

# Role and Responsibility of BRICS Countries in Air Pollution Control: An Evaluation of Scholarly Communication

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## ABSTRACT

Scientometrics is a method used to analyze and quantify the bibliographic data, offering a powerful set of methods and measures for studying the structure and process of scholarly communication. Cardiovascular disease amounts to about 24.8% of deaths in the SAARC nations. It is significant that the scholarly communication on Air pollution control published by BRICS Countries may be an important chain of knowledge to the world. Air pollution levels remain at dangerously high levels in many parts of the world. New data reveals that 9 out of 10 people breathe air containing high levels of pollutants. However, the BRICS countries are still challenged by different pollutions among them. Air pollution is reported to be top first. The present study examines the research trend, authorship, collaborative pattern and activity index of five BRICS countries. The results of the study reveal that China is a leading country among BRICS nations with major research output followed by India in Air Pollution research. The international collaboration results that USA, England and France are the top collaboration countries for BRICS nations. China and India support other BRICS countries in the cases of Air Pollution research output and proves collaborative within the BRICS domicile. China and India are competing with other developed countries and show higher activity within the context of their individual productivity.

**Key words:** BRICS Countries, Air Pollution, Research Trend, CAGR, Authorship Pattern, Collaboration Study, Activity Index, Collaboration Coefficient, Modified Collaboration Coefficient, Degree of Collaboration.

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## INTRODUCTION

Scientometrics analysis is an evaluative tool by which the state of science and technology can be observed, through the overall production of scientific literature at a given level of specialization. It provides an approach for situating a country concerning the world, an institution with a country and even individual scientists about their peers.

BRIC Countries are called as “Big Four.” An abbreviation, BRICS (means to Brazil, Russia, India, China and later South Africa) was first authored by Jim O’Neil in a paper entitled “Building Better Global Economies BRICs”. It is predicted that BRIC economies will overtake G7 economies in the course of 2027. As ahead of schedule as 2003, Goldman Sachs anticipated that China and India would turn into the first and third biggest economies by 2050 with Brazil and Russia

catching the fifth and 6<sup>th</sup> places. BRIC nations are assumed for much of the raise in science and technology research inputs and scientific publications. From 2002 to 2007, the present expenditure on science research will be multiplied by China, India and Brazil. By 2020, China intends to put 2.5% of GDP in science explore.<sup>[1]</sup>

## Review of Related Literature

A very few studies on the scientific output of business group BRICS countries have been done in the past. A research was carried out on the scientific output of BRIC countries and overseas countries during 1999 – 2007 in the field of limnology. Norbert Walz.<sup>[2]</sup> An analysis was done on the scientific output of BRIC countries during 2004 – 2009 in the field of climate change research.<sup>[3]</sup> A comparative study was made on the research performance between BRIC countries and N-11 countries.<sup>[4]</sup> Another study was performed to measure the scientific output of BRIC countries.<sup>[5]</sup> In addition, scientists did a comparison on the growth trends of BRIC countries in the field of photosynthesis during 1992 – 2010.<sup>[6]</sup> A result has been brought from the above studies that there was a study on tribology research output in BRIC countries has been

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reported.<sup>[7]</sup> The purpose of the present study is to investigate the air pollution and air control research output in BRIC countries reflected in the Web of Science database during 2009–2018. The research activities in BRIC countries are highly accounted in recent years. In Particular, the pollution control research concentration in BRIC countries are found in multiple during the last ten years. Therefore, in the present research paper analysis is made on the air pollution control research output given by BRIC countries from 2009 to 2018. The related analysis data are collected from the WOS online database.

