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# Scientometric analysis of Pakistan's S&T research output

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The study analyses the research output of Pakistan for the period 2001-10 on several parameters including its growth and share in the world's research output, pattern of research communication in core domestic and international journals, geographical distribution of publications, share of international collaborative publications at the national level as well as across subjects and characteristics of high productivity institutions, authors and cited papers. The Scopus citation database has been used to retrieve the publications data for 10 years. Concludes that Pakistan needs to increase its output and bring about improvement in the quality of its research efforts. This can be done by investing much more in R&D expenditure, increase in the deployment of more qualified manpower and in increasing international collaboration and by modernizing and strengthening its research infrastructure.

**Keywords:** Scientometrics, Pakistan, Research output

## Introduction

Science and Technology (S&T) has been central to Pakistan's development efforts since the time of its Independence. At the time of independence, the scientific and the technological base of the country was very small and consisted of only 4 small laboratories, two universities and one agricultural college. But today it consists of a wide spectrum of infrastructure in terms of laboratories, R&D institutions, in-house R&D establishments' etc., covering several disciplines. For policy formulation at the national level, there is a National Commission for Science & Technology (NCST) (established in 1984) under the Prime Minister. There is a Pakistan Council for Science & Technology (PCST) which advices the government on science and technology policies and act as a Secretariat of the NCST. For policy formulation at the sectoral level, there are ministries of Science & Technology, IT &Telecom, Agriculture, Health, Industries, Higher Education Commission and Pakistan Atomic Energy Commission[1].

Pakistan's S&T infrastructure today consists of 85 major R&D organizations with 224 attached research institutes, centres and laboratories (35 under federal governments and 50 under provincial governments) and 133 universities, including 17 in engineering & technology, 6 in agriculture and 9 in medical science and technology, 28 in business/IT, besides 2000 affiliated colleges. The total S&T workforce in Pakistan is around 1,37,220 during 2009-10. Out of this, the total number of researchers and scientists is 54,689, but only 10% (5300) of these hold PhD in S&T. Eighty percent of these PhDs are employed in higher education institutions. Of the 54,689 researchers and scientists in Pakistan, 12,896 are in natural sciences, 9651 in engineering, 8509 in medical sciences, 8020 in agricultural sciences, etc. Its present stock consists of 54,689 researchers, which comes to 334 researchers per million and 169 researchers per million (FTE). The growth of R&D expenditure as a percentage of GDP has increased from 0.11% in 1999-2000 to 0.46% in 2008-09[1].

Although the gross primary school education rates were 84.8% in 2008 (World Bank), but only 32.9% of the Pakistani children are receiving secondary education and around 5% are enrolled for tertiary education. Currently, 7% to 8% of the 17-23 age group have access to higher education in Pakistan, increasing from 2.6% eight years ago. The enrollment of students in universities & colleges in the age group of 17-23 has increased from 2.6% in 2002 to 5.1% in 2009[2].

Pakistan has made an investment of more than Rs. 97 billion for the development of universities since the formation of Higher Education Commission in 1992, a twelve-fold increase over the Rs 7.5 billion spent during 1978-2002[3].

As a result, the number of universities has increased from 98 to 133 and enrollment from 1,35,000 in 2003 to 8,03,507 in 2008. Since HEC founding, 3509 PhDs have been produced, 200 more than the 3309 produced in the 55 years earlier. Currently, HEC is funding 7500 scholars for PhD at both local and foreign universities. The number of PhDs awarded by the Pakistani universities is currently 700 per year[4].

A few scientometric studies on Pakistan's research output are available. Among these studies, Mehbuba and Rousseau[5] has compared Bangladesh, Pakistan and Sri Lanka research output with India using three indicators, such as percentage of uncited articles, number of citations per document and *h*-index. Gupta, Munshi and Mishra[6] analysed India's collaboration with South Asian countries during 1992-99 using SCI database. Naim[7] mapped scientific research in OIC countries (including Pakistan and Bangladesh), using the indicators such as human resources in R&D, R&D expenditure, high technology exports, patents and publications. Under publications, trends in publications and relative impact of research in terms of citations during 1998-2007 have been undertaken. Majid[8] analysed the trends in Pakistan agricultural research by analyzing papers in ten volumes of *Pakistan Journal of Agricultural Research*. However, there has been no detailed study on the Pakistan's scientific output so far and hence this study was undertaken.

## Objectives of the study

- To analyze Pakistan's research publications growth rate and its share in global R&D output;
- To identify the most, medium, low and least productive areas of research;
- To find the share of international collaborative papers and identification of major collaborative partners; and
- To understand characteristics of its highly productive institutions, authors and highly cited papers.

## Methodology

This study uses Scopus international database (http://www.scopus.com/search/) to extract relevant publications data on Pakistan S&T for the 10 year period (2001-10). Scopus database is an international multi-disciplinary database indexing over 18,000 titles from more than 5,000 publishers, including 16,500 peer-reviewed journals, 600 trade publications, 350 book series and 3.6 million international conference/seminar papers. Scopus has a worldwide coverage, of which more than half of the Scopus contents originate from Europe, Latin America and the Asia & the Pacific Region. Given its wider coverage of journals and conference/seminar proceedings from developed and developing countries (including from Pakistan) compared to another international multidisciplinary database, Web of Science, the use of Scopus is expected to generate a better picture of Pakistan S&T indicators and hence its selection for this study.

For citations data, three years, two years and one year citations window have been used for computing average citations per paper during 2001-08, 2009 and 2010. For example, for papers published in 2001, citation window is three years from 2001-04. For papers published in 2002, citation window is three years from 2002-2005 and so on. For calculating the total international collaborative papers, a separate search strategy, which combines Pakistan's collaboration with more than 150 major countries, was prepared and used. For analyzing institutional, authors and journals output, separate search strategies were used. For generating highly-cited papers, the main string is first run. Then, the tag "citation to" is ticked, which rearranges the entire output in the decreasing order of citations received by each paper with most cited papers at the top. Then these highly-cited papers are marked and downloaded for analyses. The study has used a number of absolute publications, citation and collaborative measures for developing S&T indicators as needed for depicting Pakistan's status in science and technology from 2001 to 2010.

## Analysis

### S&T publications output

Pakistan has produced 34,195 papers during the last ten years (2001-10), which is increasing at an annual average growth rate of 20.86%. As per the Scopus data, cumulative publications growth, the cumulative S&T publications output of Pakistan had increased

from 8981 publications during 2001-05 to 25,214 publications during 2006-10, experiencing a growth rate of 180.75% (Table 1). The *h*-index of its total publications during 2001-10 was 85 and the number of highly-cited papers recorded was 64. Its average citation impact on a three year citation window for its total publications during 2001-10 was 2.19. The global publications share of Pakistan during 2001-10 was 0.196, which has increased from 0.099 in 2001 to 0.328 in 2010 (Table 2). This growth could also be on account of increased coverage of journals in the Scopus database over the years.

