Can India overpower China in publishing science and engineering research articles?

Scientific research articles are an important output of the research and development (R&D) activities of a nation, which depend on the financial resources and infrastructure available for R&D and qualified manpower.

According to the National Science Foundation, USA, 564,644 science and engineering (S&E) articles were published globally in 1995 and 788,347 articles in 2009, with an average yearly growth rate of 2.4% (ref. 1). The top 15 countries that contributed to > 80% of S&E articles published in 1995 were USA, Japan, UK, Germany, France, Canada, Russia, Italy, Australia, The Netherlands, Spain, India, Sweden, China and Switzerland. In 2009, Sweden and Switzerland were replaced by South Korea and Taiwan in the above list.

The average annual growth rate with respect to publishing S&E articles was 16.2% for China compared to 5.6% for India during the period 1995–2009. India marginally improved its ranking from 12th (1995) to 11th (2009), whereas China took a great leap from 14th position (1995) to second (2009). Though the annual average growth rate for USA was just 0.6% during the period, it was far ahead of China in terms of the number of articles published.

Considering R&D expenditure, India spent US$ 24 billion during 2007 compared to US$ 102 billion by China and US$ 377 billion by USA[1]. However, India published 758 articles per billion US$ in comparison to 557 by China and USA. Data pertaining to the S&E articles published and gross expenditure on R&D indicate that the number of articles published is directly proportional ($r = 0.98$) to R&D expenditure. Since the number of articles published by India per billion US$ is higher than that of China and USA, an increase in R&D funding by India would have a great impact in improving its position.

Among the top 15 countries, the maximum number of researchers per million population was in Japan followed by USA, South Korea, UK, Canada, Australia, Germany, France, Russia, The Netherlands, Spain, Taiwan, Italy, China and India[2]. However, the absolute number of researchers (calculated using researchers per million population data[2] and total population data[3]) was maximum in USA followed by China, Japan, Russia, Germany, UK, South Korea, France, India, Canada, Spain, Italy, Australia, Taiwan and The Netherlands. It is interesting to note that the total number of researchers is almost the same in USA and China, but the output of articles is much lower in China compared to USA. Furthermore, the absolute number of researchers in China is approximately nine times higher than that in India, whereas the number of articles per 100 researchers in India is more than double that of China.

The marginal increase in the number of articles published by USA during 1995–2009 indicates that no steep leap is expected in the near future. China's share in engineering research articles (1273) was just 3% in 1995 in comparison to 30% (12,645) for USA. In 2009, China's share increased to 15.3% (12,234), whereas the share of USA (14,609) decreased to 17.6%. In science research articles, China's share increased from 1.5% (1995) to 8.7% (2009), whereas the share of USA decreased from 34.6% to 27.5%. India's share in science articles increased slightly from 1.6% in 1995 to 2.3% in 2009, whereas for engineering articles it increased from 2.8% in 1995 to 4.1% in 2009.

In 2008, the number of engineering Ph Ds produced in USA, China and India was 8,110 (ref. 1), 15,276 (ref. 1) and 1,427 (ref. 4) respectively, whereas in science it was 25,249 (ref. 1), 13,163 (ref. 1) and 5,301 (ref. 4) respectively. Since the number of articles published is proportional to the number of researchers[5], directed efforts are required to augment the number of S&E researchers in India.

Hence, an increase in R&D expenditure and quality S&T manpower is needed to help India emerge as a leading country in the knowledge-base economy of the world.

1. www.nsf.gov/statistics/seind12
2. http://chartsbin.com/view/1124
3. www.worldatlas.com/aatlas/populations/ctypopls.htm
4. UGC, Annual Report 2008–2009, University Grants Commission, New Delhi.
5. Chidambaram, R., *Curr. Sci.*, 2005, **88**, 856–860.

S. A. HASAN
SUSHILA KHILNANI
RAJESH LUTHRA*

Human Resource Development Group,
Council of Scientific and Industrial Research,
Library Avenue, Pusa,
New Delhi 110 012, India
**e-mail: luthra57@rediffmail.com*

Save and promote soil biodiversity

Soil biodiversity plays a major role in stabilizing and regulating the earth's climate. It is a vast frontier and a potential goldmine for countless new genes and biochemical pathways to probe for enzymes, antibiotics and other useful molecules for agriculture and industry. According to the global biodiversity assessment report, one gram of typical soil contains about 1 billion bacteria; but only 1% can be successfully grown (cultured) in laboratory[1]. Fewer than 5% of all microbial species have been discovered and named – and even less is known about the diversity within those species[1]. The staggering diversity of soil biota may be orders of magnitude higher than above-ground diversity, but none has ever documented the extinction of a bacterium[2], or made an exhaustive census of even one natural habitat[3]. Worldwide, the

