

Use of open access journals by Indian researchers

Subbiah Gunasekaran* and Subbiah Arunachalam

Indian researchers have published more than 43,400 papers in over 4,600 journals in 2009 as seen from Science Citation Index (SCI) – Expanded. Of these, over 6,900 (or one in six) papers were published in 445 open access (OA) journals. The proportion of papers published by Indian researchers in OA journals is considerably higher than the world average, which is estimated to be 8.5–10.0%. Although India publishes well over a thousand journals, including about 360 OA journals, SCI Expanded indexed in 2009 only 101 Indian S&T journals including 46 OA journals. It is likely that the percentage of Indian papers in OA journals as seen from SCI will be higher if more Indian journals are indexed in SCI Expanded.

Keywords: Indian researchers, Impact factor, open access journals, research papers, Science Citation Index Expanded.

In a recent paper, Madhan and Arunachalam¹ looked at the use made by Indian researchers of selected high impact open access (OA) journals, particularly Public Library of Science (PLoS) and BioMed Central (BMC) journals and *Acta Crystallographica Section E*. In this article, we report the use made by Indian scientists of OA journals that are indexed in Science Citation Index (SCI) Expanded. Web of Science (WoS) – SCI Expanded, indexes 8,368 journals, of which 836 are OA. We obtained the list of 836 OA journals from Thomson Reuters (Scientific).

Since 1989–1990 when the first four OA journals – *Bryn Mawr Classical Review* (<http://bmc.brynmawr.edu/>), *Postmodern Culture*, *Psychology* (<http://www.ils.unc.edu/~arnsj/inls180-01/harnard.htm>), and *Public-Access Computer Systems Review* – started publication, thousands of OA journals have been published. The number of OA journals, as well as those indexed in WoS, are increasing steadily². Heather Morrison has been following the growth of OA journals over the past decade³ (Figure 1). Informatics India Ltd, publisher of *Open J-Gate*, has also started following the growth of OA journals (Figure 2). Currently (as on 30 September 2011), there are 7,070 OA journals according to the *Directory of Open Access Journals (DOAJ)* and over 9,300 OA journals (including more than 6,200 peer-reviewed) from over 5,000 publishers, according to *Open J-Gate*⁴. Indeed, the growth rate has accelerated in the past few years, and currently it stands at four new titles per day.

Subbiah Gunasekaran is in the Knowledge Resource Centre, CSIR – Central Electrochemical Research Institute, Karaikudi 630 006, India and Subbiah Arunachalam is in the Centre for Internet and Society, No. 194, 2nd 'C' Cross, Domlur 2nd Stage, Bangalore 560 071, India.

*For correspondence. (e-mail: guna1970@gmail.com)

OA not only plays a crucial role in disseminating scientific knowledge at a low cost, making it more accessible and more visible locally and globally, but also plays an important role in preserving indigenous knowledge to

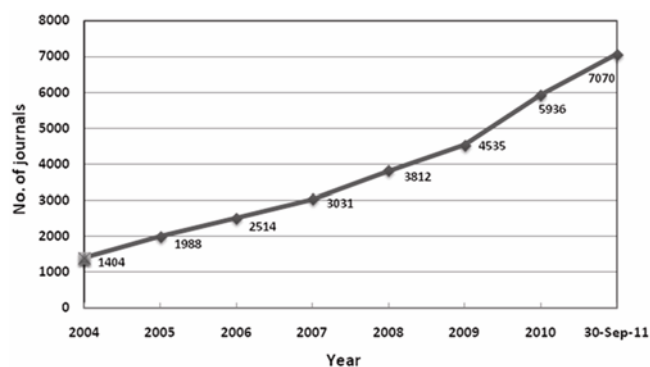


Figure 1. Growth of open access (OA) journals as seen from the Directory of Open Access Journals. Source: Based on the data provided by Morrison³.

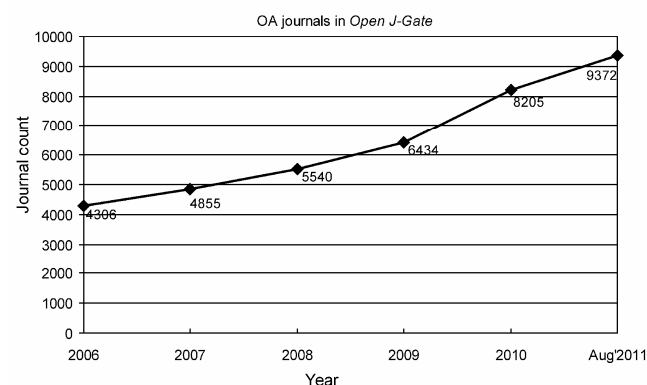


Figure 2. Growth of OA journals as seen from *Open J-Gate*. Source: S. Jothy⁴; Open Gate/J-Gate currently indexes more than 9,300 (over 6,200 are peer reviewed) OA journals from over 5,000 publishers. *Open J-Gate* is the largest portal for OA journal literature.

enrich the new generations, says Iryna Kuchma⁵. New publishing models are emerging too. While PLoS publishes only seven OA journals and BMC publishes 221 peer-reviewed OA journals (as on 1 October 2011), SciELO publishes 875 OA journals from ten countries (as on 2 October 2011), and J-STAGE provides a portal for over 757 Japanese journals (as on 1 October 2011), most of them OA.

Earlier studies have shown that the greater accessibility and visibility of research papers published in OA journals have improved their impact and citations⁶⁻⁹. Evans and Reimer¹⁰ have shown that the openly available articles, especially from developing countries, are cited much more often by peers than articles behind a toll barrier. It is important to know how aware Indian researchers are of OA.

