

## Research impact and productivity of Indian Engineering according to the Web of Science Database (2016 to 2020)

<sup>1</sup>Shambulinga B. Jali, <sup>2</sup>Dr. V. M. Bankapur, <sup>3</sup>Dr. Malatesh N. Akki, & <sup>4</sup>Dr. Vitthal T. Bagalkoti

<sup>1</sup>Research Scholar, CMR University, Bengaluru. India.

<sup>2</sup>Professor, Dept. of Library and Information Science, Rani Channamma University, Belagavi. India.

<sup>3&4</sup>Library & Information Officer, CMR University, Bengaluru. India.

Email: <sup>1</sup>srsjali@gmail.com, <sup>2</sup>bankapur@rediffmail.com, <sup>3</sup>malatesh.akki@gmail.com, & <sup>4</sup>vitthallis@gmail.com

**Abstract:** *In this study, we have examined the research impact and productivity of Indian engineering according to the Web of Science (WoS) database for the year 2016 to 2020. The article focuses on year-wise research output, major subject categories, national and international collaboration, top journals for publications, most prolific authors, highly cited papers, top most productive institutions etc. The bibliographic and citation data of 13,142 documents were extracted from Web of Science database.*

**Key Words:** *Engineering, Research impact, Productivity, Web of Science, Collaboration and VOSviewer.*

### 1. INTRODUCTION :

India has the largest numbers of engineers as well as the largest number of engineering education institutes and infrastructure in the world. In 2021, India annually produces one million engineering graduates, has 3500 engineering colleges, 3400 polytechnics, and 200 schools of planning and architecture, and many times more Industrial training institutes. A combination of these imparts undergraduate and graduate courses in architecture, engineering, applied engineering, and sciences.

Engineering is the design and development of structures and constructions for influencing the world around us and improving our journey inside it. Engineers use the quintessential ideas of mathematics, physics, and chemistry to create machines that allow us to travel faster, furnish increased scientific care, and process greater tricky information. India's most impactful area in terms of research output is engineering whilst it is most prolific in phrases of citations are chemistry, physics, and computer science in accordance with the Web of Science citation database. (Jaali, Bagalkoti, Chaman Sab, & Kappi, 2021) have studied that India's contribution to engineering research from a global perspective and they have found out the in the fifteen years, 2003–2017 Indian researchers have published 1,589,361 papers in 1,266 journals. (Tahira, Alias, & Bakri, 2013) have analyzed the usefulness of the most noted metric h-index along with other selected indicators in the field of Engineering in Malaysian universities. (Ravichandra Rao I, 1999) has studied have found that the Indian engineers published their articles mostly in journals; almost all of them published in the English language all published in a selected few journals. (Starovoytova, 2017) have studied average annual-research-productivity, of individual academicians in the field of Engineering. (Oosthuizen & Pretorius, 2020) have studied bibliometric Method for Analysis of Systems Engineering and found that the Research data provides the trends in topic coverage over time. (Karanatsiou, Li, Arvanitou, Misirlis, & Wong, 2019; Williams & Neto, 2012) have analyzed taxonomical analysis and citation analysis, and applied to papers from the first 2011 number of IEEE. (Belter & Seidel, 2013) have analyzed that the possible supplement to climate change mitigation and adaptation strategies. (Elango, 2019; Gholampour, Behzad and Noruzi, 2021; Mohanty & Jena, 2019; Neto & Williams, 2012) have used bibliometric study on publications receiving growing attention in engineering education research as an approach that can bring a number of benefits. In this paper, and they are analysed discipline and author affiliation analysis of journal articles to provide data on the development of Engineering Education Research.

### 2. METHODS AND MATERIALS :

In this study, the data on Indian Engineering research publications downloaded from online multidiscipline database "Web of Science" (WoS) science citation database which is an international indexing and abstracting database. We searched for the terms TS=Topic in "Engineering" for the period 2016 to 2020. Totally 251,898 world research papers were retrieved, in that again refined India in Country/Regions, we got 13,142 research papers on 08<sup>th</sup> June 2021. The collected data has been classified using Microsoft Excel for the purpose of analysis and used R Biblioshiny and VOSviewer.

