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Visualizing Global Nanotechnology research on publication deeds, 1989-2014

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Abstract

This study highlights the publication analysis in nanotechnology research outputs in global level as identified the data in Web of Science (WoS) Core Collection database, Thomson Reuters, Philadelphia, USA. It is found that a total output of worldwide scholarly communications in the field of nanotechnology is 20825 during the period between 1989 and 2014. The maximum numbers of outputs of 7269 records (34.91 %) were published by USA which is placed in the first rank. The next position has got by China with 2121 research papers (=10.19%) and followed by Germany is in the third rank. The primary sources are articles with 14564 scholarly papers (=6525%) is ranked in the first place. To predict the value of scientific world publications, time series analysis used and the value predicted for the year 2020 (i.e. 18 years) is 1259.06 and the predicted literature output for the year 2025 in 1377.41(i.e. 23 years). The world growth rate is increasing trend as well as the Indian growth rate is also upward trend.

Keywords: Nanotechnology, publication analysis, bibliometrics, citation analysis, RGR, DT, AGR, CAGR, collaborative research, Indian research.

Introduction

In the recent decades, Nanotechnology is one the emerging thrust areas in the knowledge science and technology world significantly. At present, nanotechnology is a powerful tool and technique not only in medical technology but also almost every filed and it is very practical in improving nanoparticles for diagnostic and screening points, artificial receptors and in DNA sequencing, development of unique drug delivery systems, gene therapy applications and the enablement of tissue engineering (Emerich and Thanos 2003). According to The U.S. National Nontechnology Initiative (NNI), defines as 'Nanotechnology is the understanding and control of matter at dimensions between approximately 1 and 100 nanometers, where unique phenomena enable novel applications. Encompassing nanoscale science, engineering, and technology, nanotechnology involves imaging, measuring, modeling, and manipulating matter at this length scale'.

Scientometric study is a type of quantitative analysis to evaluate the science based publication as well as any type of related data. Generally, scientometrics is a science of branch of

science. This study is very useful measuring the growth of literature outputs, status of research impact and efforts of a country, institution and also an individual in different domains of scientific and technical activities. It will support the policy makers and science administrators to have better perceptions in framing science policy and supervising the researchers. This method is the best way to trace the recent trends in terms of publication growth and development nanotechnology research and not only nanotechnology but also any field or domain of science and technology. This type of quantitative technique is used to compute in different aspects such as different kinds of document, Language wise production, growth analysis of research output in India and World, source Journal and country-wise production, productive organizations, Top 25 Country-wise productions, Top 25 productive Research Areas, Top 20 Funding Agencies and subject wise distribution. To evaluate the scientific publications the scientometric indicators such as Trend line analysis, Relative growth rate (RGR) and doubling time (DT), RoG and CARG are used to retrieve relevant outputs of the research on nanotechnology during the period of study.

Nanotechnology has been progressively prefigured as talented field which will evocatively impact the socio-economic growth and development. A number of studies have already been done by different eminent scholars and researchers in different domain and different years. Here, for the present study, we have taken small amount of earlier studies to enhance support of the paper. Heinze, T et al (2007) carried out and identified the research results on nanotechnology and human genetics, Kostoff, et al (2006) found the structure and infrastructure of the global nanotechnology research output, Lee (2006) investigated the nanotechnology patent and followed by Youtie; Shapira and Porter (2008) analyzed the research papers and citations on nanotechnology.

Bhattacharya; Bhati & Jayanthi (2011) reported in their outcomes from the case study on Nanotechnology research India. Huang; Notten & Rasters (2010) have explained search strategies on Nanoscience and technology publications and patents in the year 2010. Refining search terms for nanotechnology (Porter, A.L., *et al.2008), research trends in different countries such as China, Russia and India (*Liu, X., *et al. 2009),* Language trends in nanoscience and technology (Lin and Zhang, 2007), longitudinal analysis in nanotechnology literature (Li, X., et al. 2008), Nanotechnology and its descriptions in terms of journals and patents (Leydesdorff and Zhou, 2007), nanotechnology worldwide research outputs and metrics (Kostoff; Koytcheff and Lau, 2007), Collaborative patterns and differences in Nanotechnology (Meyer and Persson, 1998, Schummer, 2004) and Patent citation analysis with special reference to nanoscience and nanotechnology (Meyer, 2001).

We have some selected for consideration few of the published papers of authors' earlier works in different disciplines as well as solo journals of scientometric analysis in different period of study for the present analysis such as publication trends on Indian Journal of Biotechnology by Velmurugan and Radhakrishnan (2015), Journal of Information Literacy by Velmurugan and Radhakrishnan (2015), Quantitative Analysis of Scientific Publications Output on Engineering Journal by Velmurugan and Radhakrishnan (2015), Literature output of Supply Chain Management Journal by Velmurugan and Radhakrishnan (2015), Authorship trends and collaborative research work on Library Herald by Velmurugan and Radhakrishnan (2015),

Scientometric Analysis of Research Papers on Pharmacognosy as reflected in the Web of Science by Velmurugan and Radhakrishnan (2015), Journal of Intellectual Property rights by Velmurugan (2013, 2014), Annals of Library and Information Studies for the year 2007-2012 by Velmurugan (2013) Indian Journal of Pure and Applied Physics for the Year 2009 – 2012 by Velmurugan (2014), Technical Review Journal by Velmurugan (2014).

Objectives of the Study

The main purpose of this study is to investigate and evaluate the literature outputs of nanotechnology. The other objectives are to compare the research outputs between India and World, to find out the growth analysis of nanotechnology, to notice the different kinds of publications, to identify the geographical based research productivity, to demonstrate the Institution / University based research papers and to express the source Journals, to identify the research area and subject-wise distribution, to illustrate the most significant authors and organizations, and top twenty funding agencies in the field of Nanotechnology research.

Hypotheses

The hypotheses have been formulated for this study based on the purposes of Nanotechnology Literature.

- Growth of research outputs in Nanotechnology is lower than the developed countries.
- The scholarly publications in Nanotechnology are dominated by the English language.
- There exist sovereignty of source journals in Nanotechnology
- There exist inadequate research publications on Nanotechnology and
- The journals are the significant source of literature outputs

Materials and Method

To achieve a goal based on the objectives, the required data of Nanotechnology global wise scientific publications have retrieved from the web of science core collection database. A total of 20825 global literatures collected for period between 1989 and 2014. The collected bibliographic collections have transferred to MS Excel spreadsheet for further analysis. To examine and evaluate the research outputs the following indicators have been used for this analysis to retrieve the better results during the period of study.

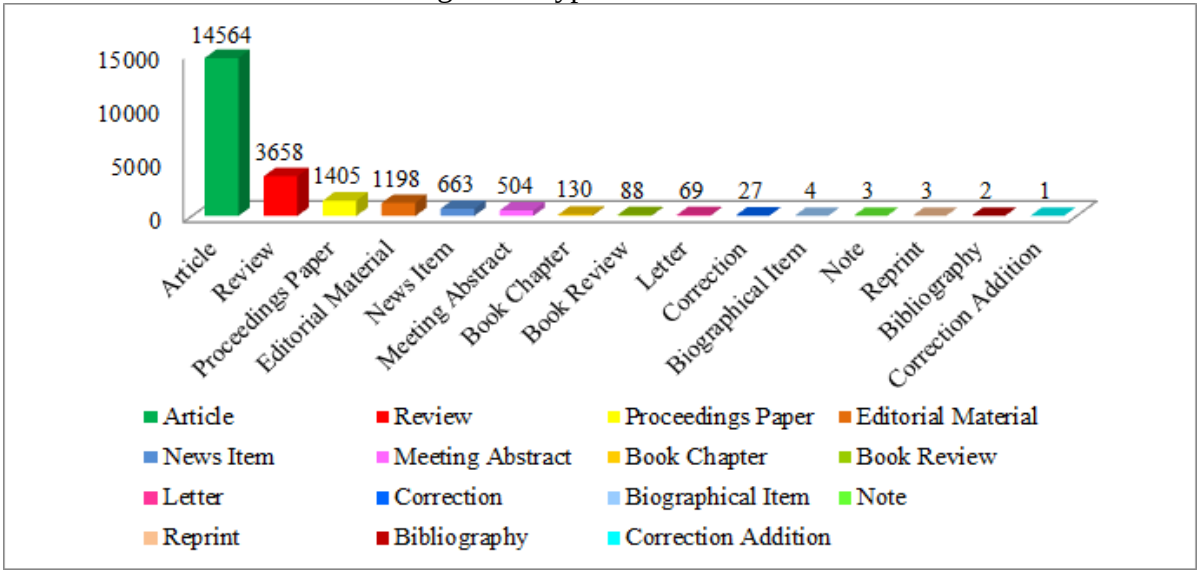
1. Relative growth rate (RGR)
2. Doubling Time (DT)
3. Compound Annual Growth Rate (CAGR)
4. Time series analyses (TSA)
5. Trend line analysis such as Liner, Exponential and Logarithmic growth and
6. R^2 Value for publications.

