

Growth and impact of research output of University of Mysore, 1996-2006: A case study

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Describes the growth, contribution and impact of research carried out by the scientists of University of Mysore in science and technology. Indicate the patterns of communications of university scientists and studies the extent of concentration and scattering of their research output in different journals. Analyses the strong and weak areas of university research, their growth rate and impact in terms of average citations received. Also studies the output and impact of research under different existing subject departments of the university. Analyses the international collaborative share of research output at the overall level as well as across various subjects, indicating also the major countries involved in international collaboration. Describes the share and characteristics of select highly cited papers and the top productive authors

Introduction

Research productivity in higher education is gaining importance for the past one decade in India. Faculty members of the universities in India have two functions to perform, teaching and research. Teaching is one of the canonically performed functions. However, research in universities has gained momentum during the past one and half decade, mainly due to support received through Ph.D programme, in-house projects, and extra-mural funding projects from major government scientific agencies. The research output of the university scientists in the form of research papers in peer-reviewed scholarly journals is being considered as one of the main criteria for assessing the performance of the university scientists and faculty. The University of Mysore has been accredited “A+” by National Assessment and Accreditation Council in 2006.

The University of Mysore is among the foremost institutions of its kind, and is an enduring symbol in the sphere of higher education in India. It was founded by the then Maharaja of Mysore, His Highness Sri Krishnaraja Wodeyar IV and his Dewan, the renowned engineer statesman, Sir M. Visvesvaraya, on July 27, 1916. The Maharaja of Mysore became its first chancellor. A Bill to establish and incorporate the University was introduced in Mysore Legislative Council in 1916. It was passed unanimously on 17th July 1916. The first meeting of the University Council was held on

12th August 1916 and the first meeting of the senate on 12th October 1916.

The first Act of the University came in the year 1933 (University of Mysore Act 1933). The University offered a two-year intermediate course, three year B.A.(Hons), B.Sc.,(Hons) Degree courses and M.A., M.Sc. courses. There were also the faculties of Medicine and Engineering. The University also offered diplomas in vocational subjects. The University Extension Lectures and Publication Bureau were notable features of the university. The main campus of the university created in 1960, lies in a picturesque area of 739 acres at the western end of the Kukkarahalli Lake. The university headquarters, the Crawford Hall, is located right across the lake on the eastern end. This inspiring locale of the campus was aptly named Manasagangotri (fountainhead of the Ganges of the Mind) by the poet-laureate, Dr. K.V. Puttappa (Kuvempu). In due course, two satellite campuses were set up in response to the demands of postgraduate education from semi-urban/rural areas: Sir M.Visvesvaraya Postgraduate Centre at Tubinakere in Mandya, and the Mysore University Postgraduate Centre at Hemagangotri in Hassan.

There are 37 postgraduate departments in University of Mysore, of which 14 are science departments. In all 132 faculty members are working in these 14 science departments. An attempt has been made in this study to

analyze the contribution, growth and impact of the research output of the university scientists working in different S&T departments and faculties of the University of Mysore for the past one decade.

Objectives

The main objectives are:

- To study the publication pattern of faculty of science and technology of University of Mysore between 1996 to 2006;
- To study the impact of research output of the faculty of science and technology of University of Mysore;
- To analyze the contribution of the authors of University of Mysore in national and international journals;
- To identify strong and weak disciplines of University of Mysore with reference to the research output;
- To study the international collaborative efforts by the academics of University of Mysore; and
- To rank the academics of University of Mysore based on their research output.

Methodology and literature review

The data for the study was downloaded from the Scopus database in June 2007. Scopus is an international multidisciplinary database indexing over 15,000 international peer reviewed journals in science and technology, besides more than 500 international conference/seminar proceedings. Publications data for eleven years from 1996 to 2006, were used for analyzing the growth and impact of university research. A larger time coverage data has been used to ensure accurate results. In addition, citations data for qualitative analysis of Indian research output was used. Three years citations window has been used for computing average citations per paper for all papers published by India from 1996 to 2003. Two years citations window was used for all papers published in 2004, and one-year citations window used for all papers published in 2005.

