

India's International Collaboration in Biotechnology

Manohar Pathak¹ Atul Bhatt¹ N K Prasanna^{2*}

Gujarat University, Ahmadabad-380009, Gujarat, India

CSIR- National Institute of Science Communication & Policy Research, New Delhi-110012

*Corresponding author: prasanna@niscpr.res.in

Abstract

This paper analyses 6451 research publications in the field of Biotechnology by Indian researchers in collaboration with other countries indexed in the web of Science core collections from 1975 to 2021. These 6451 publications received 228989 citations with 181 h-index. During the period the total number of publications from India are 33236 out of which 6451(19.40%) are in international collaboration. There were only 2 publications in 1973 which rose to 825 in the year 2021. Ashok Pandey from CSIR-IITR is the most productive author while CSIR is the leading organization in collaborating with international partners. Microalgae is the most frequent keyword, Journal Bioresource technology is the most preferred journal for publication. The United States, South Korea, and Peoples Republic of China is the most preferred country for collaboration by an Indian scholar.

Keywords: Biotechnology, Scientometric, Research evaluation, Collaboration

Introduction

Collaboration in research is seen as a proxy for quality in academia. Research collaboration is done to share the knowledge, resources, and tools to the worldwide research community to produce new findings and achievements. Due to rapid change in new knowledge in every do-

main of knowledge, it is rare to produce new knowledge or findings through individual efforts, therefore collaboration becomes necessary. In the field of Biotechnology, changes are so rapid that some of the developments cannot be imagined without the help of the industrial partners. Collaboration also occurs when a group or organization with the least research facility approaches the larger groups or well-established laboratories with greater research facilities. However, the major objective of research collaboration is to improve research quality by utilizing the research expertise in the field. In a field like Biotechnology, collaboration is required to meet the global challenges. New information and emerging technologies have created newer subdomains in the field of Biotechnology which is not possible for a single organization or research group to work upon. The field of Biotechnology is becoming wide and wide every year. From tissue culture to gene editing falls under the broad category of Biotechnology. In recent times PCR has been gain popularity in order to test the presence of Coronavirus. The application of PCR is an excellent example of research and innovation in the field of biotechnology. Especially in 21st-century research in life sciences and Biotechnology has made tremendous progress and innovations and major breakthrough have become continuous and its frequency is rising day by day leading to bioeconomy. There are many modes of collaboration

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but collaboration identified through co-authorship has been studied by several researchers in detail. Zhao et al (2016)¹ studied characteristics of research collaboration in Biotechnology in China by analysing the publications indexed in SCIE. Patra and Chand (2005)² analysed the Biotechnology research profile of India. Payumo & Sutton (2015)³ assessed collaboration among ASEAN countries in plant biotechnology. Earlier Pathak & Prasanna (2019)⁴ analysed the international collaboration in Pharmaceutical Sciences for the period 2014-2018 and concluded that further study with a longer time range should be studied for wider insight. Garg *et al*⁵, Basu and Kumar⁶, Prakasan *et al*⁷, Gupta and Dhawan⁸, and Raina *et al*⁹ used the Web of science to investigate collaboration patterns of Indian science. Pathak & Bharti^{10,11} analysed the Indian Journal of Traditional knowledge and Botanical Survey of India output using the Web of Science as source of data.

Materials and Methods

Data for this study was retrieved from Web of Science-core Collection Database using advance search. Keyword Biotechnology was used in Research Area Category for the year range 1945-2021. From the countries section India was selected and document types were restricted to Articles and Review. Retracted publications were excluded from the study. In this way 33226 results were retrieved. For further analysis, the publications which have India and any other countries in the address were selected exclusively. Collaboration was determined through co-authorship by the address given in the database.