Analysis and Discussion

1. Different kinds of Document in Global Nanotechnology research

It is seen from the Figure 1 that the various types of manuscripts in the form of publications such as Article, Review, Proceedings Paper, Editorial Material, News Item, Meeting Abstract, Book Chapter, Book Review, Letter, Correction, Biographical Item, Note, Reprint, Bibliography and Correction Addition are collected from the web of science database during 1990-2014 on nanotechnology research in globally and it is found that the key primary sources are articles with 14564 scholarly papers (=65.25%) is ranked in the first place and followed by review papers with 3658 (=16.40%) are in the second position, in the third place got by Proceedings Paper, 1405 (=6.30%) and fourth rank is occupied by Editorial Material with 1198 (=5.37%) papers. The next place got by News Item with 663 papers (= 2.97%) and followed by Meeting Abstract with 504 papers (=2.25%). The other remaining research items are below 1 percent as shown in the table. The results describe the most of the publications in this research are mostly covered by journal articles and has placed top rank.

Figure 1: Types of Document



2. Language wise production

For every research, the way in which we write is essential and it depends upon the language as the language is the asset in every nation. In this context, publishing scientific research papers are in peer-reviewed research journals is most important in a particular subject or topic. Based on the study, the huge number at most 98 percent of literature outputs are written in English (=20372) so as to the English is the predominant and followed by German (=93 papers), Chinese (=89 papers), French (=81 papers), Japanese (=45 papers), Spanish (=38 papers), Portuguese (=36 papers), Polish (=20 papers), Russian (=15 papers), Czech (=11 papers) and Croatian(=10 papers) and other languages such as Slovenian and Turkish(=3 papers each), Hungarian and Serbo Croatian(= 2 papers each) and Dutch, Finnish, Italian and Korean (=1 paper each). The findings indicates that the countries from Dutch, Finnish, Italian and Korean

scientists are not interesting to publish their papers in nanotechnology whereas German, Chinese and French academicians papers growth rate is in the upward trend as they are very eager to publish their publications.

S. No	Languages	Record Count	Percent
1	English	20372	97.825
2	German	93	0.447
3	Chinese	89	0.427
4	French	81	0.389
5	Japanese	45	0.216
6	Spanish	38	0.182
7	Portuguese	36	0.173
8	Polish	20	0.096
9	Russian	15	0.072
10	Czech	11	0.053
11	Croatian	10	0.047
12	Slovenian	3	0.014
13	Turkish	3	0.014
14	Hungarian	2	0.010
15	Serbo Croatian	2	0.010
16	Dutch	1	0.005
17	Finnish	1	0.005
18	Italian	1	0.005
19	Korean	1	0.005
20	Romanian	1	0.005
		20825	100.0

Table 1: Language wise production

3. Growth of Research Output in Nanotechnology research

Table 2 and Figure 2-4 indicate that the growth of worldwide scientific publication trends in nanotechnology research. In the below table we have analyzed research outputs in India and World in terms of comparative study. Based on the study, the world growth rate is increasing trend as well as the Indian growth rate is also upward trend. In the world outputs range is from 4 papers (=0.019%) in the year 1990 to 2560 papers (=12.932%) in the year 2014. In the beginning the growth rate was very slow and the significant growth rate was in the year 1999 onwards and the greatest number of growth is in the year 2014.

Table 2: Growth of Research Output in India and World

Sl.no	PY	WRC (%)	IRC (%)	India share (%)
1	1990	4 (0.019 %)	-	-
2	1991	19 (0.091%)	-	-
3	1992	9 (0.043 %)	-	-
4	1993	24 (0.115 %)	1	4.17

5	1994	37 (0.178 %)	-	-
6	1995	29 (0.139 %)	-	-
7	1996	46 (0.221 %)	-	-
8	1997	44 (0.211 %)	-	-
9	1998	80 (0.384 %)	1 (0.1%)	1.25
10	1999	101 (0.485 %)	-	-
11	2000	153 (0.735 %)	-	-
12	2001	220 (1.056 %)	3 (0.3%)	1.36
13	2002	327 (1.570 %)	8 (0.8%)	2.45
14	2003	553 (2.655 %)	14 (1.4%)	2.53
15	2004	797 (3.827 %)	10 (1.0%)	1.25
16	2005	986 (4.735 %)	22 (2.2%)	2.23
17	2006	1123 (5.393 %)	33 (3.4%)	2.94
18	2007	1372 (6.588 %)	42 (4.3%)	3.06
19	2008	1680 (8.067 %)	67 (6.8%)	3.98
20	2009	1888 (9.066 %)	86 (8.7%)	4.55
21	2010	1942 (9.325 %)	99 (10.1%)	5.10
22	2011	2143 (10.291 %)	117 (11.9%)	5.46
23	2012	2238 (10.747 %)	130 (13.2%)	5.81
24	2013	2450 (11.765 %)	164 (16.7%)	6.69
25	2014	2560 (12.293 %)	187 (19.0%)	7.30
	Total	20825	984	4.73