In this article, we have studied the contribution of Indian researchers to OA journals indexed in *SCI Expanded* in the calendar year 2009. There is another multidisciplinary abstract and citation database of research literature, viz. *Scopus* published by the Reed Elsevier group. Even though it indexes a larger number of journals and has citation data and other features available in *WoS*, it has some limitations when one wants to download and analyse large amounts of data. For instances, at any given time *Scopus* allows downloading only a limited number, viz. 2000 records. *WoS* does not impose any restrictions on the number of records downloaded. One can download metadata for the downloaded data, 500 records at a time and go on adding in steps of 500 using the 'marked list' facility. *WoS* has a history of about half a century and as its founder Eugene Garfield was interested in scientometric research of all kinds, his team shaped the database to lend itself not only to perform its primary function, viz. searching the literature, but also to provide a source for a variety of other tasks such as building science indicators and carrying out scientometric studies with ease. Surely *Scopus* will offer such features as more and more researchers and science analysts start using it for such applications. Another database, viz. *Open J-Gate* also indexes a large number of OA journals, but it does not provide citation information and hence could not be used in this study.

Methodology

We collected bibliographic data of research papers published by Indian researchers in the calendar year 2009 from the *SCI Expanded* section of *WoS*. Papers were included if at least one author had given an address in India. The data were downloaded in comma-separated-values (CSV) format and imported into MS Access. We wrote a few SQL scripts for analysing the data. We separated the list of the 836 OA journals indexed in *SCI* for our analysis. Apart from the list of 836 OA journals pro-

vided by the Thomson Reuters, there are nine other journals registered as OA in the *Scopus* source list (e.g. *Chem. Pharm. Bull.*, Japan, ISSN 0009-2363, IF 1.507) which have been considered as OA journals in our study. The countries of publication of journals were collected from the source data indexed in *Scopus*. We preferred *Scopus* over the *SCI* database, because occasionally the country assigned to a journal in the source data of *SCI* differs from the individual entry for the paper in the set of records downloaded for our analysis. For example, *Chinese Chemical Letters*, published by the Chinese Chemical Society, Beijing, China, is also attributed to Elsevier Science Inc., New York, USA; the *Chinese Journal of Chemistry*, published by the Chinese Chemical Society, Shanghai, China, is attributed to Wiley-VCH, Weinheim, Germany in the data downloaded and also attributed to Wiley-Blackwell, Malden, USA in the list of journals indexed in *SCI Expanded* and *Eur. Phys. J. – Appl. Phys.*, published by the Cambridge University Press, New York, is also attributed to EDP Sciences, France. Impact factor (IF) values of journals were assigned from *Journal Citation Reports (JCR) 2010*. Some journals are shown as having an IF value of zero; it means that either they were not indexed in *JCR*, or indexed recently but not yet assigned an IF. When assigning IF values from *JCR 2010* by matching the ISSN using SQL script in MS Access, we found that 150 journals in our dataset did not match with the ISSN given in *JCR 2010* (same title, but different ISSN – maybe of on-line and print version). For these 150 journals, we checked the journal titles manually and assigned IF values. Only 19 journals had IF and the rest (131) did not, and we assigned a value of zero. Some titles also had different abbreviations; for example, *An. Stiint. U. Al. I-Mat.* (in *JCR*) is rendered as *Analele Stiint Univ.* in *SCI*, and *Probl. Atom. Sci. Tech.* (in *JCR*) is rendered as *Probl. At. Sci. Tech.* in *SCI*. Thomson Reuters will do well if they take care of such discrepancies in journal title abbreviations and assignment of publishing countries.

Results

Indian researchers have used 4,603 journals to publish 43,481 research papers in 2009. They used 445 OA journals to publish 6,904 papers, which accounted for 15.88%, and 4,158 non-OA journals to publish 36,577 papers (Table 1). Of the 445 OA journals, 15 are published by MedKnow, Mumbai, India, and these carried 1,282 papers (<http://www.medknow.com/>). Björk *et al.*¹¹ have shown that the number of OA papers has been growing and for articles published in 2008, it stood at 20.4% of all papers published – 8.5% in journals (publisher sites) and 11.9% in searchable repositories. A subsequent study commissioned by the European Commission called the SOAP project survey, the largest to touch issues in OA publishing

Table 1. Journals used by Indian researchers in 2009 classified by their open access status (as seen from *Web of Science – Science Citation Index Expanded* accessed on 1 September 2011)

| Journal category | No. of journals | % share of journals | No. of papers | % share of papers | Sum of citations | % share of citations | Citations per paper (CPP) |
|------------------|-----------------|---------------------|---------------|-------------------|------------------|----------------------|---------------------------|
| Non-OA journals | 4,158 | 90.33 | 36,577 | 84.12 | 105,314 | 92.29 | 2.88 |
| OA journals | 445 | 9.67 | 6,904 | 15.88 | 8,794 | 7.71 | 1.27 |
| Total | 4,603 | 100.00 | 43,481 | 100.00 | 114,108 | 100.00 | 2.62 |

Table 2. Distribution of papers published by Indian researchers in 2009 by document type (as seen from *SCI Expanded*, search made on 1 September 2011)

| Document type (as given in <i>SCI Expanded</i>) | No. of papers (all journals) | Sum of citations | No. of papers (OA journals) | Sum of citations |
|---|---------------------------------|---------------------|--------------------------------|---------------------|
| Article | 36,193 | 98,531 | 5,436 | 7,402 |
| Article; book chapter | 7 | 18 | 0 | 0 |
| Article; proceedings paper | 1,036 | 2,784 | 37 | 61 |
| Biographical item | 51 | 5 | 23 | 4 |
| Book review | 10 | 0 | 0 | 0 |
| Correction | 128 | 15 | 4 | 0 |
| Editorial material | 892 | 618 | 313 | 215 |
| Editorial material; book chapter | 1 | 1 | 0 | 0 |
| Letter | 1,475 | 750 | 554 | 209 |
| Meeting abstract | 2,177 | 73 | 222 | 2 |
| News item | 53 | 10 | 13 | 3 |
| Reprint | 2 | 0 | 0 | 0 |
| Review | 1,432 | 11,210 | 302 | 898 |
| Review; book chapter | 23 | 93 | 0 | 0 |
| Software review | 1 | 0 | 0 | 0 |
| Total | 43,481 | 114,108 | 6,904 | 8,794 |

so far¹², reports that approximately 10% of papers published currently appeared in OA journals. Thus, contrary to the prevailing perceptions, Indian researchers are publishing a substantially larger percentage of their papers in OA journals than the rest of the world.

