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The Intrinsic Structure of Nuclear Chemistry: A Scientometric Study

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ABSTRACT: *In the last two decades, the research in nuclear chemistry has experienced a regular as well as voluminous structural changes and has grown notably with interaction from other fields in terms of theory building, methodology, and applications. This study focus a quantitative assessment of the scientific literature for mapping the intellectual structure of nuclear chemistry research and its scientific development over a 11-year period from 2008 till 2018. A total of 109281 publications were subjected to examination in order to draw statistics and depict dynamic changes to shed new light upon the growth, dispersion and structure of the studied domain. In general this work characterizes the papers, in terms of growth, institution, document type, prominent authors and institutions, and geographical distribution.*

Keywords: Nuclear Chemistry, SCOPUS Database, Scientometrics, CAGR

1. Introduction

Scientific journals perform the core function of carrying the research done in a domain to the members of scientific community. In assessment of scientific performance, bibliometric and citation indicators are among the most important impact measures of scientific literature [1]. Routine evaluation of scientific activities of these journals will provide a clear view of journal motion track and the subject areas [2]. The assessment of scientific productivity in a discipline provides a constructive feed to the scientists and policymakers for understanding and decision making. Scientometrics enables the scientific community in all disciplines to analyze and measure scientific productivity using several parameters. Major research issues addressed in the scientometric literature include the measurement of impact and the reference sets of articles to investigate the impact of journals and institutes, understanding of scientific citations, mapping scientific fields, and the production of indicators for use in policy making and management contexts [3, 4]

Chemical sciences is a major broad subject category in scientific databases. Nuclear Chemistry is a major branch of chemistry which records a significant output in Chemical sciences. Briefly, nuclear chemistry may be defined as a large umbrella which covers all chemical studies related to radioactive materials and nuclear radiation including the fine sub- branches such as radiochemistry, radiation chemistry, radio analytical chemistry, radiopharmaceutical chemistry, environ- mental radiochemistry.[5] The papers published in scientific journals in nuclear chemistry were selected for analysis and evaluation of the distribution of publications and citations, for the numerical characterization of nuclear science research performance.

2. Aim of the Work

Analysis of broader disciplines give rise to the understanding of the structure and growth in a given time. Besides, it helps to visualise other parameters such as authorship and institution productivity. Based on this understanding we have fixed the major aims as follows:

1. This work characterize the detailed study of the generic bibliometric view of the Nuclear Chemistry publications by examining the most prominent articles, institutions, authors, themes, document types, and so on.

2. The purpose of this study is to understand the intrinsic structure of nuclear chemistry and the output research areas where the contributions are recorded.

3. A detailed study of the nuclear chemistry publication base is also performed to understand the knowledge base of the sub-domain which is measured in terms of document types, core journals, and countries.

4. The top cited journals in this filed are ranked in order to identify the core journals contributing to the analysed domain.

5. Statistical techniques and analysis of the literature output helps to determine the nature of the nuclear chemistry.

3. Methodology

The repository of Scopus was used as the data set for this study, which is a scientific citation indexing service maintained by Elsevier. The coverage of Scopus is broader than the Web of Science as it includes several thousands of journals. It is a primary source of bibliographic data which is used in many scientometric studies and considered a standard data source for bibliometrics. The data span of the current study is from 2008-2018 where the data was collected in 2019. A total of 109281 publications were retrieved for the above said period. The query used in the search engine with the search strings “(KEY(nuclear chemistry) AND (LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR, 2013) OR LIMIT-TO (PUBYEAR, 2012)OR LIMIT-TO (PUBYEAR, 2011)OR LIMIT-TO (PUBYEAR, 2010)OR LIMIT-TO (PUBYEAR, 2009)OR LIMIT-TO (PUBYEAR, 2008))” that has used for the data extraction from the database”. Each record of the data retrieved from the Scopus comprises a number of fields such as author, author affiliation, title, abstract, citations record, and so on.

We have carried out the basic exercises such as authorship, form of output, journals and institution analysis. We have used a few basic indicators as well as some other ones as indicated below.

Compound Annual Growth Rate (CAGR)
CAGR, or compound annual growth rate, is a useful measure of growth over multiple time periods. In economics it was first used where it can be thought of as the growth rate that gets the user from the initial investment value to the ending investment value if one assume that the investment has been compounding over the time period. In an early work of Choi et al., (2011) [6], the Growth rate was measured with Compound Growth Rate (CAGR). This indicator is measured (CAGR) as follows.

$$CAGR = \frac{Ending\ Value}{Beginning\ Value}$$

4. Review of Literature

Domain and discipline analysis is performed in scientometrics for many years by subjecting many individual disciplines. Normally the whole output of a particular domain is considered by downloading the data from either a multidisciplinary database or domain-specific database.