**Subject profile in science & technology**

As per the publications data for 2001-10, Pakistan's research profile by broad disciplines emerges as follows. Health sciences subjects together contributed the highest publications share (32.10%), followed by physical sciences (30.15%), life sciences (27.04%) and engineering sciences (26.04%). Its publications share has increased in physical sciences from 25.75% to 31.72%, engineering sciences from 18.41% to 28.76% and life sciences from 23.85% to 28.17%, as against decrease in health sciences from 40.20% to 29.22% from 2001-05 to 2006-10 (Table 3).

**High productivity subject areas**

Medicine, agricultural & biological sciences, engineering, chemistry and physics have been identified as the five high priority areas of Pakistan in S&T with each contributing publication share between 10.76% and 30. 85% in the cumulative national publication output of Pakistan during 2001-10 (Table 4).

Table 1—Pakistan's research output

| Year | TP | ACPP | ICP | ICP share (%) |
|---|---|---|---|---|
| 2001 | 1318 | 1.76 | 248 | 18.82 |
| 2002 | 1464 | 1.77 | 275 | 18.78 |
| 2003 | 1583 | 2.67 | 465 | 29.37 |
| 2004 | 1977 | 2.62 | 507 | 25.64 |
| 2005 | 2639 | 2.63 | 634 | 24.02 |
| 2006 | 3288 | 2.95 | 873 | 26.55 |
| 2007 | 3920 | 3.42 | 1132 | 28.88 |
| 2008 | 4910 | 3.24 | 1424 | 29.00 |
| 2009 | 5960 | 1.81 | 1701 | 28.54 |
| 2010 | 7136 | 0.52 | 2243 | 31.43 |
| 2001-05 | 8981 | | 2129 | 23.71 |
| 2006-10 | 25214 | | 7373 | 29.24 |
| 2001-10 | 34195 | 2.19 | 9502 | 27.79 |

TP=Total Papers; ACPP=Average Citations per Paper; ICP=International Collaborative Papers

Table 2—Pakistan's publication share in world literature

| Year | Count of papers | | |
|---|---|---|---|
| | Pakistan | World | Pakistan's share(%) |
| 2001 | 1318 | 1326979 | 0.099 |
| 2002 | 1464 | 1371936 | 0.107 |
| 2003 | 1583 | 1426444 | 0.111 |
| 2004 | 1977 | 1579618 | 0.125 |
| 2005 | 2639 | 1749574 | 0.151 |
| 2006 | 3288 | 1832242 | 0.179 |
| 2007 | 3920 | 1927447 | 0.203 |
| 2008 | 4910 | 2006228 | 0.245 |
| 2009 | 5960 | 2087381 | 0.286 |
| 2010 | 7136 | 2175243 | 0.328 |
| 2001-10 | 34195 | 17483092 | 0.196 |

Table 3—Distribution of papers by broad subjects

| Broad subjects | Number of papers | | | Publications share (%)* | | |
|---|---|---|---|---|---|---|
| | 2001-05 | 2006-10 | 2001-10 | 2001-05 | 2006-10 | 2001-10 |
| Physical Sciences | 2313 | 7997 | 10310 | 25.75 | 31.72 | 30.15 |
| Engineering Sciences | 1653 | 7252 | 8905 | 18.41 | 28.76 | 26.04 |
| Life Sciences | 2142 | 7103 | 9245 | 23.85 | 28.17 | 27.04 |
| Health Sciences | 3610 | 7367 | 10977 | 40.20 | 29.22 | 32.10 |

**There are overlapping journals under physical, engineering, life and health sciences*

Table 4—High productivity subject areas

| Subject | National publication share (%) | | | World publication share (%) | ICP share (%) | ACPP | *h*-index | HCP |
|---|---|---|---|---|---|---|---|---|
| | 2001-05 | 2006-10 | 2001-10 | 2001-10 | | | | |
| Medicine | 39.15 | 27.89 | 30.85 | 0.222 | 18.66 | 2.00 | 56 | 20 |
| Agricultural & Biol. Sciences | 14.12 | 18.07 | 17.03 | 0.493 | 24.46 | 2.04 | 39 | 7 |
| Engineering | 10.81 | 13.53 | 12.81 | 0.115 | 30.69 | 1.72 | 38 | 9 |
| Chemistry | 12.70 | 12.63 | 12.65 | 0.331 | 36.29 | 2.44 | 39 | 5 |
| Physics | 6.40 | 12.31 | 10.76 | 0.190 | 50.72 | 3.09 | 38 | 6 |

ACPP=Average Citations per Paper; ICP=International Collaborative Papers; HCP=Highly Cited Papers

The highest national publication share of Pakistan in medicine was 30.94%, followed by agricultural & biological sciences (17.03%), engineering (12.81%), chemistry (12.65%) and physics (10.76%). The national publication share of Pakistan has witnessed the largest increase in physics by 5.91% (from 6.40% to 12.31%), agricultural & biological sciences by 3.95% (from 14.12% to 18.07%) and engineering by 11.26% in medicine (from 39.15% to 27.89%) from 2001-05 to 2006-10. The highest global publications share (0.493%) of Pakistan in these high productivity subject areas was observed in agricultural & biological sciences, followed by chemistry (0.331%), medicine (0.222%), physics (0.190%) and engineering (0.137%) during 2001-10. The largest international collaborative publications share (50.72%) of Pakistan was observed in physics, followed by chemistry (36.29%), engineering (30.69%), agricultural & biological sciences (24.46%) and medicine (18.66%) during 2001-10 (Table 4).

The highest average citation impact per paper (3.09) for all its publications in high productivity subject areas was observed in physics, followed by chemistry (2.44), medicine (2.09), agricultural & biological sciences (2.04) and engineering (1.72) during 2001-10. The highest *h*-index (56) of Pakistan publications during 2001-10 was achieved by medicine, followed by agricultural & biological sciences and chemistry (39 each) and engineering and physics (38 each) during 2001-10. The largest number of highly-cited papers (20) was recorded by Pakistan in medicine, followed by engineering (9), agricultural & biological sciences (7), physics (6) and chemistry (5) during 2001-10 (Table 4).

**Medium productivity subject areas**

Computer science, biochemistry, genetics & molecular biology, materials science, mathematics, pharmacology, toxicology & pharmaceutics and environmental science are considered as the six medium priority areas of Pakistan in S&T, each contributing publication share between 3.80% and 9.62% in the cumulative national publication output of Pakistan during 2001-10 (Table 5).

