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Scientometric Study of the Journal- Carbon

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Scientometric Study of the Journal- Carbon

Abstract

Scientometric evaluations have gained popularity in the academic and research fields over the last decade. The present study is a comprehensive scientometric evaluation of the Journal - Carbon. Carbon is a peer-reviewed international journal published by Elsevier and created in collaboration with the American Carbon Society. The author metrics, the applicability of Lotka's Law and the word metrics in the output during the years 2016-2020 are attempted in this study. The results show that the journal is widely cited. The analysis of author metrics reiterates the extent of collaborative authorship in the journal.

Scientometric analysis; Journal metrics/metrics; Journal impact; Metric studies.

Introduction

Scientometrics is a multi-disciplinary subject field that makes its presence in diverse subject areas. Scientometric evaluations have gained popularity in the academic and research fields over the last decade. Due to severe budget restrictions, research organisations and funding agencies are being forced to be more cautious in their research funding decisions. In the research funding process, determining the productivity of research areas, organisations, and individuals has become critical. As an effect, institutions and well-known writers are struggling to find high-impact factored journals in which to publish their findings. In this sense, reviewing journals based on scientometric parameters has a broad range of implications. Over time, journal studies have discussed various aspects like visibility, authorship pattern; content analysis; the collaboration of authors; institutions; citation counts; impact factors, the representation of new authors and institutions over a period, and recently their visibility in indexing, abstracting and other databases

The present study is a comprehensive scientometric evaluation of the Journal - *Carbon*. *Carbon* is a peer-reviewed international journal published by Elsevier and created in collaboration with the American Carbon Society. It has an impact factor of 8.821. The Journal publishes recent, important, and significant findings related to the scientific developments in the field of carbon materials, including low-dimensional carbon-based nanostructures and its technological applications.

Objectives and Scope of the study

Carbon was launched in October 1963, with just one volume published in its first year. From the following year 1964 till 1966, two volumes were published every year. From 1967 to 2012, only one volume was published each year. Since 2013, multiple volumes have been published. The present study covers the published output in the journal Carbon from 2016 to 2020. This includes 75 volumes that have been published in the last five years.

The study aims to find out the following

- The author metrics like the collaboration of papers, co-authorship index, Degree of Collaboration, prolific author, etc., of documents published in the journal carbon by using scientometric measures.
- The applicability of Lotka's law with respect to documents published during the study period
- The word matrices, reference, and geographical matrices of documents published in this journal

Literature review

Agrahari^[1] in his study on subject coverage of articles in the "Journal of Scientometrics," found that research articles dominated non-research articles for the study period between 2001 and 2010. Wolfgang Glanzel was the most prolific author in this study, and R. Rousseau was the most prolific co-author. The scientometric characteristics of the journal "The Journal of Corporate Finance" published by Elsevier for the period of the first 25 years (1994-2018) was studied by Baker, Kumar, and Pattnaik^[2]. The study revealed this journal's major intellectual clusters, the prolific authors, and top-cited papers, many of which were linked to corporate governance. Krauskopf^[3] in the study on the Spanish Journal "Enfermeria Nefrologica" found that only about 50 percent of the articles published by the journal were retrieved through Scopus database. The study was attempted after seeing the study about the same journal which retrieved records using Publish or Perish from googlescholar(GS). The study emphasized the need for routine quality checks of documents indexed in indexing databases. Ahamed, Asif, Alam & Slots^[4] studied the bibliometric characteristics of the journal Periodontology 2000, a prominent journal in the field of dental science. The analysis based on the data taken from Web of Science- All databases collection revealed that the

citation count for the top 100 cited articles varied for Web of Science, Scopus and Google Scholar. The country and institution details were taken based on the affiliation details of the first author. It was found that the majority of the articles were by US authors. Mondal^[5] studied the contribution of Indian scientists in selected physical review journals for 15 years(2004-2018).The data for the study were extracted from the Web of Science. It was found that 23.8% of the articles were three authored papers. It was also reported that Indian scientists collaborated more with their counterparts in the USA.

Methodology

The web of science database is the chief source of bibliographic data used in the study. The data was gleaned from Web of Science for the period of 5 years from 2016 to 2020. The data was extracted on 31 December 2020. Bibexcel and Biblioshiny tools were used to convert the metadata downloaded from WOS to formats suitable for analysis. The above-mentioned applications, as well as Microsoft Excel, were also used to perform the data analysis. The visualization of Bibliometric networks and mapping analysis was made using the VOS Viewer program.