### 3. OBJECTIVES OF THE STUDY:

The main objectives of the study are, (i) to examine the growth of Indian engineering, (ii) to identify the document type of the publications, (iii) to examine the Collobratvive counntries, (iv) to identify the most contributed subjects, (v) to examine the most participated organisations, (vi) to identify the prolific authors, (vii) to analyse the most cited publications, (viii) to define the most produced sources, (ix) to exhibit the keywords.

### 4. RESULTS:

Description	Results
<b>MAIN INFORMATION ABOUT DATA</b>	
Timespan	2016:2020
Sources (Journals, Books, etc)	2313
Documents	13142
Average years from publication	2.79
Average citations per documents	11.7
Average citations per year per doc	2.918
References	592399
<b>DOCUMENT TYPES</b>	
article	10870
article; book chapter	10
article; early access	180
article; proceedings paper	172
article; retracted publication	1
biographical-item	1
book review	3
correction	24
editorial material	82
editorial material; early access	1
letter	11
meeting abstract	79
news item	2
reprint	1
retraction	1
review	1668
review; book chapter	9
review; early access	27
<b>DOCUMENT CONTENTS</b>	
Keywords Plus (ID)	27103
Author's Keywords (DE)	36961
<b>AUTHORS</b>	
Authors	34890
Author Appearances	72062
Authors of single-authored documents	308
Authors of multi-authored documents	34582
<b>AUTHORS COLLABORATION</b>	
Single-authored documents	364
Documents per Author	0.377
Authors per Document	2.65
Co-Authors per Documents	5.48
Collaboration Index	2.71

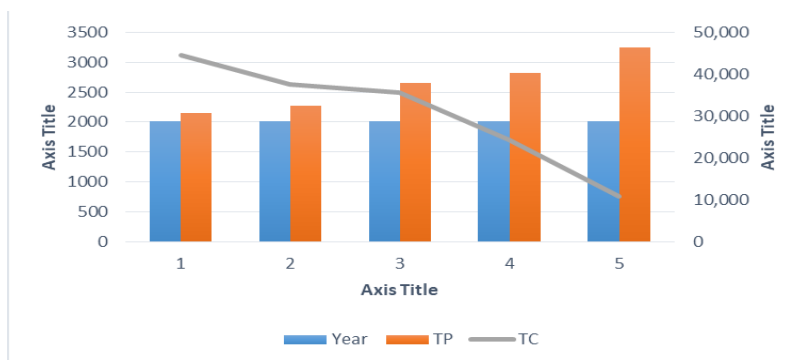
#### 4.1. ANNUAL GROWTH AND CITATION COUNT

Year wise distribution of publication is an important indicator of publication productivity shows growth every year (Chaman Sab M, Dharani Kumar P, Biradar, 2017). The total publications covered in Web of Science (WoS)

database during 2016 – 2020 were 13,142. The annual output registered 2.79 average year from growth rate, average citations per document registered 11.7. Table 1 and Figure 1 highlights the annual growth of world engineering research distribution of publications, and found that most productive year in terms of publication count is 2020 with 3254 publications and 10946 citations, Lowest publication registered 2150 publication in the year of 2016, Highest citation registered 44628 in the year 2016 and lowest citation founded 10946 in the year 2020.

**Table - 1: Annual growth and citation count**

Year	TP	TC	ACP	H-index
2016	2,150	44,628	20.76	78
2017	2,266	37,614	16.6	71
2018	2,657	35,582	13.39	66
2019	2,815	24,284	8.63	52
2020	3,254	10,946	3.36	29



**Fig. 1: Annual growth and citation count**

**4.2. FORMS OF DOCUMENTS USED FOR COMMUNICATING :**

Table illustrad the forms for communicating of engineering research, these includes articles published in the scholarly journals, conference proceedings, reviews, editorial materils, book chapters, meeting abstracts etc. (Kappi, Chaman Sab, Bhovi & Bagalkoti, 2020). The present study observed that a total of 13,142 publications in engineering research output from India has been observed from table 2, many communicating channales are used by authors to publish their research articles in Indian engineering research. The majorty of publications are published in Journal articles i.e. 11,233 (85.47%), followed by Reviews 1,704 (12.97%) and etc. publications published.

