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Research Article

The Research Publications Growth Rate of Pakistan in the Field of Material Sciences: Comparison with 50 countries

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Abstract: The world has produced 289454 and 308238 research publications in materials sciences in 2019 and 2020, respectively. Twenty-four (24), Thirty-four (34) and Forty-six (46) countries have published atleast 3000, 2000 and 1000 research documents, respectively. Based on the number of publications, the top three countries for the year 2020 are China (n=124207/40.29%), United States (n=37245/12.08%) and India (n=22754/7.38%). We also calculated the relative growth rate (GR) (for the year 2019-2020) of top fifty (50) countries. The highest GR was recorded for Viet Nam (n=43.83), Saudi Arabia (N=40.03), Indonesia (n=38.77), United Arab Emirates (n=37.23) and Pakistan (n=33.75). It is worth noting that, based on the number of publications in 2020, Pakistan also occupied 20th position (n=3844) globally. This motivated us to explore the publication history of Pakistan in Material Sciences. From 1947 to 2000, Pakistan published only 819 documents. Infact, the 1st document was published in 1964. We also provided the per year global production (after 1964) and contribution of Pakistan. The lowest ranking was recorded in 1998 (n=71st), where Pakistan published only 46 research documents (0.04% global share). From 1964 to 2000, the average per year share was only 0.036%. From 2001 to 2020, Pakistan published 19313 documents. Or the average per year global share was 11.66 times higher than 20th century i.e. 0.42%. Based on the number of publications, the list of top 50 researchers, universities and sources are described for both eras. This astonishing increase in publication could be attributed to the establishment of higher education commission (HEC) Islamabad, increase in number of universities, rise in educational budget, funding, and international collaboration.

Keywords: Scopus, Material Sciences, Research Growth Rate and Pakistan

1. INTRODUCTION

Bibliometric analysis is a set of quantitative techniques used for the study or measurement of huge datasets. It is beneficial to construct or generate the literature structure, assess the significance of publications, and explore a research topic or country's evolution [1, 2]. During the last few decades, there have been significant studies that reported the scholarly publication and productivity of numerous countries in different fields such as environmental sciences, geography, medical sciences, pediatrics, urology and nephrology, environmental occupational public health, infectious disease research and cultural safety etc... For example, the bibliometric studies of France have been reported in several fields, such as AIDS [3], orthopedics and traumatology [4], neurosurgery [5], intestinal microbiota in obesity [6]. Iran has experienced a considerable growth in the quality and quantity of the research output. Several bibliometric publications have analyzed the research production of Iran in mood disorder [7] and health education [8]. Currently, in the Asian countries, Taiwan is one of most influential country in research publication for example in Computer Methods and Programs in Biomedicine [9], traditional medicine for stroke [10] and library and information science [11]. The bibliometric analysis of Thailand in various disciplines like antimalarial drug resistance [12], chemical engineering researchers [13], marking [14] etc.. is also reported. Similarly, Sweden's productivity and publication in bariatric surgery [15], suicidology [16] have also

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been widely explored.

However, there is a scarcity of bibliometric data about different fields of research in Pakistan. A few studies are reported which focused on history and development of biotechnology [17], library and information science [18], social sciences [19] and computer science [20]. The present project is designed to explore for the 1st time the research productivity of Pakistan in material sciences.

2. MATERIALS AND METHODS

2.1 Ethics Statement

The study did not involve human or non-human subjects. Therefore, neither approval by the institutional review board nor informed consent was required.

2.2 Study Design

This was a bibliometric study of a specific topic from a literature database.

2.3 Data Sources/Measurement:

On 16th May, we retrieved the publications data from Scopus database. In advance search field, we selected the subject "materials science". The code was SUBJAREA(MEDI). Scopus added the following subjects under it.

1. Materials Science(all)
2. Materials Science(miscellaneous)
3. Biomaterials
4. Ceramics and Composites
5. Electronic, Optical, and Magnetic Materials
6. Materials Chemistry
7. Metals and Alloys
8. Polymers and Plastics and
9. Surfaces, Coatings, and Films.

We only analyzed research articles and reviews. While the publications data of 2021 was ignored in the analysis.