The major field analysis was performed by many earlier researchers such as in management [7,8], energy & fuels [9,10], psychology [11,12], Dielectric and bioimpedance research [13], Selfish memes [14], Non-communicable Diseases,[15] Neurocomputing [16] and so on. In many investigations, a single journal or a narrow field is considered for extraction and analysis of scientometric data. Such studies are characterized by long term window as well as large source of data.

There are a few more studies that addressed in the analysis of small themes. In the early period, many related research has been reported in smaller or narrow disciplines such as cloud computing [17] (Heilig and Voß 2014), remote sensing (Zhuang et al. 2013, Peng et al. 2015 [18,19]), human geography (Wang and Liu 2014 [20]), knowledge management (Gu 2004 [21], Serenko and Bontis 2004 [22]), economics and business (Nederhof and van Raan 1993 [23], De Bakker et al. 2005 [24]), tourism (Michael Hall 2011 [25]), wastewater research (Zheng et al. 2015 [26]), and earthworm research (Xiang et al. 2015 [27]).

Some of the studies took specific sub-disciplines in medicine as the relative output in the subfields of medicine is rather voluminous. The following are predominant; neurology (Garnett et al. 2013 [28], Gupta et al. 2014 [29]), dentistry (Yang et al. 2001 [30]), nursing (Estabrooks et al. 2004 [32]), clinical radiology (Rahman et al. 2005 [32]), alternative medicine (Chiu and Ho 2005 [33]), and epidemiology (Dannenberg 1985 [34], Ugolini et al. 2007 [35]).

While it is clear that a large number of analyses were carried out at each domain level in the last two decades, there is definitely a lack of a general and comprehensive scientometric studies. Each study has been done with a specific focus by considering a few micro-level indicators. This paper aims to carry out a thorough scientometric analysis focusing on multiple aspects, with an addition of basis indicator analysis.

Dataset

In this study, the Scopus database was selected as the primary source of scientific publication analysis. There are reasons for this selection which are not limited to the below 1) the coverage of Scopus is more than the rival Web of Science and a much greater number of non-English-language journals are indexed by Scopus, than by the Web of Science (Li, Qiao, Li, & Jin, 2014 [36]; Mongeon & Paul-Hus, 2016 [37]; Vieira & Gomes, 2009 [38]); 2) Scopus was technically easier to manage and data mine. (György Csomós [39].)

5. Data Analysis

Year Wise Publications

The year wise distribution of Nuclear Chemistry research publications is given in Table 1 for the eleven years period.

Table 1. Publication Output of Nuclear chemistry

2018	13590
2017	14482
2016	14366
2015	16196
2014	12193
2013	7151
2012	6352
2011	6107
2010	6387
2009	6276
2008	6181

Total Records: 109281

This scientific output analysis focuses on productivity, dispersion of journals, domain analysis in Nuclear Chemistry analyzing a global perspective and their influence throughout the period under study. Quantity and discipline indicators were used, such as: number of publications, growth in the study period, sub-domain productivity, form of documents preferred, ranking of contributed journals and so on.