PY – Publication year, WRC – World Record Count, India Record Count

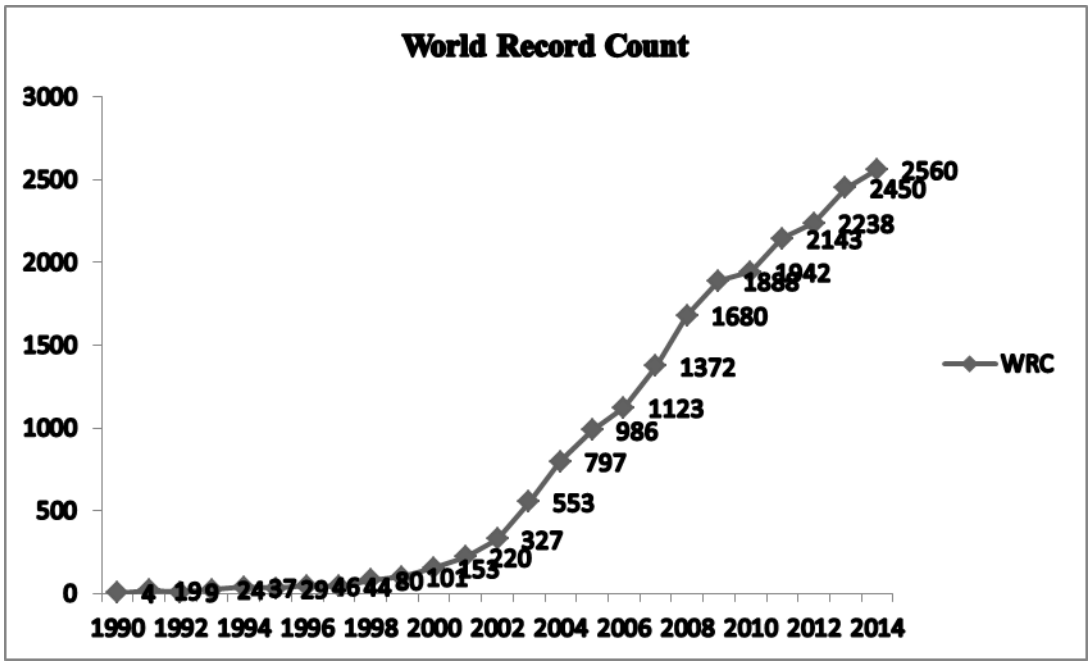


Figure 2: Worldwide Research publication

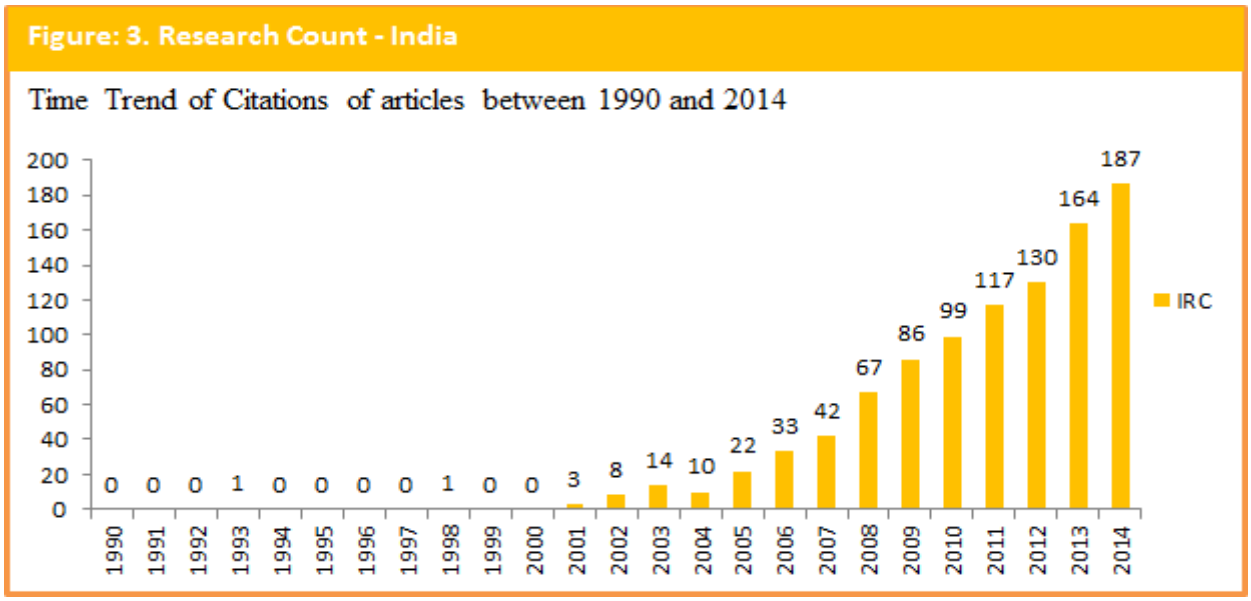


Figure 3: Research Publication - India

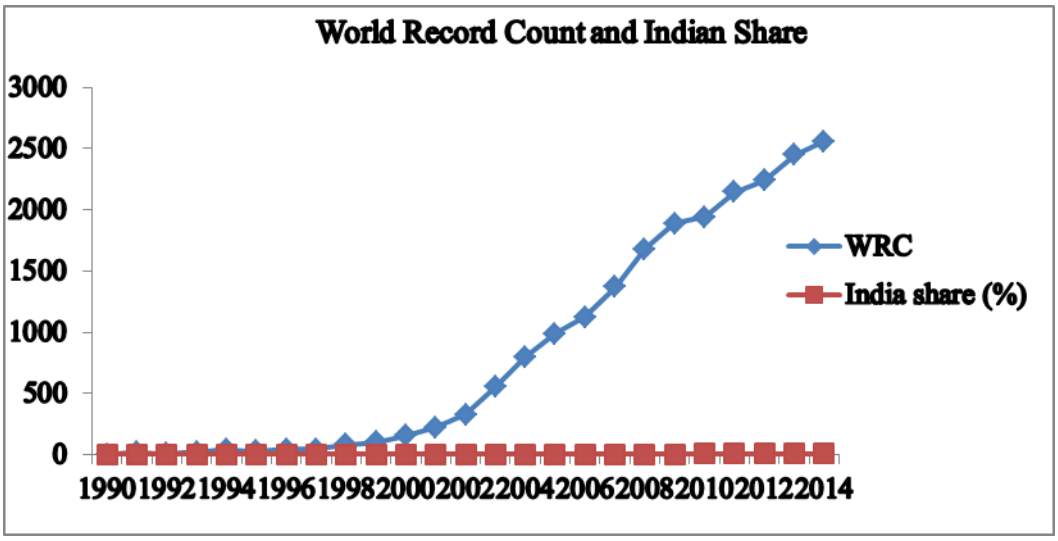


Figure 4: World output and share of Indian publicaiton

4. Time series analysis of world literature in Nanotechnology

Trend analysis is one of the best tools to analyze the trend values in any field of research. In a series, it gives a convenient basis for obtaining the line of best fit. The equation of straight line trend is: Y = a+bX, Where, Y = indicates that the estimated values of the trend and X = represents that the deviations in time period and 'a' and 'b' are constants.

Table 3: Growth of Literature Trends

PY	RO	X	X^2	Xy
1990	4	-12	144	-48
1991	19	-11	121	-209
1992	9	-10	100	-900

1993	24	-9	81	-216
1994	37	-8	64	-296
1995	29	-7	49	-203
1996	46	-6	36	-276
1997	44	-5	25	-220
1998	80	-4	16	-320
1999	101	-3	9	-303
2000	153	-2	2	-306
2001	220	-1	1	-220
2002	327	0	0	0
2003	553	1	1	553
2004	797	2	4	1594
2005	986	3	9	2958
2006	1123	4	16	4492
2007	1372	5	25	6860
2008	1680	6	36	10080
2009	1888	7	49	13216
2010	1942	8	64	15536
2011	2143	9	81	19287
2012	2238	10	100	22380
2013	2450	11	121	26950
2014	2560	12	144	30720
Total	20825		1298	

PY- Publication year, RO- Research outputs

The above Table 3 describes for future growth performance of nanotechnology world literature research under the Time Series Analysis during the period of study. For this purpose, the Straight line equation has been applied to arrive at estimates of the literature outputs. The formula is Straight Line Y = a+bX and evaluates as per the statistical equation;

Since $\sum x = 0$

$$a = \frac{\sum Y}{N} = \frac{20825}{25} = 833$$

$$b = \frac{\sum y}{\sum x^2} = \frac{30720}{1298} = 23.67$$

Estimated scientific publications in 2020 is when X = 2020- 2002 = 18

= 833+23.67 x 18 = 833+426.06

= **1259.06**

The Estimated research outputs in 2025 is when X = 2025 – 2002 = 23

= 833+23.67 x 23 = 833+544.41

= **1377.41**

In this analysis, the predicted value of scientific world publications for the year 2020 (i.e. 18 years) is 1259.06 and the predicted literature output for the year 2025 in 1377.41(i.e. 23 years). The study adopted the application of time series analysis, the findings show that the future trends of growth rate of world research publications produced in the field of nanotechnology is in the upward trend and it is evident that from the inference of the analysis and depicts that optimistic progress in the research.

5. Relative growth rate (RGR)

The analysis of the relative growth rate (RGR) is the increase in the number of research publications/pages per unit of time. The relative growth rate and the doubling time models have established by Garg and Padhi in the year 1999 to evaluate and examine the scientific publications. The growth rate of total research output published by faculty members from Periyar University has been evaluated as per the following equation.

$$R\,(a) = \frac{(W2 - W1)}{(T2 - T1)}$$

Where,

R (a) = Relative Growth Rate over the specific period of interval,
w1= logw1 (Natural log of initial number of publications),
w2= log w2 (Natural log of final number of publications),
T2- T1 = Unit difference between the initial and final time and
R (a) = per unit of publications per unit of time (Year).

