

## A Comparative Study of Authorship and Collaboration Pattern of Four SAARC Countries in Biotechnology Research

**Manendra Kumar Singh**

Senior Research Fellow  
Department of Library & Information Science  
Banaras Hindu University  
Varanasi, Uttar Pradesh-221005

**Dr. Kunwar Singh**

Assistant Professor  
Department of Library & Information Science  
Banaras Hindu University  
Varanasi, Uttar Pradesh-221005  
Email: manebhu007@gmail.com

**Abstract** - *The study presents the trends in authorship pattern and author collaborative in the Biotechnology research field with the sample of 18119 articles which collected from Scopus database for the year 2007 to 2016. The search string used for data download is same for all country and all data downloaded for each country. The three scientometric tools; Collaboration Coefficient, Authorship pattern and Activity Index have been used for the data analysis. The multi- authorship articles are greater than single authorship. The study found that the researchers in Biotechnology move towards team research or group research rather than solo research. The average Activity Index of four SAARC countries for ten years' time span is highest for India and lowest counted for Sri Lanka followed by Pakistan and Bangladesh at the 3<sup>rd</sup> and 4<sup>th</sup> place. The international collaboration shows that the United States has taken the top position for India and Sri Lanka, another hand China important for Pakistan and Bangladesh contributed with Japan.*

**Keywords:** *Scientometric Analysis, SAARC, Collaboration Coefficients (CC), Authorship Pattern (AP), Biotechnology, Activity index (AI).*

### Introduction

The study explores the scientific relationship among four SAARC<sup>1</sup> (South Asian Association for Regional Cooperation) countries: India, Pakistan, Bangladesh and Sri Lanka. The biotechnology is the most researchable area now in the world. It has the strength to fill the large population needs and demands in coming future by which SAARC countries has been suffering from decades. Global Warming creates the cause of decline productivity of agriculture in all over the world. India and its adjacent countries agricultural systems are primarily depend on rainfall, which is regularly affected by the global warming. These countries have cumulated 1.71 billion populations which are largest in the world. They are also suffering in poverty, low income, water crisis, decreasing fertility of land and lower production of agriculture with global warming effect that will create the hazard in future. For securing future, it is necessary to enhance cooperation in the field of science and technology mainly biotechnology, because it has a capacity to reduce the future livelihood problem of these nations.

Scientometrics is a 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. This study reveals the pattern of SAARC countries which is compared to know the author contribution pattern. The activity index counted individually of SAARC countries, but it shows the status of biotechnology research against world data. Year wise publication distribution growth rate enumerate the individual country research in the particular year. The collaboration coefficient tool used to evaluate the measurement of single and multi-author collaborative research pattern. The number of authorship pattern is an interesting part of any bibliometric study. By these scientometric tools, we able to present the current status as well as the future aspect of biotechnology research within the vicinity of SAARC countries. Every SAARC countries need to increase their agricultural production to serve the food for all but how it possible, either by individual, or collaborative research activity, so that we conduct the scientometric study and try to reveal the objectives.

### **Review of Literature**

O'Neill (1998)<sup>2</sup> scrutinized the authorship pattern in two theory based journals; one is from American journal Educational Theory (1955-1994) and another from Canadian journal, Journal of Educational Thought (1970-1974). The author found that majority of authorships were single in both the journals regardless of the date of publication against de Solla Price's prediction that co-authorship would eventually increase and single-author paper will be extinct.

Gupta, *et al.* (2002)<sup>3</sup> examined Indian scientific research collaboration with South Asian countries and set a finding that India has vital collaborative link exist with Bangladesh rather than Pakistan, Sri Lanka, and Nepal. Sevukan & Sharma (2008)<sup>4</sup> studied the biotechnology research work contribution of pre-defined central universities of India during 1997-2006. They have found the growth pattern of literature in biotechnology has consistently added by 15 articles in the year 1997 to 43 articles in 2006. The BHU identified as leading university that contributed 42.55 %, and there was a trend exists about collaborative research that two-authored papers dominated on three-authored papers. Gopikuttan & Aswathy (2014)<sup>5</sup> studied Year-Wise, form-wise, subject-wise classification of published articles. The study shows a maximum number of prolific authors and preferred journals of University of Kerala for the period of 13 years that was 2000 to 2012.

