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Scientometric Analysis of Nanotechnology Research with Special Reference to India (2008-17)

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Abstract

Nanotechnology research covered in the Web of Science database during the period 2008-17 has been analyzed. A total of 16935 articles were retrieved and this forms the basis of this study. The growth of the article over the study window is 123 articles per year. 2017 is the most productive year with 2220 (13%, approx) articles. Journals and authors' productivity are analyzed based on their h-index and z-index. Among the 30 top productive journals taken for the study, ACS Nano is occupying the top position with 400 articles. The paired t-test showed a strong and significant correlation of h-index and z-index of authors and journals. The top ten leading countries have also been identified in the study and the USA has topped the rank with 29.68% of world share publication while India is in third position with 7.29% of share next to China (i.e. 15.23%). The same rank is observed for India in the Relative Citation Impact, however, with below world average (i.e. 0.81). This study will be beneficial for the library staff as well as for the Nanotechnology researchers towards identifying the most productive works, the most prolific authors and organizations affiliated to those works.

Key-words

Scientometrics, h-index, z-index, co-authorship pattern, Nanotechnology

Introduction

Nanotechnology is a multidimensional field which have various applications in different fields (viz. engineering, medical etc). The term ‘Nanotechnology’ was first used by the Late Norio Taniguchi in 1974 (Tolochko, 2009). The U.S. National Nontechnology Initiative (NNI) defined that ‘Nanotechnology is the understanding and control of matter at dimensions between approximately 1 and 100 nanometres, where unique phenomena enable novel applications’ (Tolochko, 2009, p. 2).

Nanotechnology is one of the emerging thrust areas in the knowledge science and technology world and it provides a window of opportunities for countries like India to develop economic growth through technological intervention.

Scholarly resources housed and in the subscription and accessibility are the primary sources for a library to generate knowledge. Burgeoning growth of primary literature particularly has caused an unprecedented and serious challenge before the library managers to identify, acquire and collate this. However, secondary bibliographic and indexing databases (*viz.* Web of Science, Scopus, PubMed, Google Scholar, etc) are great respite to the librarians as these significantly ease the job of a librarian. Still some sort of synthesis of the information by the information intermediaries (*i.e.* the library workers) is very much expected towards channelizing the users with the precise literature out of the millions of records in the databases, which are again diversified across databases. This is followed by the issue of the availability of a given source in a given library, due to certain obvious reason, most important of which is the high cost of subscription.

Identification of most influential authors and the source are corollary to the works in a given subject of domain of subjects. Scientometricians are focusing on formulation and application of different metrics pertaining to quantitative and qualitative analysis of different parameters of the scholarly literature towards arriving at precision in the identification and extraction of the most influential research works. In this study, three assessment metrices namely Relative Citation Index, h-index and z-index have been taken to analyze the research progress in the field of nanotechnology. However, the criticisms and refined versions of the named metrics are not taken into the study.

Previous Studies

Arencibia-Jorge and Rousseau (2009) studied the influence of researcher staff on institutional impact. They applied Prathap's approach to successive h-indices and calculated the relation between h_1 and h_2 index and found a high correlation between the two indicators. They concluded from the study that an institution having a large h_1-index, the probability increases that many scientists with a high h-index work at this institute. Egghe (2009) stated one disadvantage of h-index that it is only a number and it reduces the evaluation of a researcher. This paper studied four different h-index sequences for which a Lotkaian model was also given and found that the consecutive h-index sequences have increasing values when compared to each other. Alonso, Cabrerizo, Herrera-Viedma and Herrera (2010) introduced a new index called hg-index and tried to characterise the scientific output of researchers based on both h-index and g-index by minimising their disadvantages. They introduced the definition of hg-index as the geometric mean of h-index and g-index of a researcher, that is $hg = \sqrt{h \times g}$, and proposed that the hg-index provides more granularities and fine-grained way to compare researchers. Zhai, Yan and Zhu (2014) defined a new index h_l and explained the problem regarding h-index that in calculating h-index all the citations received by a paper is treated equally though not all citations

contribute equally to the academic impact. Instead, suggested to put different weights on citations a paper receives based on the academic impact of those papers that citing the focal paper. This was documented that it is possible to evaluate a paper's academic impact based on the academic impact of papers that cite it and suggested constructing a citation network based on the citation links. Prathap (2013) discussed about Impact Citation Exergy (iCX), Impact Paper Exergy (iPX) and composite indicators named Zynergy. Hazarika (2017) studied the seismology research in India retrieving the data from Web of Science database in the window period of 2001-2015 and found a high correlation between h-index and z-index.