3. RESULTS AND DISCUSSION

The total publications in material sciences for 2019 are 289454. Based on the number of publication and % share, the top ten countries are China (n=119649/41.34%), United States (n=36341/12.56%), India (n=21283/7.35%), Germany (n=15049/5.20%), South Korea (n=14198/4.91%), Japan (n=13427/4.64%), Russian Federation (n=12345/4.26%), United Kingdom (n=11293/3.90%), France (n=9266/3.20%), and Iran (n=8705/3.01%). While, in 2020, the total publications were 308238. The highest documents are published by China (n=124207/40.30%), United States (n=37245/12.08%), India (n=22754/7.38%), South Korea (n=16066/5.21%), Germany (n=15633/5.07%), Japan (n=14276/4.63%), Russian Federation (n=12828/4.16%), United Kingdom (n=12113/3.93%), France (n=9884/3.21%) and Iran (n=9327/3.03%).

We also calculated the growth rate for the year 2019-2020. Although we retrieved the publication data of 160 countries, we calculated the growth rate for those countries that have published atleast three thousand research documents. In this regard, twenty-four (n-24) countries were selected. The highest growth rate was noted for Saudi Arabia (n=40.03), followed by Pakistan (n=33.75), Egypt (n=32.17), Poland (n=23.02), Taiwan (n=20.16), Italy (n=16.16), Spain (n=15.67), Malaysia (n=14.72), Turkey (n=14.34), and South Korea (n=13.16). Based on the number of publications, we also calculated the GR for the top fifty countries. The highest GR was recorded for Viet Nam (n=43.83), Saudi Arabia (N=40.03), Indonesia (n=38.77), United Arab Emirates (n=37.23) and Pakistan (n=33.75). The data for growth rates of all 50-countries with the number of publications is provided in Table 1.

3.1 Focus on Pakistan

Its worthy to note that based on the number of publication Pakistan occupied 20th position (n=3844) in year 2020. Infact Pakistan is well ahead of some prominent countries like Malaysia (n=3818), Singapore (n=3408), Sweden (n=3018), Switzerland (n=2972), Netherlands (n=2912), Hong Kong (n=2911), Czech Republic (n=2643), Ukraine (n=2447), Portugal (n=2446), Mexico (n=2439), Belgium (n=2341), Viet Nam (n=2215), Romania (n=2074), Austria (n=1984), Thailand (n=1683), Finland (n=1676), South Africa (n=1614), Denmark (n=1436), Israel (n=1393),

Table 1. List of publications and relative growth rate (RGR) of the top 50 countries. NoP= Number of Publications.

S. No.#	Country	2019 NoP	2020 NoP	2019-2020 RGR
1.	Vietnam	1540	2215	43.83
2.	Saudi Arabia	4014	5621	40.03
3.	Indonesia	828	1149	38.77
4.	United Arab Emirates	658	903	37.23
5.	Pakistan	2874	3844	33.75
6.	Egypt	2854	3772	32.17
7.	Slovakia	785	980	24.84
8.	Ireland	810	1001	23.58
9.	Poland	5269	6482	23.02
10.	Morocco	735	900	22.45
11.	Thailand	1389	1683	21.17
12.	Iraq	1049	1265	20.59
13.	Taiwan	4394	5280	20.16
14.	Norway	946	1127	19.13
15.	Portugal	2086	2446	17.26
16.	Italy	7105	8253	16.16
17.	Czech Republic	2282	2643	15.82
18.	Spain	6619	7656	15.67
19.	Denmark	1251	1436	14.79
20.	Malaysia	3328	3818	14.72
21.	Greece	1055	1210	14.69
22.	Turkey	4415	5048	14.34
23.	South Africa	1420	1614	13.66
24.	South Korea	14198	16066	13.16
25.	Tunisia	845	947	12.07
26.	Mexico	2177	2439	12.03
27.	Brazil	5113	5685	11.19
28.	Australia	6874	7584	10.33
29.	Singapore	3140	3408	8.54
30.	Canada	6013	6521	8.45
31.	Finland	1550	1676	8.13
32.	Austria	1837	1984	8.00
33.	United Kingdom	11293	12113	7.26
34.	Iran	8705	9327	7.15
35.	India	21283	22754	6.91
36.	France	9266	9884	6.67
37.	Japan	13427	14276	6.32
38.	Israel	1313	1393	6.09
39.	Netherlands	2756	2912	5.66
40.	Belgium	2226	2341	5.17
41.	Algeria	1229	1286	4.64
42.	Switzerland	2844	2972	4.50
43.	Sweden	2892	3018	4.36
44.	Russian Federation	12345	12828	3.91
45.	Germany	15049	15633	3.88
46.	Ukraine	2357	2447	3.82
47.	China	119649	124207	3.81
48.	United States	36341	37245	2.49
49.	Hong Kong	2944	2911	-1.12
50.	Romania	2390	2074	-13.22