Table 2 shows the distribution of the papers by document type. About 83% of papers in all journals and 78.7% of papers in OA journals are articles, and 2.38% of papers in all journals and 0.54% of papers in OA journals are papers from proceedings. A little over 2% of papers in all journals and about 4.5% of papers in OA journals are editorial material.

Journal country

The 4,603 journals used by Indian researchers are published from 64 countries, but a substantial number of papers, more than 88%, have appeared in journals from five countries. These include 1,351 US journals publishing 10,284 (or 23.65% of all) Indian papers, 775 journals from The Netherlands publishing 9,202 (or 21%) of all Indian papers and 1,119 UK-based journals publishing 8,710 papers (accounting for 20%). Indian researchers used 101 Indian journals to publish 8,258 papers

(18.99%) and 361 German journals to publish 2,195 papers. Table 3 gives a list of country of origin of journals, number of journals, number of OA journals and the total number of papers published in journals from each country. Out of the 1,351 US journals, 59 are OA; of the 1,119 UK journals, 71 are OA; of the 101 Indian journals 46 are OA and of the 361 German journals, 11 are OA; but only one of the 775 journals from the Netherlands is OA. This is largely because The Netherlands is the home of the world's leading journal publishing companies and unlike in the USA, UK and India, there is hardly any journal in The Netherlands published by non-commercial publishers of scholarly journals. Indeed one of the companies has made a contribution to the election fund of an American Senator who brought up amendments to stall the Federal Research Public Access Act (FRPAA). Many of these commercial publishers had even hired a public relations consultant 'to take on the free-information movement, which campaigns for scientific results to be made freely available'¹³.

One may wonder at the small number of Indian journals. In fact, Indian scientists publish in many more Indian journals, but they are not indexed in *SCI Expanded* or *JCR*. The distribution of OA journals indexed in *SCI Expanded* by country is revealing (Table 4). While

GENERAL ARTICLES

Table 3. Distribution of journals used by Indian researchers by journal publishing country and OA status (as seen from WoS – SCI Expanded accessed on 1 September 2011; only journal countries with more than 90 papers are listed)

| Country | All journals | | | | OA journals | | | |
|--------------------------|-----------------|---------------|------------------|------|-----------------|---------------|------------------|------|
| | No. of journals | No. of papers | Sum of citations | CPP | No. of journals | No. of papers | Sum of citations | CPP |
| United States of America | 1,351 | 10,284 | 34,725 | 3.38 | 59 | 354 | 1,163 | 3.29 |
| The Netherlands | 775 | 9,202 | 34,987 | 3.80 | 1 | 6 | 1 | 0.17 |
| United Kingdom | 1,119 | 8,710 | 27,694 | 3.18 | 71 | 703 | 1,695 | 2.41 |
| India | 101 | 8,258 | 4,761 | 0.58 | 46 | 4,258 | 3,687 | 0.87 |
| Germany | 361 | 2,195 | 5,398 | 2.46 | 11 | 76 | 239 | 3.14 |
| Switzerland | 73 | 572 | 1,176 | 2.06 | 10 | 44 | 158 | 3.59 |
| Japan | 78 | 361 | 556 | 1.54 | 25 | 97 | 190 | 1.96 |
| Singapore | 38 | 357 | 316 | 0.89 | 2 | 71 | 66 | 0.93 |
| Romania | 29 | 317 | 299 | 0.94 | 8 | 88 | 84 | 0.95 |
| South Korea | 45 | 266 | 374 | 1.41 | 9 | 84 | 143 | 1.70 |
| Poland | 52 | 232 | 339 | 1.46 | 24 | 80 | 140 | 1.75 |
| Canada | 51 | 202 | 237 | 1.17 | 8 | 24 | 40 | 1.67 |
| China | 51 | 196 | 324 | 1.65 | 3 | 16 | 47 | 2.94 |
| Hungary | 21 | 170 | 224 | 1.32 | 5 | 28 | 22 | 0.79 |
| France | 32 | 140 | 348 | 2.49 | 3 | 8 | 0 | 0.00 |
| Italy | 47 | 136 | 130 | 0.96 | 8 | 30 | 8 | 0.27 |
| Iran | 25 | 129 | 190 | 1.47 | 15 | 105 | 182 | 1.73 |
| Kenya | 2 | 121 | 79 | 0.65 | 2 | 121 | 79 | 0.65 |
| Nigeria | 6 | 111 | 116 | 1.05 | 4 | 81 | 75 | 0.93 |
| Israel | 14 | 104 | 64 | 0.62 | 1 | 3 | 1 | 0.33 |
| Australia | 32 | 102 | 120 | 1.18 | 4 | 20 | 29 | 1.45 |
| Russia | 37 | 102 | 90 | 0.88 | 1 | 1 | 0 | 0.00 |
| Serbia | 12 | 99 | 277 | 2.80 | 11 | 98 | 274 | 2.80 |
| Brazil | 24 | 93 | 108 | 1.16 | 24 | 93 | 108 | 1.16 |
| Turkey | 23 | 92 | 80 | 0.87 | 16 | 68 | 52 | 0.76 |
| 39 other countries | 204 | 930 | 1,096 | 1.18 | 74* | 347 | 311 | 0.90 |
| Total | 4,603 | 43,481 | 114,108 | 2.62 | 445 | 6,904 | 8,794 | 1.27 |

*OA journals from 32 other countries.

countries like England and USA have 115 and 102 OA titles, The Netherlands has just 3 OA journals.