6. Doubling Time

There exists a direct equivalence between the relative growth rate and the doubling time. If the number of articles or pages of a subject doubles during a given period then the difference between the logarithms of numbers at the beginning and end of this period must be logarithm of the number 2. If natural logarithm is used this difference has a value of 0.693. Thus the corresponding doubling time for each specific period of interval and for both articles and pages can be calculated by the formula.

$$\text{Doubling Time (DT)} = \frac{0.693}{\text{RGR}}$$

7. Annual Growth Rate (AGR)

The annual growth rate is computed to know the growth level of scientific publications during the period of study in every literature of any discipline. The equation is expressed as:

$$AGR = \frac{End\ Value - First\ Value}{First\ Value}\ X\ 100$$

The year-wise annual growth rate of the total research papers were computed in the Table 4 and Figure 6. The results show that the annual growth rate is fluctuation trend all over the year of publications. The AGR for global literature output of nanotechnology has increased in the year 1991 (375) and 1993 (166.67) but, the growth rate has decreased (2010, 2012 and 2014) and sometimes three was a negative value (=-4.35 in 1997 and -21.62 in 1995). The average annual growth rate during the period of study is 49.952 percent. Hence, the report indicates that there was a fluctuation trend in the publications of nanotechnology globally.

8. Compound annual growth rate (CAGR)

The Compound annual growth rate (CAGR) is one of the most scientometric observations based on the nanotechnology literature outputs. To figure out the Compound annual growth rate (CAGR) of the collecting intellectual scientific research papers during the period between 1990and 2014, It is divided the ending value of our portfolio by the portfolio's starting value (2560/4 = 640). Next we raise the result to the power of 1 divided by the number of years (1-24). As a final point, we subtract one from the resulting value. We can compute based on the data of nanotechnology and evaluate;

The formula is = CAGR (t_0, tn) = $\left(\frac{V(tn)}{V(t0)}\right)\frac{1}{tn-to}$

= [(2560/4) ^ (1/24)]
= 1.3089 -1
= 0.3089 or 30.89%

Therefore, the compound annual growth rate for the period of 25 years of global-wise Nanotechnology literature output is equal to 30.89%.

9. Relative growth rate and doubling time

S. No	PY	R. o/p	Rt(P)	Mean R (a) (1-2)	Dt(P)	Mean Dt (a) (1-2)	AGR	CARG
1	1990	4					-	
2	1991	19	0.19		3.65		375	
3	1992	9	1.26	0.64	0.55	1.15	78.95	
4	1993	24	0.85		0.82		166.67	
5	1994	37	0.92		0.75		54.17	
6	1995	29	1.43		0.48		-21.62	
7	1996	46	1.29		0.53		58.62	
8	1997	44	1.58	1.38	0.44	0.5	-4.35	
9	1998	80	1.29		0.54		81.82	
10	1999	101	1.35		0.51		26.25	
11	2000	153	1.27		0.55		51.49	
12	2001	220	1.25		0.55		43.79	30.89%
13	2002	327	1.2	1.19	0.57	0.58	48.63	

14	2003	553	1.09		0.64		69.11
15	2004	797	1.12		0.62		44.12
16	2005	986	1.25		0.55		23.71
17	2006	1123	1.41		0.49		13.89
18	2007	1372	1.46	1.45	0.47	0.48	22.17
19	2008	1680	1.5		0.46		22.45
20	2009	1888	1.62		0.43		12.38
21	2010	1942	1.77		0.39		2.86
22	2011	2143	1.85		0.37		10.35
23	2012	2238	1.96	1.94	0.35	0.36	4.43
24	2013	2450	2.01		0.34		9.47
25	2014	2560	2.09		0.33		4.49
	Total	20825		1.32		0.61	