Various studies have been conducted in the past analyzing the contribution and impact of individual organizations. Jeevan and Gupta^{1,2} have analyzed the contribution and impact of Indian Institute of Technology, Kharagpur by

suggesting a methodology for studying the quantitative profile of a research cum teaching institute, with a view to get idea about the its performance and impact. Similarly Singh et al³ studied the research contribution and impact of Indian Institute of Technology, Roorkee from 1993 to 2001. The present study looks at the methodology of evaluation and covers wider aspects in comparison to the earlier studies.

Data Analysis

Growth and impact of research

The University of Mysore published a total of 1518 research papers in different disciplines of science and technology during 1996-2006, as seen from the Scopus database. During these 11 years, its publications output rose significantly, growing nearly by six times from 55 papers in 1996 to 307 in 2006. Its annual growth rate, computed on 11 years data averaged at 23.9%. Given its current pace of publication activity, it is estimated that the university publication output may rise to 400 papers per annum by 2010 (Table 1, Fig 1).

The impact of research was ascertained in terms of citations received by university papers during the first three years of their publication. This citations data for its papers published during 1996-2003 was normalized into an indicator 'average citations per paper' mainly for studying and understanding comparative growth in citations impact over previous years. The university has come to demonstrate significant rise in terms of average citations per paper from 1.53 in 1996 to 2.62 in 2003.

Table 1— Growth and impact of research

Year	No. of papers	Annual Ave. growth rate %	No. of citations	Ave. citations per paper
1996	55		84	1.53
1997	99	80.00	146	1.47
1998	86	-13.13	158	1.84
1999	119	38.37	183	1.54
2000	79	-33.61	200	2.53
2001	110	39.24	171	1.55
2002	153	39.09	395	2.58
2003	121	-20.92	317	2.62
2004	175	44.63		
2005	214	22.29		
2006	307	43.46		
Total	1518	Ave 23.94		

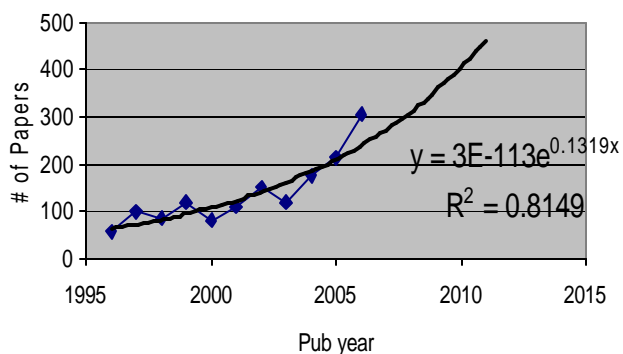


Fig. 1 — Growth of research papers in Mysore University

Table 2 — Frequency distribution of papers in various source journals

No. of papers	No. of source journals	No. of papers	No. of source journals	No. of papers	No. of source journals
1	214	11	2	23	2
2	51	12	2	26	1
3	47	13	4	32	1
4	16	14	2	34	1
5	11	15	2	43	1
6	9	17	1	106	1
7	9	18	1		
8	14	19	2		
9	5	21	3		
10	2	22	1		

Hence, it could be stated that the university has indeed progressed and has shown good quality research during 2000-03, except for the year 2000 (Table 1, Fig 2).

The university published its total research output in 405 peer reviewed national and international source journals in different disciplines of science and technology. The frequency distribution of university output in these 405 journals revealed a typical publication scattering pattern (Table 2). For example, the university faculty members published more than 100 papers in just one single journal, in 3 different journals it published between 26 to 43 papers each, and in the remaining 401 journals, its publication frequency had been ranging between 1 and 26 each in 11 years. This data seeks to demonstrate that visibility of the university in most source journals has been very low. This is also evident from the low cumulative productivity of university papers in different journal sets (Table 3). It is only in relatively select few

