

A Small Town in the World of Big Science: Contributions of Roorkee to Scientific and Technological Research, 1996-2005

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Abstract

Roorkee, a town in the Uttarakhand state of India, has the distinction of being a town of excellence in terms of advanced engineering education and scientific research for over a century. Three international level for institutions scientific and engineering education and research i.e IITR, CBRI and NIH are located in this small town of just over a 100,000 inhabitants. An attempt has been made to provide detailed analysis of 2047 research papers contributed from Roorkee, covered by SCI Web of Science for the period from 1996 to 2005. The share of Roorkee in overall national contribution in science and technology for the same period has also been determined. Scientific productivity of these three organizations has been analysed and most proliferate authors have been identified. Ranked lists of subject-wise break-up of research papers and most productive journals have been prepared. Ten highly cited papers indicating average citations per year for five years period from 2002 to 2006 have also been identified

1. Introduction

Roorkee, as a geographical entity, is too small to find a place on the world map. It may not be found even on some maps of India. However, this small town has the distinction of one of the oldest site of engineering education and scientific research all over the Globe. The story began in 1847

(Mital 1996) when the site for an engineering college was selected near a village situated about thirty kilometres southwest of the ancient holy city of Haridwar (whose fame goes back from history into mythology) because a challenging feat of engineering was being accomplished there in the shape of an aqueduct carrying a canal over a river. After under going several incarnations, the College is now known as Indian Institute of Technology Roorkee (IITR).

Since its inception main emphasis of the College remained on civil engineering and, therefore, three other civil engineering oriented institutes were established at Roorkee. The Council of Scientific and Industrial Research (CSIR), a central agency to coordinate the development of applied science and industry oriented research established the Central Building Research Institute (CBRI) in 1948. State Government established the Irrigation Research Institute (IRI) in 1949 and the Ministry of Water Resources established the National Institute of Hydrology (NIH) in 1979 (Mital 1997). Roorkee thus provides ideal setting for analysis of research from a small town.

No work has been done in India to assess the scientific productivity of such a small town though many institution-wise studies have been carried out by various scientometricians. Singh et al. (2004) studied the research contribution and impact of research of Indian Institute of Technology, Roorkee, 1993 to 2001. Sinha and Furqan Ullah (1993) have conducted bibliometric study of eleven years (1980-90) of CBRI research output. Gupta et al. (1999) have

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made a gender based comparison of productivity of scientists of Council of Scientific and Industrial Research, India. Jeevan and Gupta (2002) have analysed the research productivity of Indian Institute of Technology Kharagpur, India.

National research output in various disciplines of science has been analysed by many authors. Karki (1990) has made an analysis of Environmental Science research in India. Satyanarayana (2000) has mapped the Indian contributions in biomedical sciences based on the research papers published in various journals and indexed in three databases, viz Index Medicus, Excerpta Medica and Tropical Diseases Bulletin of 1990 and 1994. Similarly, Arunachalam (2000) analysed the contribution of Indian researchers to life sciences research as indexed in *BIOSIS (Biological Abstracts)* 1992-1994. Ravichandra Rao and Suma (2000) attempted to find out India's share in the global output of engineering literature, in different forms of publications including journals used by Indian engineers and researching their contributions using *COMPENDEX PLUS* (CD-ROM) database of 1990 and 1994. Several other papers have also appeared on mapping of Indian publications in different spheres of scientific knowledge (Basu and Nagpaul 2000; Mehta 2000; Sahu 2000). Recently Gupta and Dhawan (2008) have analysed India's research output in Condensed Matter Physics.

The present study has been undertaken with the following main objectives

- (a) Over all assessment of contribution of Roorkee to scientific and technological research in the last decade and its share in national scientific and technological research;
- (b) To assess the individual contributions of the three organisations of international repute, viz IITR, CBRI and NIH;
- (c) To identify the basic subjects in which research papers from Roorkee have mainly been appeared;
- (d) To mark the most productive channels of communication;
- (e) To identify most productive contributors;
- (f) To highlight most cited papers.