Results and Discussion

The first publication in international collaboration appeared in the year 1973 and there were only 92 publications in collaboration with foreign countries upto the year 1990. In the next decades i.e. during 1991-2000 there was a significant increase in the number of publications in international collaboration. There were 395 publications during this period. There were 1300 publications during 2001-

2010 which is more than 3 times from previous decades. The recent most years have witnessed the highest number of publications in association with foreign collaborators by Indian scholars in the field of biotechnology. 73% of total publications in international collaboration i.e. 4664 publications appeared during 2011-2021 which is evident that there is exponential decadal growth in international collaboration in the field of biotechnology. Figure 1 highlights the yearwise growth of publications in the field of biotechnology from India in international collaboration.

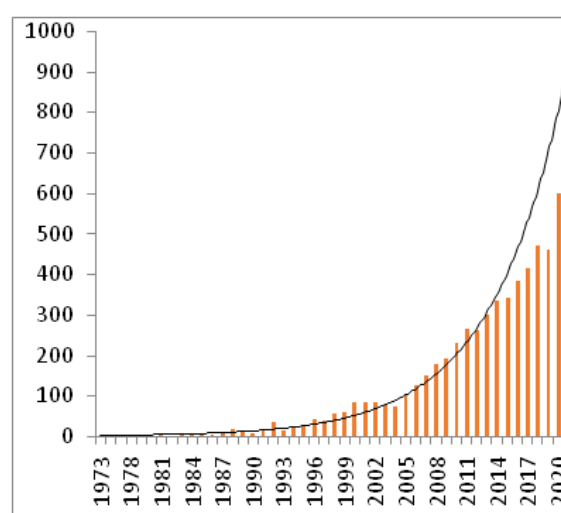


Figure-1: Year-wise growth of publications

There are 240 source titles or journals in which these 6451 research documents were published. There is 11 journals that published 100 or more research outputs by Indian authors in collaboration with International counterparts and contributes 2274 of 6451 publications. 50 % of the total publications were published in 23 journals. Table 1 enlist the list of productive journals with more than 100 publications Bioresource technology is the most productive journal which published 649 publications which are 10% of the total publications, followed by 3 biotech, with 219 publications Biomed research international with 212 publications There are 46 journals which published only one article. Thirteen journals pub-

lished 2 articles each. Eight journals published 3 articles each. Seventeen journals published 4 articles each.

Analysis of Productive authors suggests that Ashok Pandey from CSIR Indian institute of Toxicological research is the most productive author followed by Rajesh J Banu from the Central University of Tamil Nadu with 73 publications, Sunita Varjani from Gujarat Pollution Control Board with 41 publications, Raveendran Sindhu from TKM Institute of Technology Kollam Kerala with 37 publications and Hosakatte Niranjana Murthy, Karnataka University with 35 publications (Table 2). Among the authors from foreign countries, Rajeev K Varshney with 63 publications from Murdoch University is the most preferred author for collaboration by Indian Scientist, followed by Arivalagan Pugazhendhi from Ton Duc Thang University with 58 publications.

Among the organizations, CSIR India is the most productive organization with 844 publications is the most productive organizations followed by the Indian Institute of Technologies with 641 publications, the Indian Council of Agricultural Research with 372 publications, DBT India with 261 publications, the University of Delhi with 143 publications. Other productive organizations include Anna University, Banaras Hindu University, NIT, Table 1: list of productive journals with more than 100 publications

Publication Titles	Record Count
Bioresource Technology	649
3 Biotech	219
Biomed Research International	212
Applied Biochemistry And Biotechnology	194
Process Biochemistry	175
Applied Microbiology And Biotechnology	156
Biosensors Bioelectronics	151
World Journal of Microbiology Biotechnology	142
Environmental Technology Innovation	133
Bmc Genomics	126
Human Vaccines Immunotherapeutics	117