One of the studies identified the research output of the business group countries, known as the BRICS by research papers/articles indexed in Web of Science. A total of 2,552,490 records were retrieved for BRICS, which is 10.67% of the global records for the twenty years' period. Further, they analyzed the annual output of research papers growth trend of the publications, country-wise individual share, collaboration pattern with global countries and amongst/within the BRICS; top-ranked institutions, subject dispersion and top-ranked journals.<sup>[8]</sup>

A study was taken to analyze the pollution control research output in BRIC countries from 2006 to 2015. Two relative indicators are the Absolute Citation Impact (ACI) and Relative Citation Impact (RCI) has been taken up to compare the quality and impact of the Pollution Control Research in BRIC countries. Finally, the highly productive journals on pollution control publications for BRIC countries are identified and ranked.<sup>[9]</sup> The scientometric study corroborates the G8 countries research output with the citation analysis and they imply with the impact on recent researches.<sup>10</sup> (Batcha, 2009). Similar type of study conducted to evaluate the research activity of cardiology scientists of G8 countries which provides the researchers with various concepts, models and techniques that may be applied to any discipline in order to explore its foundations, state, intellectual core and potential future development.<sup>[11]</sup>

### Objectives of the Study

The main objectives of this study are to study the research performance of BRICS countries on Air Pollution during 2009–2018, based on publications output covered in the Web of Science database. The BRICS countries have brought out considerable research output on Air Pollution. The data from the Web of Knowledge are taken for analysis for the present study. In particular, the study focuses on the following objectives:

- To analyze the publication output and CAGR during 2009–2018;

- To identify the authorship pattern adopted in BRICS nations;
- To measure the research activity of BRICS nations on par with the global output;
- To analyze the country-wise collaboration and the impact;
- To examine the collaborative network among other nations and Activity Index.

## MATERIALS AND METHODS

The in applied in the present study is a scientometric analysis of Air pollution research publications on BRICS countries during 2009–2018 from Web of Science presently Web of Knowledge international multidisciplinary indexing and abstracting database. For the present study, the following search strategy has been used in the combined field of Title, Abstract. The study retrieved and downloaded 10-year publication data of the 5 BRICS countries on Air Pollution research from the Web of Science database covering the period 2009–2018. Keywords, such as “Air Pollution” OR “Air Control” was incorporated in the search string and qualified with all the keywords given in the mesh terms were used for searching and the period defined was between 2009 and 2018. Finally, this search string was applied for searching BRICS countries publication data on Air Pollution research. The search string was subsequently refined, using analytical functions and tags in Web of Science database, by “subject area tag”, “country tag”, “source title tag”, “journal title name” and “affiliation tag”, to get data/information on the distribution of publications output by subject, collaborating countries, author-wise, organization-wise and journal-wise, etc.. A total of 20,718 records were retrieved as a research output of 5 BRICS countries. Open source software Bibexcel and Excel were used for tabulation of data. The Air pollution research outputs of all 5 BRICS countries during 2009 – 2018 are taken for analysis.

### Statistical Tools and Methods

#### Compound Annual Growth Rate (CAGR)

$$\text{Engind value}^{1/n - 1} \text{CAGR} = \frac{1}{\text{Beginning value}}$$

Where:

EV: Ending Value

BV: Beginning Value

N: Number of Compounding Periods

### Degree of Collaboration (DC)

Subramanyam propounded the DC, a measure to calculate the proportion of single and multi-author papers and to interpret it as a degree. According to Subramanyam.<sup>[12]</sup>

$$N_m DC = \frac{\text{No. of Multi – authored papers}}{\text{No. of Single + No. of multi – Authored papers}}$$

#### a. Collaboration Co-efficient (CC)

Ajiferuke suggested a single measure to measure collaborative research and termed it as collaborative coefficient.<sup>[13]</sup> The method is based on fractional productivity defined by Price and Beaver 29. The following formula denotes CC. The symbols used have been explained as under:

$$CC = 1 - \frac{\sum kj(1/j).f_j}{N}$$

Where  $f_j$  is the number of  $j$  authored papers;  $N$  is the total number of research papers published and  $k$  is the greatest number of authors per paper According to Ajiferuke,  $CC$  tends to zero as single authored papers dominate and to  $1-1/j$  as  $j$ -authored papers dominate. This implies that higher the value of  $CC$ , higher the probability of papers with multi or mega authors.