2. Data Source and Methodology

Data referred in this study have been downloaded from *Science Citation Index Extended (SCIE)* through its web interface i.e. *Web of Science (WoS)* for the period 1996- 2005 using "Roorkee" as a search term in address field. A total 2047 records were retrieved. These records were downloaded in Excel worksheet. This data was further analysed using various data analysis tools available with *WoS*, statistical techniques and tools available with Microsoft Excel. Census data was downloaded from Census of India website¹.

SCIE in its present online form i.e. Web of Science devised by Eugene Garfield has been used in most of such studies, although other secondary sources such as *Inspec-Physics* or *Physics Abstracts* (Todorov 1989; Tsay et al. 1989), *SciFinder Scholar* – online version of *Chemical Abstracts* (Marshakova-Shaikovich 2001, Neuhaus 2008), *Biotechnology Abstracts* (McCain 1995; Dalpe 2002) have also been used by several authors. There are also articles on the comparison of different services as data source and there are arguments in favour and disfavour (Whitney 2002; Neuhaus 2008). However without going into that discussion we have selected the SCIE for the following reasons.

1. Scientific Literature from Roorkee have appeared over a wide spectrum of Science, Technology and Medicine journals which may be separately covered by *Inspec-Physics*, *SciFinder Scholar*, *Medline*, *Compendex*, *Metadex* and so on. Collection of data from all these sources and then analyse that would have proved very time consuming, cumbersome and thus error prone. SCIE covers literature from all across the STM spectrum..

¹http://www.censusindia.gov.in/Census_Data_2001/National_Summary/National_Summary_DataPage.aspx.

2. Many of these journals may have been covered by more than one service and therefore removal of duplicates would have become very difficult. This difficulty is also removed as one article will be covered once only in SCIE.
3. Citation pattern in different services is different. It would have added to difficulty in data collection. This problem had also not occurred in SCIE.
4. The journal selection method of SCIE is very transparent and respected.
5. Citation indexing in SCIE is very exhaustive compared to other services such as Google Scholar and Scopus. As these services are yet to establish themselves.
6. Lastly, this study is indicative not exhaustive and concentrated on quality literature only.

3. Results and Analysis

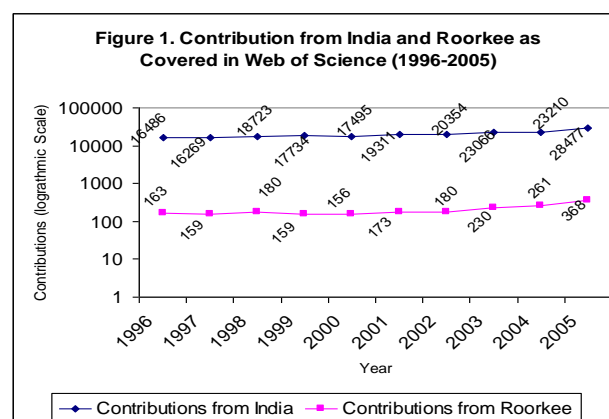
3.1 Contributions from Roorkee vis a vis contributions from India

As per the 2001 census, the total population of India was 1028.7 million while the population of Roorkee was 0.115 million which comes out to be approximately 0.011% of the total population. The number of research papers contributed from India as indexed in the SCIE from 1996 to 2005 were 201125, out of them 2047 have been contributed from Roorkee. The share of Roorkee in overall national contribution in science and technology is thus 1.01% which is about 100 times of its population percentage. Table 1 gives an account of the year-wise contribution of India and the share of Roorkee in total scientific and technological research from the year 1996 to 2005 as indexed in the SCIE.

Table 1. Contributions from India and Roorkee in SCIE during 1996-2005

| Year | Total Indian Contributions | Contributions from Roorkee | Share of Roorkee |
|-------|----------------------------|----------------------------|------------------|
| 1996 | 16486 | 163 | 0.98% |
| 1997 | 16269 | 159 | 0.97% |
| 1998 | 17734 | 180 | 1.01% |
| 1999 | 18723 | 159 | 0.84% |
| 2000 | 17495 | 156 | 0.89% |
| 2001 | 19311 | 173 | 0.89% |
| 2002 | 20354 | 180 | 0.88% |
| 2003 | 23066 | 230 | 0.99% |
| 2004 | 23210 | 261 | 1.12% |
| 2005 | 28477 | 368 | 1.29% |
| Total | 201125 | 2047 | 1.01% |

It can be observed from the table that the contribution of Roorkee has increased remarkably in the years 2004 and 2005 as being 1.12 % and 1.29 % of the national contribution respectively. Main reason for this increase may be attributed to the conversion of University of Roorkee into IIT Roorkee that has resulted in the increased intake of research scholars. Figure 1 gives the graphical representation of contributions from India vis a vis from Roorkee for the period 1996-2005.