Table 4: Relative growth rate and doubling time

Figure: 5. Relative growth rate and doubling time

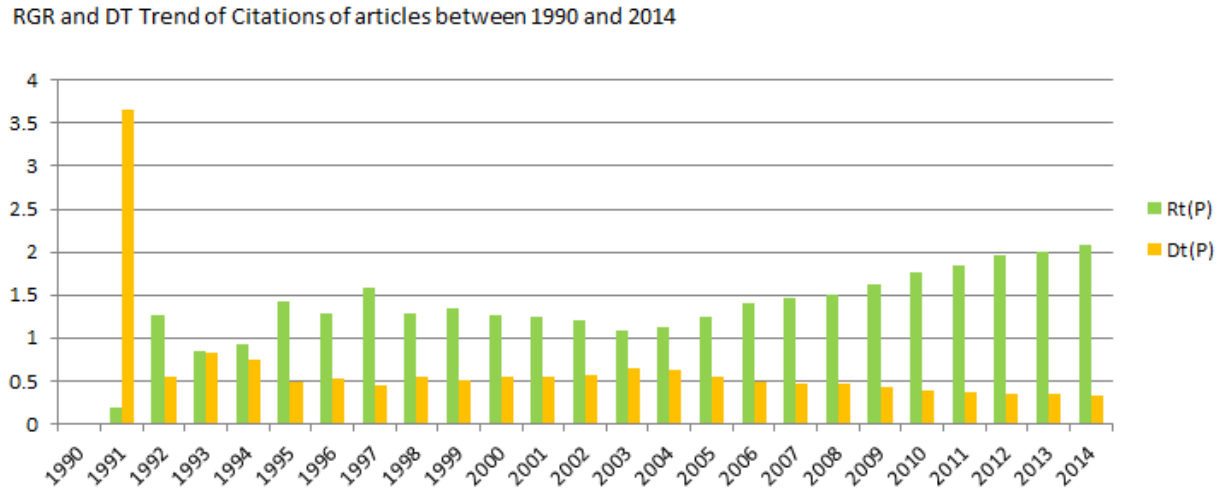


Figure: 6. Annual growth rate of papers

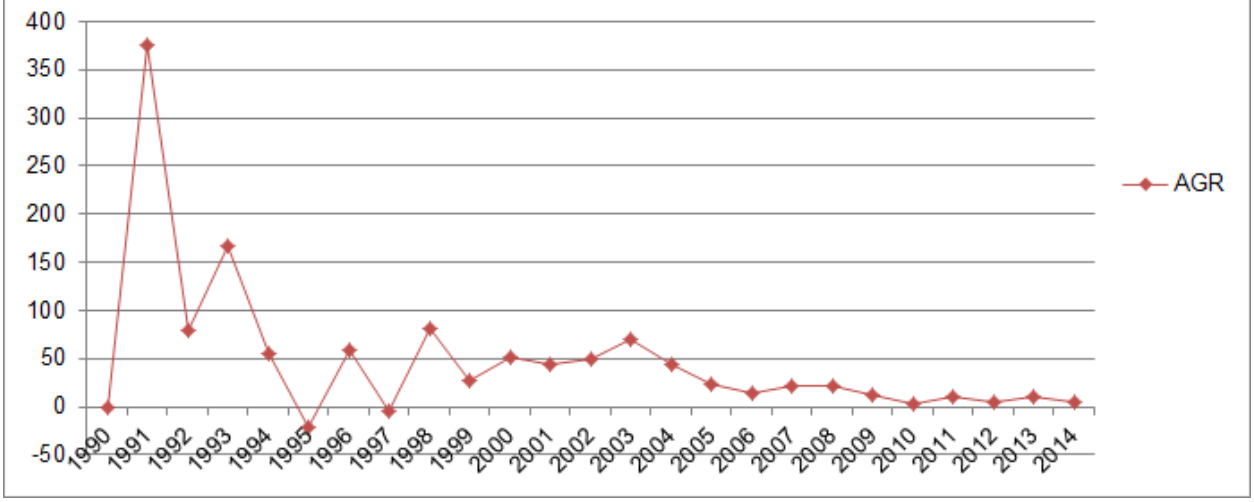


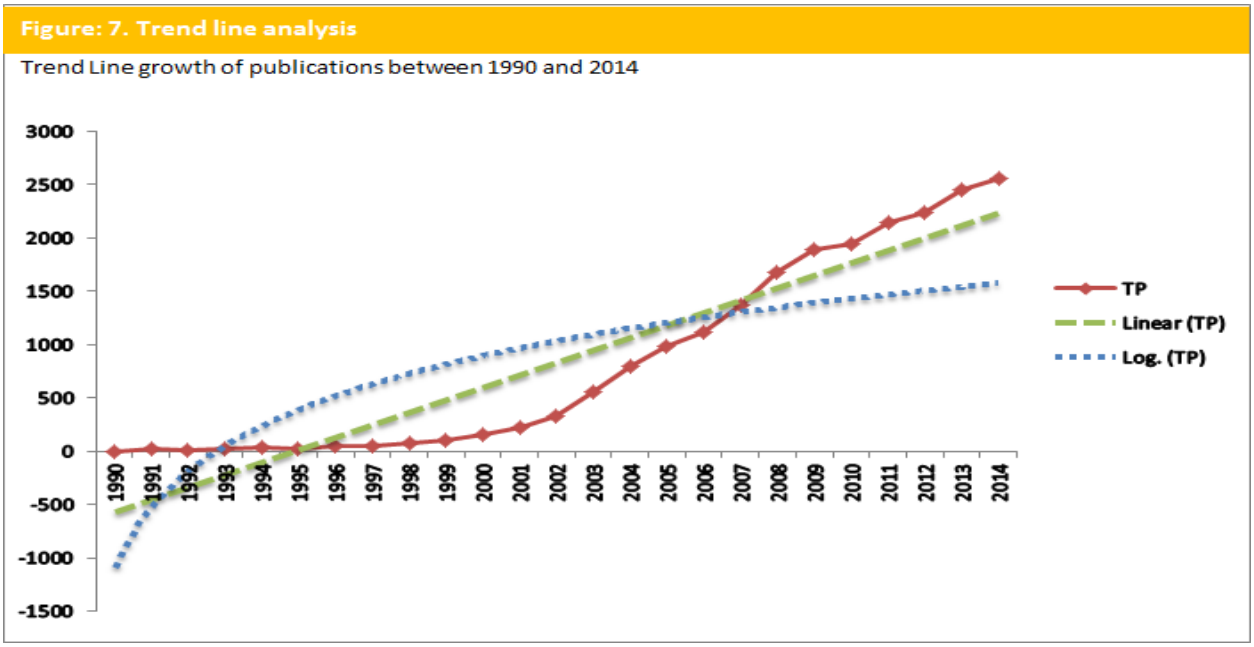
Table 4 and Figure 5 depict the relative growth rate (RGR) and doubling time (DT) of total publications of nanotechnology. It is very crystal clear and understandable that the relative growth rate of total research papers published has been fluctuation trend from 1991 to 2003 and in the year 2004 onwards, the growth rate has been progressively increased. The growth rate is 1.09 in 2003, which is increased up to 2.09 in the 2014. The five block wise value has been measured in relative growth rate in which in first block (0.64) in 1990-1994 and the fifth block is 1.94 and the average value of all blocks is 1.32.

The doubling time is 3.65 during the period 1990-1991 and the mean value in the first block is 1.15. But, in the year 1992 onwards, the level growth has been suddenly decreased till 2014 (0.33) and the average mean value is 0.61. It is noted that the doubling time of scientific literature outputs of nanotechnology has identified decreasing trend and the relative growth rate has seen increasing trend.

10. Trend line analysis on Nanotechnology research

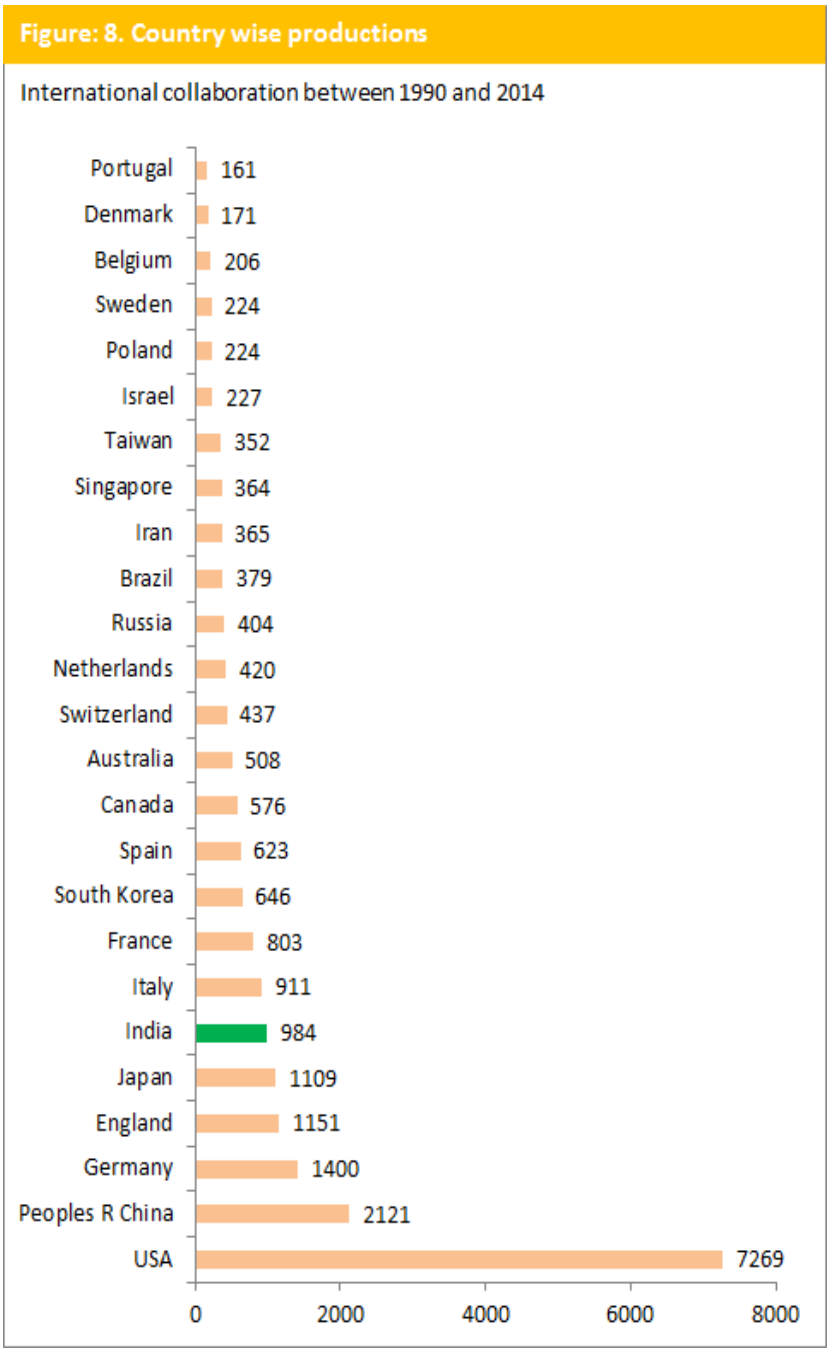
Figure 7 shows the trend line analysis on nanotechnology research during the period of study. Based on the analysis, the Linear trend estimation were measured in nanotechnology publications and the value is $y = 116.9x - 686.83$ and R^2 value is 0.8779. The Logarithmic trend analysis is also were computed and the value is $y = 831.14\ln(x) - 1095.5$ and $R^2 = 0.5703$.

Figure: 7. Trend line analysis



11. Top 25 Country-wise productions

Of the 88 countries and territories of this nanotechnology filed, researchers have considered and computed only top 25 geographical areas and the Figure 8 brings out the results that the maximum numbers of outputs of 7269 records (34.91 %) were published by USA which is placed in the first rank. The next position has got by China with 2121 research papers (=10.19%) and followed by Germany is in the third rank with 1400 (=6.723%) literature outputs and England has ranked in the fourth position with 1151 scholarly papers (5.527%) and fifth place has occupied by Japan of 1109 research articles (=5.325%). It is noted that Indian literature outputs are 4.725 percent (=984) and has placed with sixth position and the results show that India is one of the top 10 countries in the nanotechnology world research as reflected in the web of science bibliographic database during the period of study.