Greece (n=1210), Indonesia (n=1149), Norway (n=1127), Ireland (n=1001), Slovakia (n=980) and Morocco (n=900), to name a few. This confirms a profound growth of Pakistan in the field of materials science. We also retrieved the publication data since independence i.e. 1947. Based on our analysis, the 1st document was published in 1964. Till December 2020, Pakistan has published 22611 research documents majorly comprising of articles (n=19409), conference papers (n=1943), reviews (n=736), book chapters (n-233), errata (n=111), short surveys (n=44), notes (n=36), editorials (n=34), letters (n=29), retracted documents (n=18), books (n=11), business articles (n=2) and undefined documents (n=5). For detail analysis we only focused on research articles and reviews (n=20145). The total years are divided into two eras i.e. 20th and 21st centuries. From 1947 to 2000, Pakistan published only 819 documents. Infact, 13 documents are published before independence (from 1925 to 1942). In affiliation, the following addresses were noted i.e. Chemische Abteilung, Forman Christian College (Lahore), Lahore, Pakistan, University Chemical Laboratories, Panjab University, Lahore, Pakistan, Department of Chemistry, Forman Christian College, Lahore, Pakistan, and Forman Christian College, Lahore, Pakistan.

After independence, the 1st document (The Chemical Constituents and Molecular Weights of Cellulose in Different Parts of Jute Fiber) was published by Bashiruzzaman M et al., in 1964. It was published in Textile Research Journal. Total three documents were published in 1964. From 1964 to 1992, less than fifty documents were published each year. Till 2000, only 819 documents were published. The average per year articles production was 22.12 and the average global share was only 0.036%. The per year publication details and world rankings are provided in Table 2.

Based on the number of publications, the top ten authors in this era were; Butt, M.Z. (N=40), Khan, A.Q. (N=34), Maqsood, A. (n-30), Zulfiqar, S. (n=27), Ahmad, Z. (n=20), Khwaja, F.A. (n=19), Zubairy, M.S. (n-18), Hasanain, S.K. (n=17), Butt, N.M. (N=16) and Ul Haq, A. (N=16). Institutionally, Quaid-i-Azam University published the highest documents (n=237), followed by Pakistan Institute of Nuclear Science and Technology (N=117), University of the Punjab, Lahore (n=101), Government College University Lahore (N=65), Dr. A. Q. Khan Research Laboratories (n=62), University of Karachi (N=43), Metallurgy Division Pakistan (N=36), Bahauddin Zakariya University (N=32), Ghulam Ishaq Khan Institute of Engineering Sciences and Technology (n=30) and Pakistan Atomic Energy Commission (n=19). Mostly these documents are published in Journal Of Materials Science Letters (N=67), Journal Of Materials Science (n=53), Polymer Degradation And Stability (n=32), Optics Communications (N=30), Physica Status Solidi A (n=30), Journal Of Materials Engineering And Performance (N=26), Solid State Communications (n=24), Journal Of Physics D Applied Physics (n=21), Inorganica Chimica Acta (n=15), and Materials Science And Technology United Kingdom (n=15).

From 2001 to 2004, Pakistan published only 60-85 documents. From 2005 an increasing publication tendency was observed. In 2009, Pakistan published for the 1st time 500 documents, in 2015, 1000 documents, in 2018, 2000 documents and in 2020, 3000 documents. The % global share remarkably increased from 0.04 in 2001 to 1.24 in 2020. The highest world ranking was observed in 2020 (20th), 2019 (24th) and 2018 (28th). While, the average share in this era was 0.42%. In total Pakistan published 19313 research documents (articles=18579, reviews=734). The top ten authors in this era are; Tahir, M.N. (n=530), Hayat, T. (N=358), Khan, I.U. (N=268), Kausar, A. (n=266), Naseem, S. (n=266), Ali, S. (n=209), Alsaedi, A. (n=205), Riaz, S. (n=198), Badshah, A. (n-=162) and Khan, N.A. (n=159). Quaid-i-Azam University (n=3277) can be ranked top university, followed by COMSATS University Islamabad (n=1868), National University of Sciences and Technology Pakistan (n=1682), University of the Punjab, Lahore (n=1495), Government College University Lahore (N=1027), University of Engineering and Technology Lahore (n=972), University of Sargodha (n=919), Bahauddin Zakariya University (n=871), COMSATS Institute of Information Technology Lahore (N=839) and University of Peshawar (n=698). While, the highest documents are published in IEEE Access (n=1502), Acta Crystallographica Section E Structure Reports Online (N=1360), Ceramics International (N=436), Journal of Molecular Liquids (n=432),