#### b. Modified Collaboration Co-efficient (MCC)

Savanur and Srikanth modified the  $CC$  and derived the  $MCC$  as follows;<sup>[14]</sup>

$$MCC = 1 - A \frac{\sum kj(1/j).f_j}{A - 1.N}$$

### Activity Index

Activity Index is identified the relative research attempt of a country in a given field and it defined as;

$$AI = \left\{ \frac{\text{(given field's share in the country's publication output)}}{\text{(given field's proportion in the world's publication output)}} \right\} \times 100$$

In this study, the activity index for BRICS countries have been calculated separately for different years to see how the BRICS countries research activity changed during different years. By using the formula which is first suggested by Frame and used among others by Sehubert and,<sup>[15]</sup> Price,<sup>[16]</sup> Karki and Garg.<sup>[17]</sup> Activity index represent as the related research work of a country in a given field. It counted by the formula as given below:

$$AI = \left\{ \left( \frac{I_i}{I_o} \right) / \left( \frac{W_i}{W_o} \right) \right\} \times 100 \text{ whereas}$$

$I_i$  = A BRICS Country output in the year  $i$

$I_o$  = Total BRICS countries output

$W_i$  = World output in the year  $i$

$W_o$  = Total world output

## FINDINGS AND DISCUSSION

### Year-wise growth of Air Pollution Literature in BRICS Countries

Table 1 represents the year wise growth analysis of 5 BRICS countries. The world research output accounted during the study period was 75,390. Out of which, the total output of 5 BRICS countries retrieved was 20,718. China proves to be a leading country among BRICS nations with major research output about 14,166 (68.38%) followed by India 3164 (15.27%), Brazil 2111 (10.19%), Russia 765 (3.69%) and South Africa 512 (2.47%). The years between 2009 and 2018 the growth rate of China was appreciable and found constant growth. India stands to be the second in air pollution research output showing gradual growth except in the year 2017. Brazil has recorded 10.19 percent of research output among BRICS nations. Russia and South Africa have brought out

**Table 1: Year wise growth analysis of BRICS countries.**

Year	China	%	India	%	Brazil	%	Russia	%	S.Africa	%	BRICS	%
2009	521	3.68	158	4.99	140	6.63	37	4.84	22	4.30	878	4.24
2010	572	4.04	194	6.13	149	7.06	48	6.27	27	5.27	990	4.78
2011	666	4.70	224	7.08	158	7.48	47	6.14	32	6.25	1127	5.44
2012	768	5.42	236	7.46	155	7.34	41	5.36	37	7.23	1237	5.97
2013	985	6.95	271	8.57	161	7.63	52	6.80	45	8.79	1514	7.31
2014	1209	8.53	302	9.54	212	10.04	62	8.10	54	10.55	1839	8.88
2015	1555	10.98	404	12.77	211	10.00	99	12.94	61	11.91	2330	11.25
2016	2072	14.63	450	14.22	286	13.55	120	15.69	61	11.91	2989	14.43
2017	2629	18.56	432	13.65	328	15.54	136	17.78	90	17.58	3615	17.45
2018	3189	22.51	493	15.58	311	14.73	123	16.08	83	16.21	4199	20.27
<b>Total</b>	14166	68.38	3164	15.27	2111	10.19	765	3.69	512	2.47	20718	100
<b>CAGR</b>	<b>0.20</b>	<b>19.86%</b>	<b>0.12</b>	<b>12.05%</b>	<b>0.08</b>	<b>8.31%</b>	<b>0.13</b>	<b>12.76%</b>	<b>0.14</b>	<b>14.20%</b>	<b>0.17</b>	<b>16.94%</b>

less than five percent of publication output on Air pollution. China (19.86) and India (12.05) have shown substantial compound annual growth rate among BRICS nations.

It is observed that the core concentration on Air Pollution is highly recorded by China and more numbers of research activities are carried out by China. India and Brazil are lagging four to five times behind the research activities compared to China. Russia and South Africa have not given much importance in the Air pollution research. The Compound Growth Rate has shown a set back at the middle of the years and it is in increasing status at the recent years of study. The trend line Exponential growth shows the steep development by three countries. Figure 1

### Analysis of Activity Index of BRICS Countries

To measure the relevant research of BRICS countries in Air Pollution a detailed account of activity index has been presented in Table 2. The world output is showing an increasing trend. The Activity index of BRICS records more than hundred percentages reflecting above activity only from the years 2016 onwards. While analyzing individual BRICS

countries, China has recorded more than hundred percentages appreciable research output activity during the study period 2009 to 2015. India has recorded higher activity from 2009 to 2015 and thereafter in recent years it has shown decreasing activity.