The highest national publication share (9.62%) of Pakistan was recorded in computer science, followed by biochemistry, genetics & molecular biology (8.43%), materials science (6.64%), mathematics (5.51%), pharmacology, toxicology & pharmaceutics (3.80%) and environmental science (3.80%) during 2001-10. The national publication share of Pakistan has witnessed the largest increase in computer science by 9.39% (from 2.69% to 12.08%), materials science by 4.90% (from 3.03% to 7.92%), mathematics by

4.43% (from 2.24% to 6.67%), biochemistry, genetics & molecular biology by 2.15% (from 6.84% to 8.99%) and environmental science by 0.64% (from 3.33% to 3.97%), as against decrease in pharmacology, toxicology & pharmaceutics by 0.24% (from 3.98% to 3.74%) from 2001-05 to 2006-10. The highest global publications share (0.232%) of Pakistan in these medium productivity subject areas was observed in computer science, followed by mathematics (0.220%), pharmacology, toxicology & pharmaceutics (0.209%), environmental science (0.185%), materials science (0.159%) and biochemistry, genetics & molecular biology (0.138%) during 2001-10. The largest international collaborative publications share (47.59%) of Pakistan was observed in biochemistry, genetics & molecular biology, followed by materials science (47.09%), mathematics (44.18%), pharmacology, toxicology & pharmaceutics (36.92%), environmental science (36.72%) and computer science (30.69%) during 2001-10 (Table 5).

The highest average citation impact per paper (4.02) for all its publications in medium productivity subject areas was observed in environmental science, followed by biochemistry, genetics & molecular biology (3.99), pharmacology, toxicology & pharmaceutics (3.44), mathematics (2.61), materials science (2.18) and computer science (0.66) during 2001-10. The highest *h*-index (51) of Pakistan publications was achieved by biochemistry, genetics & molecular biology in 2001-10, followed by pharmacology, toxicology & pharmaceutics (33), environmental science (32), mathematics (30), materials science (25) and computer science (18) during 2001-10. The largest number of highly-cited papers (13) was recorded by Pakistan in biochemistry, genetics & molecular biology, followed by mathematics and environmental science (3 each) and computer science (1) during 2001-10 (Table 5).

**Low productivity subject areas**

Immunology & microbiology, chemical engineering, energy, earth & planetary sciences and nursing are found as the five low priority areas of Pakistan in S&T, each contributing publication share between 1.21% and 2.98% in the cumulative national publication output of Pakistan during 2001-10 (Table 6).

Among the low productivity subjects, the highest national publication share (2.98%) of Pakistan was recorded in immunology & microbiology, followed by chemical engineering (2.63%), energy (1.94%), earth & planetary sciences (1.80%) and nursing (1.21%) during 2001-10. The national publication share of Pakistan has witnessed the largest increase in chemical engineering by 0.91% (from 1.96% to 2.87%), nursing by 0.88% (from 0.57% to 1.44%), immunology & microbiology by 0.51% (from 2.61% to 3.11%) and energy by 0.12% (from 1.86% to 1.98%), as against decrease in earth & planetary sciences by 0.27% (from 1.99% to 1.73%) from 2001-05 to 2006-10. The highest global publications share (0.181%) of Pakistan in these low productivity subject areas was observed in immunology & microbiology, followed by energy (0.168%), nursing (0.156%), chemical engineering (0.115%) and earth & planetary sciences (0.082%) during 2001-10. The largest international collaborative publications share

Table 5—Medium productivity subject areas

| Subject | National publication share (%) | | | World publication share (%) | ICP share (%) | ACPP | *h*-index | HCP |
|---|---|---|---|---|---|---|---|---|
| | 2001-05 | 2006-10 | 2001-10 | 2001-10 | | | | |
| Computer Science | 2.69 | 12.08 | 9.62 | 0.232 | 30.69 | 0.66 | 18 | 1 |
| Biochem., Genet. & Mol. Biology | 6.84 | 8.99 | 8.43 | 0.138 | 47.59 | 3.99 | 51 | 13 |
| Materials Science | 3.03 | 7.92 | 6.64 | 0.159 | 47.09 | 2.18 | 25 | 0 |
| Mathematics | 2.24 | 6.67 | 5.51 | 0.220 | 44.18 | 2.61 | 30 | 3 |
| Pharmacology, Toxicology & Pharmaceutics | 3.98 | 3.74 | 3.80 | 0.209 | 36.92 | 3.44 | 33 | 0 |
| Environmental Science | 3.33 | 3.97 | 3.80 | 0.185 | 36.72 | 4.02 | 32 | 3 |

ACPP=Average Citations per Paper; ICP=International Collaborative Papers; HCP=Highly Cited Papers

(51.79%) of Pakistan was observed in earth & planetary sciences, followed by immunology & microbiology (38.96%), chemical engineering (35.15%), nursing (22.41%) and energy (19.10%) during 2001-10 (Table 6).

The highest average citation impact per paper (4.97) for all its publications in low productivity subject areas was observed in immunology & microbiology, followed by chemical engineering (4.46), earth & planetary sciences (3.06), energy (2.36) and nursing (1.56) during 2001-10. The highest *h*-index (34) of Pakistan publications was achieved by immunology & microbiology in 2001-10, followed by energy (29), earth & planetary sciences (26), energy (21) and nursing (15) during 2001-10. The largest number of highly-cited papers (8) was recorded by Pakistan in immunology & microbiology, followed by chemical engineering and earth & planetary sciences (3 papers each) during 2001-10 (Table 6).

**Least productivity subject areas**

Veterinary science, neurosciences, public health and dentistry are found as the four productive subject areas of Pakistan in S&T, each contributing publication share between 0.14% and 0.98% in the cumulative national publication output of Pakistan during 2001-10 (Table 7).

The highest national publication share (0.98%) of Pakistan was recorded in veterinary science, followed by neurosciences (0.53%), public health (0.43%) and dentistry (0.141%) during 2001-10. The national publication share of Pakistan has witnessed the largest increase in veterinary science by 0.39% (from 0.69% to 1.08%) and dentistry by 0.03% (from 0.12% to 0.15%), as against decrease in public health by 0.17% (from 0.56% to 0.39%) and neurosciences by 0.29% (from 0.75% to 0.46%) from 2001-05 to 2006-10. The highest global publications share (0.194) of Pakistan in these least productivity subject areas was observed in veterinary science, followed by public health (0.060), dentistry (0.051) and neurosciences (0.038) during 2001-10. The largest international collaborative publications share (60.42%) of Pakistan was observed in dentistry, followed by neurosciences (56.59%), public health (43.92%) and veterinary science (22.39%) during 2001-10 (Table 7).