Biradar (2006)<sup>6</sup> studied for years 1994, 1999, and 2004 revealed that an average number of references per article during 1994, 1999 and 2004 were 10.6, 11.0 and 13.2 respectively. Out of 370 articles, two authored articles were 144 (38.9 %) followed by three authored articles 96 (25.9 %) and single authored articles 57 (15.4 %). Organization-wise contributions indicate that universities were major contributors with 31.6 % followed by colleges with 24 % and research institutions with 23.7 %.

Singh (2014)<sup>7</sup> examined the *Indian Journal of Pure and Applied Physics* out of 657 articles during 2006 to 2010 revealed that highest number of 144 articles were published in 2007, followed by 143 articles in 2006 and 131 articles in 2008. Authorship pattern indicates that 174 were two-authored per articles, 162 by three-authored per articles, and 145 four authored per articles. The Institution-wise contributions showed that Council of Scientific and Industrial Research CSIR hold first ranked with 54 articles and IIT with 50 articles. Out of total 1229 citations, articles published in 2007 received the highest number of 291 citations,

followed by 282 citations in 2006. The study shows the most prolific author was R. Kumar who topped by 21 papers and second one A. Kumar with 20 articles.

Verma & Singh (2017)<sup>8</sup> observed the authorship pattern and degree of collaborative in Journal of Librarianship and Information Science (JOLIS) with a sample of 255 articles during 2010-2016. The findings revealed that the degree of collaboration during the seven years (2010-2016) is 0.83 to 0.77. It was concluded that in the seven years of period, the multi-authorship articles has dominated the sole authorship. In another similar study, Singh & Varma (2017)<sup>9</sup> studied and reveals that 540 authors have contributed 274 papers. The finding of the study shows that multi-authored papers with 71.53% of contributions have dominated this field of research. Therefore, it is revealed that collaborative research has dominated in the IRJLIS out of 274 two-authored papers during the period 2011-2016, 133(48.50%), followed by three-authored papers 49(17.88%), four-authored paper 8(2.92%) and five-authored paper 6(2.19%). Price (1963)<sup>10</sup> was considered first-time authorship pattern and opined that multi-authored papers are gradually increasing with a simultaneous reduction in single-authored papers.

### **Objective of Study**

- To know year wise comparative publication distribution of literature.
- To measure the collaborative coefficient ratio of the India and neighbour country.
- To find out nature of authorship pattern in biotechnology research.
- To measure an Activity Index of the individual country.

### **Scope and Limitation**

The study covers a ten year period between 2007 and 2016; both years accounted inclusively. Records during the term of study have been downloaded exclusively from SCOPUS online database. The generalisation of study based on the downloaded data pertained to the ten years period. Nations which fall under 'SAARC countries' during period and coverage of study have alone taken into purview as the standard geographical entity for this research investigation. Any later proposal for the inclusion or exclusion of/from this SAARC group and possible change of nomenclature after 2016 will not considered for this study. There are 18119 data are related to our study have been used.

### **Data and Methodology**

An international online bibliographic database namely SCOPUS has been taken up for the study. Scopus covers nearly 22,000 titles from over 5,000 publishers, of which 20,000 are peer reviewed journals in the scientific, technical, medical, and social sciences (including arts and humanities).<sup>11</sup> It is owned by Elsevier and is available online by subscription. Searches in Scopus also incorporate searches of patent databases.

The following search string (Biotechnology OR biomedicine OR bioremediation OR biosynthesis OR bioinformatics OR bioengineering OR biogenetics OR biomedicine OR cell biology OR biofuels) has been adopted for the extract the record. There exist 18917 records in Scopus database from 2001 to 2016 in Biotechnology. These files have full bibliographical details such as Title, Authors, Source, Year, Abstract, Affiliation, Language, Document Type, etc. The data extracted from the database further processed and analyzed using Microsoft Excel software. The data were administrated by the scientometrics tools and techniques to ascertain the fulfilment of objectives and its measurement methods.