**Table – 2: Forms used for communicationg**

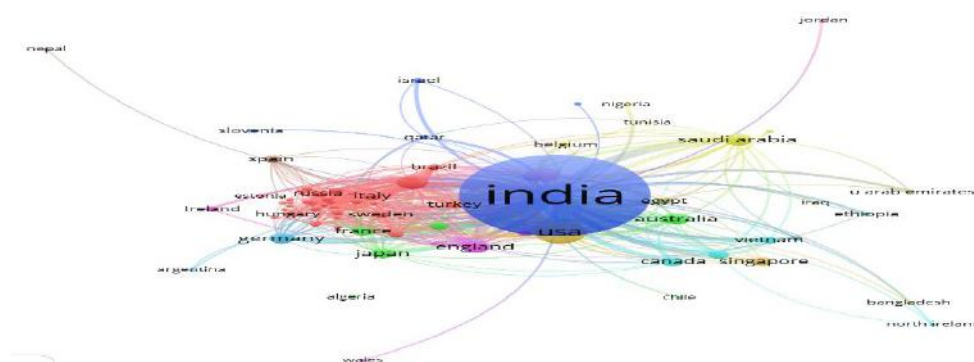
Document Types	Records	% of 13142
Article	11233	85.47
Review	1704	12.97
Early Access	208	1.58
Proceedings Paper	172	1.31
Editorial Material	83	0.63
Meeting Abstract	79	0.60
Correction	24	0.18
Book Chapter	19	0.15
Letter	11	0.084
Book Review	3	0.023
News Item	2	0.015
Biographical Item	1	0.008
Reprint	1	0.008
Retracted Publication	1	0.008
Retraction	1	0.008

### 4.3. COUNTRY COLLABORATION :

Due to the interdisciplinary growth of subject, the universe of knowledge is very dynamic and is very ever-growing. More and more specialization in the subjects achieved by the authors, which is a result of increased participation of group of researchers of different expertise. It has been found from earlier studies that collaboration in research varies from to discipline and for the same discipline from time and from one country to another (Chaman Sab & Sedam, 2021). Country collaboration of article are presented in table 3. Which gives the country wise-distribution of total 13,142 articles, USA contributed 999 (7.602%) publications, followed by South Korea published 430 (3.272%) publications, Peoples R China published 405 (3.082%) publications, and England contributed 303 (2.306%) publications, Saudi Arabia 292 (2.22%) publications, Australia published 284 (2.161%) publications and many countries contributed with below 1.0% share with India in engineering research during 2016 to 2020.

**Table - 3: Country wise Collaboration**

Sl. No.	Countries/Regions	Records	% of 13142
1	USA	999	7.602
2	South Korea	430	3.272
3	Peoples R China	405	3.082
4	England	303	2.306
5	Saudi Arabia	292	2.222
6	Australia	284	2.161
7	Germany	227	1.727
8	Japan	210	1.598
9	Canada	178	1.354
10	France	175	1.332
11	Malaysia	172	1.309
12	Singapore	141	1.073
13	Taiwan	137	1.042
14	Italy	132	1.004
15	South Africa	122	0.928
16	Iran	114	0.867
17	Spain	105	0.799
18	Vietnam	96	0.73
19	Russia	95	0.723
20	Sweden	91	0.692



**Fig. 2: Country wise collaboration**

### 4.4. MOST PREFERRED SUBJECT/RESEARCH ARIAS

Subject wise distribution of citation is helps to know the distribution of citation among the sub branches and allied subjects of engineering besides to know the research trend in engineering (Chaman Sab M, Dharani Kumar P, Biradar, 2019). Table 222 indicates the subject-wise productivity of Indian engineering research with 13142 publications, Engineering with 4985 (37.932%) publications followed by Material Science published 3144 (23.923%) publications, Chemistry published 2179 (16.58%) publications, Science Technology other Topics published 1562 (11.886%) publications, Physics published 1303 (9.915%) publications and remaining all are published below 1000 publications.