Table 6—Low productivity subject areas

| Subject | National publication share (%) | | | World publication share (%) | ICP share (%) | ACPP | *h*-index | HCP |
|---|---|---|---|---|---|---|---|---|
| | 2001-05 | 2006-10 | 2001-10 | 2001-10 | | | | |
| Immunology & Microbiology | 2.61 | 3.11 | 2.98 | 0.181 | 38.96 | 4.97 | 34 | 8 |
| Chemical Engineering | 1.96 | 2.87 | 2.63 | 0.115 | 35.15 | 4.46 | 29 | 3 |
| Energy | 1.86 | 1.98 | 1.94 | 0.168 | 19.10 | 2.36 | 21 | 0 |
| Earth & Planetary Science | 1.99 | 1.73 | 1.80 | 0.082 | 51.79 | 3.06 | 26 | 3 |
| Nursing | 0.57 | 1.44 | 1.21 | 0.156 | 22.41 | 1.56 | 15 | 0 |

ACPP=Average Citations per Paper; ICP=International Collaborative Papers; HCP=Highly Cited Papers

Table 7—Least productivity subject areas

| Subject | National publication share (%) | | | World publication share (%) | ICP share (%) | ACPP | *h*-index | HCP |
|---|---|---|---|---|---|---|---|---|
| | 2001-05 | 2006-10 | 2001-10 | 2001-10 | | | | |
| Veterinary Science | 0.69 | 1.08 | 0.938 | 0.194 | 22.39 | 2.05 | 15 | 0 |
| Neurosciences | 0.75 | 0.46 | 0.53 | 0.038 | 56.59 | 4.47 | 17 | 0 |
| Public Health | 0.56 | 0.39 | 0.43 | 0.060 | 43.92 | 3.87 | 18 | 0 |
| Dentistry | 0.12 | 0.15 | 0.14 | 0.051 | 60.42 | 2.81 | 7 | 0 |

ACPP=Average Citations per Paper; ICP=International Collaborative Papers; HCP=Highly Cited Papers

The highest average citation impact per paper (4.47) for all its publications in low productivity subject areas was observed in neurosciences, followed by public health (3.87), dentistry (2.81) and veterinary science (2.05) during 2001-10. The highest *h*-index (18) of Pakistan publications was achieved by public health in 2001-10, followed by neurosciences (17), veterinary science (15) and dentistry (7) during 2001-10. The number of highly-cited papers recorded by Pakistan in all the four subjects was zero each during 2001-10 (Table 7).

**International collaboration**

The share of international collaborative papers in the Pakistan research output was 27.79% during 2001-10. Its share of internationally collaborative papers has increased from 23.71% during 2001-05 to 29.24% during 2006-10. In terms of citation impact of international collaborative papers, Pakistan has achieved a citation impact of 3.93 per paper during 2001-10. Table 8 depicts the international collaborative linkages of Pakistan with top 45 countries during 2001-10. The largest number of collaborative linkages (2243) of Pakistan was with United States with 23.61% share, followed by United Kingdom (20.23% share), Germany (9.75% share), China (9.02% share), Canada, Japan, Saudi Arabia, South Korea, India, Australia, Italy, France and Malaysia (with share varying from 3.14% to 6.69%), Turkey, Switzerland, Sweden, Iran, Austria and South Africa (with share varying from 2.07% to 2.98%), Netherlands, Spain, Russia, Brazil, Bangladesh, Egypt, Romania, Mexico, Singapore, Kuwait, Thailand, New Zealand, Belgium and Poland (with share varying from 1.01% to 1.77%). Of the top 45 international collaborating countries, Pakistan collaborative linkages have decreased in 16 countries, with largest decrease seen in authorship with United States by 8.08%, followed by UK (5.29%), Japan (2.38%), Italy (1.06%), Sri Lanka (0.54%), Nepal (0.36%), Australia (0.33%), Bangladesh (0.33%), Canada (0.27%),Germany (0.21%), Columbia (0.20%), Singapore (0.17%), Argentina (0.17%), Thailand (0.13%), France (0.09) and Jordan (0.04%) from 2001-05 to 2006-10. In contrast, Pakistan collaborative linkages has increased with 29 other countries, with maximum increase of 6.90% with China, followed by South Korea (2.72%), Sweden (1.54%), Austria (1.23%), Turkey (1.11%), New Zealand (1.05%), South Africa (1.04%) and less than 1% in other 22 countries from 2001-05 to 2006-10 (Table 8).

On further grouping 45 collaborating countries and individual country share, it was found that Pakistan's combined collaborating papers share was highest (73.26%) with G-8 countries, followed by 18 developing countries (39.01% share), 13 European countries (19.46% share), 4 South Asian countries (6.82% share), and 2 Pacific countries (4.98%) during 2001-10. Among these five group of countries, Pakistan's combined collaborating papers share has decreased by 16.45% with G-8 countries and by 0.72% with South Asian countries, as against increase by 17.36% with developing countries, 8.39% with European countries and 0.72% with Pacific countries from 2001-05 to 2006-10. Here the combined share of 45 collaborating countries is more than 100 per cent, because in each international collaborative paper from Pakistan, there are one or more than one collaborating countries (Table 8).

**Geographical distribution of papers**

Islamabad, Karachi and Lahore are the three most productive geographical areas in Pakistan who have individually contributed 17.46% to 26.64% share individually (together 70.58%) to the total research output of Pakistan during 2001-10. The cumulative number of papers has increased in Islamabad by 5.29% (from 22.74% to 28.03%) and in Lahore by 3.99% (from 14.52% to 18.51%), as against decrease in Karachi by 12.62% (from 35.79% to 23.17%) from 2001-05 to 2006-10 (Table 9).

Faisalabad, Rawalpindi, Peshwar, Multan and Jamshoro are the five medium productive geographical areas with their individual publication share between 2.68% and 7.96%, (together 28.28%) to the total research output of Pakistan during 2001-10. The cumulative number of papers has increased in Faisalabad by 3.26% (from 5.56% to 8.81%), in Rawalpindi by 1.25% (from 6.50% to 7.75%), in Jamshoro by 1.08% (from 1.88% to 2.96%) and in Multan by 0.64% (from 2.75% to 3.39%), as against decrease in Peshawar by 0.52% (from 7.37% to 6.85%) from 2001-05 to 2006-10 (Table 9).

Sargodha, Bahawalpur, Abbottabad, Quetta and Topi are the five low productive geographical areas with their individual publication share between 1.18% and 1.83% (together 7.40%) to the total research output of Pakistan during 2001-10. The cumulative number of