OA journals used

OA journals used by Indian researchers in 2009 are listed in Table 5. Only the 24 journals with at least 70 papers from India are shown. Of these 24 journals, only five have an IF of greater than 1.000, and only 18 have at least 100 papers from India and these 18 journals together accounted for 50.69% of India's total OA journal output. Of these 18 OA journals, 16 are from India and one each from United Kingdom and Kenya. Of the 445 OA journals, *Current Science* (IF = 0.897) published by the Current Science Association in association with the Indian Academy of Sciences, Bangalore, tops the list with 597 papers, followed by *Acta Crystallogr. Sect. E-Struct. Rep.* (IF = 0.413) published from the United Kingdom, with 440 papers. The journal *Indian J. Pharm. Sci.* (IF = 0.455) has 326 papers. The overall average citation per paper (CPP) in OA journals is 1.27, a rather small number, and smaller than CPP for Indian papers published in all journals (including non-OA journals; 2.62). This is

contrary to expectations and needs to be probed further; several studies have shown the citation advantage of OA⁶⁻⁹. Is there a difference in citability of papers published in OA journals by authors from developing and developed countries? Our results are for papers published in 2009 and the CPP is likely to improve with the passage of time.

But there are certain OA journals which have recorded high CPP for Indian papers. Notably, the UK-based journal *Mol. Syst. Biol.* (IF = 9.667) has one paper which received 23 citations. Similarly, *Nucl. Acids Res.* (IF = 7.836) has 17 papers from India which together received 321 citations for a CPP of 18.88. Five papers published in *Molecules* (IF = 1.988) received 69 citations. Three papers that appeared in *PLoS Genet.* (IF = 9.543) received 39 citations. Two review articles that were published in *Biogeosciences* (IF = 3.587) received 25 citations. Similarly, nine papers that appeared in *PLoS Med.* (IF = 15.617) received 101 citations for a CPP of 11.22. The *Int. J. Electrochem. Sci.* (IF = 2.808), being published by the Electrochemical Science Group, Serbia, since 2006, and indexed in *JCR* only from 2009, has 33 Indian papers that have received 227 citations, with an average citation per paper of 6.88.

Table 4. Distribution of OA journals indexed in *WoS (SCI Expanded)* by country*

| Country | No. of journals | Country | No. of journals |
|--------------------------|-----------------|----------------------------|-----------------|
| England | 115 | People's Republic of China | 8 |
| United States of America | 102 | Romania | 8 |
| Brazil | 88 | Australia | 8 |
| India | 48 | Pakistan | 7 |
| Japan | 47 | Venezuela | 7 |
| Poland | 37 | South Africa | 7 |
| Turkey | 31 | Denmark | 6 |
| Spain | 30 | Hungary | 6 |
| Chile | 23 | Finland | 6 |
| Germany | 21 | Nigeria | 5 |
| Iran | 19 | Lithuania | 5 |
| Croatia | 18 | Slovenia | 5 |
| Serbia | 16 | Taiwan | 4 |
| Switzerland | 15 | Ukraine | 4 |
| Czech Republic | 14 | Greece | 3 |
| Mexico | 13 | Norway | 3 |
| Colombia | 12 | Portugal | 3 |
| Italy | 12 | New Zealand | 3 |
| Canada | 11 | The Netherlands | 3 |
| South Korea | 11 | 24 other countries | 36 |
| France | 8 | | |
| Argentina | 8 | Total | 836 |

*The list of 836 OA journals indexed in *Web of Science (SCI Expanded)* was obtained from Thomson Reuters.

Impact factor of journals

The 4,603 journals in which Indian researchers have published have been classified by IF of journals as seen from *JCR 2010* (Table 6). We notice that the ratio of OA journals to the total number of journals decreases with an increase in IF. This is to be expected, as many of the toll access journals with high IF have been around for a long time and most OA journals are less than 10 years old. About 2.5% of papers from India have appeared in 131 journals (including 26 OA journals), which are either not indexed in *JCR 2010* or recently indexed but not assigned IF values. We have assigned their IF as zero. A little over 34% of all papers published by Indian researchers appeared in 1,471 journals, which include 235 OA journals with IF less than 1. About 56.5% of papers have appeared in 2,645 journals with IF in the range 1–4.499. Only 357 papers appeared in 66 journals, including three OA journals, with IF > 10. Of the 6,904 papers in OA journals, less than 4% of papers appeared in journals with IF = 0 and over 73% of papers published in 235 journals with IF less than 1. An item classified as 'editorial material' appeared in the OA journal *CA-A Cancer J. Clin.* (IF = 94.262) which has received three citations. Among the 445 OA journals, the high IF journals, e.g. *PLoS Med.* (IF = 15.617) has nine papers, viz. five articles, three editorial materials and one review which together received 101 citations; and *PLoS Biol.* (IF = 12.469), *Mol. Syst. Biol.* (IF = 9.667) and *PLoS Pathog.* (IF = 9.079) have one paper each and they have received 9, 23 and 6 citations respectively.