**Table – 4: Most proffered research areas**

Sl. No.	Research Areas	TP	% of 13142
1	Engineering	4985	37.932
2	Materials Science	3144	23.923
3	Chemistry	2179	16.58
4	Science Technology Other Topics	1562	11.886
5	Physics	1303	9.915
6	Polymer Science	904	6.879
7	Computer Science	775	5.897
8	Environmental Sciences Ecology	775	5.897
9	Biochemistry Molecular Biology	641	4.877
10	Biotechnology Applied Microbiology	607	4.619
11	Optics	513	3.904
12	Energy Fuels	409	3.112
13	Mechanics	296	2.252
14	Pharmacology Pharmacy	282	2.146
15	Construction Building Technology	279	2.123
16	Geology	242	1.841
17	Plant Sciences	232	1.765
18	Metallurgy Metallurgical Engineering	220	1.674
19	Water Resources	217	1.651
20	Mathematics	208	1.583

**4.5. TOP MOST PRODUCTIVE ORGANIZATIONS :**

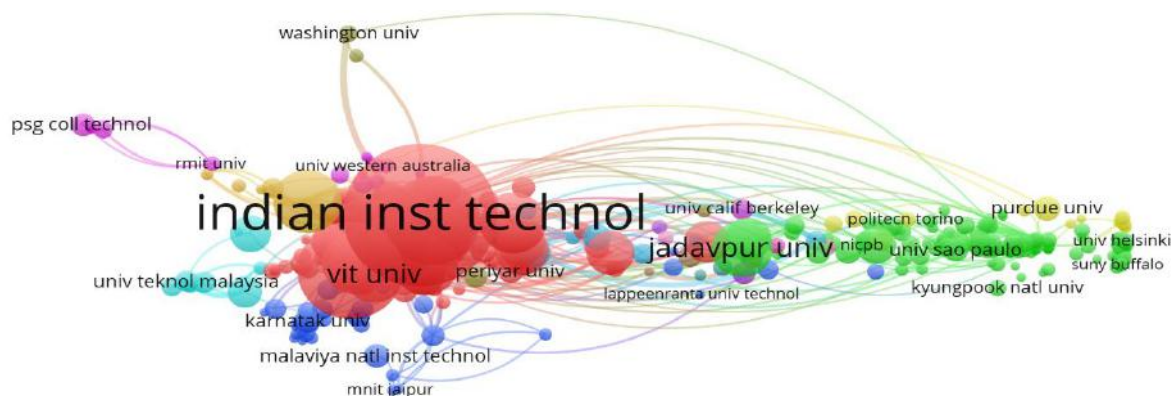
A total of 6389 organizations are credited with the documents in Indian engineering of which 689 organizations had at least ten or more than ten documents to their credit. The majority of contributions came from Indian Institute of Technology System IIT System 3366 (11.05%), followed by National Institute of Technology NIT System published 1511 (9.44%) publications, Council of Scientific Industrial Research CSIR India published 1157 (12.21%) papers, A list of top twenty organizations according to the number of document contributions has been depicted in table 8. The organizations that were found to be having the same number of documents were given the same position in the table.

**Table – 5: Top Most productive organizations**

Sl. No.	Name of the Organization	TP	TC	ACP	H index
1	Indian Institute of Technology System IIT System	3366	37192	11.05	63
2	National Institute of Technology NIT System	1511	14271	9.44	47
3	Council of Scientific Industrial Research CSIR India	1157	14132	12.21	48
4	Indian Institute of Science IISC Bangalore	482	5998	12.44	38
5	Indian Institute of Technology IIT Kharagpur	473	4715	9.97	29
6	Indian Institute of Technology IIT Delhi	411	3794	9.23	27
7	Indian Institute of Technology IIT Bombay	409	5306	12.97	28
8	Vellore Institute of Technology	383	4722	12.33	35
9	Department of Science Technology India	371	5574	15.02	36
10	Indian Institute of Technology IIT Roorkee	368	4633	12.59	31
11	Indian Institute of Technology IIT Madras	363	3141	8.65	24
12	Indian Institute of Technology IIT Guwahati	299	4162	13.92	32
13	Academy of Scientific Innovative Research ACSIR	285	3385	11.88	27
14	Indian Institute of Technology IIT Kanpur	257	3389	13.19	26
15	Anna University	249	2263	9.09	25
16	Indian Institute of Technology Indian School of Mines Dhanbad	244	2597	10.64	26
17	Indian Council of Agricultural Research ICAR	242	2602	10.75	26
18	Department of Biotechnology DBT India	216	2853	13.21	27
19	National Institute of Technology Rourkela	216	2592	12	26
20	Anna University Chennai	209	2059	9.82	24



TP: Total Paper, TC: Total Citation, ACP: Average citations per paper.