Table 8—Pakistan's collaboration with top 45 countries

| Sl. no. | Collaborating country | Number of collaborative papers | | | Share of collaborative papers | | |
|---|---|---|---|---|---|---|---|
| | | 2001-05 | 2006-10 | 2001-10 | 2001-05 | 2006-10 | 2001-10 |
| 1. | USA | 636 | 1607 | 2243 | 29.87 | 21.80 | 23.61 |
| 2. | UK | 518 | 1404 | 1922 | 24.33 | 19.04 | 20.23 |
| 3. | Germany | 211 | 715 | 926 | 9.91 | 9.70 | 9.75 |
| 4. | China | 78 | 779 | 857 | 3.66 | 10.57 | 9.02 |
| 5. | Canada | 147 | 489 | 636 | 6.90 | 6.63 | 6.69 |
| 6. | Japan | 159 | 375 | 534 | 7.47 | 5.09 | 5.62 |
| 7. | Saudi Arabia | 101 | 416 | 517 | 4.74 | 5.64 | 5.44 |
| 8. | S.Korea | 68 | 436 | 504 | 3.19 | 5.91 | 5.30 |
| 9. | India | 86 | 300 | 386 | 4.04 | 4.07 | 4.06 |
| 10. | Australia | 87 | 277 | 364 | 4.09 | 3.76 | 3.83 |
| 11. | Italy | 91 | 237 | 328 | 4.27 | 3.21 | 3.45 |
| 12. | France | 75 | 253 | 328 | 3.52 | 3.43 | 3.45 |
| 13. | Malaysia | 58 | 240 | 298 | 2.72 | 3.26 | 3.14 |
| 14. | Turkey | 45 | 238 | 283 | 2.11 | 3.23 | 2.98 |
| 15. | Switzerland | 61 | 221 | 282 | 2.87 | 3.00 | 2.97 |
| 16. | Sweden | 25 | 200 | 225 | 1.17 | 2.71 | 2.37 |
| 17. | Iran | 34 | 190 | 224 | 1.60 | 2.58 | 2.36 |
| 18. | Austria | 26 | 181 | 207 | 1.22 | 2.45 | 2.18 |
| 19. | S.Africa | 27 | 170 | 197 | 1.27 | 2.31 | 2.07 |
| 20. | Netherlands | 36 | 132 | 168 | 1.69 | 1.79 | 1.77 |
| 21. | Spain | 20 | 132 | 152 | 0.94 | 1.79 | 1.60 |
| 22. | Russia | 16 | 123 | 139 | 0.75 | 1.67 | 1.46 |
| 23. | Brazil | 22 | 113 | 135 | 1.03 | 1.53 | 1.42 |
| 24. | Bangladesh | 35 | 97 | 132 | 1.64 | 1.32 | 1.39 |
| 25. | Egypt | 15 | 118 | 133 | 0.70 | 1.60 | 1.40 |
| 26. | Romania | 15 | 116 | 131 | 0.70 | 1.57 | 1.38 |
| 27. | Mexico | 19 | 108 | 127 | 0.89 | 1.46 | 1.34 |
| 28. | Singapore | 29 | 88 | 117 | 1.36 | 1.19 | 1.23 |
| 29. | Kuwait | 15 | 99 | 114 | 0.70 | 1.34 | 1.20 |
| 30. | Thailand | 27 | 84 | 111 | 1.27 | 1.14 | 1.17 |
| 31. | New Zealand | 7 | 102 | 109 | 0.33 | 1.38 | 1.15 |
| 32. | Belgium | 14 | 83 | 97 | 0.66 | 1.13 | 1.02 |
| 33. | Poland | 15 | 81 | 96 | 0.70 | 1.10 | 1.01 |
| 34. | Finland | 8 | 75 | 83 | 0.38 | 1.02 | 0.87 |
| 35. | Taiwan | 14 | 68 | 82 | 0.66 | 0.92 | 0.86 |
| 36. | Sri Lanka | 26 | 50 | 76 | 1.22 | 0.68 | 0.80 |
| 37. | Czech Republic | 9 | 56 | 65 | 0.42 | 0.76 | 0.68 |
| 38. | Philippines | 12 | 47 | 59 | 0.56 | 0.64 | 0.62 |
| 39. | Columbia | 16 | 41 | 57 | 0.75 | 0.56 | 0.60 |
| 40. | Nepal | 18 | 36 | 54 | 0.85 | 0.49 | 0.57 |
| 41. | Nigeria | 3 | 48 | 51 | 0.14 | 0.65 | 0.54 |
| 42. | Ukraine | 2 | 44 | 46 | 0.09 | 0.60 | 0.48 |
| 43. | Argentina | 12 | 29 | 41 | 0.56 | 0.39 | 0.43 |
| 44. | Jordan | 9 | 28 | 37 | 0.42 | 0.38 | 0.39 |
| 45. | Slovenia | 0 | 14 | 14 | 0.00 | 0.19 | 0.15 |
| | Total* | 2129 | 7373 | 9502 | 100.00 | 100.00 | 100.00 |

**Total collaborative papers of Pakistan. In all international collaborative papers of Pakistan, there are one or more foreign collaborating countries. As a result, the combined output of 45 collaborative countries listed above in Pakistan international collaborative output will be more than its total international collaborative papers*

papers has increased in Sargodha by 1.95% (from 0.39% to 2.34%), in Bahawalpur by 0.74% (from 1.20% to 1.95%), in Abbottabad by 0.39% (from 1.04% to 1.43%) and in Topi by 0.10% (from 1.10% to 1.20%), as against decrease in Quetta by 0.28% (from 1.53% to 1.25%) from 2001-05 to 2006-10 (Table 9).

**Institutional profile**

***Universities***

The top 28 universities in Pakistan together have published 17,738 papers, which account for 51.87% share of the total research output of Pakistan during 2001-10. The output of individual universities, however, varied from 82 to 3355, with an average productivity of 700 papers per organization. The international collaborative share of these 28 universities account for 30.66% share (varying from 8.98% to 55.77%) of their total output during 2001-10. These 28 universities have an *h*-index of 65 (varying from 5 to 44) and number of highly-cited papers published was only 32 (varying from 0 to 12). A complete profile of these 28 universities is given in Table 10**.**

***Research institutes***

The top 14 research institutes in Pakistan together have published 5942 papers, which account for 17.30% share of the total research output of Pakistan during 2001-10. The output of individual research institutes, however, varied from 67 to 1137, with an average productivity of 447.36 papers per organization. The international collaborative share of these 14 research institutes account for 27.52% share (varying from 15.00% to 46.62%) of their total output during 2001-10. These 14 research institutes have an *h*-index of 49 (varying from 6 to 32) and number of highly-cited papers published was only 18 (varying from 0 to 9). A complete profile of these 14 research institutes is given in Table 11**.**

***Medical colleges & hospitals***

The top 18 medical colleges & hospitals in Pakistan together have published 4890 papers, which account for 14.30% share of the total research output of Pakistan during 2001-10. The output of individual medical colleges & hospitals, however, varied from 100 to 1575, with an average productivity of