We notice that the average CPP correlates well with the IF of journals. For journals with IF up to 1.5, CPP is less than 2.0 and for journals with IF in the range 7–20, CPP is higher than 9.0. Indian papers published in 37 OA journals have CPP of 5 or greater. In contrast, Indian papers published in 149 non-OA journals have CPP of 10 or above.

Non-OA journals

Table 7 presents the use of non-OA journals by Indian researchers in 2009. They used 4,158 non-OA journals to publish 36,577 papers in 2009. Of the 101 Indian journals used, 55 are non-OA and they had carried 4,000 papers. Two Indian journals have been used to publish more than 300 papers, viz. *Asian J. Chem.* (IF = 0.247, 481 papers) and *Indian J. Anim. Sci.* (IF = 0.147, 312 papers). Other frequently used non-OA journals are from the US, The Netherlands and UK. Some non-OA journals have decent CPP values [e.g. *Astrophys. J. Suppl. Ser.* (IF = 15.199) and *Nat. Rev. Neurosci.* (IF = 29.510) have each one paper from India with CPP of 505 and 112 respectively; other notable non-OA journals are *Rep. Prog. Phys.* (2 Indian papers, CPP 91.00), *Chem. Rev.* (4 papers, CPP 60.00), *Nano Today* (1 paper, CPP 59.00), *N. Engl. J. Med.* (20 papers, CPP 55.90), *Phys. Rev. Lett.* (82 papers, CPP 11.68), *J. Org. Chem.* (73 papers, CPP 10.22), *Tetrahedron Lett.* (264 papers, CPP 6.44), *J. Hazard Matter* (225 papers, CPP 8.02), *Eur. J. Med. Chem.* (156 papers, CPP 6.74) and *Phys. Rev. D* (165 papers, CPP 7.58)]. The 170 papers Indian researchers have published in the

GENERAL ARTICLES

Table 5. OA journals used by Indian researchers in 2009* (as seen from WoS – SCI Expanded accessed on 1 September 2011)

| Journal | ISSN | Impact factor 2010 | Country** | No. of papers | Sum of citations | CPP |
|--|-----------|-----------------------|-----------|------------------|---------------------|------|
| <i>Curr. Sci.</i> | 0011–3891 | 0.897 | IND | 597 | 436 | 0.73 |
| <i>Acta Crystallogr. Sect. E</i> | 1600–5368 | 0.413 | GBR | 440 | 586 | 1.33 |
| <i>Indian J. Pharm. Sci.</i> | 0250–474X | 0.455 | IND | 326 | 69 | 0.21 |
| <i>Indian Pediatrics</i> | 0019–6061 | 0.900 | IND | 227 | 179 | 0.79 |
| <i>Indian J. Med. Res.</i> | 0971–5916 | 1.826 | IND | 197 | 346 | 1.76 |
| <i>E-J. Chem.</i> | 0973–4945 | 0.716 | IND | 188 | 163 | 0.87 |
| <i>Indian J. Pathol. Microbiol.</i> | 0377–4929 | 0.570 | IND | 180 | 115 | 0.64 |
| <i>Indian J. Dermatol. Venereol. Leprol.</i> | 0378–6323 | 0.932 | IND | 168 | 118 | 0.70 |
| <i>Indian J. Chem. Sect. B</i> | 0376–4699 | 0.562 | IND | 150 | 132 | 0.88 |
| <i>Neurol. India</i> | 0028–3886 | 0.834 | IND | 145 | 107 | 0.74 |
| <i>Indian J. Ophthalmol.</i> | 0301–4738 | 0.827 | IND | 119 | 180 | 1.51 |
| <i>Indian J. Exp. Biol.</i> | 0019–5189 | 0.702 | IND | 116 | 164 | 1.41 |
| <i>Afr. J. Biotechnol.</i> | 1684–5315 | 0.573 | KEN | 114 | 66 | 0.58 |
| <i>Indian J. Pure Appl. Phys.</i> | 0019–5596 | 0.511 | IND | 113 | 97 | 0.86 |
| <i>J. Sci. Ind. Res.</i> | 0022–4456 | 0.514 | IND | 108 | 92 | 0.85 |
| <i>Pramana – J. Phys.</i> | 0304–4289 | 0.561 | IND | 106 | 112 | 1.06 |
| <i>J. Environ. Biol.</i> | 0254–8704 | 0.000 | IND | 105 | 134 | 1.28 |
| <i>Indian J. Tradit. Knowl.</i> | 0972–5938 | 0.232 | IND | 101 | 44 | 0.44 |
| <i>Indian J. Med. Microbiol.</i> | 0255–0857 | 1.006 | IND | 87 | 94 | 1.08 |
| <i>PLoS One</i> | 1932–6203 | 4.411 | USA | 87 | 385 | 4.43 |
| <i>J. Chem. Sci.</i> | 0974–3626 | 1.075 | IND | 78 | 127 | 1.63 |
| <i>Indian J. Chem. Sect. A</i> | 0376–4710 | 0.920 | IND | 76 | 124 | 1.63 |
| <i>J. Postgrad. Med.</i> | 0022–3859 | 1.589 | IND | 72 | 97 | 1.35 |
| <i>Singap. Med. J.</i> | 0037–5675 | 0.730 | SGP | 70 | 66 | 0.94 |
| 421 other journals | | | | 2,934 | 4,761 | 1.62 |
| Total | | | | 6,904 | 8,794 | 1.27 |

*Only journals in which Indian researchers have published at least 70 papers are listed. **ISO 3166-1-alpha-3 country codes assigned for journals.