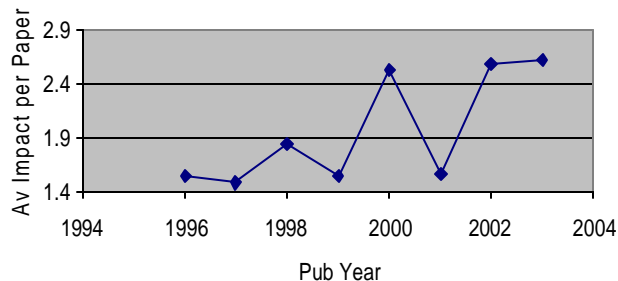


Fig. 2 — Average impact per paper

Table 3 — Cumulative productivity in journals

Top cumulative journals	Cumulative no of papers	Cumulative share of papers
10	351	0.23
20	516	0.34
30	631	0.42
40	719	0.47
50	799	0.53
60	868	0.57
70	926	0.61
80	975	0.64
90	1015	0.67

journals that its publication frequency has been somewhat better. The list of top 19 source journals is shown in Table 4.

Subject-wise study of research papers

The University of Mysore has published in nearly 16 major disciplines in science and technology during 1996-2006. However, it is in four major disciplines that research activity of the university has been dominating. Chemistry, physics and astronomy, biochemistry, genetics and molecular biology, and agriculture and biological sciences are the most prominent areas of its research. Based on publications data for 1996-2006, its publications share in these four disciplines varied between 18% and 48%. In addition, the university has been making strides in new and emerging areas of research. For example, chemical engineering, energy, immunology and microbiology, and biochemistry, genetics and molecular biology are its emerging areas of research.

Although the size of publications activity in these subject areas is still small (ranging between 1 to 46 papers in

Table 4 — List of most productive journals, 1996-06

S.No.	Source journal title	No of papers
1	<i>Acta Crystallographica Section E Structure Report Online</i>	106
2	<i>Indian Journal of Chemistry Section B organic & Medicinal Chemistry</i>	43
3	<i>Molecular Crystals & Liquid Crystals Science and Technology Section A</i>	34
4	<i>Asoan Journal of Chemistry</i>	32
5	<i>Oxidation Communications</i>	26
6	<i>Current Science</i>	23
7	<i>Synthetic Communications</i>	23
8	<i>Journal of Applied Polymer Science</i>	22
9	<i>Indian Journal of Chemical Technology</i>	21
10	<i>Synthesis and Reactivity in Inorganic & Metal Organic Chemistry</i>	21
11	<i>Analytical Sciences</i>	21
12	<i>Asian Journal of Microbiology, Biotechnology & Environmental Sciences</i>	19
13	<i>Indian Journal of Experimental Biology</i>	19
14	<i>Journal of Geological Society of India</i>	18
15	<i>Journal of Indian Chemical Society</i>	17
16	<i>Farmaco</i>	15
16	<i>Journal of Reinforced Plastics & Composites</i>	15
17	<i>Journal of Food Science & Technology</i>	14
18	<i>Journal of Pharmaceutical and Biomedical Analysis</i>	14
19	<i>Pattern Recognition Letters</i>	13

four years), but its growth rate in these disciplines has been relatively faster, rising from 100% to 2100%. Besides, the average citation per paper in these disciplines has been remarkably high, ranging between 3.16 and 3.97. In comparison, the average citations per paper in the traditional subject disciplines have been varying between 1.17 and 2.34. It seeks to demonstrate that the university research has been doing comparatively better in terms of research impact in its emerging areas of research (Table 5).

Department-wise profile of the university

As seen from publications data for University of Mysore indexed in Scopus database for 1996-2003, research output in science and technology is confined to 12 science departments of the university (Table 6). Chemistry department leads in publications productivity with 379 papers during 1996-2006, followed by physics department (179 papers), and zoology department (63 papers). The research output by the remaining nine departments has been very small ranging between 9 and 43 papers during 1996-06. However, despite showing publications output of smaller size, publishing 27 papers only, biochemistry department has emerged stronger in its average impact per paper. It showed the highest

average impact per paper of 3.15. The geology department with average impact per paper of 2.81 and chemistry department with average impact per paper of 2.36, followed the biochemistry department. The remaining departments showed average impact per paper in the lower ranges, varying between 0.25 and 1.83. Hence, departments of biochemistry and geology have indeed shown good performance in terms of quality research (Table 6).