3.2 Institutional Contribution

Institution-wise break-up of contributions shows that almost all the papers have been contributed by mainly three organisations viz IITR, CBRI and NIH. The figure of total contributions (2087) of these three organisations is slightly higher than the figure as indicated in Table 2. This is due to inclusion of papers of the researchers who contributed from other centres of the same organisations at the places other than Roorkee or due to research collaboration with other organisations.

Table 2. Institution-wise Productivity From Roorkee during 1996-2005 as covered by SCIE

| Year | IITR | CBRI | NIH | Total |
|-------|------|------|-----|-------|
| 1996 | 144 | 12 | 7 | 163 |
| 1997 | 137 | 13 | 9 | 159 |
| 1998 | 162 | 10 | 8 | 180 |
| 1999 | 136 | 14 | 12 | 162 |
| 2000 | 128 | 17 | 17 | 162 |
| 2001 | 149 | 9 | 19 | 177 |
| 2002 | 156 | 11 | 17 | 184 |
| 2003 | 197 | 13 | 25 | 235 |
| 2004 | 229 | 14 | 29 | 272 |
| 2005 | 339 | 14 | 40 | 393 |
| Total | 1777 | 127 | 183 | 2087 |

It can be observed from the table that maximum number of papers are brought out from IITR. This is due to the vast infrastructure, technical facilities and scientifically highly skilled human resource. The trend is more or less the same from 1996 to 2005 as shown in Figure 2. It can also be observed that the contributions from IITR have significantly improved after the conversion of erstwhile University of Roorkee to an Indian Institute of Technology in 2001 as With it came resources to improve the infrastructure and also more emphasis on research. Number of research scholars also more than doubled during this period (281, 364, 516, 597 and 655 in 2001, 2002, 2003, 2004, 2005 respectively)². All these factors

². Annual Reports (2001-2005) IIT Roorkee

have resulted in more than 100% increase in papers from IITR during 2001-2005. Papers from CBRI and NIH have shown around 50% growth.

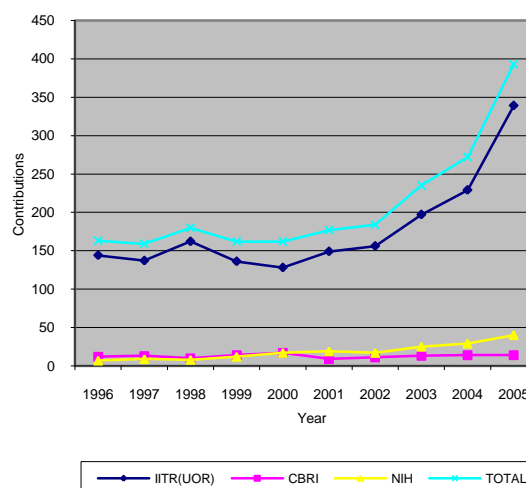


Figure 2. Contributions from IITR, CBRI and NIH during 1996-2005

3.3 Subject –wise Distribution

The entire coverage of the SCIE related with the contributions of Roorkee from 1996 to 2005 (2047) records as indexed by the database) is divided into 72 subjects. These 72 subjects have been recategorised in 25 broader subjects. Due to multidisciplinary nature of the research contributions, a record may appear under more than one subject categories. The maximum research papers from Roorkee have been contributed in Chemistry (26.36 %) followed by Physics (19.31 %), Water Resources (12.41 %), and Earth Sciences (12.22 %). Management Science (1.52 %), Energy & Fuels (1.47 %), Instrumentation Engineering (1.23 %) and Telecommunications (1.18 %) are the disciplines in which minimum number of papers have been contributed from Roorkee in last ten years. Table 3 gives the top ten contributing subjects.