In recent years, many researchers have conducted scientometric study in different subject fields. Mooghali, Alijani, Karami and Khasseh (2011) studied the scientometric literature available in Web of Science database during 1980-2009. Packiyaraj and Manoharan (2014) analysed quantitative and qualitative growth and development of world literature on textile technology published during 1999-2012 on Web of Science. Makhoba and Pouris (2017) investigated the development in the nanoscience and nanotechnology research in the window of 2005-2015 in South Africa and observed that nanotechnology research have shown a remarkable growth in South Africa after the launching of the National Nanotechnology Strategy in 2005. They also found a high level of international collaboration with different countries in this field and the collaboration was highest with India. Varma and Singh (2017) studied the literature on Big Data available in Scopus database during the period 2012-2016 to find out the growth of big data research in India and found that publication rate have been increased. Ahmi and Mohammad (2019) analysed the literature on Web accessibility published during 1996-2018 available in Scopus database. The study revealed that USA is ranked first in productivity. They have also mapped the keyword using the VOS viewer software and found "web accessibility" as the highest occurred word.

Objectives

The study has been carried out with the following objectives:

i. To analyse the growth rate of the literature.
ii. To find out the most prolific authors and journal based on h-index and z-index in the discipline.
iii. To analyse the co-authorship pattern.
iv. To find out the Relative Citation Impact (RCI) and Absolute Citation Impact (ACI) of top ten countries.
v. To find out the top ten leading organization of Nanotechnology research in India

Hypotheses

Two hypotheses have been formulated for the study:

Hypotheses 1:

H_{a0}: Correlation between h-index and z-index of authors is not significant.

H_{a1}: Correlation between h-index and z-index of authors is significant.

Hypotheses 2:

H_{b0}: Correlation between h-index and z-index of journals is not significant.

H_{b1}: Correlation between h-index and z-index of journals is significant.

Methodology

z-index

The 3D evaluation metrics proposed by Prathap (2011a, 2011b) has been used to evaluate the research on nanotechnology. The total number of publications (P) represents the quantity, and the impact (i) is C/P (C- number of citations). He showed that it is possible to define second-order, energy-like terms $E = \sum c_i^2$ and X = iC, where X represents a second dimension which Prathap (2014) introduced as Exergy. And, a third dimension of quality η is introduced for calculate the consistency.

Mathematically, Exergy (X), Energy (E) and z- index can be described as follows:

If P is the total number of publication and C is the total number of citation received by P publications then

Exergy, $X = i^2P = iC$ (since $i = C/P$)

Energy, $E = \sum C_K^2$ (The complete citation sequence of each paper of K in the citation window). The consistency term, $\eta = X/E$, $Z(\text{Zynergy}) = \eta X = \eta^2 E$ and $z = Z^{1/3}$

ACI and RCI

Absolute Citation Impact (ACI) and Relative Citation Impact (RCI) have been adopted in the study to compare the research performance of different countries to the total global outputs (Kumari, 2009).

ACI is computed as the average number of citations per publications, also called Citation Per Paper (CPP).

$$\text{Absolute Citation Impact} = \frac{\text{Total number of citations}}{\text{Total number of publications}}$$

RCI measures both the influence and visibility of research credited against a nation to the global perspective.

$$\text{Relative Citation Impact} = \frac{\text{A country's share of world citation in the speciality}}{\text{Country's share of world publications in the speciality}}$$

If RCI = 1, then Country's citation rate is equal to world citation rate

If RCI<1 then Country's citation rate is less than world citation rate. This implies research efforts are higher than its impact

If RCI > 1, then Country's share of citation rate is higher than the world citation rate. This implies high impact research in that country.

h-index

There are different type of metrics to find out the productivity and impact of a researcher. The h-index proposed by Hirsch (2005) is used in this study to find out the impact and significance of different scientists. He explained that "A scientist has index h if h of his or her Np papers have at least h citations each and the other (Np - h) papers have less than or equal to h citations each." (Hirsch, 2005, p. 16569-16572).

The articles included in the present study are collected from the Web of Science (WoS) database. Initially the following search expression was used to gather data.

TOPIC: (Nanotechnology) AND LANGUAGE: (English) AND DOCUMENT TYPES: (Article) Timespan=2008-2017. Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI.

Microsoft Excel, Bibexcel and VoSViewer have been used to carry out required statistical work and presentation of data.

Analysis and Results

Total 16935 records retrieved from the WoS database on Nanotechnology published during 2008-2017 form the source of data for this study.

1. **Publication Growth**

The growth of article over the study window is 123 articles per year (table 1). The value of r^2 (≈1) depicts that the growth is highly consistent during the period 2008-17 (fig. 1).