International collaborative research

The university published nearly 14% of its papers through international collaboration with institutions from USA, Germany, Japan, Canada, South Korea, and Denmark etc. Its collaborative research output during 1996-06 was the largest with USA (51%), followed by Germany (23%), Japan (10%), Canada (6%), South Korea (5%), and Denmark (4%). The publications activity through international collaborative research was the largest in physics (38.4%), followed by biochemistry (35.6%), and chemistry (28%). In other disciplines, its publication share of the international collaborative output has been small, varying between 0.5% and 13% (Table 7)

Table 5 — Subject-wise break-up of papers and impact

	No. of papers			No. of citations			Average citations per paper		
	96-99	00-03	96-03	96-99	00-03	96-03	96-99	00-03	96-03
Chemistry	131	205	336	252	533	785	1.92	2.6	2.34
Physics & Astronomy	66	69	135	57	101	158	0.86	1.46	1.17
Bioch, Genet. & Mol. Biol.	41	85	126	87	311	398	2.12	3.66	3.16
Agr. & Biol. Sci.	57	68	125	50	164	214	0.88	2.41	1.71
Materials Science	33	31	64	49	75	124	1.48	2.42	1.94
Pharm., Toxic. & Pharmaceutics	17	46	63	24	226	250	1.41	4.91	3.97
Chemical Engineering	1	22	41	24	17	41	24	0.77	1
Earth & Planet. Sci.	22	17	39	58	29	87	2.64	1.71	2.23
Environment Science	18	20	38	25	12	37	1.39	0.6	0.97
Engineering	17	12	29	33	22	55	1.94	1.83	1.9
Medicine	14	13	27	12	14	26	0.86	1.08	0.96
Mathematics	13	10	23	12	9	21	0.92	0.9	0.91
Computer Science	13	9	22	25	18	43	1.92	2	1.95
Multidisciplinary	11	4	15	17	9	26	1.55	2.25	1.73
Immunology & Microbiology	4	11	15	2	13	15	0.5	1.18	1
Energy	1	6	7	2	24	26	2	4	3.71
Health Professions	1	0	1	2	0	2	2	0	2
Total	359	463	696	471	1083	1554	1.31	2.34	2.23

Table 6 — Department wise breakup of papers by University of Mysore

	No. of papers			No. of citations			Average citations per paper		
	96-99	00-03	96-03	96-99	00-03	96-03	96-99	00-03	96-03
App. Botany	14	21	35	15	59	64	1.07	2.81	1.83
Botany	13	10	23	8	10	18	0.62	1.00	0.78
Statistics	3	1	4	0	1	1	0.00	1.00	0.25
Physics	86	93	179	112	138	250	1.30	1.48	1.40
Zoology	31	32	63	56	46	102	1.81	1.44	1.62
Chemistry	140	239	379	260	635	895	1.86	2.66	2.36
Geology	26	17	43	64	57	121	2.46	3.35	2.81
Food Science	8	4	12	10	2	12	1.25	0.50	1.00
Biochemistry.	14	13	27	34	51	85	2.43	3.92	3.15
Comput. Sci.	6	6	12	6	6	12	1.00	1.00	1.00
Mathematics	7	6	13	1	1	2	0.14	0.17	0.15
Environment Science	4	5	9	8	4	12	2.00	0.80	1.33

Author productive profile of university members

Table 8 gives the details of top cumulative authors, the corresponding number of cumulative papers and their cumulative share. It can be observed from Table 8 that research activity in the University of Mysore seems to be highly skewed. This is because top 80 authors account

for 72% of total publications output by the university. This analysis is based on publication data in respect of the university in science and technology for its research papers published during 1996-06. The cumulative distribution of their publications also seeks to convey the point that the excellence in University of Mysore is confined to a body of select few authors. In other words,