Table 6. Impact factor (IF) range of journals used by Indian researchers to publish their papers (as seen from WoS – SCI Expanded accessed on 1 September 2011)

| IF range (JCR 2010) | All journals | | | | OA journals | | | |
|------------------------|--------------------|------------------|---------------------|-------|--------------------|------------------|---------------------|-------|
| | No. of journals | No. of papers | Sum of citations | CPP | No. of journals | No. of papers | Sum of citations | CPP |
| 0.000 | 131 | 1,100 | 838 | 0.76 | 26 | 271 | 333 | 1.23 |
| 0.001–0.499 | 586 | 6,997 | 3,031 | 0.43 | 102 | 1,833 | 1,112 | 0.61 |
| 0.500–0.999 | 885 | 8,112 | 8,348 | 1.03 | 133 | 3,244 | 2,971 | 0.92 |
| 1.000–1.499 | 761 | 6,070 | 11,154 | 1.84 | 57 | 532 | 872 | 1.64 |
| 1.500–1.999 | 579 | 5,446 | 14,198 | 2.61 | 36 | 495 | 1,007 | 2.03 |
| 2.000–2.499 | 491 | 5,266 | 15,602 | 2.96 | 25 | 77 | 240 | 3.12 |
| 2.500–2.999 | 296 | 2,838 | 12,126 | 4.27 | 18 | 124 | 529 | 4.27 |
| 3.000–3.499 | 242 | 1,984 | 9,949 | 5.01 | 10 | 49 | 189 | 3.86 |
| 3.500–3.999 | 153 | 1,734 | 8,640 | 4.98 | 10 | 39 | 232 | 5.95 |
| 4.000–4.499 | 123 | 1,224 | 6,822 | 5.57 | 5 | 116 | 542 | 4.67 |
| 4.500–4.999 | 85 | 867 | 5,775 | 6.66 | 5 | 21 | 107 | 5.10 |
| 5.000–6.999 | 144 | 1,017 | 6,290 | 6.18 | 10 | 65 | 157 | 2.42 |
| 7.000–9.999 | 61 | 469 | 4,565 | 9.73 | 5 | 27 | 390 | 14.44 |
| 10.000–14.999 | 37 | 156 | 1,808 | 11.59 | 1 | 1 | 9 | 9.00 |
| 15.000–20.000 | 11 | 87 | 1,082 | 12.44 | 1 | 9 | 101 | 11.22 |
| >20.000 | 18 | 114 | 3,880 | 34.04 | 1 | 1 | 3 | 3.00 |
| Total | 4,603 | 43,481 | 114,108 | 2.62 | 445 | 6,904 | 8,794 | 1.27 |

Swiss journal *Ann. Nutr. Metab.* (IF = 2.173) have not received any citation during the period. Of these 170 papers, 169 are meeting abstracts. Similarly, 102 meeting abstracts published in *Abstr. Pap. Am. Chem. Soc.* have not received any citations.

Distribution of Indian papers by subject

SCI provides a broad classification of journals by subjects and subfields. The classification is at the level of journals and not individual articles. In Table 8, we provide

Table 7. Non-OA journals used by Indian researchers in 2009* (as seen from WoS – SCI Expanded accessed on 1 September 2011)

| Non-OA journals | ISSN | Impact factor 2010 | Country** | No. of papers | Sum of citations | CPP |
|----------------------------------|-----------|-----------------------|-----------|------------------|---------------------|------|
| <i>Asian J. Chem.</i> | 0970–7077 | 0.247 | IND | 481 | 101 | 0.21 |
| <i>Indian J. Anim. Sci.</i> | 0367–8318 | 0.147 | IND | 312 | 63 | 0.20 |
| <i>J. Alloy. Compd.</i> | 0925–8388 | 2.134 | NLD | 305 | 1,275 | 4.18 |
| <i>Tetrahedron Lett.</i> | 0040–4039 | 2.618 | NLD | 264 | 1,699 | 6.44 |
| <i>Indian J. Agric. Sci.</i> | 0019–5022 | 0.156 | IND | 233 | 53 | 0.23 |
| <i>J. Appl. Phys.</i> | 0021–8979 | 2.064 | NLD | 230 | 802 | 3.49 |
| <i>J. Indian Chem. Soc.</i> | 0019–4522 | 0.301 | IND | 229 | 96 | 0.42 |
| <i>J. Hazard. Mater.</i> | 0304–3894 | 3.723 | NLD | 225 | 1,804 | 8.02 |
| <i>J. Appl. Polym. Sci.</i> | 0021–8995 | 1.240 | USA | 202 | 393 | 1.95 |
| <i>Indian J. Pediatr.</i> | 0019–5456 | 0.502 | IND | 199 | 106 | 0.53 |
| <i>Ann. Nutr. Metab.</i> | 0250–6807 | 2.173 | CHE | 170 | 0 | 0.00 |
| <i>Phys. Rev. D</i> | 1550–7998 | 4.964 | USA | 165 | 1,250 | 7.58 |
| <i>J. Nanosci. Nanotechnol.</i> | 1533–4880 | 1.351 | USA | 159 | 371 | 2.33 |
| <i>Eur. J. Med. Chem.</i> | 0223–5234 | 3.193 | NLD | 156 | 1,051 | 6.74 |
| <i>Spectrochim. Acta, Part A</i> | 1386–1425 | 1.770 | GBR | 156 | 554 | 3.55 |
| <i>J. Geol. Soc. India</i> | 0016–7622 | 0.396 | IND | 151 | 103 | 0.68 |
| <i>Ind. Eng. Chem. Res.</i> | 0888–5885 | 2.071 | USA | 144 | 398 | 2.76 |
| <i>Phys. Rev. B</i> | 1098–0121 | 3.772 | USA | 141 | 818 | 5.80 |
| <i>Indian J. Phys.</i> | 0973–1458 | 0.291 | IND | 139 | 54 | 0.39 |
| <i>J. Phys. Chem. B</i> | 1520–6106 | 3.603 | USA | 136 | 733 | 5.39 |
| <i>J. Phys.-Condes. Matter</i> | 0953–8984 | 2.332 | GBR | 129 | 386 | 2.99 |
| <i>Physica B</i> | 0921–4526 | 0.856 | NLD | 128 | 244 | 1.91 |
| <i>J. Phys. D</i> | 0022–3727 | 2.105 | GBR | 125 | 402 | 3.22 |
| 4,135 other journals | | | | 31,998 | 92,558 | 2.89 |
| Total | | | | 36,577 | 105,314 | 2.88 |

*Only journals in which Indian researchers have published 125 or more papers are listed.

