

## 25. Bibliometric Analysis of Radiochemistry Research Output During 1989- 2021

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**Abstract:**

*The paper represents the analysis of 1122 articles related to radiochemistry published on various journals which are indexed in web of science database. Time duration of thirty-two years from 1989 to 2021 is taken for the study. The analysis shows that 61.51% of the literature related to the field published in the form of journal article. The average annual growth rate of subject is 15.39% and sometimes it shows negative growth rate. The Bradford's Law is applicable in the radiochemistry literature. From the study it is highlighted that multi- authored paper is more than the single- authored and the degree of collaboration is 88.59. This bibliometric analysis will help the researcher in the particular field to find out the most relevant literature in this field as well as to find the core journals and highest cited papers too.*

**Keywords:**

*Bibliometric Analysis, Radiochemistry, Research, Core Journals, Bradford's Law.*

### 25.1 Introduction:

Research works are increasing in every field day by day and it leads to the exponential growth of research literature. Especially in the field of scientific research everyday new research outcomes are coming out.

Radiochemistry is also such a branch of chemical science where a huge amount of research is conducted. Radiochemistry is the chemistry of radioactive materials; it involves study of chemical transformations of radioactive substances, dealing with actinides and transuranium elements, development of physicochemical principles of handling radioactive waste from nuclear power engineering, solving radioecology problems, developing methods for manufacturing sources of radioactive emissions, and separation of radioactive isotopes (Obodovski, 2019). For this study scholarly communication research outputs such as journal articles, proceedings, book review etc., which are indexed in web of science database are taken into consideration.

The last two decades are the golden time of research activities in which most of the developments are occurred. So, for this study the literature of radiochemistry for the last 32 years is taken into consideration.

### **25.2 Review of the Literature:**

Varma and Singh, 2017 analysed 1265 articles of big data research for the period 2012-2016 which were collected from the Scopus database. They found an increasing rate of publication over the years. Conference papers was found as the mostly used form to publish research work in big data.

In the selective review of bibliometric study of the Indian physics and astronomy research output 156 papers are reviewed and investigate the growth pattern of the research outputs. A comprehensive bibliography is also prepared. The study shows that 67% of the total literature is multi authored and 33% are single authored (Das et al., 2021).

Piriyadharisini et al., 2021 study about the global research product of nuclear chemistry, particularly by analyzing the records from web of science databases and highlighted on the points like publication sources, geographical region and also tested applicability of Bradford's Law on the research articles. In the study it is found that that most of the literatures are published in the form of articles (80%) followed by reviews (11%). USA, Germany, China and UK were the top four contributor country.

Garg et al., 2021 made the bibliometric analysis of veterinary science research output during 2001- 2020. In the article the chronological distribution, citation per paper, distribution of research article, distribution of citation etc. are analysed. Data on the research output indicates that during the year 2007-2008 the publication are in peak point. 26 prolific institutions produced more than two third of the total research output. The study also found that no highly cited authors were among the prolific authors.

Deka and Hazarika, 2021 made a scientometric study on nanotechnology research during 2008-2017. They collected 16935 articles from Web of Science database and found from the analysis that the growth of article over the window period is 123/year. They also found that USA topped the rank in case publication as well as citation in comparison to the other countries.

### **25.3 Objectives of The Study:**

The study has been carried out with the following objectives:

1. To find out the growth rate of literature.
2. To determine the core journals in the discipline.
3. To calculate the degree of collaboration.
4. To find out the Relative Citation Impact (RCI) and Absolute Citation Impact (ACI) of prolific countries.
5. To identify the top ten highly cited papers.

## 25.4 Methodology:

The data for the present study has been collected from Web of Science database using the following search query Radiochemistry (Topic) and Articles (Document Types)

Timespan: 1989-12-31 to 2021-12-31(Publication Date)

Query link: (<https://www.webofscience.com/wos/woscc/summary/d4012a7a-2d81-4f88-be70-c12211cff775-367c55d6/relevance/1>)

The document type selected for the study is only articles and total 1122 articles have been retrieved to make the study during the above-mentioned time period. The analysis has been done using MS- excel.