Table 3. Subject-wise productivity of Roorkee during 1996-2005

| Rank | Subject Category | No. of papers | % of 2029 |
|------|--------------------------------------|---------------|-----------|
| 1 | CHEMISTRY | 535 | 26.36 |
| 2 | PHYSICS | 392 | 19.31 |
| 3 | WATER RESOURCES | 252 | 12.41 |
| 4 | EARTH SCIENCES | 248 | 12.22 |
| 5 | CIVIL ENGINEERING | 229 | 11.28 |
| 6 | ENVIRONMENTAL SCIENCE & ENGG | 177 | 8.72 |
| 7 | MATERIALS SCIENCE | 173 | 8.52 |
| 8 | ELECTRONICS & ELECTRICAL ENGINEERING | 136 | 6.70 |
| 9 | MECHANICAL ENGINEERING | 129 | 6.35 |
| 10 | BIOTECHNOLOGY | 123 | 6.06 |

3.4 Journal-wise Distribution

All the research papers contributed from Roorkee have been published in more than five hundred journals and conference proceedings. For the purpose of the study only ten most productive journals have been ranked in which at least twenty five research papers have appeared (Table 4). It can be noted from the table that the journals "*Current Science*" and "*Journal of Scientific and Industrial Research*" are at the top of the rank in which 2.07 % of the papers from the total contributions from Roorkee in last decade have been published. *Journal of Irrigation and Drainage Engineering* (1.92 %), *Journal of Hydraulic Engineering* (1.77%) and *International Journal of Remote Sensing* (1.62%) are placed at second, third and fourth rank, respectively. It can also be observed that out of the ten top journals four are Indian journals. This shows that the scientists from Roorkee publish more frequently in Indian journals.

Table 4. Top ten journals by productivity covering research contributions from Roorkee for the period 1996-2005

| Rank | Source Title | Number | %-age |
|------|---|--------|-------|
| 1 | <i>Current Science</i> | 42 | 2.07 |
| 1 | <i>Journal of Scientific & Industrial Research</i> | 42 | 2.07 |
| 2 | <i>Journal of Irrigation & Drainage Engineering -ASCE</i> | 39 | 1.92 |
| 3 | <i>Journal of Hydraulic Engineering - ASCE</i> | 36 | 1.77 |
| 4 | <i>International Journal of Remote Sensing</i> | 33 | 1.62 |
| 5 | <i>Hydrological Sciences Journal</i> | 32 | 1.57 |
| 5 | <i>Indian Journal of Chemistry - Section A</i> | 32 | 1.57 |
| 6 | <i>Journal of Physics - B</i> | 31 | 1.52 |
| 7 | <i>Journal of the Geological Society of India</i> | 29 | 1.42 |
| 8 | <i>Hydrological Processes</i> | 25 | 1.23 |

3.5 Author Productivity

Table 5 ranks ten most productive authors who have made significant contributions from Roorkee in the last decade. Dr V.K. Gupta from Chemistry is on the top of the rank who has contributed 89 (4.38%) papers in the journals covered by SCI. Dr A. Kumar (3.0%), Dr R.N. Goyal (2.61%) also from the field of Chemistry and Dr P.K. Swamee (2.36 %) from Water Resources come in second, third and in fourth rank,

respectively. It can be observed from this table that out of ten most productive authors, six authors are affiliated to Department of Chemistry, IIT Roorkee. The contribution of this department is quite remarkable as 15.17 % of the total contributions are made by this department.

Table 5. Ten top producing authors from Roorkee during 1996-2005

| Rank | Author/ Affiliation | Num- ber | % age 2047 |
|------|--------------------------------|-------------|---------------|
| 1 | Gupta, VK, Chem. IITR | 89 | 4.38 |
| 2 | Kumar, A, Chem. IITR | 61 | 3.00 |
| 3 | Goyal, RN, Chem. IITR | 53 | 2.61 |
| 4 | Swamee, PK, Civ.Engg. IITR | 48 | 2.36 |
| 5 | Srivastava, R, Phys., IITR, | 42 | 2.06 |
| 6 | Maurya, MR, Chem. IITR | 36 | 1.77 |
| 7 | Sondhi, SM, Chem. IITR | 35 | 1.72 |
| 8 | Jain, AK, Chem. IITR | 34 | 1.67 |
| 8 | Jain, SC, Mech. Engg. IITR | 34 | 1.67 |
| 9 | Ray, S, Metallurgy, IITR | 33 | 1.62 |