12. Most prolific authors in Nanotechnology global outputs

Table 5 represents that the authors wise production in terms of research articles during the period of study. Based on the scientometric observations, 'Anonymous' authors have published most number of research articles and they have placed in the first position and followed by 'Webster TJ' (=93 articles) has in the second rank and followed by Liu Y, (=85 articles) is in the third position, Wang J, (=76 articles), Feng SS, (=72 articles), Wang Y, (=65 articles), Seeman NC, (=62 articles), Guo PX, (=54 articles), and Yan H, (=50 articles). The

study found out that the majority of 348 literature outputs have published by Anonymous authors and has ranked in the first.

Sl.no	Authors	Records	% of 20825
1	Anonymous	348	1.67
2	Webster TJ	93	0.446
3	Liu Y	85	0.408
4	Wang J	76	0.365
5	Feng S S	72	0.346
6	Wang Y	65	0.312
7	Seeman N C	62	0.298
8	Guo P X	54	0.259
9	Yan H	50	0.24
10	Li Y	48	0.23
11	Li J	47	0.226
12	Zhang Y	46	0.221
13	Ferrari M	45	0.216
14	Roco MC	44	0.211
15	Wang X	40	0.192
16	Scheufele DA	40	0.192
17	Lee J	40	0.192
18	Kim J	39	0.187
19	Chen Y	39	0.187
20	Ariga K	39	0.187
21	Zhao Yl	36	0.173
22	Zhang J	36	0.173
23	Shapira P	36	0.173
24	Langer R	36	0.173
25	Seifalian AM	35	0.168

Table 5: Most prolific authors

13. Most productive organizations in Nanotechnology research

It is evident from the Table 6 and Figure 9 indicates that out of 8448 organizations throughout the world, only top 25 most productive research organizations have chosen for analysis purpose for the present study. Of the top 25 organizations, the most productive (=416, 1.998%) research outputs were received by Chinese Academic Science from China and has identified it is the first place being published more research papers by them. The second place goes to MIT, USA with 257 research articles (=1.234%), and followed by Harvard University from USA, has produced 242 literature outputs (=1.162%) which is placed in the third rank and the fourth rank has occupied by Georgia Institute of Technology with 231 (=1.109%) records and fifth position has National University of Singapore with 216 (=1.037%) research outputs. The results of the study indicate that the most of the research papers were published in USA in

different parts of the country and ranked in the first place based on the country wise production. It shows that unites states is very interesting and involving to publish their research articles in nanotechnology research and followed by China, United Kingdom and Singapore have occupied in the second place and Russia is in the third rank based on the publications.

Table 6: Organizations in Nanotechnology research

S. No	Organizations	Country	Record Count	%
1	Chinese Academic Science	China	416	1.998
2	MIT	USA	257	1.234
3	Harvard University	USA	242	1.162
4	Georgia Institute of Technology	USA	231	1.109
5	National University of Singapore	Singapore	216	1.037
6	University of Illinois	USA	172	0.826
7	Russian Academic Science	Russia	169	0.812
8	Arizona State University	USA	164	0.788
9	Purdue University	USA	159	0.764
10	University of Wisconsin	USA	156	0.749
11	CNRS	Europe	147	0.706
12	University of Calif Los Angeles	USA	144	0.691
13	Northwestern University	USA	139	0.667
14	University of Cambridge	United Kingdom	128	0.615
15	Rice University	USA	126	0.605
16	Nanyang Technology University	Singapore	124	0.595
17	University of Michigan	USA	123	0.591
18	Stanford University	USA	120	0.576
19	University of Calif Berkeley	USA	120	0.576
20	University of Washington	USA	116	0.557
21	UCL	United Kingdom	115	0.552
22	CSIC	Spain	110	0.528
23	University of Calif Santa Barbara	USA	109	0.523
24	Brown University	USA	108	0.519
25	Tsinghua University	China	106	0.509

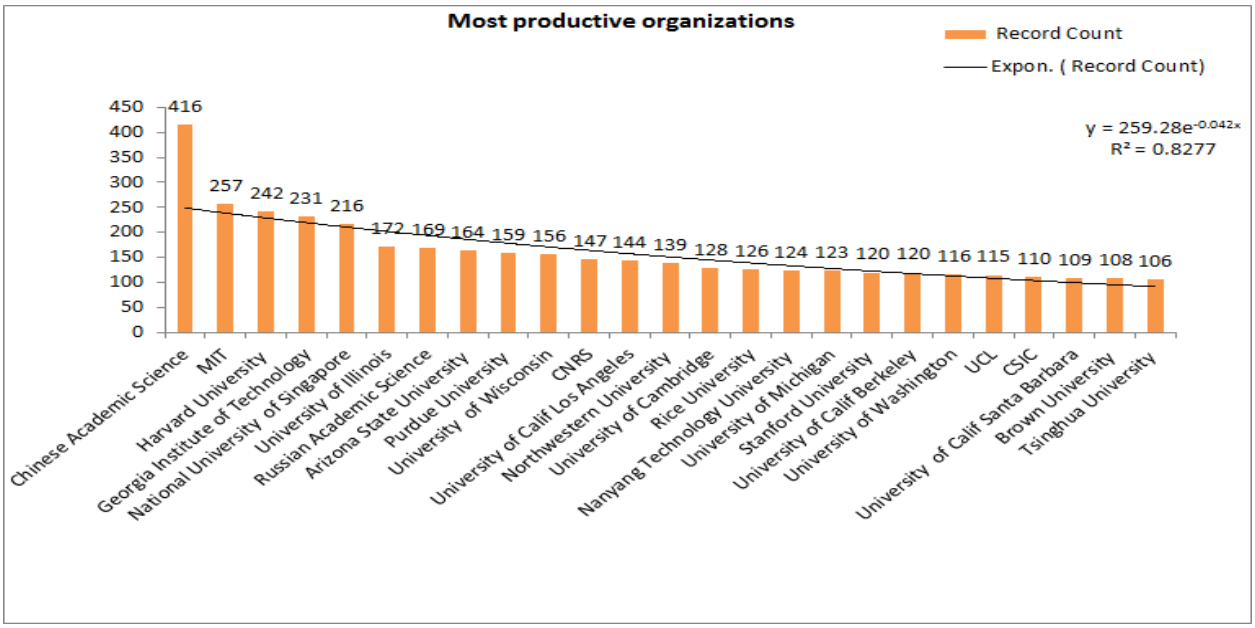


Figure 9: Organizations in Nanotechnology research

14. Top 25 productive Research Areas in Nanotechnology research

In the knowledge world, research field is vital in every subject and every sphere in the knowledge era to comprehend and examine the valuable output significantly to the academic society. In this scientometric analysis, Table 7 and Figure 8 show that out of 113 research areas in worldwide, authors have chosen only most productive top 25 research fields to analyze the research areas in the field of nanotechnology in global level during the study period. It is found that out of 20825 scholarly communications, more than 31 percent (=6570, 31.549%) of research articles have occupied in the research field of 'Chemistry' as this filed is one of the top most research domain in science and technology and also among the top 25 research areas in nanotechnology research and ranked at first place and followed by 'Materials Science' is in the second place as it has 5797 research papers (=27.84%) were published, and in the third rank got by 'Science Technology Other Topics' with 5242 (=25.17%) research outputs, the next rank received by 'Physics' with 4311 (=20.70%) articles, Engineering (=2833, 13.604%), Computer Science (=396, 1.90%), Food Science Technology and Oncology (=254, 1.20%) respectively. It is noted that the small number of research papers (=173, 0.83%) were produced in the field of Social Sciences Other Topics and the results reveal that most productive scientific publications were published in the field of Chemistry as the scientists from chemistry are most willing to publish their papers in nanotechnology area and it is also depicts that there is a close relationship by the scientists of nanotechnology.

