

Research output of CSIR-Central Electro Chemical Research Institute (CECRI): A study

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The study analyses bibliographical details of 1282 research articles published by the scientists of CECRI during the period 2000-2009. It is found that 2009 was the most productive year with 194 articles (15.13%) published in the year. Collaborative research was dominant with the highest degree of collaboration being 0.98, in the year 2005. Further, the study investigated authorship pattern, co-authorship pattern, highly prolific authors and highly preferred journals by the scientists of CECRI.

Introduction

Research output assessments are increasingly becoming an integral part of research and development institutions worldwide. Among the research and development institutions in India, the Council of Scientific and Industrial Research (CSIR) is a leading contributor to India's R&D output. CSIR has a network of 37 laboratories with each laboratory pursuing cutting edge research in various areas of chemical, physical, engineering, biological and information sciences.

Central Electro Chemical Research Institute (CECRI)¹ is one of the laboratories researching on all facets of electrochemical science and technology viz., corrosion science and engineering, electrochemical, materials science, functional materials and nanoscale electrochemistry, electrochemical power sources, electrochemical pollution control, electrochemicals, electrocatalysis, electrometallurgy, industrial metal finishing, computer networking and instrumentation and so on.

CECRI was established in 1953 at Karaikudi, Tamil Nadu and is one of the largest electrochemical laboratories in the world and it has got three extension centres located at Chennai, Mandapam camp and Tuticorin. CECRI assists the Indian industry by conducting surveys and undertaking consultancy

projects. The institute also conducts short-term refresher courses for the benefit of the industry and academia. As part of its human resource development programme, CECRI runs Anna University's B.Tech and M.Tech courses in chemical & electrochemical engineering.

Bibliometrics techniques are used to evaluate the research productivity of individuals, organizations, countries, journals and so on. Quantitative studies are also available to verify the fitness of classic laws of bibliometrics, factors of productivity and impact of research conducted in various countries. This study analyses the research output of CECRI for a ten year period, 2000-2009.

Review of literature

A few studies on CSIR institutes have been carried out in the past. Gupta, Suresh Kumar and Aggarwal² found that male scientists produced more research output while compared with female scientists and Gupta, Suresh Kumar and Khanna³ examined the performance of different Council of Scientific and Industrial Research (CSIR) laboratories in physical, biological and engineering sciences based on the productivity profile of scientists. The study revealed that the scientists contributing ten or less papers give a flat productivity distribution. Moreover between 11

and 29 papers, tend towards an inverse-square relation- ship; and more than 29 papers, indicate a flat productivity distribution.

Varghese and Rajan⁴ in their study found that 2003-2004 is the most productive period and 1995-1996 is the least productive periods and also this study shows that the productivity of female scientists is higher than that of males in Rajiv Gandhi Centre for Biotechnology. Sharma⁵ has conducted a study on 2603 research articles published by the scientists of Central Potato Research Institute (CPRI) during 1991 to 2007, who collected the data from annual reports of CPRI and Journal of the Indian Potato Association. The study found that most of the scientists preferred to publish research papers in joint authorship (82.67%) having 0.82 degree of collaboration and also shows no uniform pattern of literature growth.

Price and Beaver⁶ found that the most productive members were also most collaborative in the literature of oxidative phosphorylation and terminal electron transport. Oyedokun⁷ analysed scientist' activities in the agricultural research institutes in Nigeria and reported that activities of scientists in agricultural research institutes span through technological development delivery.

Lal⁸ prepared a ranked list of journals from the view points of soil scientists working in India. A similar study was conducted by Sharma and Singh⁹ to study the characteristics of soil science literature used by Indian scientists to find out the major contributing authors, ranking of Indian soil science journals, seepage and obsolescence of literature. Kademani et al¹⁰ have studied the publication productivity of the chemistry division at Bhabha Atomic Research Centre. The study covered 1733 papers published during 1970-1999 in various domains. The study dealt with year- wise publication productivity, collaboration trend, author productivity and Lotka's law, most productive authors and use of communication channels.

As can be seen from the foregoing, not many studies have been conducted on CSIR laboratories. Hence this study was been undertaken on CECRI, one of the prestigious laboratories of CSIR.