Results

The analysis of the web of Science shows that the Journal Carbon published total 5335 documents of various forms between 2016 and 2020 (Table 1). With 5084 papers, articles came on top, followed by reviews. Abstracts, letters, editorial material, corrections, and biographical items were among the other types of documents published. The total number of Carbon authors in the web of science databases is 17992, which includes first, second, third, and so on authorship positions. There were 34 single-authored documents and 17958 multi-authored documents. The h-index, g-index and m-index of the journal during the study period were 101, 133 and 16.93 respectively. The journal received a total citation(TC) of 97316 during the study period.

Table 1. Vital statistics of the journal Carbon

Main information	Count
Article	5084
Biographical-item	6
Correction	41
Editorial material	10
Letter	30
Meeting abstract	49
Review	115
Keywords Plus (ID)	7684
Author's Keywords (DE)	4647

Authors	17992
Author Appearances	33670
Authors of single-authored documents	34
Authors of multi-authored documents	17958
Single-authored documents	40
h index	101
g index	133
m index	16.83333
TC	97316

Authorship Distribution & Collaborative Coefficient

The journal carbon reflects a trend of collaborative publishing. The journal Carbon had a higher number of documents with multiple authors. Six authors collaborated on 823 (15.42%) publications; seven authors collaborated on 729 (13.6%) publications; and seven authors collaborated on 681 (12.76%) publications.. This indicates that nearly 42% of documents had writers with a number between 5 and 7. This demonstrates the growing trend of global collaboration among researchers in the field.

The collaborative coefficient (CC) is a metric for evaluating how collaboration between authors exist in a subject field. Ajiferuke ^[6] devised a formula to measure the collaborative coefficient. The majority of the documents in the journal Carbon are multiauthored, as shown in Table 2. The CC value found as per the formula given below is calculated as under.

$$\begin{aligned}
 CC &= 1 - \sum_{j=1}^K \left(\frac{1}{j}\right) F_j/N \\
 &= 1 - \left[\left(\frac{1 \times 40 + \frac{1}{2} \times 273 + \dots + \frac{1}{10} \times 635}{5335} \right) \right] \\
 &= 0.80
 \end{aligned}$$

Table 2. Authorship pattern

No of authors	Records
1	40
2	273
3	504
4	645
5	729
6	823

7	681
8	578
9	427
10 & > 10	635
Total	5335

Growth of Literature, Degree of collaboration & Co-Authorship Index

The degree of collaboration is the proportion of the number of multi authored publications to the total number of publications in the discipline through a specific period of time. Degree of collaboration is calculated using the formula devised by Subramaniam^[7].

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

Nm is the number of multi authored papers and Ns is the number of single authored papers.

Co-Authorship Index (CAI) is obtained by calculating proportionally the output by single, two, three or more authored papers for different blocks of the years / nations / sub – disciplines. CAI is calculated by the formula suggested by Garg and Padhi^[8] given below

$$CAI = \left(\frac{N_{ij}}{N_{oj}} \right) \div \left(\frac{N_{io}}{N_{oo}} \right) \times 100$$

Where N_{ij} = No. of publication for the particular authorship pattern for a particular country / sub – discipline / year

N_{io} = total output for the particular authorship pattern

N_{oj} = total output of the particular year

N_{oo} = total output of the year

Table 3. Degree of collaboration & Co-authorship index

Year	Records	Single Author records	Multiple Author records	DC	CAI Single Author	Two Author Records	CAI Two Authors	Three Author Records	CAI Three Authors
2016	1041	10	1031	0.99	128.12	59	121.30	122	167.21
2017	1084	7	1077	0.99	86.13	60	118.46	103	135.57
2018	1022	8	1014	0.99	104.40	42	87.95	96	134.02
2019	1175	6	1169	0.99	68.11	59	107.46	97	117.79
2020	1013	9	1004	0.99	118.50	53	111.97	86	121.13
	5335	40	5295	0.99		273		504	

According to the Table 3, the year 2019 has the maximum output, followed by 2017. The number of Single authored documents were very less in number. Multi-authored papers made up 5295 (99 percent) of the total 5335. According to the study Degree of collaboration was found to be higher in the case of documents published in the journal Carbon. For the years from 2016 to 2020 the DC was 0.99. In the case of single and multiple authored documents the CAI varied for the years.