Table 7: Most productive Research Areas

S. No	Research Areas	Record Count	% of 20825
1	Chemistry	6570	31.549
2	Materials Science	5797	27.837
3	Science Technology Other Topics	5242	25.172

4	Physics	4311	20.701
5	Engineering	2833	13.604
6	Pharmacology Pharmacy	1460	7.011
7	Biochemistry Molecular Biology	1127	5.412
8	Biotechnology Applied Microbiology	892	4.283
9	Polymer Science	872	4.187
10	Environmental Sciences Ecology	534	2.564
11	Research Experimental Medicine	488	2.343
12	Instruments Instrumentation	415	1.993
13	Computer Science	396	1.902
14	Optics	362	1.738
15	Toxicology	361	1.733
16	Business Economics	323	1.551
17	Electrochemistry	307	1.474
18	Biophysics	298	1.431
19	Food Science Technology	254	1.220
20	Oncology	254	1.220
21	Cell Biology	217	1.042
22	History Philosophy Of Science	197	0.946
23	Metallurgy Metallurgical Engineering	188	0.903
24	Education Educational Research	179	0.860
25	Social Sciences Other Topics	173	0.831

15. Source Journal wise production in Nanotechnology research

It can be observed from the Table 8 and Figure 10 represent that of the 3249 source journal titles, we select only top ranked source journals for the present study. By the way, the maximum number of research articles (=334, 1.604%) were published in the source journal 'Abstracts of Papers of the American Chemical Society' and it is occupied in the top rank and followed by 321 (=1.541%) scientific papers were produced in 'Angewandte Chemie International Edition' and placed in the second rank and the third position has got by' Journal of Nanoparticle Research' with 317 literature outputs (=1.522%) and the next position has occupied by 'ACS Nano ' with 287 articles were published (=1.378%). The fifth rank has received by 'Nanotechnology' with 282 research papers (=1.354%) were published during the period of study. In this way, researchers identified the exponential growth trend i.e. $y = 336.54e^{-0.049x}$ and the R^2 source value is $R^2 = 0.97$.

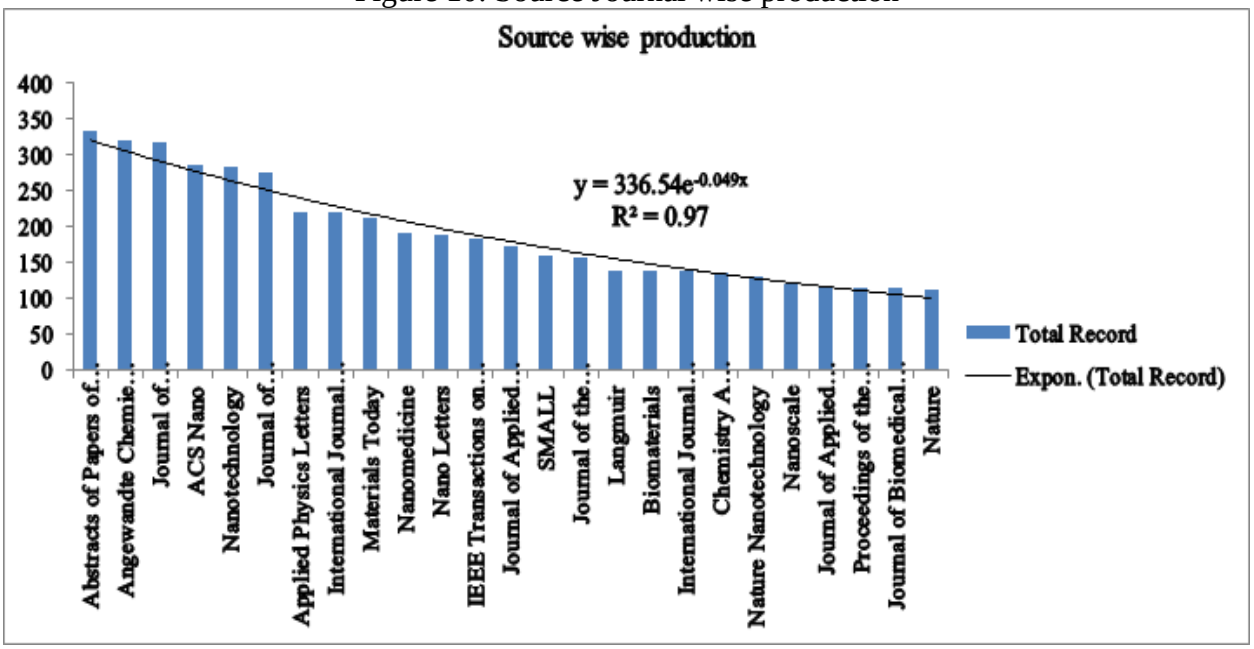
Table 8: Source Journal wise production

S. No	Source Journal	TR	TR%
1	Abstracts of Papers of the American Chemical Society	334	1.604
2	Angewandte Chemie International Edition	321	1.541
3	Journal of Nanoparticle Research	317	1.522
4	ACS Nano	287	1.378
5	Nanotechnology	282	1.354
6	Journal of Nanoscience and Nanotechnology	276	1.325

7	Applied Physics Letters	219	1.052
8	International Journal of Nanomedicine	219	1.052
9	Materials Today	213	1.023
10	Nanomedicine	190	0.912
11	Nano Letters	187	0.898
12	IEEE Transactions on Nanotechnology	183	0.879
13	Journal of Applied Polymer Science	171	0.821
14	SMALL	158	0.759
15	Journal of the American Chemical Society	156	0.749
16	Langmuir	139	0.667
17	Biomaterials	138	0.663
18	International Journal of Nanotechnology	138	0.663
19	Chemistry A European Journal	135	0.648
20	Nature Nanotechnology	130	0.624
21	Nanoscale	119	0.571
22	Journal of Applied Physics	117	0.562
23	Proceedings of the National Academy of Sciences, USA	115	0.552
24	Journal of Biomedical Nanotechnology	114	0.547
25	Nature	112	0.538

Note: TR- Total records

Figure 10: Source Journal wise production



16. Top 20 Funding Agencies in Nanotechnology research

It is inferred from the Table 9 and Figure 11 that the funding agencies for the nanotechnology research during the period. The funding agencies are playing a vital role in any

field of research throughout the world. For this study, out of 11, 160 funding agencies globally, we have selected top 20 funding agencies as ranking based analysis. Researchers have selected more than 50 scientific papers and the first place goes to 'National Natural Science Foundation of China with 630 (=3.025%) research outputs and followed by 'National Science Foundation' is in the second place with 480 (=2.305%) literature outputs

Table 9: Funding Agencies in Nanotechnology research

Rank	Funding Agencies	TR	TR%
1	National Natural Science Foundation of China	630	3.025
2	National Science Foundation	480	2.305
3	NIH	324	1.556
4	NSF	320	1.537
5	National Institutes of Health	194	0.932
6	National Basic Research Program of China	140	0.672
7	European Union	99	0.475
8	NSFC	94	0.451
9	European Commission	89	0.427
10	CNPQ	88	0.423
10	National Science Foundation NSF	88	0.423
11	Fundamental Research Funds for the Central Universities	86	0.413
12	National Basic Research Program of China Program	80	0.384
13	EU	78	0.375
14	National Science Foundation of China	73	0.351
15	Australian Research Council	68	0.327
16	Office of Naval Research	65	0.312
16	Program for New Century Excellent Talents in University	65	0.312
17	Ministry of Education Science and Technology	63	0.303
18	EPSRC	62	0.298
18	Natural Science Foundation of China	62	0.298
19	Chinese Academy of Sciences	61	0.293
20	Natural Sciences and Engineering Research Council of Canada	57	0.274