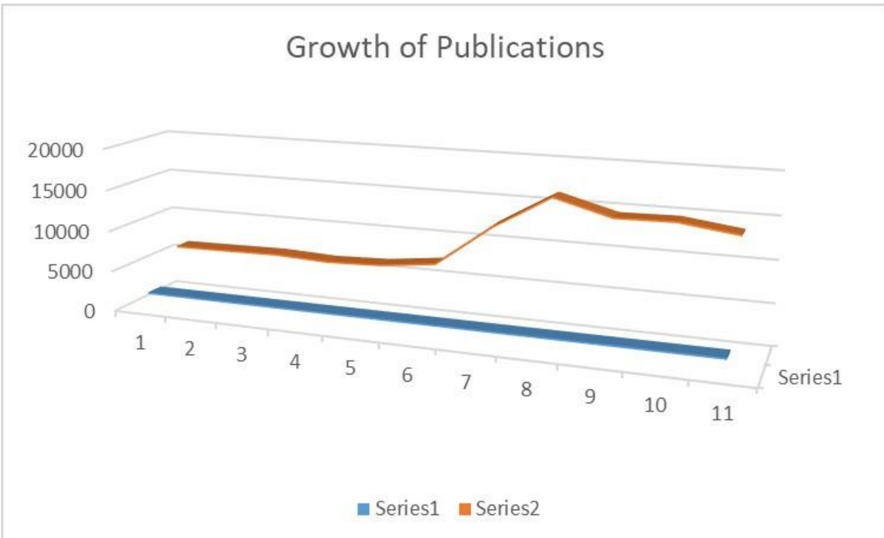

Figure 1. Growth of publications
Note: Series 1- Year and Series 2- No of papers

Research reporting negative growth did not produce significant decreases in research activity, as measured by the number of other publications in a given time considering the limited period of the coverage. Figure 1 exhibits the data of the Nuclear Chemistry production and other supporting indicators. In the period under study, the total indexed papers annual productivity has shown inconsistent output. Out of the total 109281 papers for eleven-year period, exhibits skewed distribution.The year 2018 has reflected a negative trend which is not because of the decreasing productivity but due to incomplete coverage of papers by the database.

The inconsistent output leads to a difficult status of arriving at any definite conclusion of the productivity. The uneven growth that is neither increase nor decrease is unclear and it would be rather inconclusive to limit to the database coverage policy due to the limited study period.

The first half of the analyzed period has a poor relative growth comparing to the second half of the analysed period.

Year Wise Growth Rate

Compound Annual growth rate is useful tool to identify the trends on any domain. The year wise CAGR shown in Table 1 (Figure 2 and 3).

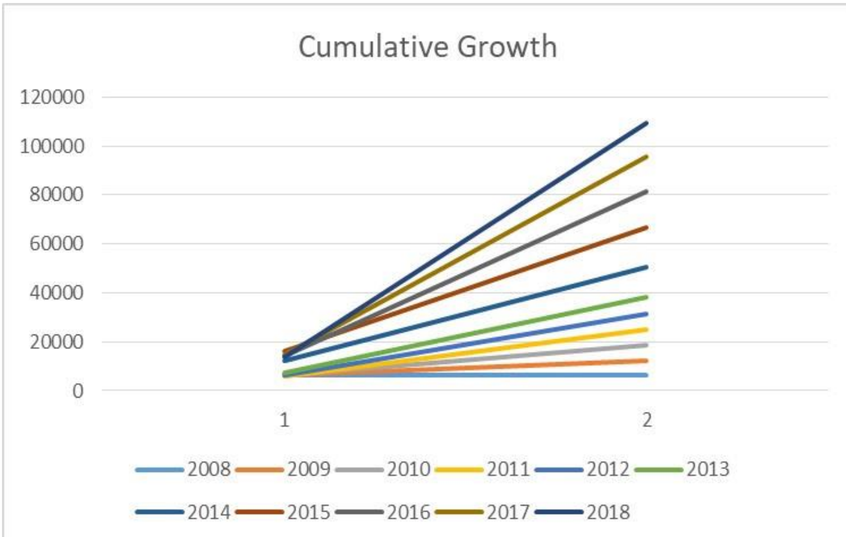

Figure 2. Cumulative Growth versus period

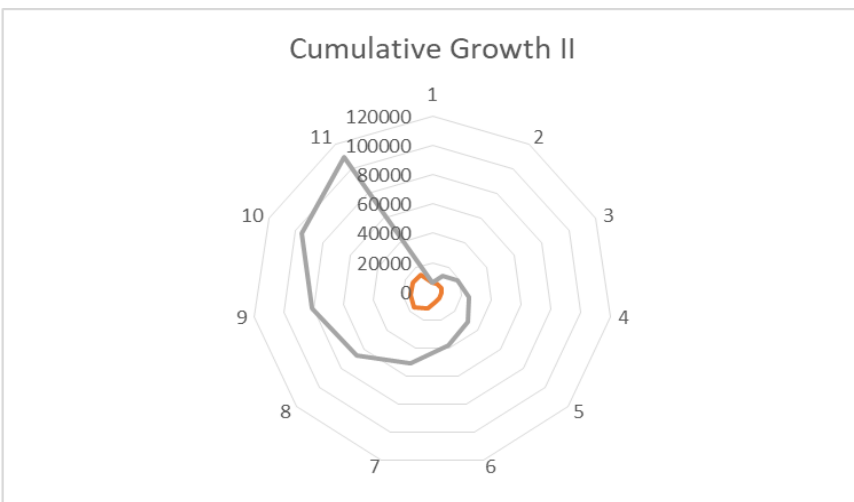

Figure 3. Cumulative Growth rate of Nuclear Chemistry

The Table 2 (Figure 2 and 3) shows that a total of 109281 research publications in Nuclear Chemistry during 2008 – 2018 were published with an average 10928 papers per year. The maximum number of publications is in 2015 and 2017 with 16196 and 14482 papers. Regarding Compound annual growth rate (CAGR), Maximum CAGR observed in 2015 and 2017 negative growth observed in the year 2016 and 2018.