Table 1: Growth of Publication (2008-2017)

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Articles	1162	1313	1347	1514	1561	1732	1848	2062	2176	2220
Slope	123.097									

Fig. 1: Growth of Publication

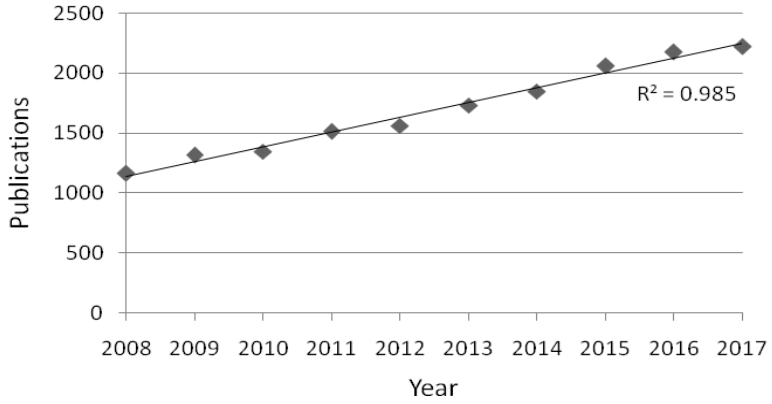


Table 2: Most Prolific Authors

Author	Affiliation	Publication (P)	Citation (C)	$E=\sum C_k^2$	I=C/P	X=IC	η=X/E	Z=ηX	$z=Z^{1/3}$	h-index
Webster Thomas, J	Brown University, USA	81	3383	630625	41.77	141292.46	0.224	31656.78	31.63	29
Feng, Si-Shen	National University of Singapore	69	4940	685734	71.59	353675.36	0.516	182412.22	56.71	40
Guo, Peixuan	University of Kentucky,USA	62	2847	330607	45.92	130732.40	0.395	51695.70	37.25	31
Yan, Hao	Arizona State University, USA	53	3912	996548	73.81	288749.89	0.290	83665.31	43.74	27
Ariga, Katsuhiko	Natl Inst Mat Sci, Japan	50	4272	1211688	85.44	364999.68	0.301	109949.73	47.91	29
Liu, Yan	Arizona State University, USA	46	2704	377828	58.78	158948.17	0.421	66867.79	40.59	25
Scheufele, Dietram A	Arizona State University, USA	46	1703	201271	37.02	63048.02	0.313	19749.76	27.03	21
Shapira, Philip	Georgia Institute of Technology,USA	43	1294	102198	30.09	38940.37	0.381	14837.40	24.57	21
Navi, Keivan	Shahid Behashti University,Tehran	41	503	11483	12.27	6170.95	0.537	3316.26	14.91	14
Fan, Chunhai	Chinese Acad Sci, China	38	5306	2218390	139.63	740885.16	0.334	247436.57	62.78	28
Hill, Jonathan P	Natl Inst Mat Sci, Japan	35	3525	1127257	100.71	355017.86	0.315	111809.18	48.18	25
Langer, Robert	MIT, USA	35	7967	5776839	227.63	1813516.83	0.314	569315.38	82.88	29
Youtie, Jan	Georgia Institute of Technology,USA	34	1041	88411	30.62	31872.97	0.361	11490.50	22.57	16
Wang, Wei	Penn State University, USA	33	985	65133	29.85	29400.76	0.451	13271.38	23.68	17
Wang, Yu	Chinese Acad Sci, China	31	493	17205	15.90	7840.29	0.456	3572.81	15.29	13
Brossard, Dominique	Univ Winconsin Medison, USA	29	868	86994	29.93	25980.14	0.299	7758.78	19.80	15

Benelli, Giovanni	Univ Pisa, Italy	28	769	39705	27.46	21120.04	0.532	11234.25	22.40	17
Mei, Lin	Tsinghua Univ, China	28	1953	256377	69.75	136221.75	0.531	72379.21	41.67	19
Zhao, Yuliang	Chinese Acad Sci, China	28	1203	145402	42.96	51686.04	0.355	18372.83	26.39	15
Seeman, Nadrian C	NYU, USA	26	1668	644330	64.15	107008.62	0.166	17771.71	26.10	15
Couvreur, Patrick	Univ Paris Sud, France	25	1135	119819	45.40	51529.00	0.430	22160.41	28.09	16
Haque, Farzin	Univ Cincinnati, USA	25	1446	146376	57.84	83636.64	0.571	47788.49	36.29	20
Liu, Yang	Sichuan University, China	25	529	38473	21.16	11193.64	0.291	3256.77	14.82	11
Mirkin, Chad A	Northwestern University, USA	25	1898	540882	75.92	144096.16	0.266	38388.60	33.73	17
Porter, Alan L	Georgia Institute of Technology,USA	25	1028	113082	41.12	42271.36	0.374	15801.52	25.09	15
Simmel, Friedrich C	Tech Univ Munich, Germany	25	1276	209680	51.04	65127.04	0.311	20228.59	27.25	15
Schmidt, Oliver G	Technische Universitat Chemnitz, germany	24	965	69637	40.21	38801.04	0.557	21619.55	27.86	18
Sugiyama, Hiroshi	Kyoto University, Japan	24	743	61355	30.96	23002.04	0.375	8623.48	20.51	12
Tan, Weihong	Hunan University, China	24	2235	342177	93.13	208134.38	0.608	126600.91	50.21	20
Huang, Qing	Chinese Acad Sci, China	23	2839	617105	123.43	350431.35	0.568	198997.14	58.38	19
Liu, Bin	Huazhong Univ Sci & technol, china	23	1181	170213	51.35	60641.78	0.356	21604.85	27.85	14
Mao, Chengde	Purdue University, USA	23	622	41544	27.04	16821.04	0.405	6810.79	18.96	12
Willner, Itamar	Hebrew Univ Jerusalem, Israel	23	1348	209766	58.61	79004.52	0.377	29755.61	30.99	17
Losic, Dusan	University Adelaide, USA	22	1371	169719	62.32	85438.23	0.503	43010.45	35.04	17
Corley, Elizabeth A	Arizona State University, USA	21	552	26096	26.29	14509.71	0.556	8067.59	20.06	14
Labean, Thomas H	Duke University, USA	21	644	82188	30.67	19749.33	0.240	4745.66	16.80	12