**Fig. 3: Top most productive Institutions/organizations in Indian Engineering**

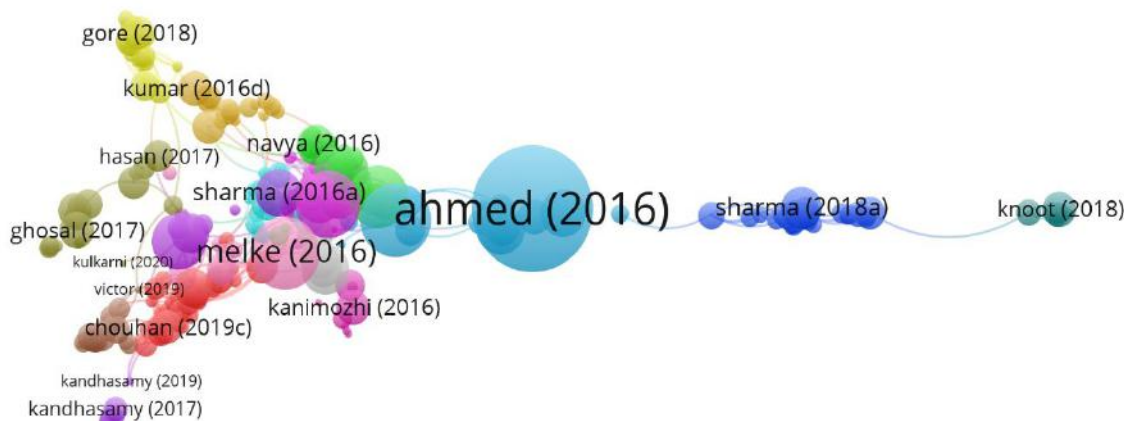
**4.6. TOP 20 PRODUCTIVE AUTHORS**

Table 6 & Figure 4 describes and depicts the most prolific authors, respectively. Kumar, Amit, u has been directing research institutes at Indian Institute of Technology Kharagpur, Advanced Technology Development Centre, Kharagpur published 299 (14.21%) publications, followed by Kumar, Sunil, National Institute of Technology Jamshedpur published 249 (12.1%) publications, Kumar, R, Panjab Univ, Chandigarh published 164 (10.95%) Publications, Singh, Shivam, Indian Institute of Technology Mumbai published 150 (14.95%) publications, Kumar, V, Indian Institute of Technology Roorkee published 136 (20.1%) Publications, etc.

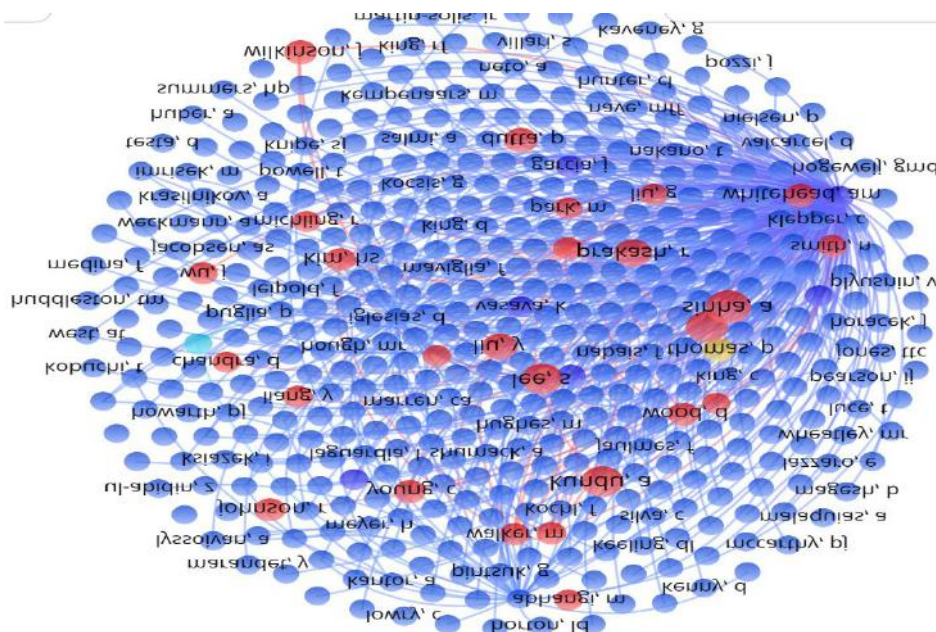
**Table - 6: Top 20 productive authors with affiliation**