**Collaborative Coefficient (CC)** Ajiferuke (1988) has proposed the measure of Collaborative Coefficient Ajiferuke. It based on fractional productivity that is covered by Price and Beaver<sup>12</sup>. Following formula gives it: Here,

$$CC = 1 - \frac{\sum_{j=1}^k \left(\frac{1}{j}\right) f_j}{N}$$

$f_j$  denotes the number of  $j$  authored research papers;  
 $N$  indicates a total number of research articles published,  
and  $k$  is the greatest number of authors per paper.

According to Ajiferuke (1988)<sup>13</sup>, “CC tends to zero as single-authored papers dominate and to  $1-1/j$  as  $j$ -authored papers dominate”. It implies that higher the value of CC, higher the probability of multi or mega authored articles.

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

AI= {(given field's share in the country's publication output) / (given field's proportion in the world's publication output)} x 100

In this study activity index for four SAARC countries have been calculated separately for different years to see how the SAARC countries research activity changed during different years. By using the formula which is first suggested by Frame and used among others by Sehubert and Braun (1986)<sup>14</sup>, Price (1981)<sup>15</sup>, Karki and Garg (1997).<sup>16</sup> Activity index represent as the related research work of a country in a given field. It counted by the formula which given below:

AI = { (  $I_i / I_o$  ) / (  $W_i / W_o$  ) } x 100 whereas

$I_i$  = Indian output in the year  $i$

$I_o$  = Total Indian output

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

$W_o$  = Total output The method used for calculating AI has been explained below for research output by different nations in different blocks.

## Analysis and Result

### Year wise growth rate of literature

The table1 shows the year wise growth rate of India, Pakistan, Bangladesh, and Sri Lanka. India has shared 89.07% of total publication within 2007-2016 period, where Pakistan 7.97%, Bangladesh 2.22% and Sri Lanka contributed only 0.74% paper. The all four countries showed the linear growth rate in biotechnology research. In 2015, India, Pakistan, Bangladesh and Sri Lanka achieved higher growth rate with 15.44%, 17.66%, 17.38%, and 17.21% respectively. In the year 2014 India shares 13.82% publications of all countries.

**Table No.1 Year wise distribution of publication**

| India |         |            | Pakistan |            | Bangladesh |            | Srilanka |            |
|-------|---------|------------|----------|------------|------------|------------|----------|------------|
| Year  | Article | Percentage | Article  | Percentage | Article    | Percentage | Article  | Percentage |
| 2016  | 2034    | 12.55      | 207      | 14.74      | 39         | 9.82       | 10       | 8.19       |
| 2015  | 2503    | 15.44      | 248      | 17.66      | 72         | 17.38      | 21       | 17.21      |
| 2014  | 2515    | 15.51      | 236      | 16.80      | 67         | 16.62      | 20       | 16.39      |
| 2013  | 2020    | 12.46      | 184      | 13.10      | 37         | 9.31       | 18       | 14.75      |
| 2012  | 1728    | 10.66      | 134      | 9.54       | 53         | 11.83      | 19       | 15.57      |
| 2011  | 1509    | 9.27       | 127      | 9.04       | 27         | 6.04       | 9        | 7.37       |
| 2010  | 1272    | 7.84       | 84       | 5.98       | 34         | 7.55       | 5        | 4.09       |
| 2009  | 1010    | 6.23       | 72       | 5.12       | 23         | 6.29       | 7        | 5.73       |
| 2008  | 900     | 5.55       | 57       | 4.05       | 16         | 4.03       | 5        | 4.09       |
| 2007  | 715     | 4.41       | 55       | 3.91       | 19         | 4.78       | 8        | 8.18       |
| TOTAL | 16206   | 100        | 1404     | 100        | 387        | 100        | 122      | 100        |

### Collaboration Coefficient

Collaboration coefficient has been counted by the formula which is given in data and methodology subpart 5.1. In Table 2 India's author collaboration indicates that two-author paper and three author papers have less difference and mega-author paper dominated with 5090 article. The average CC of India is 0.63, highest 0.65 in 2014 and lowest 0.34 in years 2016. Pakistan average CC 0.67 is greater in four countries that shown in table3. The four author paper collaboration with 283 publication is higher than single and double author paper. The higher 0.70 CC has collected by Pakistan in the year 2015. The Bangladesh trend indicates that three author paper dominates on the single and two author collaboration. The average CC of Bangladesh 0.66 and 0.71 is highest in 2014. The Sri Lankan four author collaboration dominated on single and double collaboration and its average CC is 0.63 equal to India and highest 0.72 come in the year 2009.