Park Sung Ha	Sungkyunkwan Univ, South korea	21	551	76333	26.24	14457.19	0.189	2738.14	13.99	12
Prato, Maurizio	Univ Trieste, Italy	21	1563	273255	74.43	116331.86	0.426	49525.54	36.72	15
Shu, Dan	University of Kentucky,USA	21	1039	99369	49.48	51405.76	0.517	26593.33	29.85	16
Harashima, Hideyoshi	Hokkaido university, japan	20	443	33369	22.15	9812.45	0.294	2885.44	14.24	9
Li, Hui	Jilin University, China	20	639	45023	31.95	20416.05	0.453	9257.83	21.00	12
Moaiyeri, Mohammad Hossein	Shahid Behashti University,Tehran	20	243	4797	12.15	2952.45	0.615	1817.17	12.20	11

Table 3: Most Prolific Journals

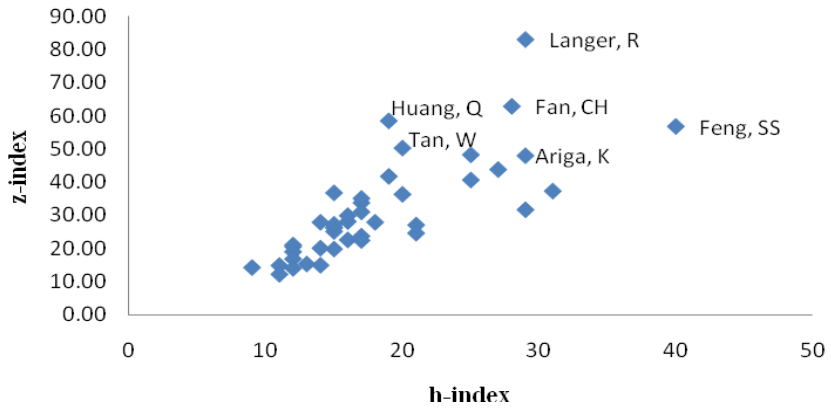
Journal name	Publication (P)	Citation (C)	i=C/P	$E=\sum C_k^2$	X=IC	η=X/E	Z=ηX	$z=Z^{1/3}$	h-index
ACS Nano	400	19539	48.85	2365117	954480.15	0.403	385195.50	72.76	73
Angewandte Chemie International Edition	249	11852	47.60	1549748	564155.20	0.364	205369.60	58.99	57
Journal of Nanoparticle Research	240	7309	30.45	1703677	222559.05	0.130	29073.90	30.74	38
International Journal of Nanomedicine	225	5040	22.40	309566	112896.00	0.364	41172.18	34.53	37
Nanoscale	205	4921	24.00	618225	118104.00	0.191	22562.26	28.25	36
Nano Letters	202	10011	49.56	1495676	496145.16	0.331	164581.10	54.80	54
Nanotechnology	191	3283	17.19	159227	56434.77	0.354	20002.16	27.14	30
Applied Physics Letters	190	6016	31.66	768372	190466.56	0.247	47213.47	36.14	37
Journal of Nanoscience and Nanotechnology	183	1309	7.15	22471	9359.35	0.416	3898.24	15.73	17
RSC Advances	170	1240	7.29	27306	9039.60	0.331	2992.54	14.41	17
Journal of the American Chemical Society	166	10677	64.32	1958063	686744.64	0.350	240859.60	62.21	56
Scientific Reports	158	1438	9.10	35448	13085.80	0.369	4830.686	16.90	18
Biomaterials	154	9813	63.72	1310612	625284.36	0.477	298319.10	66.81	55
Small	135	5219	38.66	637623	201766.54	0.316	63846.09	39.96	38
International Journal of Nanotechnology	133	626	4.71	11024	2948.46	0.267	788.59	9.23	13
ACS Applied Materials Interfaces	132	2426	18.38	88809	44589.88	0.502	22388.02	28.18	27
Langmuir	132	3147	23.84	198356	75024.48	0.378	28376.62	30.50	32
Journal of Applied Polymer Science	131	2225	16.98	73317	37780.50	0.515	19468.42	26.90	25
Journal of Pharmaceutical Sciences	127	1850	14.57	65850	26954.50	0.409	11033.33	22.26	21
Journal of Physical Chemistry C	125	3467	27.74	589400	96174.58	0.163	15693.16	25.03	29
Nanomedicine Nanotechnology Biology and Medicine	122	4150	34.02	590068	141183.00	0.239	33780.24	32.32	35
Journal of Chemical Education	115	716	6.23	9665	4460.68	0.461	2058.73	12.72	13
Journal of Applied Physics	112	1781	15.76	68031	28068.56	0.412	11580.66	22.62	24
Chemistry a European Journal	110	3673	33.39	334613	122641.47	0.366	44950.23	35.55	34
Proceedings of the National Academy of Sciences of the USA	104	8588	82.58	2141110	709197.04	0.331	234906.40	61.70	53
Scientometrics	104	1679	16.14	89337	27099.06	0.303	8220.10	20.18	21