Relative Quality Index, Publication Efficiency Index, Mean Total Citations

Relative Quality Index (RQI) is a ratio of the proportion of the number of cited publications to total citations of the year and to the proportion of total cited publications to total citations.

$$PEI = \frac{\text{number of cited publications in a year} / \text{total citations in the year}}{\text{total cited publications} / \text{total citations}}$$

Publication Efficiency Index (PEI) is used to study whether the impact of research articles published by a given country is considerably related to the research effort. In this study the formula given by Chen and Guan^[10] is used to find out Publication Efficiency Index (PEI) of this journal

$$PEI = \frac{\frac{TNCi}{TNCt}}{\frac{TNPi}{TNPt}}$$

TNCi = total number of citations in a year,

TNCt = total number of citations for all the years,

TNPi = total number of publications in a year,

TNPt = total number of publications for all the years

The value of $PEI > 1$ indicates that the impacts of publications are more than the research effort devoted.

Table 4. Relative Quality Index & Performance Efficiency Index

Year	Records	Cited Record	Citations	RQI	PEI	Mean TC per	Mean TC per Year	Citable Years
2016	1041	1032	32916	0.63	1.73	31.62	6.32	5
2017	1084	1075	27973	0.77	1.41	25.81	6.45	4
2018	1022	1012	20946	0.96	1.12	20.50	6.83	3
2019	1175	1089	12922	1.68	0.60	11.00	5.50	2
2020	1013	668	2559	5.21	0.14	2.53	2.53	1
Total	5335	4876	97316	1.00				

In the five-year study period, the relative quality index for the year 2016 was 0.63, with 1032 cited documents. The same year had received the maximum number of citations ie 32916 citations in five years. The number of citations for the year 2020 is lower, which may be due to the fact that there has only been one citeable year so far. With a value of 31.62, the mean total citations per document was found to be high in 2016, and with a value of 6.83, the mean total citations per year was found to be high in 2018. The publication efficiency index was high for the year which had maximum citeable years. It was 1.73 in 2016 and 0.14 in the year 2020 (Table 4).

Applicability of lotkas Law

Lotkas law of author productivity was tested with the data based on the productivity pattern of Carbon journal. The testing was limited to those who contributed till 30 articles. In order to verify whether the observed distribution of author productivity fits the estimated distribution, Pao^[9] suggests applying the non-parametric Kolmogorov-Smirnov (K-S) goodness-of-fit test. To this end the maximum difference between the real and estimated accumulated frequencies is calculated, this value then being compared with the critical value (c.v.) obtained.

Table 5.Lotka's Law calculation

x	y _x	X=log	Y=log _y	X ²	XY	y _x /∑y	∑(y _x /E _{y_x})	fe	∑fe	D
1	1221	0.000	4.087	0.000	0.000	0.680	0.680	0.79	0.79	0.11
2	2918	0.301	3.465	0.091	1.043	0.162	0.842	0.11	0.91	0.07
3	1192	0.477	3.076	0.228	1.468	0.066	0.909	0.03	0.95	0.04
4	579	0.602	2.763	0.362	1.663	0.032	0.941	0.01	0.97	0.02
5	345	0.699	2.538	0.489	1.774	0.019	0.960	0.00	0.97	0.01
6	194	0.778	2.288	0.606	1.780	0.011	0.971	0.00	0.98	0.01
7	111	0.845	2.045	0.714	1.728	0.006	0.977	0.00	0.98	0.01
8	94	0.903	1.973	0.816	1.782	0.005	0.982	0.00	0.99	0.00
9	78	0.954	1.892	0.911	1.806	0.004	0.987	0.00	0.99	0.00