### Annual Growth Rate (AGR):

Annual growth rate is the rate of growth and decay of literature from the previous year.

$$AGR = \frac{\text{Current year publication} - \text{previous year publication}}{\text{Previous year publicatio}} \times 100\%$$

### Annual Average Growth Rate (AAGR):

Annual average growth rate is the average growth of literature in a specific time period.

$$AAGR = \frac{(\text{Growth rate of year } a + \text{growth rate of year } b + \dots + \text{growth rate of year } n)}{\text{Total number of year } (n)}$$

### Absolute Citation Impact (ACI) and Relative Citation Impact (RCI):

Absolute Citation Impact (ACI) and Relative Citation Impact (RCI) are used to evaluate the impact of research of a given country to the global output. (Kumari, 2009)

ACI is calculated as,  $ACI = \frac{\text{Total Number of citations}}{\text{Total Number of publications}}$

RCI measures influence and visibility of a country's research to the global perspective. It

can be calculated as,  $RCI = \frac{\text{A country's share of world citations in the subspeciality}}{\text{country's share of world publications in the subspeciality}}$

If RCI=1 then the country's citation rate is equal to world citation rate

If RCI<1 then the Country's citation rate is less than the world citation rate

If RCI>1 then the Country's citation rate is greater than the world citation rate

## 25.5 Data Analysis:

### 25.5.1 Distribution of Document Type:

Total 1824 no. of documents during the 32 years 1989- 2001 are found which are published in various forms. Figure 25.1 shows that highest 1122 (61.51%) records are in the form of research articles followed by review article, meeting abstract, editorial materials and proceeding paper etc. Majority 92.87% of the literatures are in the form of these five categories. Except research article other forms are not subjected for the further bibliometric study.

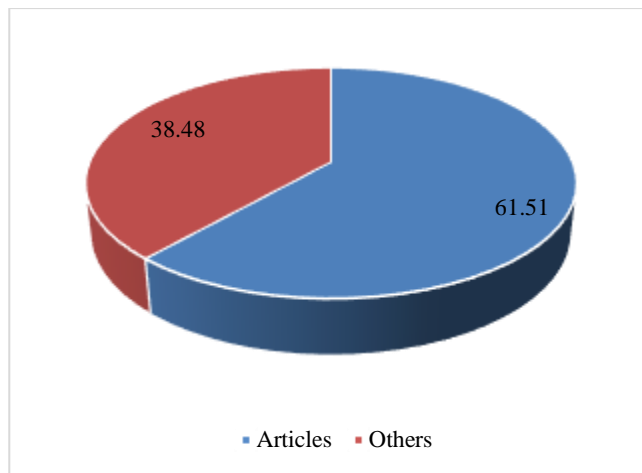


Figure 25.1: Document Type

### 25.5.2 Growth Rate of Literature:

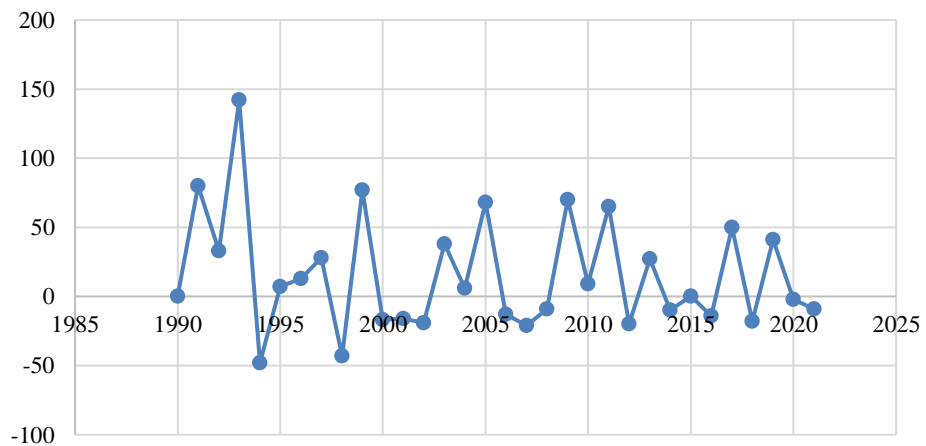


Figure 25.2: Annual Growth Rate (%)

The Average Annual Growth Rate of the subject in the window period is 15.39 % as depicted in the Table 25.2. Annual Growth Rate (AGR) is highest in the year 1993 i.e. 142% followed by 1991 (81%), 2009 (70%), 2005 (68%), 2011 (65%) and so on. In some periods 1994, the annual growth has declined.