Chemical Communications	97	3396	35.01	485801	118893.96	0.244	29097.87	30.75	32
Plos One	97	2625	27.06	191474	71032.50	0.370	26351.44	29.75	29
IEEE Transactions on Nanotechnology	90	1594	17.71	156089	28229.74	0.180	5105.53	17.21	20
Colloids and Surfaces B Biointerfaces	87	3644	41.89	721832	152647.16	0.211	32280.58	31.84	29

2. Prolific Authors

Authors credited with at least 20 publications have been considered for analysis with h-index and z-index as presented in table 2. Langer, Robert is most consistent author (z-index = 82.88) and he is in third rank as per h-index (29) in the byline of 42 authors. In case of some authors it is found that in spite of having higher number of publications and/or relatively high h-index, are not very consistent so far z index. The author Webster Thomas, J who has the highest number of publications (*i.e.* 81) is in 11th rank in case of consistency. Likewise, Fan, Chunhai in the 10th rank with 38 publications elevated to 2nd in consistency; Huang, Qing in the 30th rank on publication elevated to 2nd in consistency. Feng, Si-Shen is observed to be the author with highest consistency in publication (*i.e.* 69), h-index (*i.e.*40) and z-index (*i.e.* 56.71) score. Figure 3 is giving the scatter plot of the authors as per h and z score.

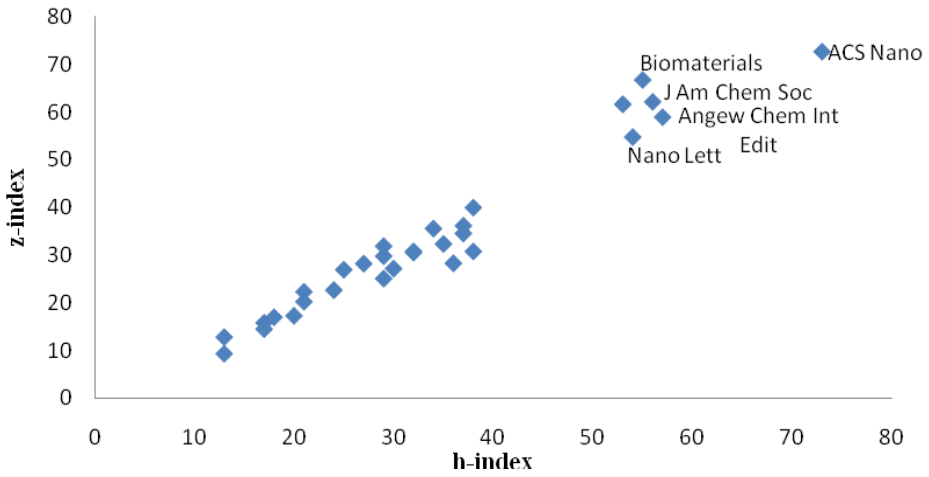
Fig 2: h-z map of prolific authors in nanotechnology



3. Most Prolific Journal

Table 3 depicts that most of journals having high h-index are also very consistent in the productivity measured in z-index. The journal ACS Nano is found to be the most prolific journal with 400 articles and the z-index (*i.e.* 72.76) and h-index (*i.e.* 73) also found to be the highest among top 30 journals. Interestingly, the Proceedings of the National Academy of Sciences of the USA in 25th rank on publication elevated to 4th in consistency. Likewise, Biomaterials elevated to 2nd rank in consistency which is in 13th rank on publication. On the other hand the journal Nanoscale which is in 5th rank on publication is declined to 17th rank in consistency. Figure 4 is giving the h-z scatter plot of the journals in this study.