Sl. No.	Author	Author Affiliation	TP	TC	ACP	H-Index
1	Kumar, A.	Indian Inst Technol Kharagpur, Adv Technol Dev Ctr, Kharagpu	299	4,277	14.3	29
2	Kumar, S.	National Institute of Technology Jamshedpur	249	3013	12.1	29
3	Kumar, R	Panjab Univ, Chandigarh,	164	1796	10.95	23
4	Singh, S.	Indian Inst Technol, Mumbai	150	2243	14.95	21
5	Kumar, V	Indian Inst Technol Roorkee,	136	2734	20.1	24
6	Kumar, P.	Indian Inst Sci, Ctr Nanosci & Engn CeNSE, Bangalore	133	1517	11.41	19
7	Ghosh, S.	Vellore Inst Technol, Vellore	122	2245	18.4	24
8	Das, S.	Goa Univ, Fac Life Sci & Environm,	112	1060	9.54	18
9	Singh, A.	Univ Lucknow, Fac Sci, Dept Chem, Lucknaw	107	1321	12.24	18
10	Kumar, M.	Indian Inst Technol Kanpur, Dept Mat Sci & Engn, Kanpur	99	1589	16.05	21
11	Sharma, S.	ICAR Indian Inst Vegetable Res, Div Crop Prod, Varanasi,	92	1066	11.59	15
12	Sharma, A.	Shoolini Univ Biotechnol & Management Sci, Sch Chem	92	737	8.01	15
13	Singh, A. K.	Indian Sch Mines, Indian Inst Technol, Jharkand	90	920	10.22	15
14	Kumar, D.	Natl Inst Technol Patna, Dept Civil Engn, Patna	88	929	10.56	16
15	Singh, R.	Natl Disaster Management Author,	82	1286	15.68	18
16	Gupta, S.	Indian Inst Technol Roorkee, Dept Math, Roorkee	77	735	9.55	15
17	Roy, S.	Birla Inst Technol & Sci BITS Pilani, Hyderabad	72	518	7.19	14
18	Chakraborty, S.	Indian Inst Technol Indore, Discipline Phys, Indore	71	566	7.79	15

19	Singh, J.	Cent Univ Punjab, Dept Phys, Sch Basic & Appl Sci, Bathinda	71	1060	14.72	17
20	Kumar, N.	Natl Inst Technol Jalandhar, VLSI Lab, Jalandhar,	68	759	11.16	14



**Fig. 3: Highly prolific authors in Indian Engineering**



**Fig. 4: Co-authorship in Indian Engineering**

**4.7. HIGHLY CITED PAPERS :**

Of the total Indian output in Engineering research (13142 publications), only two publications accumulated high end 1000+ citations ranging from 1387 to 1452 citations per paper. The distribution of 8 highly – cited papers skewed. All 8 papers accumulated citations in the range 304 – 972 per paper. Highly cited paper is “Additive manufacturing of metallic components - Process, structure and properties” published in the journal of *Progress In Materials Science* accumulated 1452 citations by DebRoy, T.; Wei, H. L.; Zuback, J. S.; et al., “Metal-organic frameworks: functional luminescent and photonic materials for sensing applications” is published in the journal of *Chemical Society Reviews* with 1387 citations by Lustig, William P.; Mukherjee, Soumya; Rudd, Nathan D.; et al., “A review on plants extract mediated synthesis of silver nanoparticles for antimicrobial applications: A green expertise” is published in the *Journal Of Advanced Research* with 972 citations by Ahmed, Shakeel; Ahmad, Mudasir; Swami, Babu Lal; et al. and “Recent Progress on Ferroelectric Polymer-Based Nanocomposites for High Energy Density Capacitors: Synthesis, Dielectric Properties, and Future Aspec” paper is published in *Chemical Reviews* with 655 citations by Prateek; Thakur, Vijay Kumar; Gupta, Raju Kumar.