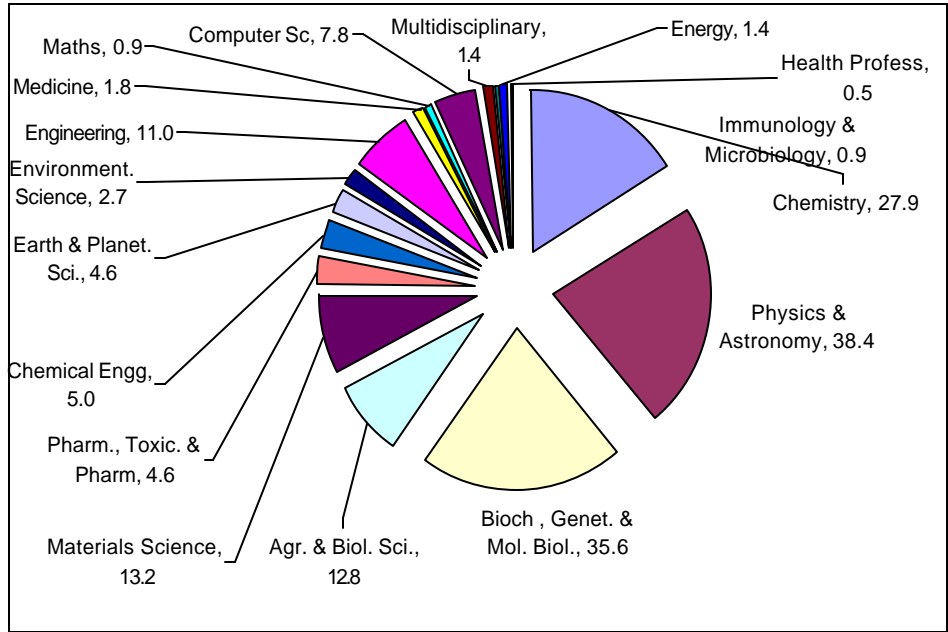


Fig 3 — Publications output by subject through collaborative research

Table 7 — Subject-wise break-up of collaborative papers

	Number of collaborative papers during 1996-06					
	USA	Germany	Japan	Canada	South Korea	Denmark
Chemistry	53	1	6			1
Physics & Astronomy	22	40	9	4	9	
Bioch, Genet. & Mol. Biol.	33	42	2			1
Agr. & Biol. Sci.	12	4	1	2		9
Materials Science	9		11		9	
Pharm., Toxic. & Pharmceutics	9		1			
Chemical Engineering	10		1			
Earth & Planet. Sci.	3	4	2	1		
Environment Science	5					1
Engineering	11		1	6	6	
Medicine	2			2		
Mathematics	2					
Computer Science	8		2	6	1	
Multidisciplinary		2		1		
Immunology & Microbiology	1					1
Energy	1		2			
Health Profession				1		
Total	112	52	22	13	11	9

a large body of authors from the university contribute very small share, nearly 29% of the total university output. It also means that majority of the authors from University of Mysore show low publication frequency (Table 8, Fig 4). The select list of highly productive authors is given in Table 9.

Highly cited papers

The University of Mysore published a total of 1518 papers in 11 years, of which 17 papers have been considered as comparatively higher cited papers, each receiving 30 citations or more since their publication during 1996-2006. Of these, seven papers were published

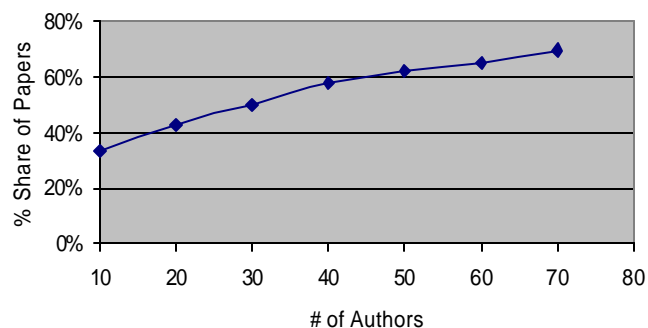


Fig 4 — Cumulative distribution of papers by Authors

Table 8 — Cumulative productivity of authors

Top cumulative authors	Cumulative no of papers	Cumulative share of papers
10	498	0.33
20	656	0.43
30	764	0.50
40	884	0.58
50	948	0.62
60	991	0.65
70	1065	0.70
80	1093	0.72