**Table No.2 India Collaboration Coefficient**

| Year  | Single Authored Paper | Two-Authored Paper | Three Authored Paper | Four Author Paper | Mega-Authored Paper | Total | Collaboration Coefficient (CC) |
|-------|-----------------------|--------------------|----------------------|-------------------|---------------------|-------|--------------------------------|
| 2016  | 153                   | 425                | 413                  | 304               | 739                 | 2034  | 0.34                           |
| 2015  | 178                   | 525                | 505                  | 396               | 899                 | 2503  | 0.64                           |
| 2014  | 151                   | 506                | 559                  | 447               | 852                 | 2515  | 0.65                           |
| 2013  | 133                   | 452                | 409                  | 380               | 646                 | 2020  | 0.64                           |
| 2012  | 133                   | 360                | 391                  | 310               | 534                 | 1728  | 0.63                           |
| 2011  | 121                   | 341                | 352                  | 269               | 426                 | 1509  | 0.62                           |
| 2010  | 120                   | 286                | 271                  | 232               | 363                 | 1272  | 0.61                           |
| 2009  | 98                    | 239                | 256                  | 164               | 253                 | 1010  | 0.60                           |
| 2008  | 79                    | 222                | 193                  | 182               | 224                 | 900   | 0.61                           |
| 2007  | 86                    | 175                | 178                  | 122               | 154                 | 715   | 0.58                           |
| Total | 1252                  | 3531               | 3527                 | 2806              | 5090                | 16206 | 0.63                           |

**Note-** Mega-authors (paper with >4 authors)

**Table No.3 Pakistan Collaboration Coefficient**

| Year  | Single Authored Paper | Two-Authored Paper | Three Authored Paper | Four Author Paper | Mega-Authored Paper | Total | Collaboration Coefficient (CC) |
|-------|-----------------------|--------------------|----------------------|-------------------|---------------------|-------|--------------------------------|
| 2016  | 18                    | 16                 | 24                   | 36                | 127                 | 221   | 0.69                           |
| 2015  | 13                    | 24                 | 41                   | 48                | 131                 | 257   | 0.70                           |
| 2014  | 14                    | 18                 | 46                   | 45                | 123                 | 246   | 0.69                           |
| 2013  | 10                    | 25                 | 37                   | 32                | 84                  | 188   | 0.68                           |
| 2012  | 11                    | 24                 | 24                   | 30                | 56                  | 135   | 0.65                           |
| 2011  | 7                     | 13                 | 23                   | 29                | 56                  | 118   | 0.69                           |
| 2010  | 5                     | 9                  | 18                   | 22                | 34                  | 78    | 0.68                           |
| 2009  | 8                     | 12                 | 15                   | 18                | 23                  | 66    | 0.63                           |
| 2008  | 2                     | 6                  | 18                   | 12                | 20                  | 51    | 0.68                           |
| 2007  | 9                     | 6                  | 14                   | 11                | 14                  | 44    | 0.58                           |
| Total | 97                    | 153                | 260                  | 283               | 668                 | 1404  | 0.67                           |