Table 2. The per year publications of the world and Pakistan. The % share and ranking of Pakistan is also described. TP= Total Publications, Pak=Pakistan and NoP= Number of Publications

S. No.	Year	World TP	Pak NoP	% Global Share	Pak Ranking
1	1964	8563	3	0.04	35
2	1965	10139	2	0.02	41
3	1966	10438	1	0.01	51
4	1967	12860	3	0.02	37
5	1968	13298	1	0.01	61
6	1969	15052	0	0.00	0
7	1970	16741	5	0.03	43
8	1971	22396	5	0.02	42
9	1972	23124	4	0.02	49
10	1973	25809	2	0.01	64
11	1974	28054	3	0.01	58
12	1975	28718	6	0.02	47
13	1976	30928	5	0.02	54
14	1977	32071	11	0.03	42
15	1978	33162	11	0.03	46
16	1979	34956	6	0.02	57
17	1980	36624	8	0.02	57
18	1981	37983	13	0.03	51
19	1982	38081	11	0.03	55
20	1983	43397	18	0.04	51
21	1984	45404	14	0.03	54
22	1985	46600	11	0.02	61
23	1986	50086	15	0.03	57
24	1987	53494	21	0.04	52
25	1988	55100	27	0.05	55
26	1989	62454	31	0.05	55
27	1990	56442	34	0.06	54
28	1991	62936	26	0.04	58
29	1992	61600	32	0.05	59
30	1993	67772	51	0.08	50
31	1994	76035	61	0.08	53
32	1995	76343	62	0.08	54
33	1996	100401	69	0.07	60
34	1997	103679	67	0.06	61
35	1998	106451	46	0.04	70
36	1999	117391	61	0.05	65
37	2000	116638	73	0.06	62
38	2001	122695	61	0.05	65
39	2002	117822	62	0.05	64
40	2003	110928	66	0.06	64
41	2004	120299	84	0.07	58
42	2005	131323	122	0.09	56
43	2006	148105	272	0.18	51
44	2007	154152	371	0.24	46
45	2008	160861	473	0.29	43
46	2009	165762	580	0.35	39
47	2010	165067	640	0.39	39
48	2011	175064	730	0.42	40
49	2012	180349	810	0.45	38
50	2013	194850	811	0.42	39
51	2014	205201	897	0.44	38
52	2015	218053	1215	0.56	35
53	2016	223808	1467	0.66	34
54	2017	241570	1794	0.74	31
55	2018	260410	2140	0.82	28
56	2019	289454	2874	0.99	24
57	2020	308238	3844	1.25	20

Materials Research Express (n=422), Journal Of Alloys And Compounds (n=399), Optik (n=353), Journal Of Magnetism And Magnetic Materials (n=297), Journal Of Materials Science Materials In Electronics (n-265), and Applied Sciences Switzerland (n=261).

From 1947 to 2020 (based on the number of publications), the top ten authors are Tahir, M.N. (n=530), Hayat, T. (N=366), Naseem, S. (n=271), Khan, I.U. (n=268), Kausar, A. (n=266), Ali, S. (n=221), Alsaedi, A. (N=205), Riaz, S.(N=198), Badshah, A. (n=169), and Khan, N.A. (N=165). The data is presented in Table 3.

While, the top ten universities are Quaid-i-Azam University (n=3514), COMSATS University Islamabad (n=1868), National University of Sciences and Technology Pakistan (n=1684), University of the Punjab, Lahore (N=1596), Government College University Lahore (n=1092), University of Engineering and Technology Lahore (n=985), University of Sargodha (n=919), Bahauddin Zakariya University (N=903), COMSATS Institute of Information Technology Lahore (n=839), Pakistan Institute of Nuclear Science and Technology (n=773) and University of Peshawar (n=711). The results are presented in Table 4. Mostly these documents are published in IEEE Access (n=1502), Acta Crystallographica Section E Structure Reports Online (n=1360), Ceramics International (N=436), Journal Of Molecular Liquids (N-432), Materials Research Express (N=422), Journal Of Alloys And Compounds (N=401), Optik (n=353), Journal Of Magnetism And Magnetic Materials (n=299), Journal Of Materials Science Materials In Electronics (n=267) and Applied Sciences Switzerland (n=261). The list is provided in Table 5.