### 25.5.3 Core Journals in The Discipline:

**Table 25.1: Source Title with h-index**

Title	Frequency	Total Citation	h-index
Journal Of Radioanalytical and Nuclear Chemistry	109	547	11
Applied Radiation and Isotopes	55	732	16
Journal Of Labelled Compounds & Radiopharmaceuticals	47	430	12
Nuclear Medicine and Biology	46	1575	19
Radiochimica Acta	36	722	13
Chemistry-A European Journal	32	492	14
Journal Of Nuclear Medicine	32	994	19
Angewandte Chemie-International Edition	31	2016	22
European Journal of Organic Chemistry	30	415	12
Journal Of Radioanalytical and Nuclear Chemistry Articles	24	68	4
Chemmedchem	17	229	10
Journal Of Chemical Education	17	51	4
Health Physics	14	75	5
Molecular Imaging and Biology	13	79	6
Nuclear Instruments & Methods in Physics Research Section B-Beam Interactions with Materials and Atoms	13	179	6
Chemical Communications	12	519	9
Journal Of Environmental Radioactivity	11	327	8
Bioconjugate Chemistry	10	191	7
Radiochemistry	10	3	1

It is found in the present study that there is total 325 journals contributing 1122 articles. The journals as per their frequency are arranged in Table 25.1 with their respective h-index.

It is found that “Journal of Radioanalytical and Nuclear Chemistry” is the most preferred source by the researchers to publish their work. On the other hand, there is a journal “Angewandte Chemie-International Edition” which has only 31 articles but the impact i.e., citation per paper of these articles is very high comparing to the other journals.

**25.6 Bradford’s Law:**

**Table 25.2: Bradford’s Law for core Journal**

No. of journals producing the articles of column B	No. of relevant articles found in each journal	Journal rank in descending order of productivity of article	Cumulative total of B
A	B	C	D
1	109	1	109
1	55	2	164
1	47	3	211
1	46	4	257
1	36	5	293
2	32	7	357
<b>1</b>	<b>31</b>	<b>8</b>	<b>388</b>
1	30	9	418
1	24	10	442
2	17	12	476
1	14	13	490
2	13	15	516
1	12	16	528
1	11	17	539
2	10	19	559
4	9	23	595
2	8	25	611
5	7	30	646
8	6	38	694
6	5	44	724
<b>12</b>	<b>4</b>	<b>56</b>	<b>772</b>
20	3	76	832
41	2	117	914
208	1	325	1122

With the help of Bradford’s law, the core journals of a discipline can be identified. In Table 25.2, the journals are arranged in the decreasing order of productivity.

As per the Bradford law; the journals can be divided into three zones such that each zone contains approximately equal number of articles. Therefore, in the present study, each zone should contain 374 articles.

It is seen in Table 25.2 that first 8 journals which are more productive contributed 388 articles which will form the first zone. In the second zone there will be 48 journals with 384 numbers of articles. The third zone will form with the remaining journal i.e.; 269 whose contribution is 350 articles.

**Table 25.3: Scattering of journals and articles over Bradford Zone**

Zone	No. of journals	No. of articles	Bradford's multiplier
1 <sup>st</sup>	8	388	---
2 <sup>nd</sup>	48	384	6
3 <sup>rd</sup>	269	350	5.6
Total	325	1122	Mean value= 5.8

As per Bradford's law the number of periodicals in each zone should be approximately in a ratio of 1: n: n<sup>2</sup>.

Here, the ratio between number of journals of the three zones is 8:48: 269: 1:6: 33.625. 8 journals found in the nucleus zone and the mean value of Bradford's multiplier is n= 5.8. Therefore, 8:8\*5.8:8\*5.8<sup>2</sup>::8:46.4:269.12.

$$\text{The percentage of error} = \frac{323.52 - 325}{325} \times 100 = -0.5\%$$

Since the percentage of error is negative here, the data fits well Bradford's law.