The other three BRICS countries have accounted gradual activity on par with BRICS research output on Air Pollution. In the case of the Activity Index of BRICS in comparison with the global output shows an increasing trend from 2015 onwards. The recent three years BRICS countries take major part in global research output on Air pollution and it is estimated as above activity. The linear forecasted trend line shows steep growth. Figure 2

### Analysis of Authorship Pattern and Collaboration Coefficient of BRICS Countries

The analysis is carried out to find out the collaboration coefficient, Modified collaboration coefficient and Degree of Collaboration of the literature published by BRICS countries. Table 3 shows CC, MCC and DC of BRICS nations. Collaboration coefficient has been counted by the formula

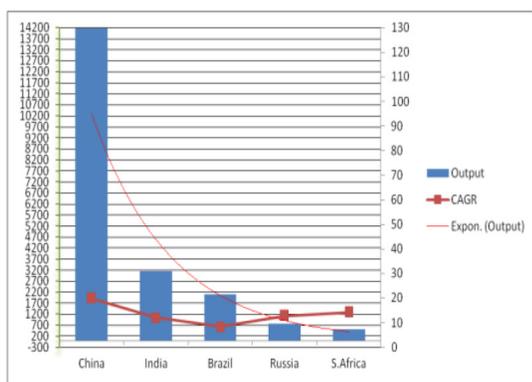


Figure 1: CAGR and Exponential Trend line Growth analysis of BRICS countries.

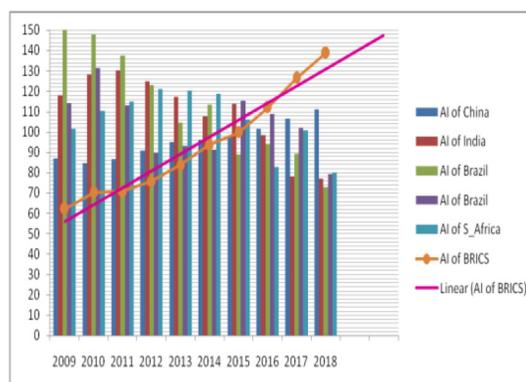


Figure 2: Activity Index of BRICS countries.

Table 2: Year Wise Activity Index of BRICS countries.

Year	AI of China	AI of India	AI of Brazil	AI of Russia	AI of S. Africa	World Output	BRICS Output	Share of BRICS	AI of BRICS
2009	86.78	117.83	156.49	114.13	101.39	5141	878	17.08	62.15
2010	84.50	128.32	147.71	131.31	110.36	5127	990	19.31	70.26
2011	86.43	130.15	137.59	112.94	114.90	5799	1127	19.43	70.72
2012	90.80	124.93	122.98	89.76	121.03	5947	1237	20.80	75.69
2013	95.15	117.21	104.37	93.02	120.27	6576	1514	23.02	83.78
2014	96.15	107.53	113.14	91.31	118.82	7144	1839	25.74	93.67
2015	97.61	113.54	88.88	115.07	105.94	8509	2330	27.38	99.64
2016	101.38	98.58	93.91	108.73	82.58	9722	2989	30.74	111.88
2017	106.36	78.25	89.05	101.89	100.74	10400	3615	34.76	126.49
2018	111.07	76.88	72.69	79.33	79.99	11025	4199	38.09	138.59
Overall %	95.62	109.32	112.68	103.75	105.60	75390	20718	27.48	93.29