Remarkably almost 96% (or 19313) documents are published after 2001. This astonishing increase could be attributed to several fundamental reasons. Some are given below.

3.2 Number of Universities

1. In 1947 there was only one University i.e. University of Punjab.
2. In 1974-77, the number of universities were 10, with 2455 teachers and 21 thousand students.
3. In 1979-80, the number of universities were 15, with 3068 teachers and 42 thousand students.
4. In 1989-90, the number of universities were 22, with 4304 teachers and 73 thousand students.
5. In 1999-2000, the number of universities were 54, with 5914 teachers and 114 thousand students.

While, in 2019-20, the total number of universities are 211. The total number of institutions (graduate and/or post graduate) are 317,323 with 50,292,570 students and 1,836,584 teachers. This shows a remarkable development.

3.3 Educational Budget

In 1975, the national education budget was only 11.3 billion, this significantly increased to 72.3 billion in 2001 and 315 billion in 2018.

3.4 Establishment of Higher Education Commission (HEC)

The Higher Education Commission was established by the government of Pakistan in 2002. HEC introduced various reforms and policies which helped in the educational development. After establishment of Higher Education Commission (HEC), the higher education budget for the years (2005-06, 2006-07, 2007-08, 2008-9 and 2009-10) also enormously increased from 21.38, to 28.74, 27.92, 32.18 and 44.00 billion, respectively.

3.5 Funding

From 1947 to 2000, only Pakistan Science Foundation has been acknowledged in 13 publications. Four other agencies and universities (each) have sponsored at least five publications. For example, Agency for Science, Technology and Research (n=7), Science and Engineering Research Council (n=7), Pakistan Atomic Energy Commission (n=6) and Quaid-i-Azam University (n=6). In total 53 sponsors have been acknowledged in research publications. The details are provided in table 6. After 2001, the trend in financial sponsorship and grants dramatically increased. Some worthy donors are National Natural Science Foundation of China (n= 1228), King Saud University (n=638), Deanship of Scientific Research, King Saud University (n=443), National Research Foundation

Table 3. The top fifty authors in two eras (20th Century) and (21st Century). NoP= Number of Publications

	1st Era (1947-2000)			2nd Era (2001-2020)	
S#	Author	**NoP**	**S#**	Author	**NoP**
1.	Butt, M.Z.	40	1.	Tahir, M.N.	530
2.	Khan, A.Q.	34	2.	Hayat, T.	358
3.	Maqsood, A.	30	3.	Khan, I.U.	268
4.	Zulfiqar, S.	27	4.	Kausar, A.	266
5.	Ahmad, Z.	20	5.	Naseem, S.	266
6.	Khwaja, F.A.	19	6.	Ali, S.	209
7.	Zubairy, M.S.	18	7.	Alsaedi, A.	205
8.	Hasanain, S.K.	17	8.	Riaz, S.	198
9.	Butt, N.M.	16	9.	Badshah, A.	162
10.	Ul Haq, A.	16	10.	Khan, N.A.	159
11.	Zulfiqar, M.	15	11.	Naqvi, Q.A.	152
12.	Abbas, T.	14	12.	Khan, M.A.	138
13.	Baber, N.	14	13.	Shafiq, M.	137
14.	Feltham, P.	14	14.	Siddiq, M.	137
15.	Hashmi, F.H.	14	15.	Arshad, M.N.	134
16.	McNeill, I.C.	14	16.	Saeed, A.	134
17.	Maqsood, M.	13	17.	Shakir, I.	123
18.	Tauqir, A.	13	18.	Ahmad, S.	121
19.	Ali, S.	12	19.	Warsi, M.F.	121
20.	Mazhar, M.	12	20.	Mumtaz, M.	115
21.	Suleman, M.	12	21.	Parvez, M.	109
22.	Zafar Iqbal, M.	12	22.	Yousuf, S.	109
23.	Ahmed, E.	11	23.	Murtaza, G.	105
24.	Ahmed, M.	11	24.	Ashiq, M.N.	104
25.	Hussain, R.	11	25.	Mahmood, K.	104
26.	Iqbal, M.Z.	11	26.	Karimov, K.S.	103
27.	Mateen, A.	11	27.	Hussain, T.	100
28.	Shamim, A.	11	28.	Bolte, M.	99
29.	Siddiqi, S.A.	11	29.	Ramay, S.M.	98
30.	Khalid, F.A.	10	30.	Atiq, S.	97
31.	Nazar, F.M.	10	31.	Nadeem, S.	96
32.	Raza, S.M.	10	32.	Maqsood, A.	95
33.	Sarwar, M.I.	10	33.	Asiri, A.M.	91
34.	Anis, M.K.	9	34.	Zulfiqar, S.	91
35.	Arshed, M.	9	35.	Khenata, R.	89
36.	Husain, S.W.	9	36.	Amin, N.	88
37.	Mohammad, D.	9	37.	Ahmad, M.	87
38.	Munir, A.	9	38.	Mahmood, A.	87
39.	Salam, I.	9	39.	Ahmad, I.	86
40.	Shah, G.B.	9	40.	Akkurt, M.	86
41.	Shaikh, M.A.	9	41.	Shah, M.R.	85
42.	Siddique, M.	9	42.	Ayub, K.	83
43.	Afridi, M.U.K.	8	43.	Iqbal, Y.	82
44.	Ahmed, W.	8	44.	Khan, I.	82
45.	Asghar, S.	8	45.	Nawab, Y.	82
46.	Demura, K.	8	46.	Mazhar, M.	81
47.	Hayat, T.	8	47.	Ahmed, E.	79
48.	Ikram, N.	8	48.	Akhter, Z.	79
49.	Khan, M.B.	8	49.	Shah, A.	79
50.	Naqvi, Q.A.	8	50.	Ahmad, R.	77