1	47	1.000	1.672	1.000	1.672	0.003	0.989	0.00	0.99	0.00
1	38	1.041	1.580	1.084	1.645	0.002	0.991	0.00	0.99	0.00
1	33	1.079	1.519	1.165	1.639	0.002	0.993	0.00	0.99	0.00
1	31	1.114	1.491	1.241	1.661	0.002	0.995	0.00	0.99	0.00
1	15	1.146	1.176	1.314	1.348	0.001	0.996	0.00	0.99	0.00
1	8	1.176	0.903	1.383	1.062	0.000	0.996	0.00	0.99	0.00
1	5	1.204	0.699	1.450	0.842	0.000	0.996	0.00	0.99	0.00
1	11	1.230	1.041	1.514	1.281	0.001	0.997	0.00	0.99	0.00
1	7	1.255	0.845	1.576	1.061	0.000	0.997	0.00	0.99	0.00
1	7	1.279	0.845	1.635	1.081	0.000	0.998	0.00	0.99	0.00
2	5	1.301	0.699	1.693	0.909	0.000	0.998	0.00	0.99	0.00
2	11	1.322	1.041	1.748	1.377	0.001	0.999	0.00	0.99	0.00
2	1	1.342	0.000	1.802	0.000	0.000	0.999	0.00	0.99	0.00
2	4	1.362	0.602	1.854	0.820	0.000	0.999	0.00	0.99	0.00
2	3	1.380	0.477	1.905	0.659	0.000	0.999	0.00	1.00	0.00
2	4	1.398	0.602	1.954	0.842	0.000	0.999	0.00	1.00	0.00
2	3	1.415	0.477	2.002	0.675	0.000	0.999	0.00	1.00	0.00
2	3	1.431	0.477	2.049	0.683	0.000	1.000	0.00	1.00	0.00
2	3	1.447	0.477	2.094	0.690	0.000	1.000	0.00	1.00	0.00
2	1	1.462	0.000	2.139	0.000	0.000	1.000	0.00	1.00	0.00
3	2	1.477	0.301	2.182	0.445	0.000	1.000	0.00	1.00	0.00
	1796	32.424	41.053	38.99	33.43					

$$n = \frac{N\sum xy - \sum x \sum y}{N\sum x^2 - (\sum x)^2} \text{-----(i)}$$

$$c = \frac{1}{\sum 1/x^n} \text{-----(ii)}$$

$$f_e = c \times x^n \text{ --- (iii)}$$

$$c.v = \frac{1.63}{(\sum y_x + (\sum y_{x/10})1/2)^{1/2}} \text{----- (iv)}$$

$$n = \frac{30 \times 33.436 - (32.424 \times 41.053)}{30 \times 38.999 - (32.424)^2}$$

$$= -2.765$$

$$C = \frac{1}{\sum x_i^n \text{ where } i=1 \text{ to } 30 \text{ and } n=-2.765}$$

$$= 0.80$$

$$c.v = \frac{1.63}{(17966 + (17966/10)^{1/2})^{1/2}}$$

$$= 0.012$$

To validate lotka's law , the values were calculated using the equations (i) to (iv). The critical value c.v was found to be 0.012 and the value of maximum difference (D) between the real and estimated accumulated frequencies from the table is 0.011, which is less than the c.v of 0.012. This indicates that the lotkas law fits to the data with regard to the author output in the journal Carbon (Table 5).

Word Dispersions

The word dispersion analysis exposes the journals key discussion topics. The word dispersions of the Journal carbon were extracted with the help of biblioshiny software. The words were categorised under four headings- Author keywords, Keyword plus words (standard words from web of science categories), Words that appear in the title and abstract. The table 6 lists the first 20 words in each category arranged in order of their frequency of appearance in the respective positions. According to the study Carbon and graphene are the most sought-after words. Graphene topped the list in keyword plus (730 times) and author keywords (220 times) category and second in the categories title words and abstract words. The term carbon appeared 2311 times in document titles and 7051 times in document abstracts. The other prominent words were performance, films, oxide etc. The figure 1 shows the prominent word dispersions in the Journal Carbon.

Table 6. Word Dispersions in the journal Carbon

Keyword plus words	N	Author Keywords	N	Title Words	N	Abstract Words	N
Graphene	730	Graphene	220	Carbon	2311	Carbon	7051
Performance	676	Graphene Oxide	75	Graphene	1728	Graphene	6666
Films	428	Carbon Nanotubes	61	Oxide	458	High	3900
Oxide	428	Carbon Nanotube	57	Properties	427	Surface	2778