**Table 3: Year Wise Collaboration Coefficient Analysis of BRICS.**

Year	Single Author	Double Authors	Three Authors	Four Authors	Mega Authors	Total	CC	MCC	DC
2009	19	117	165	141	436	878	0.73	0.73	0.98
2010	21	109	153	192	515	990	0.74	0.74	0.98
2011	33	125	195	188	586	1127	0.74	0.74	0.97
2012	23	138	177	232	666	1236	0.75	0.75	0.98
2013	24	131	199	279	881	1514	0.76	0.76	0.98
2014	29	186	241	310	1073	1839	0.76	0.76	0.98
2015	40	232	338	366	1354	2330	0.76	0.76	0.98
2016	77	275	396	455	1786	2989	0.76	0.76	0.97
2017	61	295	495	513	2251	3615	0.77	0.77	0.98
2018	56	340	504	596	2704	4200	0.78	0.78	0.99
<b>Grand Total</b>	<b>383</b>	<b>1948</b>	<b>2863</b>	<b>3272</b>	<b>12252</b>	<b>20718</b>	<b>0.76</b>	<b>0.76</b>	<b>0.98</b>

**Table 4: Total Publication Vs Total Authorship among BRICS.**

AS	China				India				Brazil				Russia				South Africa			
	TP	%	TAS	%	TP	%	TAS	%	TP	%	TAS	%	TP	%	TAS	%	TP	%	TAS	%
1	151	1.07	151	0.18	118	3.73	118	0.89	21	0.99	21	0.18	66	8.63	66	1.72	27	5.27	27	1.1
2	897	6.33	1794	2.16	702	22.19	1404	10.65	162	7.67	324	2.85	101	13.20	202	5.25	86	16.80	172	7.0
3	1602	11.31	4806	5.78	728	23.01	2184	16.56	315	14.92	945	8.32	113	14.77	339	8.82	105	20.51	315	12.8
4	2139	15.10	8556	10.29	572	18.08	2288	17.35	367	17.39	1468	12.93	109	14.25	436	11.34	85	16.60	340	13.8
5	2176	15.36	10880	13.08	343	10.84	1715	13.01	378	17.91	1890	16.64	94	12.29	470	12.22	41	8.01	205	8.3
6	1944	13.72	11664	14.02	221	6.98	1326	10.06	297	14.07	1782	15.69	71	9.28	426	11.08	36	7.03	216	8.8
7	1445	10.20	10115	12.16	143	4.52	1001	7.59	157	7.44	1099	9.68	38	4.97	266	6.92	27	5.27	189	7.7
8	1092	7.71	8736	10.50	80	2.53	640	4.85	117	5.54	936	8.24	34	4.44	272	7.07	19	3.71	152	6.2
9	728	5.14	6552	7.88	59	1.86	531	4.03	80	3.79	720	6.34	22	2.88	198	5.15	8	1.56	72	2.9
10	1992	14.06	19920	23.95	198	6.26	1980	15.01	217	10.28	2170	19.11	117	15.29	1170	30.43	78	15.23	780	31.6
G.T	14166	100	83174	100	3164	100	13187	100	2111	100	11355	100	765	100	3845	100	512	100.00	2468	100

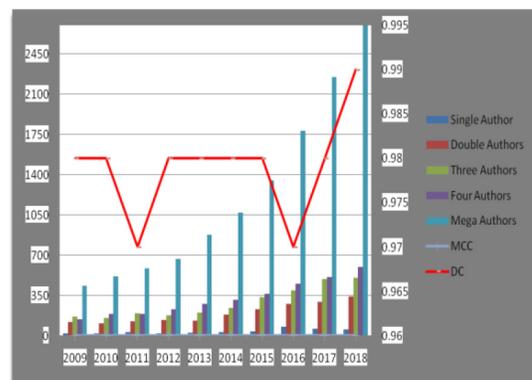
AS- Authorship; TP- Total Publication; TAS- Total Authorship

which is given in Statistical tools and Method sub parts. In Figure 3 Collaboration Pattern indicates that Single-author papers are less compared to multi authored papers. Further it is noted that mega-author papers are high followed by three and four authors' papers. The average CC and MCC of BRICS is 0.76 and DC is 0.98. The highest CC and MCC of 0.78 is observed in 2018 and lowest 0.73 in 2009. The Degree of Collaboration is maintained by 0.97. and 0.98.