**Note-** Mega-authors (paper with >4 authors)

**Table No.4 Bangladesh Collaboration Coefficient**

| Year  | Single Authored Paper | Two-Authored Paper | Three Authored Paper | Four Author Paper | Mega-Authored Paper | Total | Collaboration Coefficient (CC) |
|-------|-----------------------|--------------------|----------------------|-------------------|---------------------|-------|--------------------------------|
| 2016  | 3                     | 2                  | 9                    | 9                 | 24                  | 47    | 0.70                           |
| 2015  | 5                     | 4                  | 12                   | 11                | 4                   | 36    | 0.69                           |
| 2014  | 2                     | 2                  | 17                   | 11                | 34                  | 66    | 0.71                           |
| 2013  | 4                     | 8                  | 5                    | 6                 | 30                  | 53    | 0.69                           |
| 2012  | 6                     | 4                  | 10                   | 7                 | 19                  | 46    | 0.62                           |
| 2011  | 0                     | 4                  | 4                    | 6                 | 10                  | 24    | 0.71                           |
| 2010  | 1                     | 5                  | 11                   | 3                 | 12                  | 32    | 0.68                           |
| 2009  | 1                     | 3                  | 4                    | 4                 | 11                  | 25    | 0.67                           |
| 2008  | 0                     | 4                  | 1                    | 3                 | 9                   | 19    | 0.72                           |
| 2007  | 3                     | 4                  | 4                    | 2                 | 6                   | 19    | 0.57                           |
| Total | 27                    | 40                 | 77                   | 62                | 150                 | 387   | 0.66                           |

**Note-** Mega-authors (paper with >4 authors)

**Table No.5 Sri Lanka Collaboration Coefficient**

| Year  | Single Authored Paper | Two-Authored Paper | Three Authored Paper | Four Author Paper | Mega-Authored Paper | Total | Collaboration Coefficient (CC) |
|-------|-----------------------|--------------------|----------------------|-------------------|---------------------|-------|--------------------------------|
| 2016  | 1                     | 0                  | 2                    | 5                 | 2                   | 10    | 0.66                           |
| 2015  | 2                     | 3                  | 4                    | 3                 | 8                   | 21    | 0.64                           |
| 2014  | 1                     | 1                  | 4                    | 3                 | 10                  | 19    | 0.70                           |
| 2013  | 1                     | 1                  | 6                    | 3                 | 7                   | 19    | 0.68                           |
| 2012  | 6                     | 2                  | 5                    | 5                 | 2                   | 21    | 0.48                           |
| 2011  | 1                     | 2                  | 0                    | 2                 | 4                   | 9     | 0.63                           |
| 2010  | 1                     | 1                  | 1                    | 1                 | 1                   | 5     | 0.54                           |
| 2009  | 0                     | 1                  | 0                    | 4                 | 2                   | 7     | 0.72                           |
| 2008  | 1                     | 0                  | 0                    | 1                 | 3                   | 5     | 0.63                           |
| 2007  | 0                     | 0                  | 4                    | 1                 | 1                   | 6     | 0.70                           |
| Total | 14                    | 11                 | 26                   | 28                | 40                  | 122   | 0.63                           |

**Note-** Mega-authors (paper with >4 authors)



**Authorship Pattern**

The authorship pattern is counted separately for all countries. Table 6 Shows that two author collaboration of India dominates on single and multi-author collaboration with 2.99% of the total article and 10.35% author. The 17.04% highest ratio of author involved in four author collaboration. The four authorship of Pakistan has dominated on single author collaboration with 20.1% article and 8.22% of total authors in Table7. The three author collaboration of Bangladesh on top with 77 article and 231 of the total author in Table 8 another side four author collaboration patterns Sri Lanka shared by the total 28 article and 112 of authors.

**Table No.6 India Authorship Pattern**

| Sl. No. | Number of authors(Unit) | No. of Articles | Total No. of Authors | Percentage of articles | Percentage of Authors |
|---------|-------------------------|-----------------|----------------------|------------------------|-----------------------|
| 1       | Single                  | 1119            | 1119                 | 6.90                   | 1.64                  |
| 2       | Two                     | 3531            | 7062                 | 21.78                  | 10.35                 |
| 3       | Three                   | 3527            | 10581                | 21.76                  | 15.51                 |
| 4       | Four                    | 2906            | 11624                | 17.93                  | 17.03                 |
| 5       | Five                    | 1958            | 9790                 | 12.08                  | 14.35                 |
| 6       | Six                     | 1245            | 7503                 | 7.68                   | 10.99                 |
| 7       | Seven                   | 704             | 4928                 | 4.34                   | 7.224                 |
| 8       | Eight                   | 430             | 3440                 | 2.65                   | 5.04                  |
| 9       | Nine                    | 237             | 2133                 | 1.46                   | 3.12                  |
| 10      | Ten+                    | 549             | 10037                | 3.38                   | 14.71                 |
|         | Total                   | 16206           | 68217                | 100                    | 100                   |