Nanoparticles	422	Carbon	45	Nanotubes	386	Properties	2727
Carbon	401	SuperCapacitor	45	High	354	Materials	2399
Composites	374	SuperCapacitors	37	Nanotube	342	Structure	2141
Graphite	356	Raman Spectroscopy	36	Synthesis	314	Performance	1907
Nanosheets	343	Molecular Dynamics	34	Porous	309	Energy	1775
Nanotubes	339	Microwave Absorption	32	Performance	287	Density	1634
Reduction	300	Reduced Graphene Oxide	31	Composites	276	Thermal	1570
Nanocomposites	286	Oxygen Reduction Reaction	30	Oxygen	259	G-	1510
Growth	272	Photocatalysis	22	Efficient	253	Method	1477
Fabrication	268	Adsorption	21	Enhanced	250	Applications	1440
Mechanical-Properties	262	Anode	21	Batteries	245	Conductivity	1393
Raman-Spectroscopy	261	Conductivity	21	Graphite	240	Process	1344
Adsorption	249	Porous Carbon	21	Reduction	239	Low	1340
Nitrogen	245	Thermal Conductivity	21	Thermal	235	Temperature	1330
Carbon Nanotubes	236	Dft	20	Materials	209	Material	1247
Composite	220	Mechanical Properties	18	Surface	209	Study	1234

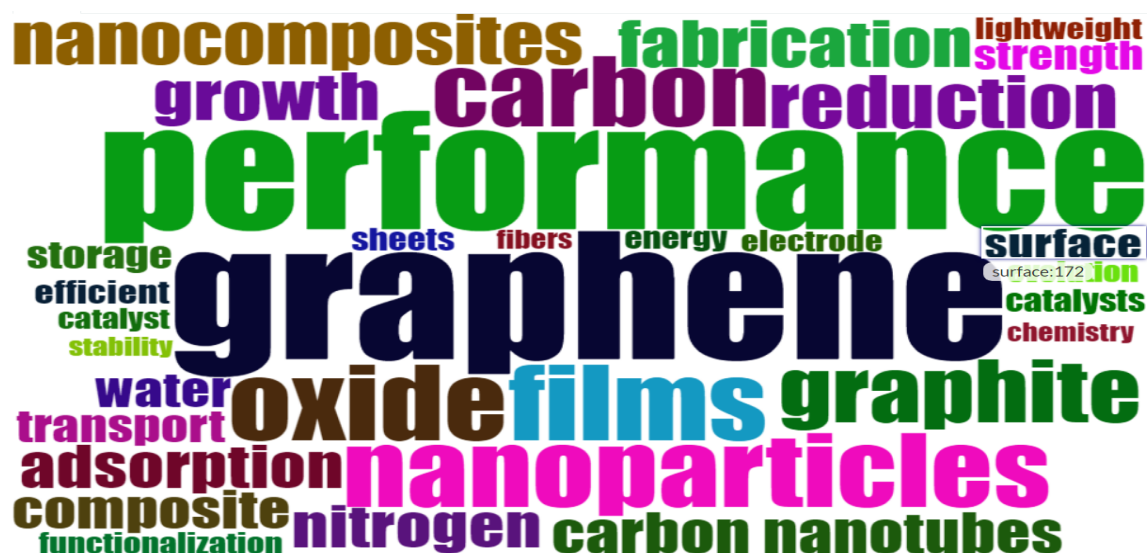


Figure 1: Word scattering based on Keyword Plus count.

Author & Country metrics

Among the top nation affiliation, Chinese writers contributed the most with 2568 documents; followed by authors from USA and Korea, who contributed of 1068 and 485 documents respectively (Table 7).

The Table 8 lists the top twenty authors of the study period (2016-2020). Zhang Y is the most prolific contributor, with 77 documents, followed by Wang Y and Li Y, who each contributed 73 and 58 documents. The above three authors top the list in terms of citations too. The figure 2 represents data visualisation of author productivity and co-citations for authors with at least 600 citations. Figure 3 is three field plot diagram showing prominent institutions, authors and countries

Table 7. Prolific Countries

Country	Articles
China	2568
USA	1068
Korea	485
Japan	356
Australia	285
Germany	278
England	258
France	253
Spain	230