**Mega Authors** (Papers with 5 and above, CC - collaboration coefficient, MCC – Modified collaboration coefficient, DC- Degree of Collaboration

**Analysis of Authorship Pattern and Collaboration Coefficient of BRICS Countries**

The authorship pattern along with total authors is counted separately for five BRICS countries. Table 4 Shows that China has published three-fold numbers of articles comparing the other nations of BRICS. The single author publications are just 1.07 percentages whereas the multi authored publications are accounted about 98 percentages. The total authors



**Figure 3:** Collaboration coefficient Analysis of BRICS.

involved in the research output of China are amounted to 83,174 and among them four and five authorships are found a highly preferred group. India is placed second in publishing the next higher number of Air Pollution research publications.

As the collaborative research activities are highly found in all the BRICS countries, India is no exception. Yet two and three authored publications are highly found in India. The total

Indian scientists involved in air pollution research are about 13,187. Brazil stands to be the third in rank publishing air pollution research output. Brazil highly prefers four and five authors' collaboration and the total scientists involved in air pollution research are about 11,355 during the study period. Russia and South Africa have published 765 and 512 publications respectively. The total authors are calculated to 3845 and 2468 and they also prefer the collaborative research.

**International Collaboration Network of BRICS countries**

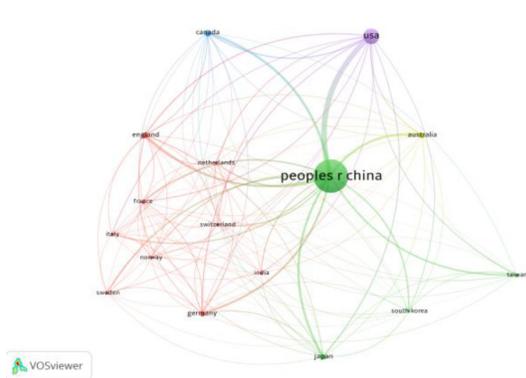
Table 5 explains the top 15 international collaboration countries of BRICS nations. Having analyzed the collaboration data,

USA stands to be top among all other nations and proves to be the first international collaborative country to BRICS nations. England ranks to the second in collaborating India, Brazil and South Africa. Canada is in the second rank order at the network of China. Russia gets France support in publication as the second preferred nation. It is noted that China is one of the top collaborative countries among the BRICS nations except Russia. India seems to be the next collaborative nation of China and South Africa within BRICS. The Network of BRICS nations are given below using VOS viewer. Every BRICS country has a minimum of three network countries which are grouped in the network mapping Figure 4-8.

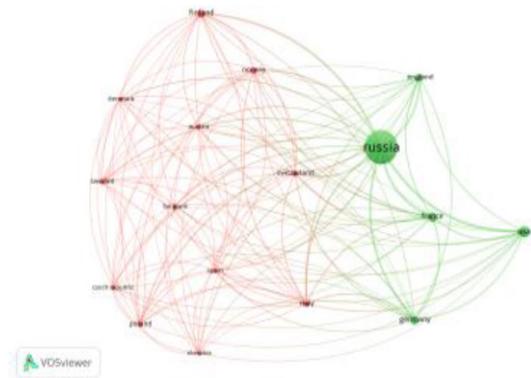
**Table 5: Collaboration Network of Air Pollution publications by BRICS Nations.**

Rank	China			India			Brazil			Russia			South Africa		
	Coll_Country	TP	TC	Coll_Country	TP	TC	Coll_Country	TP	TC	Coll_Country	TP	TC	Coll_Country	TP	TC
	USA	3045	59657	USA	405	8614	USA	215	4358	USA	84	2295	USA	94	3886
	Canada	511	10480	England	146	4921	England	74	2235	France	64	1669	England	55	2879
	Australia	499	8892	China	84	2446	France	69	1758	Germany	56	1661	Finland	40	970
	England	468	12877	Japan	75	2112	Spain	64	1194	Finland	46	897	Germany	40	1274
	Japan	434	9772	Germany	73	1859	Italy	63	1677	England	36	2089	Nigeria	34	207
	Germany	365	10797	Canada	64	1988	Germany	58	1372	Norway	33	884	Belgium	30	674
	Taiwan	223	3734	South Korea	56	508	Portugal	56	592	Italy	29	1109	China	28	2135
	France	187	6722	Australia	49	2145	Canada	48	1454	Switzerland	27	1000	India	27	850
	Netherlands	162	4919	Sweden	39	1522	Australia	41	1517	Poland	21	1049	Netherlands	24	922
	South Korea	148	2075	France	37	1473	Netherlands	32	1095	Sweden	19	480	Sweden	24	694
	Sweden	131	2805	Italy	36	1190	Colombia	31	393	Austria	17	605	France	23	2611
	Italy	115	5943	Switzerland	33	1086	Mexico	30	719	Spain	17	406	Italy	23	2672
	Switzerland	111	5463	South Africa	27	850	Argentina	28	549	Czech Republic	16	302	Canada	22	2112
	India	84	2394	Netherlands	24	1003	China	28	691	Belgium	15	258	Australia	21	597
	Norway	81	4623	Norway	24	880	Sweden	26	675	Slovakia	12	185	Switzerland	20	2505