3.5 Most highly Cited Papers

Table 6 gives an account of ten highly cited papers. Average number of citations per year from the year 2002 have been recorded against each publication. The paper titled "A review of chitin and chitosan applications", contributed by M.N.V.R. Kumar in the journal "Reactive & Functional Polymers", Vol. 46, No. 1; 2000, received maximum citations in last

five years, followed by the paper titled "Organotin (IV) complexes of amino acids and peptides, authored by M. Nath, S. Pokharia and R. Yadav, published in the journal "Coordination Chemistry Reviews", Vol. 215; May 2001. The paper published by C.K. Jain and Imran Ali on "Arsenic : Occurrence, toxicity and speciation techniques" appeared in "Water Research", Vol. 34, No. 17, December 2000, comes at third rank.

Table 6. Ten most highly cited papers from Roorkee during 1997-2006

| Rank | Bibliographic Description | Aver- age Cites Per- Year |
|------|---|---------------------------------------|
| 1 | Kumar, M.N.V.R.(2000) A review of chitin <i>Reactive & Functional Polymers</i> 46 (1), 1-27. | 30.43 |
| 2 | Nath, M., Pokharia, S. and Yadav, R (2001). Organotin (IV) complexes <i>Coordination Chemistry Reviews</i> 215, 99-149. | 11.17 |
| 3 | Jain, C.K and Ali, I(2000). Arsenic : Occurrence, tox- icity <i>Water Research</i> 34 (17) 4304-4312. | 10.71 |
| 4 | Gupta, V.K., Gupta, M., Sharma, S(2000). Process development for the re- moval of Lead <i>Water Research</i> 35 (5), 1125- 1134. | 9.67 |
| 4 | Dessert C, Dupre B, Francois LM, et al (2001). <i>Earth and Planetary Letters</i> 188 (3-4) 459-474 | 9.67 |
| 5 | Reddy, B.S.P.; Sondhi, S.M. Lown, J.W (1999). Synthetic DNA minor groove-binding drugs. <i>Pharmacology and Thera- peutics</i> 84 (1), 1-111. | 9.62 |

| | | |
|---|--|------|
| 6 | Kumar, M.N.V.R.(2000). Nano and microparticles.... <i>Journal of Pharmacy and Pharmaceutical</i> 3 (2), 234-258. | 8.71 |
| 7 | Gupta, V.K., Shrivastava, A.K. and Jain, N (2001). Biosorption of Chromium (VI)... <i>Water Research</i> 35 (17), 4079-4085. | 8.33 |
| 8 | Gupta, K.C. and Kumar, M.N.V.R.(2000) Drug release ... <i>Biomaterials</i> , 21 (11) 1115-1119. | 7.29 |
| 9 | Gupta, V.K.(1998). Equilibrium uptake.... <i>Industrial and Chemical Engineering</i> , 37 (1) , 192-202. | 6.33 |

4. Discussion

Although Roorkee is a small town with a population of over a hundred thousand which is about 0.01% of total Indian population, it has established itself as a centre of scientific and technological education and research by producing more than 1.00% of the overall Indian productivity. The three main institutions viz IITR, CBRI and NIH situated at Roorkee have made significant contributions in scientific and technological research at the international level. Chemistry continues to be the most popular subject as same trend was found by Singh et al.(2004) while analysing the data of IIT Roorkee for 1993-2001. Water resources is also a popular area of research as the research population in this area is very strong. (Besides NIH, IITR has separate departments of Hydrology and Water Resource Management. Also its Civil Engineering department has a strong hydraulics base.). The contribution of IITR is excellent due to well established infrastructure, facilities and scientifically highly skilled human resources. The citation pattern of the papers shows that the work of researchers from Roorkee has been recognised internationally.

This study was taken as an exploratory study to find out the contribution of Roorkee and not a comparative study. Further studies are needed to compare

the productivity of Roorkee with a town of similar nature. Also the factors behind the success of this small town needs to be explored. Comparison with the institutes of similar nature will bring out the strength and weakness of Roorkee institutes.

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