India	194
-------	-----

Table 8. Prolific Authors

Author	NP	h_index	g_index	m_index	citations
Zhang Y	77	23	42	3.833	1950
Wang Y	73	23	39	3.833	1675
Li Y	58	21	36	3.5	1442
Chen Y	51	16	33	2.667	1128
Liu Y	51	22	37	3.667	1417
Wang J	50	19	29	3.167	920
Zhang H	49	18	33	3	1161
Zhang J	49	19	31	3.167	1030
Wang X	48	18	31	3	1081
Lee J	42	13	20	2.167	479
Li J	41	17	27	2.833	775
Zhang X	41	17	29	2.833	933
Kim J	39	13	21	2.167	491
Liu C	38	17	24	2.833	635
Liu J	38	17	28	2.833	833
Zhang L	38	16	29	2.667	885
Terrones M	37	13	22	2.167	532
Wang L	37	15	29	2.5	896
Zhang C	35	14	26	2.333	728
Wang H	33	15	25	2.5	630

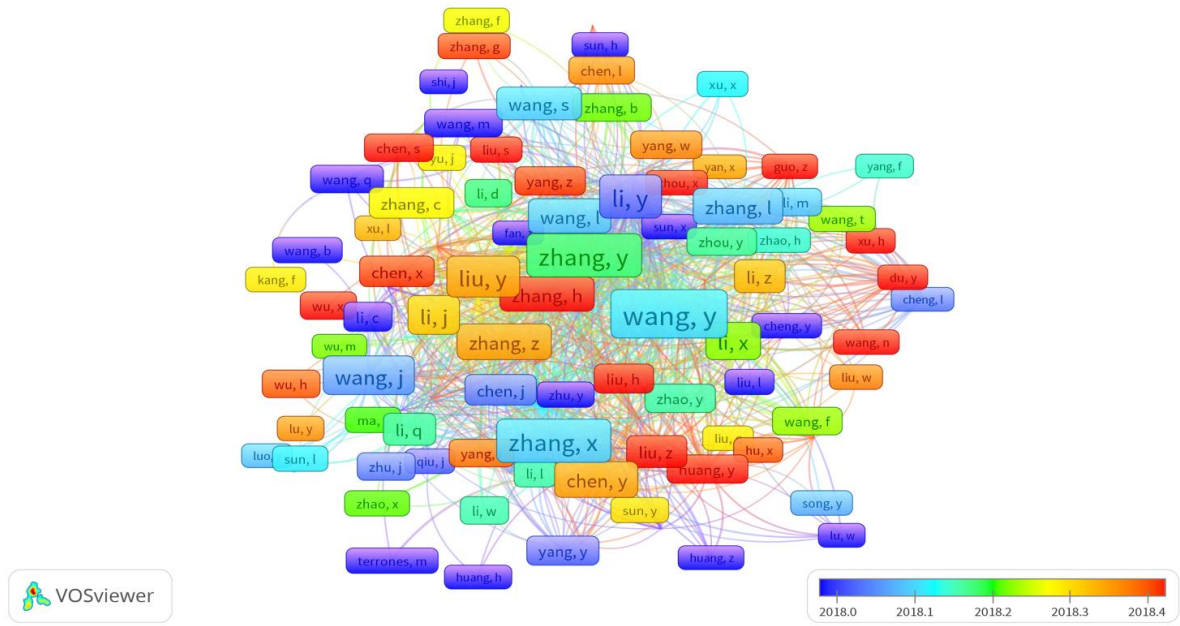


Figure 2: Data visualization of author productivity and co-citations of authors who had received minimum 600 citations.