**ISO 3166-1-alpha-3 country codes assigned for journals.

information on the distribution of Indian papers published in toll-access and OA journals by journal subfields. Chemistry (4,593 papers in 162 journals) and physics (2,694 papers in 104 journals) lead the list if we consider all journals. [Apart from chemistry we have ‘materials science: chemistry’ journals, polymer science, etc. and apart from physics, we have crystallography, ‘materials science: physics’, astrophysics, etc. That is to say the classification is not into water-tight compartments.] But if we consider only OA journals, then general science periodicals top the list (711 papers in eight journals, of which *Current Science* alone accounts for 597 papers, *Def. Sci. J.* accounts for 65 papers, *Arab. J. Sci. Eng.* accounts for 16 papers, *Int. J. Phys. Sci.* accounts for 12 papers, *Sci. Res. Essays* and *Scienceasia* have six papers each, and *Maejo. Int. J. Sci. Technol.* and *S. Afr. J. Sci.* have eight and one paper respectively). Chemistry journals come next (697 papers in 21 OA journals, of which the two sections of *Indian J. Chem.* account for 226 papers, *E-J. Chem.* accounts for 188 papers, *J. Chem. Sci.* accounts for 78 papers and *Arkivoc* accounts for 52 papers), followed by pharmacology and pharmacy (592 papers in 21 journals, of which *Indian J. Pharm. Sci.* accounts for 326 papers, *Indian J. Pharmacol.* accounts for 61 papers and *Pharmacogn. Mag.* accounts for 54 papers) and crystallography (440 papers from one journal – *Acta Crystallogr. Sect. E – Struct. Rep. Online*).

Distribution of Indian OA papers by institution and cost of publication

We did not attempt to find out the distribution of all Indian papers (or just the papers published in OA journals) by institution, as the only way it could be done was to download each record and check the author affiliation manually. Considering the large number of records we are dealing with we thought the results would not be commensurate with the effort. Nor have we attempted to evaluate the costs to India of publishing in OA journals. In 2009, Indian researchers had published 2,646 papers in 399 OA journals published from outside India. Many of these journals may charge a fee from the author; some of them charge about US\$ 3,000. However, many of these journals are ready to waive the charges for authors from the developing countries. But still some authors may have paid the fees. Gathering such data (how much Indian authors have spent in 2009 for publishing their papers in OA journals) is not an easy task. One has to contact each author.

Incidentally, no Indian OA journal charges an author side fee. Most Indian OA journals still sell subscription to their print versions; many of them carry advertisements; some of them are supported by grants from the government (Department of Science and Technology and Council of Scientific and Industrial Research (CSIR), New Delhi).

GENERAL ARTICLES

Table 8. Distribution of Indian papers by journal subfield* (as seen from WoS – *SCI Expanded* accessed on 1 September 2011)

| Subject/field | No. of journals | No. of papers | Sum of citations | CPP |
|--|-----------------|---------------|------------------|-------------|
| All journals | | | | |
| Chemistry | 162 | 4,593 | 14,637 | 3.19 |
| Physics | 104 | 2,694 | 9,037 | 3.35 |
| Pharmacology and Pharmacy | 100 | 1,437 | 3,543 | 2.47 |
| Agriculture | 73 | 1,378 | 807 | 0.59 |
| Engineering | 149 | 1,169 | 2,230 | 1.91 |
| Materials Science | 77 | 957 | 2,673 | 2.79 |
| Science and Technology – other topics | 30 | 935 | 2,246 | 2.40 |
| Mathematics | 210 | 774 | 884 | 1.14 |
| Crystallography | 10 | 623 | 1,003 | 1.61 |
| Neurosciences and Neurology | 69 | 590 | 1,010 | 1.71 |
| Polymer science | 32 | 528 | 1,470 | 2.78 |
| Materials science; physics | 16 | 505 | 1,501 | 2.97 |
| 948 other fields | 3,521 | 27,125 | 72,878 | 2.69 |
| Unknown | 50 | 173 | 189 | 1.09 |
| Total | 4,603 | 43,481 | 114,108 | 2.62 |
| OA journals | | | | |
| Science and Technology – other topics | 8 | 711 | 487 | 0.68 |
| Chemistry | 21 | 697 | 918 | 1.32 |
| Pharmacology and Pharmacy | 21 | 592 | 300 | 0.51 |
| Crystallography | 1 | 440 | 586 | 1.33 |
| Physics | 11 | 275 | 347 | 1.26 |
| Pediatrics | 3 | 238 | 187 | 0.79 |
| General and Internal Medicine | 22 | 207 | 327 | 1.58 |
| Neurosciences and Neurology | 9 | 205 | 155 | 0.76 |
| Immunology; General and Internal Medicine; Research and Experimental Medicine | 1 | 197 | 346 | 1.76 |
| Life Sciences and Biomedicine – other topics | 9 | 196 | 270 | 1.38 |
| Biotechnology and Applied Microbiology | 5 | 188 | 143 | 0.76 |
| Pathology | 2 | 185 | 126 | 0.68 |
| 147 other fields | 309 | 2,729 | 4,566 | 1.67 |
| Unknown | 23 | 44 | 36 | 0.82 |
| Total | 445 | 6,904 | 8,794 | 1.27 |

*Only fields with 500 or above papers in all journals and 185 or more papers in OA journals are listed.