**Table No.7 Pakistan Authorship Pattern**

| Sl. No. | Number of authors(Unit) | No. of Articles | Total No. of Authors | Percentage of articles | Percentage of Authors |
|---------|-------------------------|-----------------|----------------------|------------------------|-----------------------|
| 1       | Single                  | 97              | 97                   | 6.90                   | 1.38                  |
| 2       | Two                     | 153             | 306                  | 10.89                  | 4.35                  |
| 3       | Three                   | 260             | 780                  | 18.51                  | 11.1                  |
| 4       | Four                    | 283             | 1132                 | 20.15                  | 16.11                 |
| 5       | Five                    | 190             | 950                  | 13.53                  | 13.52                 |
| 6       | Six                     | 143             | 858                  | 10.18                  | 12.21                 |
| 7       | Seven                   | 82              | 574                  | 5.84                   | 8.17                  |
| 8       | Eight                   | 68              | 544                  | 4.84                   | 7.74                  |
| 9       | Nine                    | 51              | 495                  | 3.63                   | 7.04                  |
| 10      | Ten+                    | 77              | 1289                 | 5.48                   | 18.34                 |
|         | Total                   | 1404            | 7025                 | 100                    | 100                   |

**Table No.8 Bangladesh Authorship Pattern**

| Sl. No. | Number of authors(Unit) | No. of Articles | Total No. of Authors | Percentage of articles | Percentage of Authors |
|---------|-------------------------|-----------------|----------------------|------------------------|-----------------------|
| 1       | Single                  | 27              | 27                   | 6.97                   | 1.40                  |
| 2       | Two                     | 40              | 80                   | 10.33                  | 4.17                  |
| 3       | Three                   | 77              | 231                  | 19.89                  | 12.06                 |
| 4       | Four                    | 62              | 248                  | 16.02                  | 12.95                 |
| 5       | Five                    | 55              | 275                  | 14.21                  | 14.36                 |
| 6       | Six                     | 34              | 204                  | 8.78                   | 10.65                 |
| 7       | Seven                   | 29              | 203                  | 7.49                   | 10.60                 |

|    |       |     |      |      |       |
|----|-------|-----|------|------|-------|
| 8  | Eight | 27  | 216  | 6.97 | 11.27 |
| 9  | Nine  | 8   | 72   | 2.06 | 3.75  |
| 10 | Ten+  | 28  | 359  | 7.23 | 18.74 |
|    | Total | 387 | 1915 | 100  | 100   |

**Table No.9 Sri Lanka Authorship Pattern**

| Sl. No. | Number of authors(Unit) | No. of Articles | Total No. of Authors | Percentage of articles | Percentage of Authors |
|---------|-------------------------|-----------------|----------------------|------------------------|-----------------------|
| 1       | Single                  | 14              | 14                   | 11.47                  | 2.25                  |
| 2       | Two                     | 11              | 22                   | 9.01                   | 3.54                  |
| 3       | Three                   | 26              | 78                   | 21.31                  | 12.58                 |
| 4       | Four                    | 28              | 112                  | 22.95                  | 18.06                 |
| 5       | Five                    | 12              | 60                   | 9.83                   | 9.67                  |
| 6       | Six                     | 7               | 42                   | 5.73                   | 6.77                  |
| 7       | Seven                   | 6               | 42                   | 4.91                   | 6.77                  |
| 8       | Eight                   | 5               | 40                   | 4.09                   | 6.45                  |
| 9       | Nine                    | 4               | 36                   | 3.27                   | 5.80                  |
| 10      | Ten+                    | 9               | 174                  | 7.37                   | 28.06                 |
|         | Total                   | 122             | 620                  | 100                    | 100                   |

### Activity Index of all Countries

To measure the relevant research of all four countries in biotechnology a detailed account of activity index has been presented in Table 10. Activity index of these four SAARC countries has shown the lower increasing pattern from 2007-2016. The India's highest Activity Index came in 2016 (149.7) and lowest (57.8) in 2007. Pakistan same as Indian year for highest (177.6) in 2016 and lowest (55) come in 2007. Bangladesh had 140.2 in 2015 but lowest 47.8 in 2008, and Sri Lanka in 2013 (145.8) and 2010 (41.9) lowest activity index. The average Activity Index counted for ten-year, highest 98.05 taken by India followed by Pakistan 96.98, Bangladesh 96.84 and lowest 96.37 for Sri Lanka.