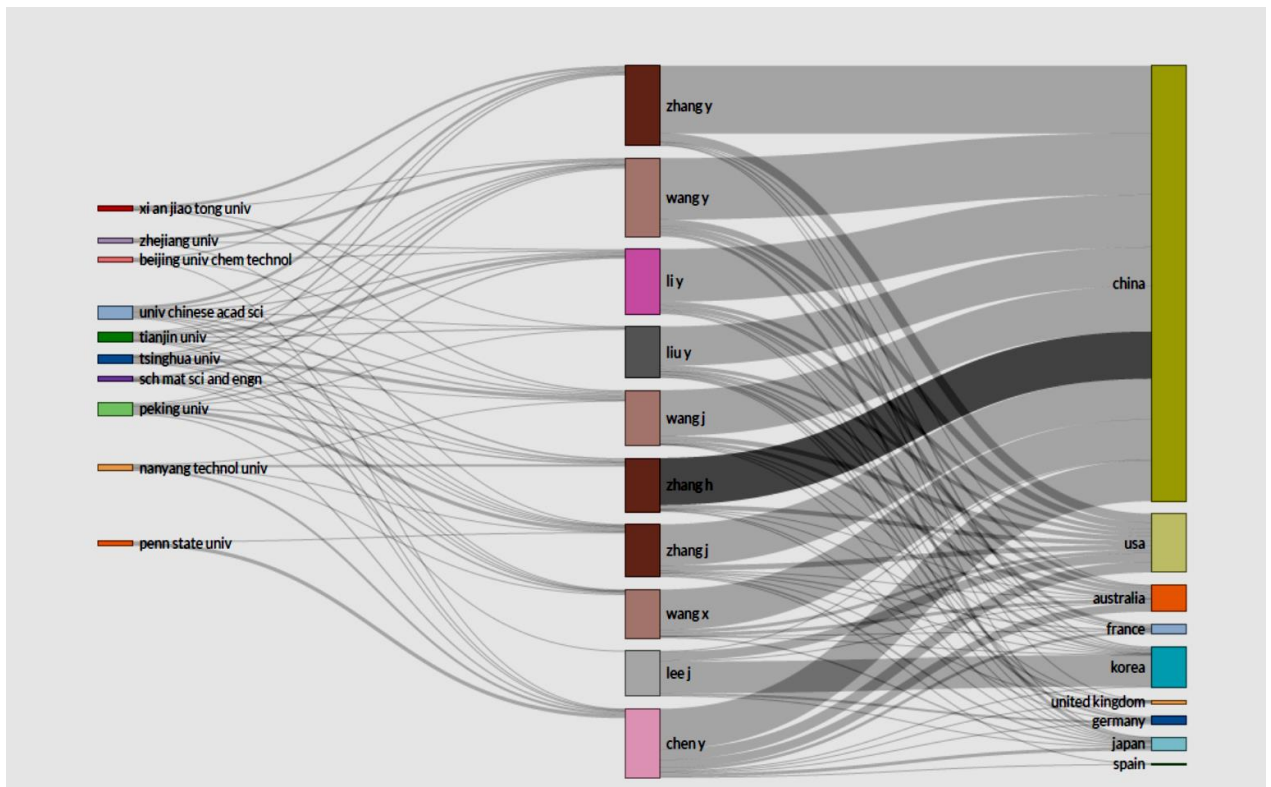


Fig.3: Three filed plot diagram showing prominent institutions, authors and countries using Biblioshiny.

Reference Matrix

Various matrices of references are mentioned in the table 9, including the most cited journal in the references, the most cited authors, citations obtained by nation, and the year which was cited the most in the journal during the study period .

Carbon journal is the most cited journal in the references of documents cited during the study period, with 23020 citations, followed by Advanced Materials and Physical Review B. Ferrari A C was the most cited author in the references, with 1113 citations for his documents. Novoslov K S and Kresse G came in second and third place, with 923 and 627 citations, respectively. Chinese documents had the most citations (54031), followed by the United States and Korea, which had 9597 and 5911 citations, respectively. The year with the most citations among the references was found to be 2015; 25775 documents were cited in the short time between 2016 and 2020. The year 2014 came in second with 24304 citations. Over the period 2016 to 2020, the years with the most citations were 2010 to 2018. Figure 4 displays a VOS Viewer visualisation of co-authorship, citations, and countries.

Table 9. Reference matrix

Most Cited Journals	N	Most Cited Author	N	Country	Citations Received	Year	Citations
Carbon	23020	Ferrari AC	1113	China	54031	2015	25775
Advanced Materials	8843	Novoselov	923	Usa	9597	2014	24304
Physical Review B	8535	Kresse G	627	Korea	5911	2016	22249
ACS Nano	8210	Wang Y	621	Australia	3573	2013	21877
Nano Letters	7937	Geim AK	557	Japan	2238	2012	18993
Science	6006	Zhang Y	557	India	2187	2017	18135
ACS Applied Materials Interfaces	5758	Perdew JP	433	France	1973	2011	16145
Journal Of Materials Chemistry A	5597	Wang L	396	Spain	1952	2010	14660
Journal of American Chemical Society	5400	Li Y	379	Germany	1847	2018	13540