Table 9—Geographical distribution of papers

| City | Number of papers | | | Share of papers | | |
|---|---|---|---|---|---|---|
| | 2001-05 | 2006-10 | 2001-10 | 2001-05 | 2006-10 | 2001-10 |
| Islamabad | 2042 | 7067 | 9109 | 22.74 | 28.03 | 26.64 |
| Karachi | 3214 | 5842 | 9056 | 35.79 | 23.17 | 26.48 |
| Lahore | 1304 | 4667 | 5971 | 14.52 | 18.51 | 17.46 |
| Faisalabad | 499 | 2222 | 2721 | 5.56 | 8.81 | 7.96 |
| Rawalpindi | 584 | 1956 | 2540 | 6.50 | 7.76 | 7.43 |
| Peshwar | 662 | 1728 | 2390 | 7.37 | 6.85 | 6.99 |
| Multan | 247 | 854 | 1101 | 2.75 | 3.39 | 3.22 |
| Jamshoro | 169 | 747 | 916 | 1.88 | 2.96 | 2.68 |
| Sargodha | 35 | 591 | 626 | 0.39 | 2.34 | 1.83 |
| Bahawalpur | 108 | 491 | 599 | 1.20 | 1.95 | 1.75 |
| Abbottabad | 93 | 360 | 453 | 1.04 | 1.43 | 1.32 |
| Quetta | 137 | 314 | 451 | 1.53 | 1.25 | 1.32 |
| Topi | 99 | 303 | 402 | 1.10 | 1.20 | 1.18 |
| Taxila | 52 | 271 | 323 | 0.58 | 1.07 | 0.94 |
| Hyderabad | 42 | 208 | 250 | 0.47 | 0.82 | 0.73 |
| Kohat | 9 | 180 | 189 | 0.10 | 0.71 | 0.55 |
| Dera Ismail Khan | 42 | 117 | 159 | 0.47 | 0.46 | 0.46 |
| Muzzaffarabad | 33 | 124 | 157 | 0.37 | 0.49 | 0.46 |
| Mansehra | 2 | 114 | 116 | 0.02 | 0.45 | 0.34 |
| Total* | 8981 | 25214 | 34195 | 100.00 | 100.00 | 100.00 |

**Total output of Pakistan. The total publications output of Pakistan cities listed above is more than the total publication output of Pakistan. This is because of the presence of national collaborative papers, where there are two or more authors involved from two different Pakistan cities.*

Table 10—Top 28 most productive universities of Pakistan

| Sl. no. | University | TP | *h*-index | HCP | ICP | ICP Share |
|---|---|---|---|---|---|---|
| 1 | Quaid-i-Azam University, Islamabad | 3355 | 43 | 12 | 1314 | 39.17 |
| 2 | University of Karachi | 2792 | 31 | 0 | 772 | 27.65 |
| 3 | The Aga Khan University, Karachi | 1751 | 44 | 12 | 555 | 31.70 |
| 4 | University of Punjab, Lahore | 1747 | 29 | 3 | 500 | 28.62 |
| 5 | National University of Science and Technology, Rawalpindi | 1327 | 18 | 1 | 421 | 31.73 |
| 6 | Government College University, Lahore | 1096 | 23 | 0 | 381 | 34.76 |
| 7 | University of Engineering & Technology, Lahore | 865 | 13 | 0 | 279 | 32.25 |
| 8 | University of Peshawar | 805 | 21 | 3 | 224 | 27.83 |
| 9 | Bahauddin Zakariya University, Multan | 715 | 24 | 1 | 209 | 29.23 |
| 10 | University of Sindh, Jamshoro | 581 | 23 | 0 | 108 | 18.59 |
| 11 | University of Sargodha | 562 | 13 | 0 | 163 | 29.00 |
| 12 | Islamia University, Bahawalpur | 445 | 20 | 0 | 114 | 25.62 |
| 13 | University of Arid Agriculture, Rawalpindi | 438 | 14 | 0 | 98 | 22.37 |
| 14 | International Islamic University, Islamabad | 361 | 9 | 0 | 82 | 22.71 |
| 15 | NWFP Agricultural University, Peshawar | 426 | 15 | 2 | 120 | 28.17 |
| 16 | Gomal University, Dera Ismail Khan | 258 | 11 | 0 | 56 | 21.71 |
| 17 | University of Balochistan, Quetta | 247 | 12 | 0 | 74 | 29.96 |
| 18 | Mohammad Ali Jinnah University, Islamabad | 243 | 8 | 0 | 44 | 18.11 |
| 19 | University of Veterinary & Animal Sciences, Lahore | 216 | 10 | 0 | 62 | 28.70 |
| 20 | NED University of Engineering & Technology, Karachi | 191 | 7 | 0 | 47 | 24.61 |
| 21 | National University of Computer & Emerging Sciences, Islamabad | 180 | 6 | 0 | 24 | 13.33 |
| 22 | Kohat University of Science & Technology (KUST), Kohat | 156 | 5 | 0 | 87 | 55.77 |
| 23 | Hamdard University, Karachi | 167 | 10 | 0 | 15 | 8.98 |
| 24 | University of Agriculture, Faisalabad | 172 | 12 | 0 | 47 | 27.33 |
| 25 | University of Azad Jammu & Kashmir, Muzaffarabad | 155 | 8 | 0 | 40 | 25.81 |
| 26 | Sindh Agricultural University, Tando Jam | 136 | 7 | 0 | 24 | 17.65 |
| 27 | Allama Iqbal Open University, Islamabad | 151 | 9 | 0 | 66 | 43.71 |
| 28 | Mehran University of Engineering & Technology, Jamshoro | 82 | 5 | 0 | 36 | 43.90 |

TP=Total Papers; ICP=International Collaborative Papers; HCP=Highly Cited Papers

283.55 papers per organization. The international collaborative share of these 18 medical colleges & hospitals account for 13.13% share (varying from 2.91% to 24.02%) of their total output during 2001-10. These 18 medical colleges & hospitals have an *h*-index of 39 (varying from 7 to 28) and number of highly-cited papers published was only 3 (varying from 0 to 1). A complete profile of these 18 medical colleges & hospitals is given in Table 12.

#### Contribution and citation impact of most productive authors

Fifteen authors have been identified as productive authors who have published 106 and above papers in

Table 11—Pakistan's top 14 most productive research institutes

| Sl. no. | Research institute | TP | *h*-index | HCP | ICP | % ICP |
|---|---|---|---|---|---|---|
| 1 | Pakistan Institute of Nuclear Science & Technology, Islamabad | 1137 | 32 | 3 | 241 | 21.20 |
| 2 | COMSATS Institute of Information Technology, Islamabad | 1229 | 27 | 3 | 573 | 46.62 |
| 3 | PCSIR Laboratories, Peshawar | 823 | 24 | 1 | 209 | 25.39 |
| 4 | National Agricultural Research Center, Islamabad | 511 | 18 | 1 | 127 | 24.85 |
| 5 | Pakistan Institute of Engineering & Applied Sciences, Islamabad | 559 | 17 | 0 | 140 | 25.04 |
| 6 | Nuclear Institute for Agriculture & Biology, Faisalabad | 428 | 13 | 0 | 80 | 18.69 |
| 7 | National Institute of Biotechnology & Genetic Engineering, Faisalabad | 392 | 32 | 9 | 133 | 33.93 |
| 8 | Ghulam Ishaq Khan Institute of Engineering Science & Technology, Topi | 383 | 17 | 0 | 148 | 38.64 |
| 9 | Center for Advanced Studies in Engineering, Islamabad | 204 | 6 | 0 | 34 | 16.67 |
| 10 | Pakistan Institute of Medical Sciences, Islamabad | 174 | 13 | 1 | 27 | 15.52 |
| 11 | Pakistan Atomic Energy Commission, Islamabad | 148 | 13 | 1 | 38 | 25.68 |
| 12 | Nuclear Institute for Food & Agriculture, Peshawar | 120 | 8 | 0 | 18 | 15.00 |
| 13 | National Institute of Health, Islamabad | 88 | 13 | 0 | 25 | 28.41 |
| 14 | Dr A.Q. Khan Research Laboratories, Rawalpindi | 67 | 13 | 1 | 18 | 26.87 |