**Table – 7: Highly cited papers in Indian engineering research**

TC	Title	Author	Source	Year
1452	Additive manufacturing of metallic components - Process, structure and properties	DebRoy, T.; Wei, H. L.; Zuback, J. S.; et al	Progress In Materials Science	2018
1387	Metal-organic frameworks: functional luminescent and photonic materials for sensing applications	Lustig, William P.; Mukherjee, Soumya; Rudd, Nathan D.; et al.	Chemical Society Reviews	2017
972	A review on plants extract mediated synthesis of silver nanoparticles for antimicrobial applications: A green expertise	Ahmed, Shakeel; Ahmad, Mudasir; Swami, Babu Lal; et al.	Journal of Advanced Research	2016
655	Recent Progress on Ferroelectric Polymer-Based Nanocomposites for High Energy Density Capacitors: Synthesis, Dielectric Properties, and Future Aspect	Prateek; Thakur, Vijay Kumar; Gupta, Raju Kumar	Chemical Reviews	2016
454	Mechanistic Basis of Antimicrobial Actions of Silver Nanoparticles	Dakal, Tikam Chand; Kumar, Anu; Majumdar, Rita S.; et al.	Frontiers in Microbiology	2016
388	China and India lead in greening of the world through land-use management	Chen, Chi; Park, Taejin; Wang, Xuhui; et al.	Nature Sustainability	2019
335	A review on chitosan and its nanocomposites in drug delivery	Ali, Akbar; Ahmed, Shakeel	International Journal of Biological Macromolecules	2018
330	Hidden attractors in dynamical systems	Dudkowski, Dawid; Jafari, Sajad; Kapitaniak, Tomasz; et al.	Physics Reports-Review Section of Physics Letters	2016
318	Silk fibroin as biomaterial for bone tissue engineering	Melke, Johanna; Midha, Swati; Ghosh, Sourabh; et al.	Acta Biomaterialia	2016
304	Current State of Knowledge in Microbial Degradation of Polycyclic Aromatic Hydrocarbons (PAHs): A Review	Ghosal, Debajyoti; Ghosh, Shreya; Dutta, Tapan K.; et al.	Frontiers in Microbiology	2016

#### 4.8. TOP 20 PRODUCTIVE SOURCES

The top 20 most productive journals accounted for 22.48% of total journals output in Indian engineering during 2016 -2020. The top most journal *Alexandria Engineering Journal* with 326 (2.481%) publications followed by *Polymer Composites* with 306 (2.328%) publications, *Journal of Industrial and Engineering Chemistry* published 241 (1.834%) papers, *Environmental Progress Sustainable Energy* published 188 (1.431%) publications, *Process Safety and Environmental Protection* published 179 (1.362%) papers etc. (Table 8 & Figure 5).

**Table – 8: Top 20 most productive journals in Indian engineering research**

Sl. No.	Source Titles	TP	% of 13142
1	Alexandria Engineering Journal	326	2.481
2	Polymer Composites	306	2.328
3	Journal Of Industrial And Engineering Chemistry	241	1.834
4	Environmental Progress Sustainable Energy	188	1.431
5	Process Safety And Environmental Protection	179	1.362
6	Optical Engineering	177	1.347
7	Journal Of The Taiwan Institute Of Chemical Engineers	169	1.286
8	International Journal Of Biological Macromolecules	149	1.134
9	Biocybernetics And Biomedical Engineering	140	1.065
10	Journal Of Manufacturing Processes	128	0.974



