.	Japan Atomic Energy Agency, Kashiwa, Japan	37	22	1851
Zhang, T.	China Institute of Atomic Energy, Beijing, China	37	11	593
Konno, C.	Japan Atomic Energy Agency, Kashiwa, Japan	36	13	766

of publications) was "*Journal of Nuclear Science and Technology*", followed by "*International Conference on Nuclear Engineering Proceeding ICONE*" with 201 (3.28%) of publications, "*Nuclear Engineering and Design*" with 125 (2.04%) publications, "*American Society of Mechanical Engineers Pressure Vessels and Piping Division Publication PVP"* with 104 (1.70%) publications, "*Fusion Engineering and Design*" with 103 constituting (1.68%) publications, "*Transactions of the Atomic Energy Society of Japan*" with 101 (1.65%) of publications, "*Radiation Protection Dosimetry*" with 94 (1.53%) of contributions, "*Nuclear Instruments and Methods in Physics Research Section A Accelerators Spectrometers Detectors and Associated Equipment*" with 93 (1.52%) publications, "*Physics of Plasmas*" with 83 (1.36%) and "*Nuclear Technology*" with 79 (1.29%) of contributions.

Table 8: Profile of the Top 10 most productive journals in 'Atomic Energy' research

Name of a Journal	No. of Publications (%)
Journal of Nuclear Science and Technology	2688 (43.89%)
International Conference on Nuclear Engineering Proceedings ICONE	201 (3.28%)
Nuclear Engineering and Design	125 (2.04%)
American Society of Mechanical Engineers Pressure Vessels and Piping Division Publication PVP	104 (1.70%)
Fusion Engineering and Design	103 (1.68%)
Transactions of the Atomic Energy Society of Japan	101 (1.65%)
Radiation Protection Dosimetry	94 (1.53%)
Nuclear Instruments and Methods in Physics Research Section A Accelerators Spectrometers Detectors and Associated Equipment	93 (1.52%)
Physics of Plasmas	83 (1.36%)
Nuclear Technology	79 (1.29%)

Significant Keywords and most productive organizations in the literature on 'Atomic Energy' research

The table 9 illustrates the significant keywords, around 160 significant keywords have been recognised from the publications during the period of study, which seeks to highlight possible trends in atomic energy research. The maximum, i.e. 'Nuclear Energy' keyword was used in 1299 (5.56%) publications, followed by 'Nuclear Power Plants' keyword in 634 (2.71%) publications and 544 (1.97%) publications, 'Article' type keywords were used. The profile of the top ten most productive organizations, which is contributed to atomic research publications. A total of 160 organizations were contributed by 7967 publications from the particular time spam of study. The highest, i.e. 1961 (19.57%) published research papers were contributed by 'Japan Atomic Energy Agency', followed by 'Korea Atomic Energy Research Institute' with 780 (7.97%) publications and 586

(5.99%) of records were contributed by 'International Atomic Energy Agency, Vienna'. The top ten keywords and organizations are listed in the table 9 in the decreasing order of the frequency of their occurrence in the literature from the marked period of study.

Table 9: Significant keywords and most productive organizations in the literature on 'Atomic Energy' research

Keywords	No. of Publications (%)	Organization Name	No. of Publications (%)
Nuclear Energy	1299 (5.56%)	Japan Atomic Energy Agency	1916 (19.57%)
Nuclear Power Plants	634 (2.71%)	Korea Atomic Energy Research Institute	780 (7.97%)
Article	544 (2.33%)	International Atomic Energy Agency, Vienna	586 (5.99%)
International Atomic Energy Agency	459 (1.97%)	Kyoto University	243 (2.48%)
Nuclear Reactors	435 (1.86%)	China Institute of Atomic Energy	210 (2.15%)
Atomic Energy Agency	422 (1.81%)	University of Tokyo	208 (2.12%)
Nuclear Fuels	401 (1.72%)	Atomic Energy of Canada Limited - Chalk River Lab	194 (1.98%)
Fuels	374 (1.60%)	Tohoku University	191 (1.95%)
Human	361 (1.55%)	Osaka University	185 (1.89%)
Radioactive Wastes	359 (1.54%)	Commissariat a L'Energie Atomique CEA	160 (1.63%)

CONCLUSION

A scientometric examination is a quantitative investigation of the development of a subject by utilizing scientometric indicators, statistical apparatuses and methods. Using research papers data from the Scopus database, this study delivers a "quantitative and qualitative description" of 'atomic energy' research covering 20 years i.e. (1999-2018). The maximum atomic research publications were published in 2002, while the less research papers were published in the starting year of the study i.e. 1999. The highest number of "annual growth rate and compound annual growth rate" was recorded in 2002 and 2000 respectively, while the minimum AGR and CAGR were recorded in 2003 and (2001, 2003) respectively. It was recorded in fluctuating trend during the period of study. The maximum "relative growth rate" was found in 2000 while the doubling time was recorded in the year 2017. Out of the total publications, large numbers of records were

found on journal articles, followed by conference paper. The highest citations were recorded in the year 2007, while the minimum citations were found in 2018. The average degree of author collaboration was 0.87, the Collaborative Index was 3.21, while the Collaboration Coefficient was 0.61 recorded from the particular time spam of study. The most productive author's name was Nakamura, T. and Nishitani, T. while a total 160 keywords have been found from the research paper from the particular time spam of study in which the maximum, i.e. 'nuclear energy' keyword was used, followed by 'nuclear power plants'. The most productive organisation's name was 'Japan Atomic Energy Agency', followed by 'Korea Atomic Energy Research Institute' during the period of study.

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