Fig 3: h-z map of prolific Journals in nanotechnology



4. Co- authorship mapping

The VOS viewer visualisation map is shown in fig. 4 where an individual circle represents an author and the size of each circle represents the link strength of the author *i.e.*, larger the size of the circle higher is the link strength. The co-authorship links of a given researcher with other researcher can be found out from the links attribute and the link strengths represents the strength of the co-authorship links. The pattern of network connections indicates the presence of a core network. The authors are divided into different clusters. In order to create a clear visualisation map, the authors having at least five publications are taken and after that top 150 authors with the greatest total link strength are selected. The red cluster in the visualization map represents the authors having highest link strength. The largest circle is occupied by author Dygai, A.M with largest link strength (*i.e.* 181) and 15 links. The authors are sorted as per the link strength and h-index (Largest to smallest) respectively. The authors having at least 50 link strengths are shown in the table 4.

Table 4: Links and Link strength of authors with h-index

Author	Links	Link strength	h-index
Dygai, A.M.	15	181	13
Zhdanov, V.V.	15	178	12
Simanina, E.V.	15	178	11
Miroshnichenko, I.A.	15	178	9
Udut, E.V.	15	178	9
Stavrova, L.A.	15	165	7
Madonov, P.G.	15	160	5
Zyuz'kov, G.N.	15	151	14
Markova, T.S.	15	141	7
Kinsht, D.N.	15	133	4
Artamonov, A.V.	15	131	15
Bekarev, A.A.	15	131	4
Gurto, R.V.	15	115	3

Chaikovskiy, A.V.	15	103	4
Fan, Chunhai	13	94	28
Minakova, M.Yu.	15	90	9
Murugan, Kadarkarai	11	86	36
Benelli, Giovanni	11	86	17
Khrichkova, T.Yu	15	81	6
Nicoletti, Marcello	11	81	34
Scheufele, Dietram A.	9	79	21
Subramaniam, Jayapal	11	74	24
Yan, Hao	8	74	27
Panneerselvam, Chellasamy	11	71	29
Liu, Yan	8	68	25
Madhiyazhagan, Pari	11	67	21
Prasad, Paras N.	10	66	14
Dinesh, Devakumar	11	65	21
Guo, Peixuan	6	63	31
Brossard, Dominique	7	62	15
Suresh, Udaian	11	58	21
Yong, Ken-tye	10	51	41

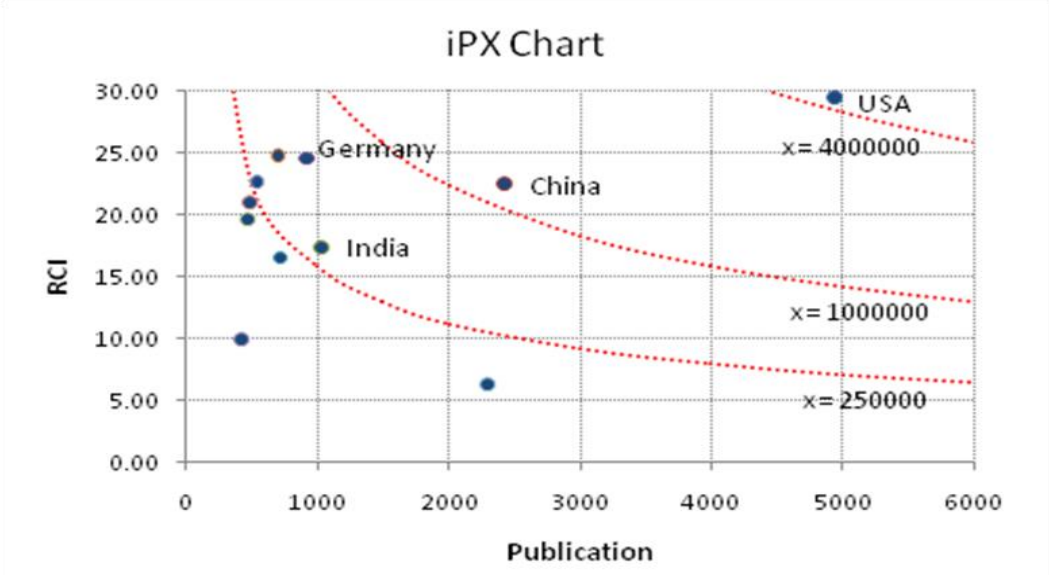
Fig 4: Co authorship analysis

5. **World Share of Publications, Citations, Relative Citation Impact (RCI) & Absolute Citation Impact (ACI): 2008-2017**