TP=Total Papers; ACPP=Average Citation Per Paper; ICP=International Collaborative Papers; HCP=Highly Cited Papers

Table 12—Pakistan's top 18 most productive medical colleges & hospitals

| Sl. no | Medical colleges & hospitals | TP | *h*-index | HCP | ICP | %ICP |
|---|---|---|---|---|---|---|
| 1 | The Aga Khan University Hospital, Karachi | 1575 | 28 | 1 | 263 | 16.70 |
| 2 | Jinnah Postgraduate Medical Center, Karachi | 333 | 12 | 0 | 32 | 9.61 |
| 3 | Liaquat National Hospital, Karachi | 282 | 13 | 0 | 34 | 12.06 |
| 4 | Dow Medical College, Karachi | 165 | 11 | 0 | 19 | 11.52 |
| 5 | Dow University of Health Sciences, Karachi | 313 | 10 | 0 | 38 | 12.14 |
| 6 | Liaquat University of Medical & Health Sciences, Jamshoro | 315 | 9 | 0 | 33 | 10.48 |
| 7 | King Edward Medical University, Lahore | 329 | 18 | 1 | 40 | 12.16 |
| 8 | Khyber Medical College, Peshawar | 215 | 9 | 0 | 8 | 3.72 |
| 9 | The Aga Khan University Medical College, Karachi | 179 | 19 | 0 | 43 | 24.02 |
| 10 | Baquai Medical University, Karachi | 218 | 12 | 0 | 45 | 20.64 |
| 11 | Mayo Hospital, Lahore | 158 | 11 | 0 | 28 | 17.72 |
| 12 | Ziauddin Medical University, Karachi | 197 | 9 | 0 | 16 | 8.12 |
| 13 | Nishtar Medical College & Hospital, Multan | 169 | 7 | 0 | 7 | 4.14 |
| 14 | Ayub Medical College, Abbottabad | 172 | 8 | 0 | 5 | 2.91 |
| 15 | Childern's Hospital, Lahaore | 139 | 11 | 0 | 18 | 12.95 |
| 16 | Shifa International Hospital, Islamabad | 137 | 10 | 0 | 11 | 8.03 |
| 17 | Army Medical College, Rawalpindi | 108 | 7 | 0 | 10 | 9.26 |
| 18 | Fatima Jinnah Medical College, Lahore | 100 | 9 | 1 | 15 | 15.00 |

TP=Total Papers; ICP=International Collaborative Papers; HCP=Highly` Cited Papers

science and technology. These 15 authors together contributed 2311 papers with an average of 154.07 papers per author and account for 6.76% share in the cumulative publications output of Pakistan during 2001-10. Seven authors have published higher number of papers than the group average (154.07). These are: M. Ashraf with 275 papers, followed by Z.A. Bhutto (199 papers), S. Ali (194 papers), I.U. Khan (184 papers), M.N. Tahir (176 papers), K.M. Khan (173 papers) and M. Arshad (160 papers). Considering the citation/impact of papers, these productive authors have received a total of 11020 citations for these 2311 papers with an average of 4.77 citations per paper (varying from 1.84 to 15.03). Four authors have registered higher citation impact than the average impact of papers of all authors. These are Z.A. Bhutto with average citation per paper of 15.03, followed by A. Asghar (9.41), T.G. Kagi (7.87) and M.I. Bhanger (5.61). These 15 authors have received an average *h*-index of 15.60 (varying from 8 to 32). Seven authors have achieved the higher *h*-index value than the group average of 15.60. These are Z.A. Bhutto with an *h*-index of 32, followed by S. Asghar (23), M. Ashraf (23), K.M. Khan (19), T.G. Kagi (19), M. Arshad (17) and M.I. Bhanger (16).

**Preferred journals for publishing by Pakistani researchers**

The top 20 most productive domestic journals publishing Pakistan's research papers in science and technology together contributed 10,180 papers, which accounts for 29.77% share in the cumulative publications output of Pakistan during 2001-10. The cumulative publications share of these 20 most productive domestic journals showed decrease in Pakistan's publications output from 40.43% during 2001-05 to 25.97% during 2006-10 (Table 14). Similarly, the top 20 most productive foreign journals publishing Pakistan's research papers in science and technology together contributed 2917 papers, which accounts for 8.53% share in the cumulative publications output of Pakistan during 2001-10. The cumulative publications share of these 20 most

Table 13—Productivity & impact of fifteen most productive Pakistani authors

| Sl. no. | Authors | Affiliation | TP | TC | ACPP | *h*-index |
|---|---|---|---|---|---|---|
| 1. | M. Ashraf | University of Agriculture, Faisalabad | 275 | 1048 | 3.81 | 23 |
| 2. | Z.A. Bhutta | Aga Khan Univ., Deptt. of Pediatrics & Child Health, Karachi | 199 | 2990 | 15.03 | 32 |
| 3. | S. Ali | Quaid-i-Azam Univ., Deptt. of Chemistry, Islamabad | 194 | 576 | 2.97 | 14 |
| 4. | I.U. Khan | Govt. College Univ. Lahore, Deptt. of Chemistry, Lahore | 184 | 391 | 2.13 | 9 |
| 5. | M.N. Tahir | Univ. of Sargodha, Deptt. of Physics, Sargodha | 176 | 405 | 2.30 | 8 |
| 6. | K.M. Khan | Pakistan Institute of Nuclear Sc. & Technology, Islamabad | 173 | 704 | 4.07 | 19 |
| 7. | M. Arshad | National Institute for Biotechnology & Genetic Engineering Pakistan, Faisalabad | 160 | 707 | 4.42 | 17 |
| 8. | A. Saeed | Quaid-i-Azam Univ., Deptt. of Chemistry, Islamabad | 135 | 249 | 1.84 | 8 |
| 9. | S. Asghar | Institute of Information Technology, Deptt. of Mathematics, Islamabad | 129 | 1214 | 9.41 | 24 |
| 10. | A.R. Shakoori | Univ. of Lahore, School of Biological Sc. , Lahore | 125 | 232 | 1.86 | 10 |
| 11. | T.G. Kagi | Univ. Of Sindh, National Centre for Excellence in Analytical Chemistry, Jamshoro | 121 | 952 | 7.87 | 19 |
| 12. | A. Badshah | Quaid-i-Azam Univ., Deptt. of Chemistry, Islamabad | 113 | 334 | 2.96 | 12 |
| 13. | W.H. Jafi | Aga Khan Univ. , Deptt. of Medicine, Karachi | 112 | 385 | 3.44 | 13 |
| 14. | M.I. Bhanger | Univ. Of Sindh, National Centre for Excellence in Analytical Chemistry, Jamshoro | 109 | 611 | 5.61 | 16 |
| 15. | V.U. Ahmad | Univ. of Karachi, H.E.J. Research Institute of Chemistry, Karachi | 106 | 222 | 2.09 | 10 |
| | | Total | 2311 | 11020 | 4.77 | 15.6 |
| | | Total of the country | 34195 | | | |
| | | Share of 15 authors in country output | 6.76 | | | |