Table 9 — List of high productivity authors

S.No.	Name of Authors	1996-06		1996-03	
		No. of papers	No. of papers	No. of citations	Average citations per paper
1	H.S. Yathirajan Dept. of Studies in Chemistry	139	41	104	2.54
2	K.S. Rangappa Dept. of Studies in Chemistry	125	30	74	2.47
3.	J. Shashidhar Prasad Dept. of Studies in Physics	105	57	173	3.03
4	M.A. Sridhar Dept. of Studies in Physics	91	39	105	2.69
5	P.Nagaraja Dept. of Studies in Chemistry	58	25	20	0.80
6	H.S. Shetty Dept. of Studies in Applied Botany & Biotechnology	56	39	30	0.77
7	K.Basavaiah Dept. of Studies in Chemistry	55	24	44	1.83
8	D.C.Gowda Dept. of Studies in Chemistry	55	15	71	4.73
9	N.K. Lokanath Dept. of Studies in Physics	42	27	38	1.41
10	C. Ranganathaiah Dept. of Studies in Physics	39	5	29	5.80
11	K. Abiraj Dept. of Studies in Chemistry	34	24	57	2.38
12	H. Somastekarappa Dept. of Studies in Physics	29	8	6	0.75
13	S. Ananda Dept. of Studies in Chemistry	29	11	7	0.64
14	G.R. Sriinivasa Dept. of Studies in Chemistry	29	20	19	0.95

15	H.D. Ravanasiddappa Dept. of Studies in Chemistry	29	7	23	3.29
16	P. Nagabhushan Dept. of Studies in Computer Science	28	0	0	0
17	P Prakash Dept. of Studies in food Science & Nutrition	27	41	104	2.54
18	K.M.Lokanatha Rai Dept. of Studies in Chemistry	26	30	74	2.47
19	M. Singha Dept. of Studies in Zoology	25	39	105	2.69
20	R.S. Narasegowda Dept. of Studies in Zoology	25	29	141	4.86

Table 10 — Highly cited papers by University of Mysore

	Authors	Affiliations	Title	Source title	Year cited	Times
1	El-Khouly M.E., Ito O., Smith P.M., D'Souza F.	Tohoku University, Katahira, Inst. Multidisc. Res. for Adv. Mat., Sendai, Japan; University of Mysore, Mysore et al	Intermolecular and supramolecular photoinduced electron transfer processes of fullerene- porphyrin/phthalocyanine systems	<i>Journal of Photochemistry and Photobiology C: Photochemistry Reviews</i>	2004	91
2	Poojary D.M., Clearfield A.	Texas A and M Univ, Dept of Chem, TX , USA; University of Mysore, ; Indian Institute of Science, Bangalore, India; et al	Application of X-ray Powder Diffraction Techniques to the Solution of Unknown Crystal Structures	<i>Accounts of Chemical Research</i>	1997, 30(10), 414-22	56
3	Rangappa K.S., Raghavendra M.P., Mahadevappa D.S., Channegowda D.	University of Mysore, Department of Studies in Chemistry, Mysore; Georgetown University Medical Center, Department of Biochemistry, Washington, DC, USA	Sodium N- Chlorobenzenesulfonamide as a Selective Oxidant for Hexosamines in Alkaline Medium: A Kinetic and Mechanistic Study	<i>Journal of Organic Chemistry</i>	1998, 63(3), 531-36	47
4	Nutman A.P., Chadwick B., Krishna Rao B., Vasudev V.N.	Australian Nat Univ, Res Sch of Earth Sciences, Canberra, ACT, Australia; Univ of Mysore, Dept of Geology, Mysore et al	SHRIMP U/Pb zircon ages of acid volcanic rocks in the Chitradurga and Sandur Groups, and granites adjacent to the Sandur schist belt, Karnataka	<i>Journal of the Geological Society of India</i>	1996, 47(2), 153-64	47
5	Rao C.N.R., Gundiah G., Deepak F.L.,	Chem. and Physics of Materials Unit, CSIR Ctr. of	Carbon-assisted synthesis of inorganic nanowires	<i>Journal of Materials Chemistry</i>	2004, 14(4), 440-50	43