Prolific Subject Areas

Nuclear chemistry may be defined as a large umbrella which covers all chemical studies related to radioactive materials and nuclear radiation including the fine sub-branches such as radiochemistry, radiation chemistry, radio-analytical chemistry, radiopharmaceutical chemistry, environmental radiochemistry. Besides, these subdivisions the papers related to nuclear chemistry and interdisciplinary papers get published in the journals of nuclear science. The classification of journals in databases do not follow a systematic way rather it is arbitrary. The total papers are widespread not necessarily in the core chemistry or chemistry related journals, but dispersed in different subject journals as identified by databases. Individual article level count only can solve the issues.

Table 2. Prolific Subject Areas of Nuclear Chemistry

Chemistry	53293
Biochemistry, Genetics and Molecular Biology	48665
Pharmacology, Toxicology and Pharmaceutics	21358
Chemical Engineering	20090
Medicine	17937
Materials Science	17479
Agricultural and Biological Sciences	9474
Physics and Astronomy	9289
Engineering	5153
Environmental Science	3935
Immunology and Microbiology	3644
Multidisciplinary	2416
Energy	2061
Computer Science	1836
Neuroscience	1661
Health Professions	753
Earth and Planetary Sciences	746
Mathematics	617
Nursing	539
Social Sciences	384
Economics, Econometrics and Finance	284
Veterinary	249
Dentistry	234
Psychology	156
Arts and Humanities	67
Business, Management and Accounting	11
Decision Sciences	7
Undefined	1

Document Type

There are different Bibliographic forms such as Conference paper, Article, Review, Article in Press, Conference Review, Book Chapter, Short Survey, Letter, Note and Editorial forms. The distribution of research production in these forms is Table 3. Scientometric analyses have traditionally addressed the document types and there are debates whether to include or exclude certain types of documents. The notes and letters to the editors appear in many journals are journals are not considered while productivity counts are made and in a few journals such as Physical Review, Nature, they are considered. While there are some objections to it, the database producer ISI argues that certain journals publish original research in notes and letters to the editors.

Table 3. Document Type

Article	99822
Review	5191
Conference Paper	1700
Book Chapter	1082
Letter	324
Editorial	322
Note	306
Short Survey	265
Book	103
Erratum	70
Conference Review	31
Retracted	11
Abstract Report	2
Data Paper	1
Undefined	51

However in nuclear chemistry, 97% of total records are research papers and reviews. Letters and notes constitute less than one percentage. A detailed study of the notes and letters by full text analysis may offer some insights and we can conclude whether to accept them or not.

Source Title Wise Distributions

Table 4 indicates that the top 20 journals are used for publishing the research papers.

Journal of Publication

The records were published in more than 500 scientific journals. The top 43 journals (with more than 500 papers) accounted for a large chunk of 44849 papers. About half the literature was concentrated in 20 journals, while the remaining half was scattered throughout the list. Table 2 lists the 24 journals containing the most records, showing their impact factor, subject category and ranking in the 2015 Journal Citation Reports (JCR) as well as their country and language of publication. While the core journals in nuclear chemistry such as Chemical Communications, Journal of The American Chemical Society, Dalton Transactions, New Journal of Chemistry, Molecules, and Chemistry A European Journal have published large volume of papers, the ‘other’ journals such as Plos One, Journal of Natural Products and a few more also contributed good amount of papers denoting the dispersion factor. When the scope of the journals are matched with the papers, we found a significant deviation.

Prolific Affiliations

To analyze further on the nuclear chemistry output we studied the authors’ affiliations and the countries in which they are located. The publications come from several countries. As in any scientific field of knowledge, the dominance of US and China over other countries is visible. Table 5 presents a detailed perspective of the distribution of countries by venue. These indicators can be crossed and compared with the data analysis in other fields where the majority of its authors was affiliated to institutions from USA, China, and UK. The recent evidence (Bartneck and Hu 2010) reveals that there are influential citation factors when considering the authors’ affiliation institution. In a narrower level of analysis, Chinese Academy of Sciences led the way as the most representative institution with 3937 papers, followed by CNRS Centre National de la Recherche Scientifique, as shown in Table 6. If we take a closer look at the top institutions (which have more than 500 papers) ranked by research productivity we find that they include only universities and research laboratories and hardly we found companies or industries. Most of these institutions are characterized with an outstanding overall reputation, strong historical back-ground and enough funding and personnel resources. This fact lead to the basis for encouraging new generations of highly qualified scientists and enables to employ several scientists working on nuclear chemistry. Research funding is crucial to shape the object of science generated by universities and research labs. Nevertheless, such studies are also guided by the demand for science at the regional level.