Coll – Collaborative Country; TP – Total Publication; TC – Total Citation



**Figure 4: China's Coll. Net.**



**Figure 5: Russia's Coll. Net.**

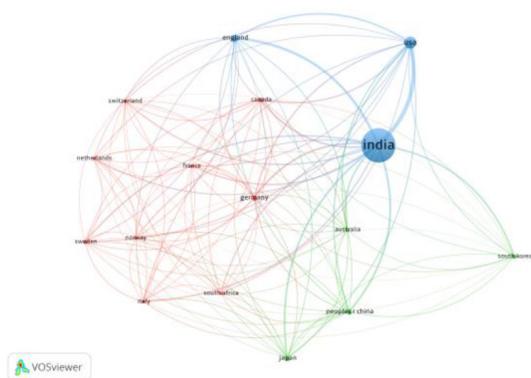


Figure 6: India's Coll. Net.

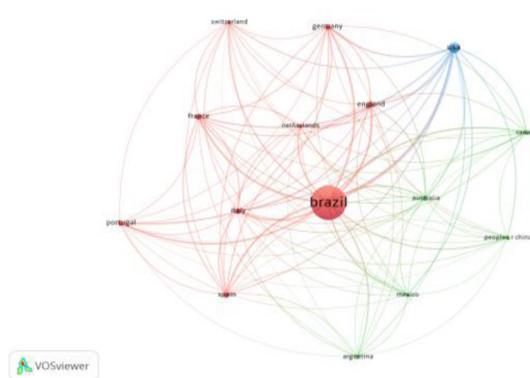


Figure 8: Brazil's Coll. Net.

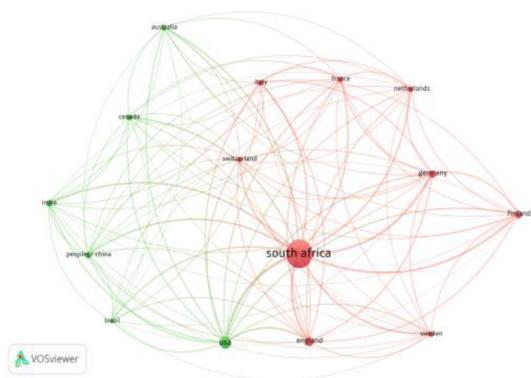


Figure 7: South Africa's Coll. Net.

## CONCLUSION

The inference shows that China proves to be a leading country among BRICS nations with major research output about 14,166 (63.38%) followed by India 3164 (15.27%) in air pollution research. China has published three-fold numbers of air pollution research articles comparing the other nations of BRICS. Authorship Pattern indicates that Single-author papers are less compared to multi-authored papers. The multi-author publication pattern is more dominated than single authorship. The Degree of Collaboration is maintained by 0.97. The total authors involved in the research output of China amount to 83,174 and among them four and five authorships are found a highly preferred group. India is placed second in publishing the next higher number of Air Pollution research publications. The collaborative research activities are highly found in all the BRICS countries, In the case of activity index, the Activity index of BRICS records more than a hundred percentages, reflecting above activity only from the years 2016 onwards. BRICS countries such as Brazil, Russia and South Africa have accounted for gradual activity on par with BRICS research output on Air Pollution. In the case of the Activity Index of BRICS in comparison with the global output shows an increasing trend from 2015 onwards. The international collaboration results that USA stands to be top among all other