and Andhra University. Among the foreign organizations, King Saud University of Saudi Arabia is the most preferred organization with 202 publications followed by CGIAR with 173 publications, and ICRISAT with 140 publications respectively (Table 3, Figure 2). Table 4 enlists of the list of most preferred countries for collaboration by Indian researchers in the field of biotechnology. The USA with 1686 publications is the most preferred country for collaboration followed by South Korea 881 publications, the Peoples Republic of China 509 publications, Germany 467 publications, and Saudi Arabia 450 publications. There are 130 countries that are in collaboration with India. Sixteen 16 countries have only one publication in collaboration with India which includes Afghanistan, Namibia, Hongkong, Zimbabwe, etc. 73 countries/regions have more than 10 publications each in collaboration with India. 25 countries have 100 or more publications in collaboration with India. The top four countries in collaboration with India have published ~55 % of the total publication in collaboration worldwide Table 5 highlights the most highly cited publications. It includes publications with more than 950 citations. There are six publications that have received more than 1000 citations. It is often opined that publications in international collaboration receive higher citations in comparison to publications not in collaboration. Publication entitled 1792 Nano based drug delivery systems: recent developments and future prospects by Patra et al published in Journal of Nanobiotechnology have received highest number of citations i.e 1792 followed by 1398 Microbial decolorization of textile-dye-containing effluents: A review by Banat et al published in Bioresource Technology with 1398 citations, 1379 Organic and inorganic contaminants removal from water with biochar, a renewable, low cost and sustainable adsorbent - A critical review by Mohan et al in Bioresource Technology with 1379 citations, 1231 Biomaterials based on chitin and chitosan in wound dressing applications by Jayakumar et al published in Biotechnology Advances with 1231 citations, 1201 Synthesis of metallic nanoparticles using plant extracts by Mittal et al in Biotechnology Ad-

Table 2: Authors from foreign countries

Total Citations	Title	Authors	Source Title
1792	Nano based drug delivery systems: recent developments and future prospects	Patra et al	Journal of Nanobiotechnology, 2018,16 -
1398	Microbial decolorization of textile-dye-containing effluents: A review	Banat et al	Bioresource Technology, 1996,58 217-227
1379	Organic and inorganic contaminants removal from water with biochar, a renewable, low cost and sustainable adsorbent - A critical review	Mohan et al	Bioresource Technology, 2014,160 191-202
1231	Biomaterials based on chitin and chitosan in wound dressing applications	Jayakumar et al	Biotechnology Advances, 2011,29 322-337
1201	Synthesis of metallic nanoparticles using plant extracts	Mittal et al	Biotechnology Advances, 2013,31 346-356
1063	Potential commercial applications of microbial surfactants	Banat et al	Applied Microbiology And Biotechnology, 2000, 53 495-508
965	Bacterial alkaline proteases: molecular approaches and industrial applications	Gupta et al	Applied Microbiology And Biotechnology, 2002,59 15-32
987	Photocatalytic degradation for environmental applications - a review	Bhatkhande et al	Journal of Chemical Technology And Biotechnology, 2002,77 102-116
972	Production, purification, characterization, and applications of lipases	Sharma et al	Biotechnology Advances, 2001,19 627-662
965	Mechanism of Salinity Tolerance in Plants: Physiological, Biochemical, and Molecular Characterization	Gupta& Huang	International Journal of Genomics, 2014,2014 -

Table 3: Authors from India

Authors	Affiliations	Publications
Ashok Pandey	Indian Institute of Toxicological Research	154
Rajesh J Banu	Central University of Tamil Nadu	73
Sunita Varjani	Gujarat Pollution Control Board	41
Raveendran Sindhu	TKM Institute of Technology Kollam Kerala	37
Hosakatte Niranjana Murthy	Karnataka University	35

Table 4: Collaboration by Indian researchers

Affiliations	Publications
Council of Scientific and Industrial research	844
IIT system	641
Indian Council of Agricultural Research	372
DBT India	261
Delhi University	143