Table 5: World Share of Publications, Citations, RCI & ACI: 2008-2017

Country	Publication (P)	World share (%) P	Citation (C)	World share (%) C	RCI	ACI	h-index
USA	5027	29.68	144982	41.66	1.40	28.84	149
China	2577	15.22	56265	16.17	1.06	21.83	100
India	1230	7.26	20658	5.94	0.82	16.80	62
Germany	1118	6.60	26897	7.73	1.17	24.06	73
Italy	903	5.33	14524	4.17	0.78	16.08	53
England	888	5.24	21430	6.16	1.17	24.13	69
Japan	733	4.33	16169	4.65	1.07	22.06	62
South Korea	691	4.08	14091	4.05	0.99	20.39	54
France	678	4.00	12922	3.71	0.93	19.06	55
Iran	629	3.71	5909	1.70	0.46	9.39	33
Total for 105 other countries	2461	14.53	14169	4.07	0.28	5.76	
Total	16935	100	348016	100	Corr	1.00	
		Scaling factor=	20.55				

Fig 5: iPX chart of Top 10 Countries



World share publications, citation and RCI of top 10 countries presented in table 5 depicts that USA has the highest worldshare publication with 29.68%. It also has the highest world share of citation (*i.e.* 41.65%). Among the countries USA, China, Germany, England and Japan have RCI> 1 which implies that these 5 countries have higher citation impact than the world average rate. It can be inferred that the research efforts of these five countries are higher than their visibility and impact. Figure 5 giving the scattering of the different countries based on the impact Paper Exergy (iPX) and depicts that USA

(p= 5027, i = 28.84) occupying the peak followed by China (p = 2577, i = 21.83), India (p= 1230 and i =16.79) and Germany (p =1118, i= 24.05).

6. **Leading Organization of Nanotechnology Research in India**

Table 6: Leading organization of Nanotechnology Research in India

Organization	No of article	%	**h-index**
Council of Scientific Industrial Research (CSIR) India	155	12.60	30
Indian Institute of Technology System (IIT)	139	11.30	24
Department of Science Technology India	44	3.57	18
Defence Research Development Organisation (DRDO)	34	2.76	12
Vellore Institute of Technology	33	2.68	14
Banaras Hindu University	31	2.52	14
Indian Institute of Science IISC Bangalore	29	2.36	13
Indian Institute of Technology IIT Bombay	29	2.36	13
IIT Delhi	29	2.36	15
Annamalai University	28	2.28	13
Total of 309 number of institution	679		
Total	1230		

The top 10 leading nanotechnology research organizations in India are listed in the table 6 according to their productivity. The CSIR India with h-index 30 occupying the top position with 155 articles which is 12.59% of the total contribution from India (*i.e.*1230) while the Annamalai University is in 10^{th} position with 28 articles and h-index 13.

Hypothesis Testing

In order to investigate the relations between h-index and z-index of authors and journals, the Karl Pearson's correlation coefficient is applied and the significance of the correlation coefficient calculated using paired t-test. The results of the tests are presented in table 7.

Table 7: Correlation between h-index and z-index of authors and journals

Sl No	**Category**	**Correlation Coefficient (r)**	**df**	**Observed value of t (two-tailed)**	**Critical value of t**	**Significance**
1	Authors	0.765	40	7.513	2.021	Significant
2	Journals	0.977	28	24.247	2.048	Significant

$\alpha = 0.05$

An inspection of the Table 6 reveals that

- There is a strong correlation between h-index and z-index in case of authors and journals.
- Both the correlations are found significant.

Therefore the formulated null hypotheses H_{a0} and H_{b0} are rejected and accepted the alternate hypotheses. That means that, the correlation between h-index and z-index of authors is significant and same is true in the case of journals.

Conclusion

The world research output of Nanotechnology research in the window period of 2008-2017 has been studied. (Data retrieved in May, 2018). Langer, Robert is the most consistent author with 82.88 z-index. On the other hand Webster Thomas, J who has the highest number of publications (*i.e.* 81) is in 11^{th} rank in case of consistency. Though the author affiliations are also included in the author table (table 2), there is a limitation that some of the authors have different affiliations in different works. The Journal ACS Nano which is found as the highest contributing journal with 400 articles, also found as the most consistent one with z-index 72.76. A strong and significant correlation is also found between h-index and z-index of authors as well as in journals. This leads to infer that z-index (i.e. consistency of the whole citation window) co-exists with the h-index. The study also reveals that USA has published highest number of article which is 29.68% of world share publication where India is in third position with 7.29% of share. Again, as per the number of publication 'The Council of Scientific Industrial Research CSIR India' is found to be the most productive organization in India in nanotechnology research.