Note: TR- Total record count

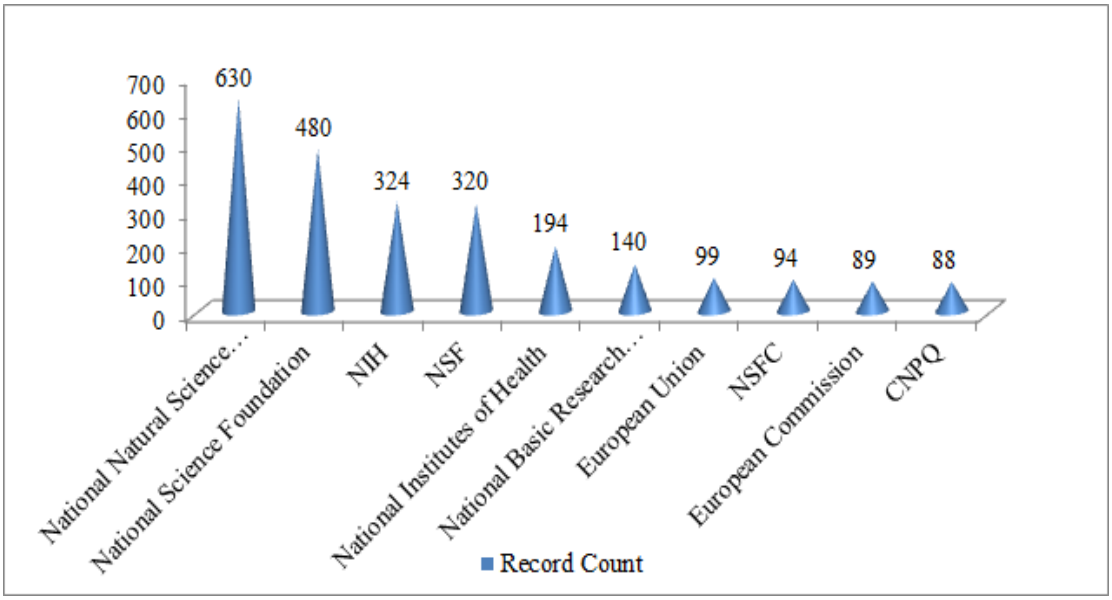


Figure 11: Top Ten Funding Agencies in Nanotechnology research

17. Subject wise distribution in Nanotechnology research

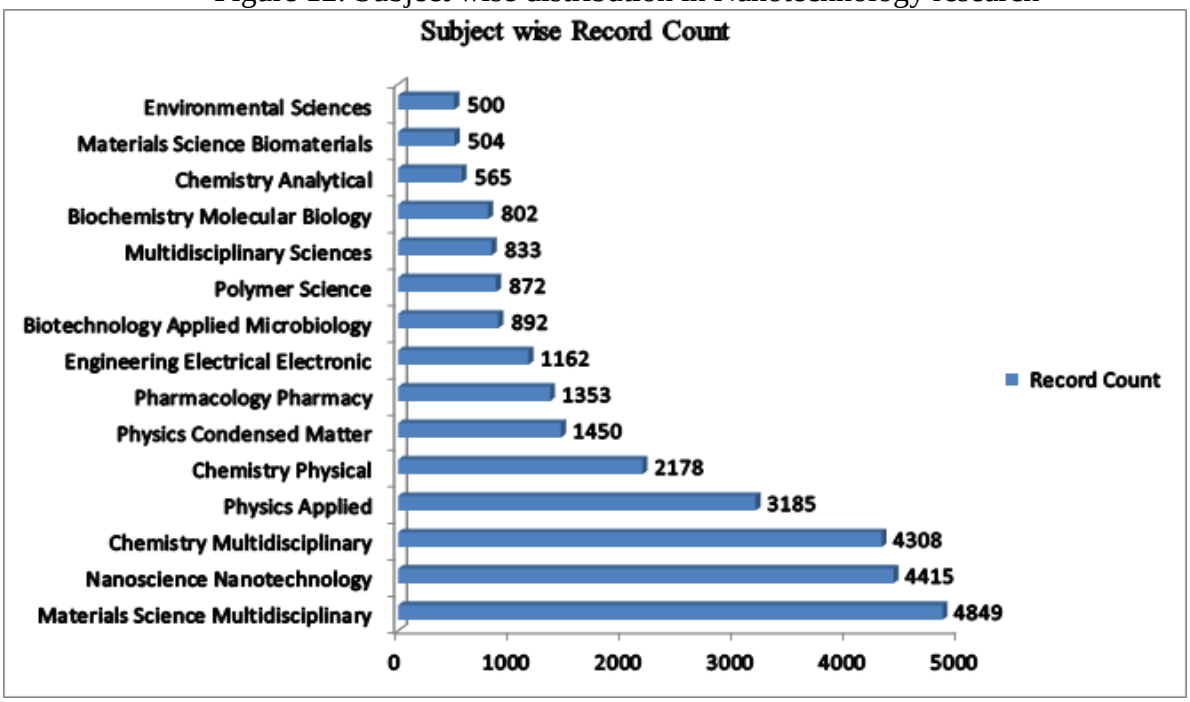
It can be seen from the Table 10 and Figure 12 that the subject based distribution of collaboration in the nanotechnology global wise research. Of the 195 the web of science categories, it is chosen only top 25 subjects and more than 300 most prolific research papers for the analysis. Of the top 25, the most productive subject is 'Materials Science Multidisciplinary' with 4849 (=23.285%) literature outputs and has placed in the first rank and followed by 'Nanoscience Nanotechnology' with 4415 (=21.2%) is in the second position, 'Chemistry Multidisciplinary' has ranked third with 4308 (=20.68%), 'Physics Applied' has occupied fourth place with 3185 (=15.29%) and 'Chemistry Physical' has positioned in the fifth rank with 2178 (=10.46%). The study reflects that the maximum number of (=4849) research papers were published in the domain of Materials Science Multidisciplinary and Nanoscience Nanotechnology is in the second place.

Table 10: Subject wise distribution in Nanotechnology research

Rank	Subject	Record Count	% of 20825
1	Materials Science Multidisciplinary	4849	23.285
2	Nanoscience Nanotechnology	4415	21.200
3	Chemistry Multidisciplinary	4308	20.687
4	Physics Applied	3185	15.294
5	Chemistry Physical	2178	10.459
6	Physics Condensed Matter	1450	6.963
7	Pharmacology Pharmacy	1353	6.497
8	Engineering Electrical Electronic	1162	5.580
9	Biotechnology Applied Microbiology	892	4.283
10	Polymer Science	872	4.187
11	Multidisciplinary Sciences	833	4.000

12	Biochemistry Molecular Biology	802	3.851
13	Chemistry Analytical	565	2.713
14	Materials Science Biomaterials	504	2.420
15	Environmental Sciences	500	2.401
16	Medicine Research Experimental	488	2.343
17	Engineering Chemical	480	2.305
18	Instruments Instrumentation	415	1.993
19	Biochemical Research Methods	410	1.969
20	Engineering Biomedical	400	1.921
21	Physics Multidisciplinary	377	1.810
22	Optics	362	1.738
23	Toxicology	361	1.733
24	Electrochemistry	307	1.474
25	Physics Atomic Molecular Chemical	302	1.450

Figure 12: Subject wise distribution in Nanotechnology research



Findings and Conclusion

Though a number of studies have already done in Nanotechnology, we have tried to evaluate and know the current status of literature output in the nanotechnology world. In this study, we have taken into consideration for analysis of nanotechnology literatures from 1990 to 2014 (data taken on August 2015). Based on the analysis, the results reveal that the most of the documents are in the form of research articles (=65.25%) and the English is the predominant language during the period of study (= 98%). The findings show that the future trends of growth rate of world research publications produced in the field of nanotechnology is in the upward

trend. It reports that there was a fluctuation trend in the publications of nanotechnology globally and the average annual growth rate during the period of study is 49.952 percent and the compound annual growth rate of global-wise Nanotechnology literature output is equal to 30.89%. It is observed from the study that the doubling time of scientific literature outputs of nanotechnology has identified decreasing trend and the relative growth rate has seen increasing trend. The analysis brings out the results that the maximum numbers of outputs of records (34.91 %) were published by USA and placed in the first rank and the next position has got by China (=10.19%) and the Germany is in the third rank (=6.723%). We have finally noted that from the scientometric observations that India is very low position compare with world literature outputs. Hence, Indian researchers have to take severe steps to publish their research papers in the field of nanotechnology and of late more number of researchers and scientists involve in nanotechnology and the researchers hope that the eminent scientists and research scholars will publish more number of scientific publications in the field of nanotechnology all over the world in future.

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