Objectives of the study

- To examine the growth of electrochemical research output of CECRI during 2000 to 2009;

- To examine and analyse the authorship pattern in electrochemical research and development in CECRI;
- To determine the degree of collaboration, and
- To identify the prolific authors and choice of journals of the researchers for publication of their research findings.

Methodology

Research findings are reported in various documentary publications viz., national and international research journals, research bulletins, annual scientific report, conferences, symposia proceedings etc. This information about the publications have been collected from the website namely www.krc.cecri.res.in/ro.html¹¹.

In all 1282 records were obtained for the 10 year period. MS Excel 2007 was used for analyzing the data.

Scientometric indicators used

The following scientometric indicators have been used in the study:

Degree of Collaboration

Subramanyam's¹³ formula below has been adopted to examine the degree of collaboration in this study.

$$C = Nm / (Nm + Ns)$$

where

C = degree of collaboration in a subject

Nm = number of multiple authored papers

Ns = number of single authored papers

Co-Authorship Index (CAI)

In order to examine how the pattern of Co-Authorship Index (CAI) has changed during the study period, the following formula of Co-authorship Index suggested by Garg and Padhi¹⁴ was used.

$$CAI = \{(N_{ij} / N_{io}) / (N_{oj} / N_{oo})\} \times 100$$

N_{ij} : Number of papers having j authors in block i;

N_{io}: Total output of block i;

Noj: Number of papers having j authors for all blocks;

Noo: Total number of papers for all authors and all blocks;

J = 1, 2, 3.....n

CAI = 100

CAI = 100 implies that co-authorship in a particular block for a particular type of authorship corresponds to the world average, CAI > 100 reflects higher than average co-authorship effort and CAI < 100 lower than average co-authorship effort in a particular block for a particular type of authorship. For calculating CAI the entire data was divided into three blocks as single authored, two authored and more than two authored publications.

Analysis and Discussion

Growth of CECRI's research output

Table 1 indicates the growth of electrochemical literature during 2000 to 2009. The highest output during the 10 year period was in the year 2009 (15.13%) and the lowest (6.86%) in 2003. Further the year-wise distribution during the years 2008 (13.42%), 2007 (11.08%), 2006 (10.69%), 2000 (9.75%) indicates that these years were relatively more productive in relation to total number of publications in electrochemical research. The less productive years were 2002 (6.86%), 2003 (7.57%), 2001 (7.88%), 2004 (8.27%), 2005 (9.27%) in electrochemical research.

Authorship pattern

To find the authorship pattern, the entire data was divided into seven blocks as single, two, three, four,

five, six and more than six authored publications as shown in Table 2. The results presented in Table 2 show that three authored publications were maximum at 31.74%. Single authored papers at 4.68% were the lowest.

Pattern of Co-Authorship Index (CAI)

Table 3 reveals that the result of co-authorship index and it is observed that the value of CAI for two authored papers is the highest and for single authored papers was lowest, which indicated that the collaborative research is increasing in the field of electrochemistry in CECRI scientist. With regard to the multiple authored publications with more than two authors, the co-authorship has shown fluctuation trend.

Degree of Collaboration

The Degree of Collaboration of authors by year-wise is shown in Table 4. The extent of Degree of Collaboration¹³ by year-wise has been calculated. Accordingly, the degree of collaboration has been calculated for the years 2000 to 2009.

The year-wise Degree of Collaboration falls between 0.91 and 0.98. The Degree of Collaboration for any subject ranges from 0.01 to 0.99 and it is always below 1 as shown in different studies including that by Karisiddappa et al¹⁴ for psychology, by Bandyopadhyay¹⁵ for different disciplines, by Rajendran et al¹⁶ for fiber optics and Ramakrishnan and Ramesh Babu¹⁷ for hepatitis.

Prolific authors producing more than 25 articles

Table 5 depicts a list of prolific authors who have produced more than 25 articles from CECRI during the period 2000-2009. Palaniswamy N with 90

Table 1—Growth of CECRI literature from 2000 - 2009

Sl. no.	Year	Productivity	Percent
1	2000	125	9.75
2	2001	101	7.88
3	2002	88	6.86
4	2003	97	7.57
5	2004	106	8.27
6	2005	120	9.36
7	2006	137	10.69
8	2007	142	11.08
9	2008	172	13.42
10	2009	194	15.13
	Total	1282	100.00