Table 4. Source Type

Chemical Communications	3905
Journal Of The American Chemical Society	2113
Dalton Transactions	2022
Plos One	1852
New Journal Of Chemistry	1753
Molecules	1686
Chemistry A European Journal	1599
Spectrochimica Acta Part A Molecular And Biomolecular Spectroscopy	1556
Rsc Advances	1465
Journal Of Organic Chemistry	1463
Journal Of Natural Products	1343
Journal Of Biological Chemistry	1159
Angewandte Chemie International Edition	1144
Journal Of Agricultural And Food Chemistry	1077
Scientific Reports	997
Bioorganic And Medicinal Chemistry Letters	952
European Journal Of Medicinal Chemistry	940
Natural Product Research	864
Magnetic Resonance In Chemistry	862
Organic And Biomolecular Chemistry	831
Journal Of Magnetic Resonance	829
International Journal Of Molecular Sciences	797
Inorganic Chemistry	791
Carbohydrate Polymers	768
International Journal Of Biological Macromolecules	750
Phytochemistry	744
Biomolecular NMR Assignments	739
Fitoterapia	711
Proceedings Of The National Academy Of Sciences Of The United States Of America	693
Journal Of Physical Chemistry B	691
Biochemistry	677
Bioorganic And Medicinal Chemistry	671
Organic Letters	657
Nucleic Acids Research	639
Journal Of Chemical Physics	634
Journal Of Asian Natural Products Research	604
Methods In Molecular Biology	590
Biomacromolecules	579
Natural Product Communications	570
Carbohydrate Research	547
Journal Of Medicinal Chemistry	544
Nature Communications	528
Langmuir	513

Table 5. Country of Publications

S.N0.	Country	No. of Publications	Rank	Order
1	United States	13054	1	
2	China	12154	2	
3	Germany	4545	3	
4	Japan	3761	4	
5	India	3630	5	
6	United Kingdom	3224	6	
7	France	2947	7	
8	Italy	2375	8	
9	South Korea	2153	9	
10	Canada	1854	10	

Table 6. Top institutions contributing to the domain

Chinese Academy of Sciences	3937
CNRS Centre National de la Recherche Scientifique	2885
Ministry of Education China	2777
University of Chinese Academy of Sciences	962
Russian Academy of Sciences	906
National Institutes of Health, Bethesda	899
Consiglio Nazionale delle Ricerche	863
Inserm	849
Harvard Medical School	826
University of Tokyo	810
Consejo Superior de Investigaciones CientÃ-ficas	741
University of Oxford	735
University of Cambridge	688
Chinese Academy of Medical Sciences	683
University of Toronto	675
Peking University	666
ETH Zurich	659
Zhejiang University	651
Peking Union Medical College	637
University of California, San Diego	593
Kyoto University	589
Fudan University	580
Sun Yat-Sen University	570
China Pharmaceutical University	552
University of Michigan, Ann Arbor	541
Sichuan University	540
Imperial College London	534
Massachusetts Institute of Technology	525
Seoul National University	520
KÃ¸benhavns Universitet	516
UniversitÃ degli Studi di Napoli Federico II	511
University of Queensland	510

In the study of institutions the constituent countries are analysed and a few dominant countries are identified. There is a clear departure of the shift to China in the last decade as in other domains of science and technology.

6. Conclusions

With the above discussions we complete a preliminary study of the field of Nuclear Chemistry. Papers dedicated to the nuclear chemistry subject have appeared in varied journals and conferences that reflect its interdisciplinary nature. In this paper, a quantitative analysis was carried out to comprehensively investigate the development and current state of nuclear chemistry related sub-disciplines with a look on the scientometric data based on the scopus database. We have investigated the growth, dispersion, distribution, and focus areas of nuclear chemistry along the lines of authorship, institutional distribution, geographical distribution and the volume of impact in terms of number of publications, and other characteristics. In difference to the deployment of structured literature analysis, a scientometric exercise can be valuable to easily obtain a general overview of a particular field of research by allowing the assessment of voluminous papers. The intention of this work was to enable the researchers in understanding the nature and evolution of this domain as a starting point for academics, practitioners, and general public to identify some of the main insights behind the existing knowledge.

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