Conclusion

OA to research findings can be provided by two ways: by publishing the papers in OA journals (the gold route) and or by placing the full text of the papers along with meta-data in interoperable OA archives (the green route). At least three leading publishers of S&T journals in India have opted to go the OA way. MedKnow publishes more than 150 OA journals. The Indian Academy of Sciences, Bangalore, adopted OA for all its journals more than ten years ago. Indeed, *Pramana*, its physics journal, was made open access in July 1998. More recently, CSIR made all 16 research journals published by the National Institute of Science Communication and Information Resources OA. A few years ago the Indian Council of Medical Research made the *Indian Journal of Medical Research* OA. While these moves are certainly welcome, we believe that the OA archives route is the ideal solution, especially for developing countries. No matter whether they publish their papers in OA or toll-access

journals, Indian researchers will do well to place the full text of their papers in institutional repositories. Stevan Harnad, founder of *Psycoloquy* stopped publishing the journal in 2001, as it became clear to him by then that author self-archiving in interoperable institutional repositories was the best route to ensure 100% OA to the world's scholarly literature.

In November 2009, 41 Nobel laureates wrote an open letter to the US Congress expressing their support to OA to research. They believed that the open availability of research 'will make it easier for scientists worldwide to better and more swiftly address the complex scientific challenges that we face today and expand shared knowledge across disciplines to accelerate breakthrough and spur innovation'¹⁴. P. Balaram told *SciDev.Net*; 'I think every institution should be encouraged to set up a repository. This is a problem-free model I want to promote. There may be a few glitches at the start, but the next generation of scientists will be comfortable with it'¹⁵. In a recent blog posting, Giridhar¹⁶ said, 'The best way to

make the work open access in India is not necessarily by publishing it in open access journals but by depositing the article in an institutional repository'. The Indian Academy of Sciences has recently set up a repository for papers by all its Fellows, both living and deceased. As of 7 October 2011, more than 60,500 papers/documents were deposited, but a vast majority of them do not provide access to the full text. One has to be content with metadata and abstracts. CSIR has decided to set up repositories in each one of its more than 35 laboratories.

1. Madhan, M. and Arunachalam, S., Use made of open access journals by Indian researchers to publish their findings. *Curr. Sci.*, 2011, **100**, 1297–1306.
2. McVeigh, M. E., Open access journals in the ISI citation databases: analysis of impact factors and citation patterns. A citation study from Thomson Scientific, October 2004; available at <http://scientific.thomsonreuters.com/m/pdfs/openaccesscitations2.pdf>
3. Morrison, H., Dramatic growth of open access: Open Data Edition – Full Data, 30 September 2011; <http://poiticeconomics.blogspot.com/2011/09/dramatic-growth-of-open-access.html>
4. Jothy, S., Bridging the knowledge gap through open access. *J. Gate Newslett.*, 2011, **3**; http://www.informaticsglobal.com/iil_newsletter_openaccess.asp
5. Kuchma, I., The state of open access publishing and open access repositories in Africa. Presented at Africa Day for Librarians, Nordic Africa Institute Library, Uppsala, Sweden, 9 November 2010.
6. Lawrence, S., Free online availability substantially increases a paper's impact. *Nature*, 2001, **411**, 521.
7. Swan, A., The open access citation advantage: studies and results to date. Technical Report, School of Electronics and Computer Science, University of Southampton, 2010; http://eprints.ecs.soton.ac.uk/18516/2/Citation_advantage_paper.pdf
8. Gargouri, Y., Hajjem, C., Larivière, V., Gingras, Y., Carr, L., Brody, T. and Harnad, S., Self-selected or mandated, open access increases citation impact for higher quality research. *PLoS One*, 2010, **5**(10), e13636.
9. Wagner, A. B., Open access citation advantage: an annotated bibliography. *Iss. Sci. Technol. Librarianship*, 2010, Winter; <http://www.istl.org/10-winter/article2.html>
10. Evans, J. A. and Reimer, J., Open access and global participation in science. *Science*, 2009, **323**, 1025.
11. Björk, B.-C., Welling, P., Laakso, M., Majlender, P., Hedlund, T. and Guðnason, G., Open access to the scientific journal literature: situation 2009. *PLoS One*, 2010, **5**(6), e11273.
12. Dallmeier-Tiessen, S. *et al.*, Highlights from the SOAP project survey. What scientists think about open access publishing, 20 January 2011; <http://arxiv.org/ftp/arxiv/papers/1101/1101.5260.pdf>
13. Giles, J., PR's 'pit bull' takes on open access. *Nature*, 2007, **445**, 347.
14. An open letter to the US Congress signed by 41 Nobel Prize winners (10 November 2009); http://www.taxpayeraccess.org/issues/frpaa/frpaa_supporters/nobelists_2009.shtml
15. Jayaraman, K. S., Open archives – the alternative to open access, interview with P. Balaram, *SciDev.Net*, 9 July 2008; <http://www.scidev.net/en/features/q-a-open-archives-thealternative-to-open-access.html>
16. Madras, G., Impact factor and journals, 15 May 2011; http://giridharmadras.blogspot.com/2011_05_01_archive.html

ACKNOWLEDGEMENTS. We thank Thomson Reuters for providing the list of OA journals indexed in the *Web of Science (SCI Expanded)*, and Ms S. Jothy, Informatics India Ltd, Bangalore, for providing Figure 2.

Received 5 June 2011; revised accepted 18 October 2011