Table 2—Authorship pattern

Sl. no	No. of authors	Number of papers	Percentage
1	Single	60	4.68
2	Two	192	14.98
3	Three	407	31.75
4	Four	293	22.85
5	Five	178	13.88
6	Six	84	6.55
7	More than six authored	68	5.31
	Total	1282	100.00

Table 3—Pattern of Co-Authorship Index

Year	Single	CAI	Two	CAI	More than two authors	CAI	Total
2000	11	188.03	26	138.88	88	87.62	125
2001	6	122.10	16	101.75	83	98.39	101
2002	4	97.12	14	106.23	70	99.01	88
2003	6	133.54	12	83.46	78	101.13	97
2004	3	61.05	14	89.03	88	104.31	106
2005	2	35.61	24	133.54	94	97.50	120
2006	4	63.31	29	143.43	102	94.04	137
2007	9	135.42	19	89.34	114	99.92	142
2008	10	124.22	17	65.99	145	104.93	172
2009	5	55.07	21	72.28	168	107.79	194
Total	60		192		1030		1282

Table 4—Degree of Collaboration

Year	Single author	Two authors	Three authors	More than three authors	Degree of Collaboration	Total
2000	11	26	40	48	0.91	125
2001	6	16	27	56	0.94	105
2002	4	14	38	32	0.95	88
2003	6	12	36	42	0.94	96
2004	3	14	27	61	0.97	105
2005	2	24	33	61	0.98	120
2006	4	29	47	55	0.97	135
2007	9	19	46	68	0.94	142
2008	10	17	54	91	0.94	172
2009	5	21	59	109	0.97	194
Total	60	192	407	623	0.95	1282

articles is the most prolific author during the period followed by Jayachandran M with 77 articles, Venkatachari G with 70 articles and so on.

Preferred journals by the scientists of CECRI

Table 6 reveals the highly preferred journals by the scientists of CECRI. Out of the 1282 articles, 87 articles have been published in “*Bulletin of Electrochemistry*”, 50 in “*Transactions of the SAEST*”, 47 in “*Journal of Power Sources*” and so on.

Discussion

Analysis shows that the scientists of CECRI published highest number of publications in the year 2009 and also it is shows that the growth rate of publications increased during the period of study 2003-2009. During the year 2002 least productivity of the CECRI scientists has been noticed. The value of CAI for two

authored papers was the highest (192) and the value of CAI for single authored papers is 60, which indicates that the collaborative research is increasing among the scientists of CECRI. The most prolific authors identified in the study holding important positions in CECRI which implies that publication productivity is one of the important indicators to identify the scientists in the electrochemical research.

The authorship pattern of journal articles published by the scientists of CECRI reveals that multi-authored papers are more than single authored papers. Most of the papers were written by three or more than three authors. Since scientific research is a team work, generally the multi-authored papers will be more than individual works. Scientific collaboration often is viewed as a virtue, and several public policies actively encourage scientific collaboration at both the individual and institutional levels. The evaluation of the productivity of individual research and

Table 5—Prolific authors producing more than 25 articles by CECRI scientists

Sl. no	Scientists	No. of articles	Rank
1	Palaniswamy, N	90	1
2	Jayachandran, M	77	2
3	Venkatachari, G	70	3
4	Sanjeeva Raja, C	61	4
5	Murali, K R	52	5
6	Renganathan, N G	51	6
7	Shukla, A K	49	7
8	Trivedi, D C	47	8
9	Yegnaraman, V	47	8
10	Ahmed Basha, C	46	9
11	Maruthamuthu, S	45	10
12	Muralidharan, V S	45	10
13	Sathiyarayanan, S	45	10
14	Prem Kumar, T	43	11
15	Kalaiselvi, N	42	12
16	Raghavan, M	38	13
17	Mohan, S	36	14
18	Muralidharan, S	36	14
19	Noel, M	35	15
20	Pitchumani, S	33	16
21	Gopukumar, S	32	17
22	Mathiarasu, J	32	17
23	Phani, K L N	31	18
24	Malathy P	28	19
25	Thirunakaran, R	28	19
26	Subramanian, B	27	20