nations and proves to be the first international collaborative country to BRICS nations. England ranks to the second in collaborating India, Brazil and South Africa. Canada is in the second rank order at the network of China. Russia gets France support in the publication as the second preferred nation. It is noted that China is one of the top collaborative countries among the BRICS nations except Russia. India seems to be the next collaborative nation of China and South Africa within BRICS. The results deduce that BRICS countries play a major role in air pollution control research at a global level and it is estimated that BRICS countries share 27.48 percentages of world output. Yet except China, the other four BRICS nations such as India, Brazil, Russia and South Africa should concentrate more on air pollution research output on par with the output of China. It is predicted that BRICS countries will prove a research hub in the global research output.

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## CONFLICT OF INTEREST

The author declare no conflict of interest.

## REFERENCES

1. <http://en.wikipedia.org/wiki/BRIC>. 2012.
2. Norbert W. Publications of BRIC and Outreach countries in International Journals on Limnology. *International Review of Hydrobiology*. 2010;95(4-5):298-312.
3. Alex P, Preedip BB. Mapping Climate Change Research in India: A Bibliometric Approach. Paper Presented at the Sixth International Conference on Webometrics, Informetrics and Scientometrics and Eleventh COLLNET Meeting Mysore. 2010
4. Rons N. Research Excellence Milestones of BRIC and N-11 countries. In: Proceedings of ISSI 2011, 13<sup>th</sup> Conference of the International Society for Scientometrics and Informetrics, Durban, South Africa. 2011;2:1049-51.
5. Kumar N, Asheulova N. Comparative analysis of scientific output of BRIC countries. *Annals of Library and Information Studies*. 2011;58(3):228-36.
6. Yu JJ, Wang MH, Xu M, Ho YS. A bibliometric analysis of research papers published on Photosynthesis: 1992-2009. *Photosynthetica*. 2012;50(1):5-14.
7. Elango B, Rajendra P, Manickraj J. Digital Commons @ University of Nebraska-Lincoln Tribology 1. Research Output in BRIC Countries: A Scientometric Dimension. *Library Philosophy and Practice*. 2013;935.
8. Singh M, Hasan N. Trend in research output and collaboration pattern among BRICS countries: A scientometric study. In 2015 4<sup>th</sup> International Symposium on Emerging Trends and Technologies in Libraries and Information Services.

- 2015;217-21. IEEE. <https://doi.org/10.1109/ETLLIS.2015.7048201>
9. Vivekanandhan S, Sivasamy K. Pollution Control Research Output in BRIC Countries during 2006-2015 from SCOPUS Database: A Scientometric Analysis. *International Journal of Next Generation Library and Technologies*. 2017;3(2).
  10. Sadik BMMA. Publication Trend in an Indian Journal and a Pakistan Journal: A Comparative Analysis using Scientometric Approach. *Journal of Advances in Library and Information Science*. 2017;6(4):442-9. Retrieved from <http://www.albayan.ae>
  11. Sadik BM, Baskaran C. Indian Journal of Information Science and Services. *Indian Journal of Information Science and Services*. 2007;1(1):1-5.
  12. Subramanyam K. Bibliometric studies of research collaboration: a Review. *Journal of Information Science*. 1983;6(1):33-8.
  13. Ajiferuke I, Burell Q, Tague J. Collaborative coefficient: a single measure of the degree of collaboration in research. *Scientometrics*. 1988;14(5-6):421-33.
  14. Savanur K, Srikanth R. Modified collaborative coefficient: a new measure for quantifying the degree of research collaboration. *Scientometrics*. 2010;84(2):365-71.
  15. Schubert A, Braun T. Relative indicators and relational charts for comparative assessment of publication output and citation impact. *Scientometrics*. 1986;9(5-6):281-91.
  16. DePrice DS. The analysis of scientometrics for policy implications. *Scientometrics*. 1981;3(1):47-54.
  17. Karki MMS, Garg KC. Bibliometrics of Alkaloid Chemistry research in India. *Journal of Chemical Information and Computer Science*. 1997;37(2):157-61.