11	Chemical Engineering Research Design	120	0.913
12	Materials Science Engineering C Materials For Biological Apl.	117	0.89
13	Scientific Reports	113	0.86
14	ACS Applied Materials Interfaces	97	0.738
15	RSC Advances	93	0.708
16	Ain Shams Engineering Journal	89	0.677
17	Journal Of Materials In Civil Engineering	86	0.654
18	Materials Research Express	85	0.647
19	Polymer Engineering And Science	85	0.647
20	Journal Of Applied Remote Sensing	67	0.51

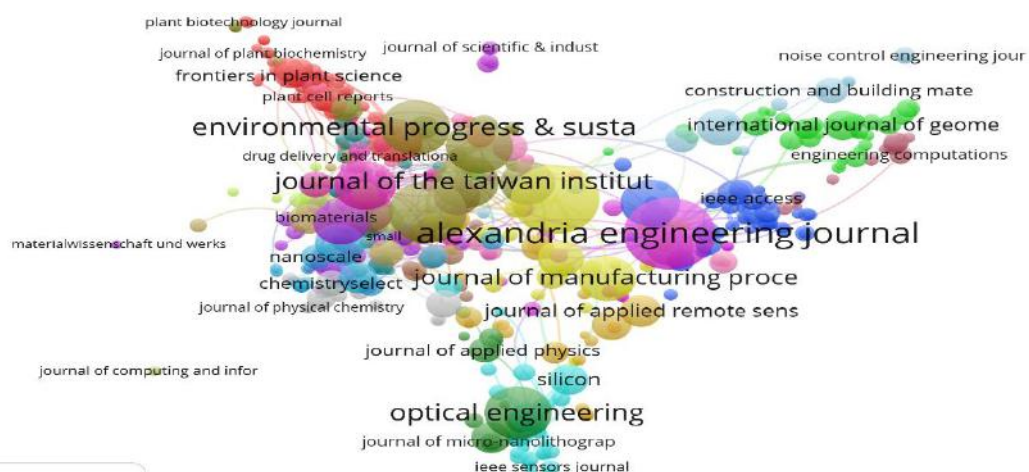


Fig. 5: Highly productive journals

4.9. SIGNIFICANT KEYWORDS :

Engineering has been the most productive keyword in searching database for literature on engineering research in India. The distribution of publications output across these keywords highlights engineering research trends in the country. The keywords top most 10 keywords are listed in table 9 and Figure 6. In decreasing order of frequency of their occurrence in the literature.

Table – 9: Top 20 most significant keywords

Sl. No.	Keywords	Frequency
1	engineering	221
2	tissue engineering	219
3	optimization	200
4	nanoparticles	145
5	drug delivery	123
6	adsorption	122
7	chitosan	118
8	electrospinning	114
9	mechanical properties	106
10	crystal engineering	94



Figure 6. Significant keywords

## 5. SUMMARY AND CONCLUSION :

The paper provides an update on the current status of engineering research in India in the global context. This study is based on bibliometric analysis of engineering research publication by India and the world. The data was scoured from Web of Science (WoS) database covering 5 years period 2016 – 2020. India is the 5<sup>th</sup> most productive country in the world in engineering research. However, compared to top countries in the world ranking – USA 999 (7.602%) South Korea 430 (3.272%) and People R China 405 (3.082%) India registered faster growth 2.79% share compared world growth. India's citation impact has been low, 3.36% in the year 2020. We have observed that a total of 13,142 publications in engineering research output from India it has been observed from table ten are many communicating channels are used by authors to publish their research articles are used by Indian engineering research literature. The majority of publications are published in Journal articles (85.474%). The majority of contributions came from Indian Institute of Technology System IIT System 3366 (11.05%). We are find the 20 top most productive journals accounted for 22.48% of total journals, the top most journal *Alexandria Engineering Journal* with 326 (2.481%) publications. Top most 10 keywords are list in the table 7 and Figure 6. The highest used keywords occupied engineering 221 times, followed by tissue engineering 219 times.

Given these developments it could be concluded that the quantitative and qualitative performance of India in Engineering research is still not a priority topic of academic research in the country. This trend in engineering research could be attributed to India's low and insignificant authorship strength at organizational level in engineering research. Just 2.65 author per document.

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