**Table No.10 Activity Index of all country**

| Year | India        | Pakistan    | Bangladesh | Sri Lanka  |
|------|--------------|-------------|------------|------------|
| 2016 | 2034 (149.7) | 207 (177.6) | 39 (142.6) | 10 (98.7)  |
| 2015 | 2503 (115.4) | 248 (133)   | 72 (132.8) | 21 (129.7) |
| 2014 | 2515 (114.9) | 236 (124)   | 67 (126.9) | 20 (121.4) |
| 2013 | 2020 (122.4) | 184 (129.5) | 37 (117)   | 18 (145.8) |
| 2012 | 1728 (107.4) | 134 (95.5)  | 53 (126)   | 19 (155)   |
| 2011 | 1503 (99.5)  | 127 (96)    | 27 (66.8)  | 9 (78.3)   |
| 2010 | 1272 (81.2)  | 84 (61.2)   | 34 (79.9)  | 5 (41.9)   |
| 2009 | 1010 (67.2)  | 72 (55.3)   | 23 (67.9)  | 7 (61.9)   |
| 2008 | 900 (65)     | 57 (47)     | 16 (46.6)  | 5 (47)     |
| 2007 | 715 (57.8)   | 55 (50.7)   | 19 (61.9)  | 8 (84)     |

### Top Ten International collaboration of all country

The high collaboration country for India is the United States with 1424 article where Pakistan partnership involves with China by 158 publication and Bangladesh mostly shared with Japan by 83 publications. For Sri Lanka, United States top collaborative countries with 27 articles.



The result shows that China has shared more collaboration than India to its adjacent countries in biotechnology research activity.

**Table No. 11 International Collaboration of SAARC countries**

| India |                |               | Pakistan       |               | Bangladesh     |               | Sri Lanka      |               |
|-------|----------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|
| No    | Country        | Collaboration | Country        | Collaboration | Country        | Collaboration | Country        | Collaboration |
| 1     | United States  | 1414          | China          | 158           | Japan          | 83            | United States  | 27            |
| 2     | South Korea    | 380           | United States  | 138           | United States  | 46            | United Kingdom | 19            |
| 3     | Germany        | 349           | United Kingdom | 94            | Malaysia       | 40            | China          | 18            |
| 4     | United Kingdom | 321           | Germany        | 69            | United Kingdom | 34            | Canada         | 13            |
| 5     | Japan          | 276           | South Korea    | 67            | South Korea    | 33            | India          | 13            |
| 6     | Australia      | 238           | Saudi Arabia   | 46            | China          | 28            | Australia      | 12            |
| 7     | France         | 214           | Australia      | 44            | India          | 24            | South Korea    | 9             |
| 8     | Saudi Arabia   | 201           | Canada         | 38            | Australia      | 19            | Japan          | 8             |
| 9     | Canada         | 190           | Austria        | 31            | Canada         | 15            | South Africa   | 6             |
| 10    | China          | 169           | France         | 31            | Saudi Arabia   | 15            | Finland        | 5             |

### Conclusion

The result shows that India is dominant in SAARC group with the 89.07% publication in biotechnology research. In collaboration coefficient average of India and Bangladesh 0.63 are same but Pakistan 0.67 average comparatively high in SAARC countries. The multi-author publication pattern is more dominated on single authorship. India's two authorship, Pakistan and Sri Lanka four, Bangladesh three authorship has dominated on single publication pattern. In The activity index Pakistan higher with 177.6 in SAARC nations. The activity index table shows the linear growth rate of all country within 2007-2016. The international collaboration shows that India not a top collaboration country for Pakistan, Bangladesh, and Sri Lanka. The Chinese biotechnology research collaboration finds the valuable place upon India's nearby countries in international collaboration. The result indicates that India needs to collaborate more in biotechnology research with Pakistan, Bangladesh, and Sri Lanka.

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