**25.7 Degree of Collaboration:**

In order to calculate the degree of collaboration among the authors in Radiochemistry Database the formula given by Subramanyam is used which mathematically expressed as, Collaborative degree of authors;

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

Where N<sub>m</sub> is the number of multi-authored papers during a specific period in a discipline & N<sub>s</sub> is the number of single-authored papers during a specific period in a discipline

**Table 25.4: Degree Collaboration**

Authorship	No. of articles
Single Authored article (N <sub>s</sub> )	128
Multi Authored article (N <sub>m</sub> )	994
DC=994/1122	88.59

So, according to the formula given above for this paper degree of collaboration will be,

$$\begin{aligned}
 DC &= 994 / (128 + 994) \\
 &= 994 / 1122 \\
 &= 88.59
 \end{aligned}$$

**Relative Citation Impact (RCI) and Absolute Citation Impact (ACI) of prolific countries**

**Table 25.5: World share of Publications, Citations, RCI & ACI**

Country	Total Publication	World share publication	Total citation	World share citation	RCI	ACI	h-Index
USA	389	34.67	7586	42.11	1.21	19.50	44
Germany	128	11.41	2936	16.30	1.43	22.94	27
France	110	9.80	1723	9.57	0.98	15.66	20
England	99	8.82	2892	16.06	1.82	29.21	27
Canada	58	5.17	1236	6.86	1.33	21.31	19

World share publications, citation and RCI of 5 countries having more than 50 publications are presented in Table 25.5. It depicts that USA has the highest world share publication with 34.67%. It also has the highest world share of citation (i.e. 42.11%). All these countries have RCI > 1 which implies that these countries have higher citation impact than the world average rate.

**25.8 Top Five Highly Cited Papers:**

**Table 25.6: Top Ten Papers**

Article Title	Source Title	Times Cited, WoS Core	Times Cited, All Databases
Effects of the synthetic estrogen 17 alpha-ethinylestradiol on the life-cycle of the fathead minnow ( <i>Pimephalespromelas</i> )	Environmental Toxicology and Chemistry	512	541
In Vivo Chemistry for Pretargeted Tumor Imaging in Live Mice	Angewandte Chemie-International Edition	349	349
Transition metal catalysis and nucleophilic fluorination	Chemical Communications	297	298
Photocatalysis fundamentals revisited to avoid several misconceptions	Applied Catalysis B-Environmental	293	296



Article Title	Source Title	Times Cited, WoS Core	Times Cited, All Databases
Standardized methods for the production of high specific-activity zirconium-89	Nuclear Medicine and Biology	290	293

Out of 1122 papers top 5 papers as per the total citation are presented in Table 25.6. The article ‘Effects of the synthetic estrogen 17 alpha-ethinylestradiol on the life-cycle of the fathead minnow (*Pimephalespromelas*)’ published in the journal ‘Environmental Toxicology and Chemistry’ is in the first spot with 541 citations. ‘In Vivo Chemistry for Pretargeted Tumor Imaging in Live Mice’ and ‘Transition metal catalysis and nucleophilic fluorination’ are in 2<sup>nd</sup> and 3<sup>rd</sup> place with 349 and 298 citations respectively.

### 25.9 Conclusion:

This paper is the bibliometric analysis of radiochemistry research output which provides an insight of that particular literature during the year 1989- 2021 indexed in web of science database. The study shows the average annual growth rate of 15.39% and highest annual growth rate in the year 1993 with 142%.

In several years’ growth rate is decreased. *Angewandte Chemie-International Edition* is the journal with highest h- index 22 and *Journal of Radioanalytical and Nuclear Chemistry* is the journal published with highest frequency. The Radiochemistry literature of that particular period follows Bradford’s law of scattering. It is found that no. of multi authored research article is higher than single authored article. USA has the highest world share publication with 34.67% and highest world share of citation (i.e. 42.11%). The findings of the paper may help the radiochemistry researchers to find out their relevant document and journal for their further study.

### 25.10 Reference:

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