Govindaraj A., Cheetham A.K.	Excellence in Chemistry, Jawaharlal Nehru Ctr. Adv. Sci. Res., Jakkur P.O., Bangalore 560 064, India; Materials Research Laboratory, University of California, Santa Barbara, CA 93106, United States; Purdue University; University of Mysore; Royal Society of Chemistry; Royal Society; Jawaharlal Nehru Ctr. Adv. Sci. Res.; University of Mysore; Indian Institute of Science; Oxford University				
6 Nagaraja P., Murthy K.C.S., Rangappa K.S., Gowda N.M.M.	University of Mysore, Manasagangotri, Department of Studies in Chemistry, Mysore; Cipla Limited, Bangalore; Western Illinois University, Department of Chemistry, Macomb, IL, USA	Spectrophotometric methods for the determination of certain catecholamine derivatives in pharmaceutical preparations	<i>Talanta</i>	1998	43
7 Meissner B., Deters P., Srikantappa C., Kohler H.	Institut für Mineralogie, Petrographie und Geochemie, München, Germany; D University of Mysore, Department of Geology, Mysore	Geochronological evolution of the Moyar, Bhavani and Palghat shear zones of southern India: Implications for east Gondwana correlations	<i>Precambrian Research</i>	2002, 114, 149-75	41
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9 Bhaskar Rao Y.J., Chetty T.R.K., Janardhan A.S., Gopalan K.	Natl. Geophysical Research Institute, Hyderabad; University of Mysore, Mysore	Sm-Nd and Rb-Sr ages and P- T history of the Archean Sittampundi and Bhavani layered meta-anorthosite complexes in Cauvery shear	<i>Contributions to Mineralogy and Petrology</i>	1996, 125, 237-50	39

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during 2000-2004, and the remaining 10 during 1996-1999. Out of these 17 papers, 11 papers involve international collaboration and 4 involve national collaboration. The paper coauthored by F D'Souza and others published in 2004 received 91 citations, the highest number of citations. It means that international collaboration has increased the citation profile of university output. The list of the 17 highly cited papers is shown in Table 10. It is to be noted that the share of highly cited papers in the total output by University of Mysore in science and technology is still not very significant.

Conclusion

The research activity in University of Mysore in science and technology is on a growing path, growing with an average rate of 23% per annum. This analysis is based on publications data consisting of 1518 research papers, published by the university staff during 1996-2006. The university has indeed progressed in terms of quality of research. Its average citations per paper have risen from 1.53 in 1996 to 2.62 in 2003. Chemistry, physics and astronomy, biochemistry, genetics and molecular biology, and agriculture and biological sciences are its most dominating research areas. Chemical engineering, energy, immunology and microbiology, and biochemistry, genetics and molecular biology are its emerging areas of research. Its quality of research and its growth rate in emerging areas of research is better than in traditional research areas.

The international collaborative research activity in the university is still very small, accounting for just 14% share. This is because the international collaborative research activity in the university is confined to select few subjects, such as physics (38.4%), biochemistry (35.6%), and chemistry (28%). In other disciplines, it is still a low-key affair, varying between 0.5% and 13%.

The collaborative research activity in the university is also confined to select few countries. It is the largest with USA (51%), followed by Germany (23%), and Japan (10%), Canada (6%). It is least with South Korea (5%), and Denmark (4%).

Research activity in the university seems to be highly skewed. The excellence in research is confined to select few authors. In other words, publication frequency of large majority of authors from the university is small. Besides, the share of highly cited papers in the university output is still not very significant.

There is need to explore new opportunities for collaborative research with all countries from the developed and the developing world especially in the emerging areas of research such as chemical engineering, energy, immunology and microbiology, and biotechnology. Within the country the university departments may explore new models of collaborative research, such as going in for university-private partnership in research, as well as university-national laboratories partnership in research. Such measures have the potential to catalyze publications activity, improve publication frequency of authors as well as help improve their quality of research.

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