economic value of soil microbial diversity is estimated to be 'at least many tens of billions of US dollars'[4]. Despite its enormous economic importance, the life in soil is still under-valued and often neglected in biodiversity debates. There is a growing concern that the invisible soil biota, which is the 'root' of a healthy soil and healthy plants and animals is losing its genetic and functional diversity due to imbalanced fertilization, injudicious use of pesticides, unabated soil pollution and negligible or no replenishment of organic residues[5,6]. Many microbes live symbiotically with higher organisms. Every plant and animal that becomes extinct is likely to take several species of microorganisms with it. The significance of extinction of soil organisms may be catastrophic, as stated by Curtis[7]: 'if the last blue whale choked to death on the last panda, it would be disastrous but not the end of the world. But if we accidentally poisoned the last two species of ammonia-oxidizers, that would be another matter. It could be happening now and we wouldn't even know.' Only by unravelling the life in the soil and linking the cause and effect relationships between the loss of soil biodiversity and the impact on terrestrial and global ecosystem processes, can we begin to conserve and better utilize its life-sustaining services. There is an urgent need to save and promote the life in soil; otherwise, future generations will have to pay the greatest price for this damage.

1. Heywood, V. H. (ed.), *The Global Biodiversity Assessment*, United Nations Environmental Programme, Cambridge University Press, Cambridge, 1995, pp. xi + 1140.
2. Miller, S. K., *New Sci.*, 1992, **135**, 7.
3. Holmes, B., *New Sci.*, 1996, **149**, 26.
4. Pimental, D. *et al.*, *BioScience*, 1997, **47**, 747–757.
5. Patra, A. K. *et al.*, *Ecol. Monogr*., 2005, **75**, 65–80.
6. Rao, D. L. N. and Patra, A. K., *J. Indian Soc. Soil Sci*., 2009, **57**, 513–530.
7. Curtis, T., *Nature Rev. Microbiol*., 2006, **4**, 488.

ASHOK K. PATRA

Division of Soil Science and Agricultural Chemistry,
Indian Agricultural Research Institute,
New Delhi 110 012, India
e-mail: patraak@gmail.com

On the tragedy of geology and geologists

The article by Valdiya[1] entitled 'The tragedy of being a geologist' is thought-provoking. The article was received by *Current Science* on 11 November 2011 and accepted on 16 November 2011. Not many geologists in India are as lucky as Valdiya for such a swift publication. The lament is not so much that of a geologist as that of Valdiya himself. *Current Science* has published a bold but strange article which emphasizes the plight of geologists but also includes many figures/diagrams from other publications. Valdiya's account on the plea of the geologists raises a mixed reaction. The article laced with several figures is a strong pointer which discusses important issues like the role of geologists in exploring the natural resources and their plight as a scientist. Altogether, he has written a brief account lamenting over the government bodies, associations and institutes for sidelining geologists and has criticized the administrative bodies of these organizations.

Valdiya, an academician has been associated with institutions like Kumaon University, Lucknow University and currently with the Jawaharlal Nehru Centre for Advanced Scientific Research. He is a geologist who has undoubtedly helped in the traverse mapping of the Himalayas. However, the points articulated in his writing indicate the opinion of one and may not represent that of the majority. He points out that the major geological institutions are headed/guided by non-geologists, for example, Geological Survey of India, the premier organization was headed by non-geologists for many years, is sternly guided by IAS in Ministry of Mines, a national Institute of Geology of Himalayas has been functioning for the last five years under the Chairmanship of Secretary to Government of India, a chemist specialized in leather technology and the Director is a micropalaeontologist. But during such appointments the geological community did not protest or demand a change. For instance, Wadia Institute of Himalayan Geology, Dehradun some years ago was headed by a geophysicist, and not someone with basic experience in Himalayan geology. Valdiya fails to mention anything about this and others in his article, but laments the fact that the micropalaeontologist heading the Institute now is a summer monsoon specialist.

Out of the several points raised by Valdiya, deep drilling is an activity which needs considerable expertise and immediate attention. Secondly, his writing is commendable for highlighting the plight of geologists who spend most of their time in the fields and the hardships faced by geologists who work in rough terrains or adverse weather conditions. But I feel that the article should have either discussed the plight of the geologists or could have been an account on natural resources. It criticizes the existing system and is a less elaborate account on natural resources or the role played by the geologists in their exploration.

I extend my appreciation to *Current Science* for publishing this article which has given an opportunity to discuss issues of prime importance. Valdiya's efforts are laudable for writing a provocative piece which may help address a few of these issues.

1. Valdiya, K. S., *Curr. Sci.*, 2012, **102**, 581–589.

A. K. PACHAURI

Former Professor at Earth Sciences,
Indian Institute of Technology Roorkee
e-mail: pachauri1945@yahoo.com