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References

Ahmi, A. & Mohammad, R. (2019). Bibliometric analysis of g;obal scientific literature on web accessibility. *International Journal of Recent Technology and Engineering*, *7* (6S2), 250-258. Retrieved on June 24, 2019 from https://www.ijrte.org/wp-content/uploads/papers/v7i6s2/F10380476S219.pdf

Alonso, S., Cabrerizo, F. J., Herrera-viedma, E., & Herrera, F. (2010). hg-index: a new index to characterize the scientific output of researchers based on the h- and g-indices. *Scientometrics* , *82*, 391-400. Retrieved on December 23, 2018 from http://eprints.rclis.org/12753/

Arencibia-Jorge, R., & Rousseau, R. (2009). Influence of individual researchers' visibility on

institutional impact: an example of Prathap's approach to successive h-indices. *Scientometrics , 79* (3), 507-516. Retrieved on January 2, 2019 from https://link.springer.com/article/10.1007/s11192-007-2025-0

Egghe, L. (2009). Comparative study of h-index sequences. *Scientometrics , 81* (2), 311-320. Retrieved on December 24, 2018 from https://www.researchgate.net/publication/220365230_Comparative_study_of_h-index_sequences

Hazarika, T. (2017). Scientometric profile of seismology research in India. In S. K. Singh, S. Brahma, P. Deka, & I. Singh (Ed.), *1st International Conference on Transforming Library 2017*, (pp. 778-785). Kokrajhar, July 8-10.

Hirsch, J. E. (2005). An index to quantify an individual's scientific research output . *PNAS , 102* (46), 16569-16572. Retrieved on January 21, 2019 from https://www.pnas.org/content/102/46/16569

Kumari, G. L. (2009). Synthetic organic chemistry research: Analysis by scientometric indicators. *Scientometrics*, 80 (3), 559-570. Retrieved on January 5, 2019 from https://link.springer.com/article/10.1007/s11192-007-1985-4

Makhoba, X., & Pouris, A. (2017). Bibliometric analysis of the development of Nanoscience research in South Africa. *S Afr J Sci.*, 113(11/12), 1-9. Retrieved on December 1, 2018 from http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S0038-23532017000700012

Mooghali, A., Alijani, R., Karami, N., & Khasseh, A. (2011). Scientometric analysis of the Scientometric literature. *International Journal of Information Science and Management , 9* (1). Retrieved on December 1, 2018 from https://www.researchgate.net/publication/267704390_Scientometric_Analysis_of_the_Scientometric_Literature

Packiyaraj, M., & Manoharan, A. (2014). Scientometric analysis of the literature on Textile Technology: a perspective. *Indian Journal of Information Sources and Services , 4* (1), 45-50. Retrieved on December 1, 2018 from http://www.trp.org.in/issues/scientometric-analysis-of-the-literature-on-textile-technology-a-global-perspective

Prathap, G. (2011a). The Energy-Exergy-Entropy (or EEE) sequence in bibliometric assessment. *Scientometrics, 87*, 515-524. Retrieved on December 23, 2018 from https://www.researchgate.net/publication/220364822_The_Energy-Exergy-Entropy_or_EEE_sequences_in_bibliometric_assessment

Prathap, G. (2011b). Quasity, when quantity has a quality all its own- towards a theory of performance. *Scientometrics, 88*, 555-562. Retrieved on December 23, 2018 from https://www.researchgate.net/publication/220364828_Quasity_when_quantity_has_a_quality_all_of_its_own-Toward_a_theory_of_performance

Prathap, G. (2013). The zynergy index and the formula for h-index. *Journal of the Association of Information Science and Technology, 65*, 426-427. Retrieved on December 22, 2018 from https://asistdl.onlinelibrary.wiley.com/doi/abs/10.1002/asi.23046

Prathap, G. (2014). A bibliometric evaluation of research on the monsoon. *DESIDOC Journal of Library & Information Technology, 34* (3), 191-196. Retrieved on November 26, 2018 from https://www.researchgate.net/publication/270492328_A_Bibliometric_Evaluation_of_Research_on_the_Monsoon

Tolochko, N.K. (2009). *Nanoscience and Nanotechnologies—History of Nanotechnology.* Retrieved January 21, 2019, from https://www.eolss.net/Sample-Chapters/C05/E6-152-01.pdf

Varma, A. K., & Singh, K. (2017). Scientometric analysis of literature on Big Data research

output in India based on Scopus database . *International Journal of Library and Information Studies , 7* (4), 90-96. Retrieved on December 3, 2018 from http://ijlis.org/img/2017_Vol_7_Issue_4/90-96.pdf

Zhai, L., Yan, X., & Zhu, B. (2014). The Hl-index: improvement of H-index based on quality of citing papers. *Scientometrics , 98*(2), 1021-1031. Retrieved on January 13, 2019 from https://link.springer.com/article/10.1007/s11192-013-1039-z