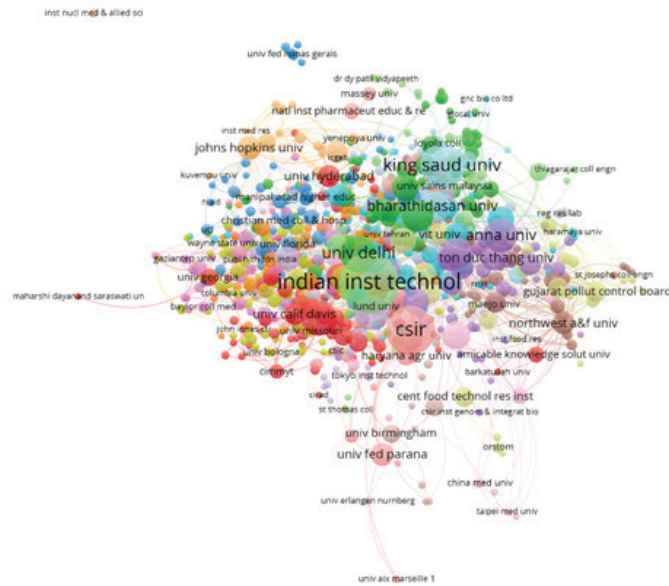


Figure 2: Co-authorship network of Organizations

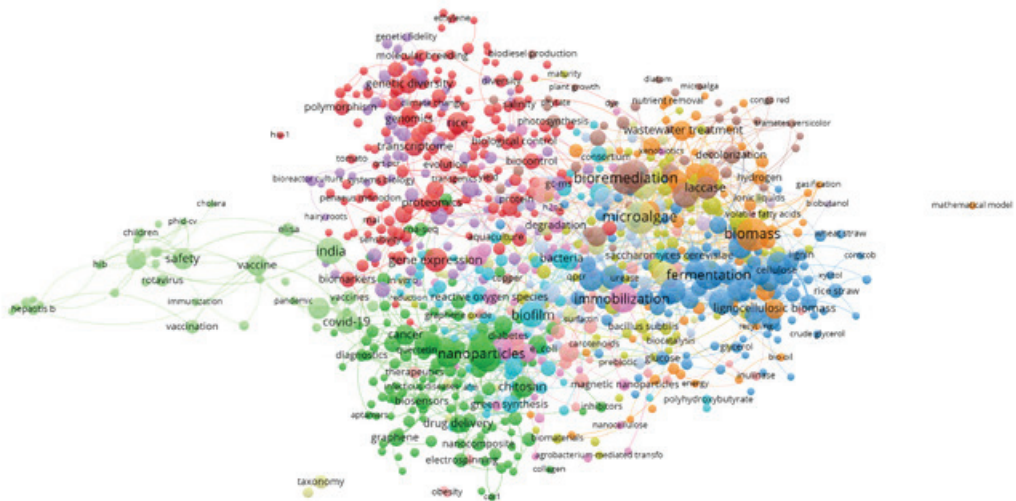


Figure 3: Keyword network

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Table 5: Most highly cited publications

Countries/Regions	Record Count
USA	1686
South Korea	881
Peoples R China	509
Germany	467
Saudi Arabia	450
United Kingdom	404
Australia	402
Japan	347
Canada	279
France	258
Malaysia	219

vances with 1201 citations and 1063 Potential commercial applications of microbial surfactants by Banat et al published in Applied Microbiology And Biotechnology with 1063 citations are the most cited publications.

Analysis of keywords reveal that there are 853 total keywords provided by authors in these 6451 publications. Microalgae with 82 occurrences is the most frequent keyword provided by biomass with 81 occurrence, bioremediation with 74 occurrence, nanoparticles with 66 occurrence and biodegradation with 65 occurrences are the top 5 keywords on the basis of frequency. Figure 3 highlights the Keyword network.

Conclusion

It can be concluded that in recent decade international collaboration in Biotechnology has grown multi-fold and has shown exponential growth in terms of publications and citations. However, most of the contributing organizations are centrally funded Institutes. Some central universities have also been identified as a major contributor in Biotechnology research but state universities are lagging in collaboration. This may also happen because in state university researchers might not be aware of publishing their research in non-indexing journals. Publications in collaboration have been communicated in journals of high repute this also played a significant role in receiving a higher citation rates.

This is only a preliminary investigation of international collaboration in Biotechnology from Indian scholars, more extensive study is required at the micro level to know the characteristics of international collaboration in Biotechnology. Comparative studies of similar countries or groups of countries may also be carried out to find greater insights.

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