Table 6—Preferred journals by the scientists of CECRI

Sl. no	Journals	No. of articles	Rank
1	<i>Bulletin of Electrochemistry</i>	87	1
2	<i>Transactions of the SAEST</i>	50	2
3	<i>Journal of Power Sources</i>	47	3
4	<i>Transactions of Institute of Metal Finishing</i>	45	4
5	<i>Journal of Applied Electrochemistry</i>	42	5
6	<i>Materials Chemistry and Physics</i>	35	6
7	<i>Electrochimica Acta</i>	33	7
8	<i>Indian Journal of Chemical Technology</i>	23	8
9	<i>Ionics</i>	23	8
10	<i>Anti-Corrosion Methods and Materials</i>	22	9
11	<i>Progress Inorganic Coatings</i>	21	10
12	<i>Corrosion Reviews</i>	18	11
13	<i>Journal of Power Sources</i>	17	12
14	<i>Journal of Applied Electrochemistry.</i>	16	13
15	<i>Synthetic Metals</i>	16	13
16	<i>Corrosion Engineering Science and Technology</i>	14	14
17	<i>Journal of the Electrochemical Society</i>	14	14
18	<i>Materials Letters</i>	13	15
	Other Journals	746	-
	Total	1282	

developmental activities is the highest contribution of the institution and hence individual scientists engaged in team research.

Conclusion

The quantitative study on the productivity of institutional research and development activities highlights the contribution of the institution and the individual scientists of CECRI research. Productivity analysis of the scientists of CECRI also provides some insights into the dynamics of research activity and it will enable the science policy makers and science administrators to make available adequate facilities and direct the research activities in a proper direction. The research trend in the field electrochemistry is collaborative in nature like any other discipline.

References

1. <http://www.cecni.res.in>.
2. Gupta B, Suresh Kumar M and Aggarwal B S, A comparison of productivity of male and female scientists of CSIR, *Scientometrics*, 45 (2) (1999) 269-289.
3. Gupta B M, Suresh Kumar M and Khanna H K, Science in India: performance of Council of Scientific and Industrial Research laboratories based on the productivity profile of scientists, *Research Evaluation*, 8 (3) (1999) 177-187.
4. Varghese R R and Rajan S, Productivity of scientists of Rajiv Gandhi Centre for Biotechnology (RGCB): an analysis, *Annals of Library and Information Studies*, 56 (3) (2009) 156-162.
5. Sharma R M, Research publication trend among scientists of Central Potato Research Institute: A bibliometric study, *Annals of Library and Information Studies*, 56 (1) (2009) 29-34.
6. Price D J and Beaver D, Collaboration in an invisible college, *American Psychologist*, 21 (11) (1966) 1011-1018.
7. Oyedokun A O, Scientists in agricultural research institutes of Nigeria: activities and performance, *Moor-Journal of Agriculture Research*, 2 (1) (2001) 75-82.
8. Lal A, Literature contribution in Indian Journal of Genetics and Plant Breeding: A citation analysis, *Annals of Library and Information Studies*, 56 (1) (1993) 65-76.
9. Sharma R M and Singh S N, Strategy to build up sound information base and service in soil science, *Indian Journal of Agricultural Library and Information Science*, 21 (1993) 49-55.
10. Kademani B S et al. Scientometric dimensions of innovation communication productivity of the chemistry division at Bhabha Atomic Research Centre, *Malaysian Journal of Library and Information Science*, 10 (1) (2005) 65-89.
11. <http://www.krc.cecni.res.in/ro.html>
12. Garg K C and Padhi P, Scientometrics of laser research in India during 1970 - 1994, *Scientometrics*, 56 (1) (2003) 81-93.
13. Subramaniam K, Bibliometrics studies of research collaboration: A review, *Journal of Information Science*, 6 (1983) 35-37.
14. Karsiddappa C R, Maheswarappa B S and Shirol M V, Authorship pattern and collaborative research in Psychology, *IASLIC Bulletin*, 35 (2) (1990) 73-78.
15. Bandyopadhyay A K, Authorship pattern in different disciplines, *Annals of Library and Information Studies*, 48 (4) (2001) 139-147.
16. Rajendran P, Ramesh Babu B and Gopalakrishnan S, Bibliometric Analysis of 'Fiber Optics' Literature, *Annals of Library and Information Studies*, 52 (3) (2005) 82-85.
17. Ramakrishnan J and Ramesh Babu B, Literature on hepatitis (1984-2003): A bibliometric analysis, *Annals of Library and Information Studies*, 54 (4) (2007) 195-200.