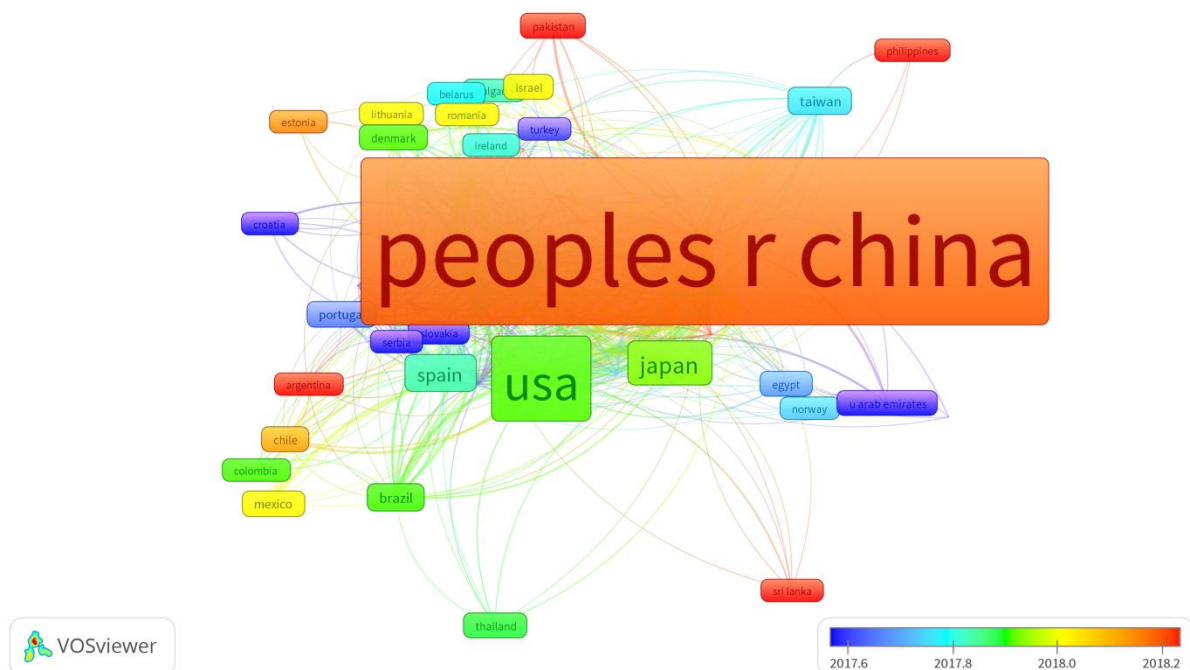


Figure 4: VOS Viewer visualization of Co-authorship, Citations & Countries (Coauthorship Vs Citations Vs Count; Minimum document count of the author 5 Vs minimum citations 2)

Conclusion

The paper unveils the Scientometric portrait of the Journal carbon. According to the findings, the journal publishes over 1000 documents every year and is widely cited, with nearly 1 lakh citations for its published output in the last five years. The majority of the publication contribution (95%) is in the form of papers, which is a strong indicator of high impact factored journals. The authorship trend indicates that the papers are written by 5 to 7 authors in this journal. The analysis of CAI, DC & CC reiterates the extent of collaborative authorship in the journal. The values received by applying Kolmogorov-Smirnov (K-S) goodness-of-fit test was in conformity with Lotkas Law values. Analysis of Word Dispersions using biblioshiny software showed that Carbon and Graphene are the most occurring words among keywords and abstracts. Chinese authors contributed the most documents to this journal, with 2568 total, followed by authors from the United States and Korea. Zhang Y is the most prolific author in this journal. The most cited source in the reference, according to the citation metrics, is the Carbon journal itself, followed by

Advanced Materials and Physical Reviews B. During the study period the majority of the documents which got cited were from the year 2015 followed by 2014. European and Asian countries dominate the list in terms of author affiliations of documents published in this journals and documents cited in this journal. The present study draws useful insights into the publication pattern and citation structure of the Journal Carbon from the period 2015 to 2020. This will help global carbon researchers in identifying prestigious authors in the field, identifying the growth trend of a subject field, identifying the top universities, top collaborating countries, institutes, major research areas to which the journal contributes, and so on. The methodology used in the study also helps the researchers who are in the field of Scientometrics to evaluate other journals in the subject field of carbon, chemistry and related areas.

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