TP=Total Papers; ACPP=Average Citation Per Paper; ICP=International Collaborative Papers

Table 14—Pakistan's top 20 most productive domestic journals

| Sl. no | Journal | Number of papers | | |
|---|---|---|---|---|
| | | 2001-05 | 2006-10 | 2001-10 |
| 1 | *Journal of the College of Physicians &Surgeons Pakistan* | 1122 | 1031 | 2153 |
| 2 | *Pakistan Journal of Botany* | 261 | 1290 | 1551 |
| 3 | *Journal of Pakistan Medical Association* | 645 | 838 | 1483 |
| 4 | *Journal of Chemical Society of Pakistan* | 275 | 612 | 887 |
| 5 | *Medical Forum Monthly* | 235 | 349 | 584 |
| 6 | *Pakistan Journal of Zoology* | 202 | 336 | 538 |
| 7 | *Pakistan Journal of Medical Science* | 207 | 275 | 482 |
| 8 | *Journal of the Ayub Medical College Abbottabad* | 126 | 345 | 471 |
| 9 | *Pakistan Journal of Scientific &Industrial Research* | 280 | 180 | 460 |
| 10 | *Journal of the Association of Pakistan Dermatologists* | 184 | 140 | 324 |
| 11 | *Journal of the Liaquat University of Medical & Health Sciences* | 0 | 182 | 182 |
| 12 | *JPMI Journal of the Postgraduate Medical Institute* | 0 | 148 | 148 |
| 13 | *Pakistan Journal of the Pharmaceutical Science* | 29 | 117 | 146 |
| 14 | *Pakistan Pediatric Journal* | 0 | 140 | 140 |
| 15 | *Rawal Medical Journal* | 0 | 135 | 135 |
| 16 | *Natural Product Research* | 46 | 85 | 131 |
| 17 | *Pakistan Journal of Biological Science* | 0 | 114 | 114 |
| 18 | *Pakistan Journal of Nutrition* | 9 | 99 | 108 |
| 19 | *Pakistan Veterinary Journal* | 0 | 74 | 74 |
| 20 | *Pakistan Textile Journal* | 10 | 59 | 69 |
| | Total Papers | 3631 | 6549 | 10180 |
| | Country's Total Papers | 8981 | 25214 | 34195 |
| | Share of Top 20 Domestic Journals in Country Output | 40.43 | 25.97 | 29.77 |

productive foreign journals showed decrease in Pakistan's publications output from 4.51% during 2001-05 to 9.96% during 2006-10 (Table 15).

#### Highly cited papers of Pakistan

Pakistan has published 63 highly-cited papers in science and technology in last 10 years (2001-10) and these have received between 101 and 615 citations per paper. Forty nine out of these 63 papers are a result of international collaboration (23 bilateral and 26 multilateral), 5 papers have authors collaborating within Pakistan and 9 papers do not have any collaboration.

Of the international collaborative papers, first authorship from Pakistan institutions was only in 8 and the remaining 41 papers had foreign institutions in first authorship. Of the 63 highly cited papers, 50 appeared as articles and 13 as review papers. In all, Pakistan participation in these 63 papers was confined to 34 institutions, which includes 12 papers each from Quaid-i-Azam University, Islamabad and Aga Khan University, Karachi, followed by National Institute of Biotechnology & Genetic Engineering, Faisalabad (9 papers), University of Agriculture, Faisalabad (4 papers), 3 papers each from COMSATS Institute of Information Technology, Islamabad, University of Peshawar, Punjab University, Lahore and Pakistan Institute of Nuclear Science & Technology, Islamabad, 2 papers from NWFP Agricultural University, Peshawar and 1 paper each from 12 other Pakistan organizations. These 63 highly cited papers appeared in 43 journals, including 10 papers in *Lancet*, 3 papers *in Nature*, 2 papers each in *American Journal of Human Genetics, Cell, International Journal of Engineering Science, International Journal of Nonlinear Science & Numerical Simulation, Journal of Applied Microbiology, Journal of the American Chemical Society, Nature Genetics, Physics Letters, Section A* and *Virology* and 1 paper each in 32 other journals.

## Conclusion

Pakistan has produced 34195 papers during the last ten years (2001-10), which is increasing at an annual

Table 15—Top 20 foreign journals publishing Pakistan's papers

| Sl. no | Journal | Number of papers | | |
|---|---|---|---|---|
| | | 2001-05 | 2006-10 | 2001-10 |
| 1 | *Acta Crystallographica Section E. Structure Reports Online* | 43 | 863 | 906 |
| 2 | *African Journal of Biotechnology* | 6 | 223 | 229 |
| 3 | *International Journal of Agriculture & Biology* | 0 | 200 | 200 |
| 4 | *Physics of the Plasmas* | 35 | 155 | 190 |
| 5 | *Applied Mathematics & Computation* | 11 | 129 | 140 |
| 6 | *European Journal of Scientific Research* | 0 | 131 | 131 |
| 7 | *Journal of the Postgraduate Medical Institute* | 63 | 58 | 121 |
| 8 | *Journal of Enzyme Inhabitation & Medicinal Chemistry* | 25 | 72 | 97 |
| 9 | *Journal of Radioanalytical & Nuclear Chemistry* | 50 | 47 | 97 |
| 10 | *Journal of the Hazardous Materials* | 3 | 93 | 96 |
| 11 | *Lancet* | 29 | 58 | 87 |
| 12 | *Physics Letters, Section A.* | 9 | 69 | 78 |
| 13 | *Journal of Alloys & Compounds* | 5 | 70 | 75 |
| 14 | *Communications in Computer & Information Science* | 0 | 75 | 75 |
| 15 | *Turkish Journal of Chemistry* | 31 | 43 | 74 |
| 16 | *Radiochimica Acta* | 26 | 41 | 67 |
| 17 | *Chemical & Pharmaceutical Bulletin* | 37 | 29 | 66 |
| 18 | *Key Engineering Materials* | 2 | 62 | 64 |
| 19 | *Journal of Ethnopharmacology* | 24 | 38 | 62 |
| 20 | *Journal of Applied Physics* | 6 | 56 | 62 |
| | Total papers | 405 | 2512 | 2917 |
| | Country's total papers | 8981 | 25214 | 34195 |
| | Share of top 20 foreign journals in Country Output | 4.51 | 9.96 | 8.53 |

average growth rate of 20.86%. Despite this growth rate, Pakistan needs to increase its output and bring about improvement in the quality of its research efforts. This can be done by investing much more in R&D, deploying more qualified manpower, increasing international collaboration and by modernizing and strengthening its existing research infrastructure.

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