Table 4. The top fifty universities in two eras (20th Century) and (21st Century). NoP= Number of Publications

	1st Era (1947-2000)			2nd Era (2001-2020)	
S. No.	**Affiliation**	**NoP**	**S. No.**	**Affiliation**	**NoP**
1)	Quaid-i-Azam University, Pakistan	237	1)	Quaid-i-Azam University, Pakistan	3277
2)	Pakistan Institute of Nuclear Science and Technology, Pakistan	117	2)	COMSATS University Islamabad, Pakistan	1868
3)	University of the Punjab, Lahore, Pakistan	101	3)	National University of Sciences and Technology Pakistan, Pakistan	1682
4)	Government College University Lahore, Pakistan	65	4)	University of the Punjab, Lahore, Pakistan	1495
5)	Dr. A. Q. Khan Research Laboratories, Pakistan	62	5)	Government College University Lahore, Pakistan	1027
6)	University of Karachi, Pakistan	43	6)	University of Engineering and Technology Lahore, Pakistan	972
7)	Metallurgy Division Pakistan, Pakistan	36	7)	University of Sargodha, Pakistan	919
8)	Bahauddin Zakariya University, Pakistan	32	8)	King Saud University, KSA	903
9)	Ghulam Ishaq Khan Institute of Engineering Sciences and Technology, Pakistan	30	9)	Bahauddin Zakariya University, Pakistan	871
10)	The University of Manchester, UK	25	10)	COMSATS Institute of Information Technology Lahore, Pakistan	839
11)	Pakistan Atomic Energy Commission, Pakistan	19	11)	University of Peshawar, Pakistan	698
12)	University of Balochistan, Pakistan	17	12)	King Abdulaziz University, KSA	695
13)	Brunel University London, UK	16	13)	Pakistan Institute of Nuclear Science and Technology, Pakistan	656
14)	Pakistan Council of Scientific and Industrial Research, Pakistan	16	14)	Islamia University, Pakistan	627
15)	University of Glasgow, UK	14	15)	International Islamic University Islamabad, Pakistan	613
16)	Imperial College London, UK	14	16)	Government College University Faisalabad, Pakistan	577
17)	University of Peshawar, Pakistan	13	17)	University of Karachi, Pakistan	568
18)	University of Engineering and Technology Lahore, Pakistan	13	18)	Pakistan Institute of Engineering and Applied Sciences, Pakistan	543
19)	PCSIR Laboratories, Pakistan	12	19)	University of Agriculture, Faisalabad, Pakistan	503
20)	Islamia University, Pakistan	9	20)	Ghulam Ishaq Khan Institute of Engineering Sciences and Technology, Pakistan	500
21)	Nihon University, Japan	8	21)	Chinese Academy of Sciences, China	493
22)	University of Salford, Uk	8	22)	University of Lahore, Pakistan	430
23)	Universität Bayreuth, Germany	8	23)	Abdul Wali Khan University Mardan, Pakistan	420
24)	Gomal University, Pakistan	8	24)	National Textile University Faisalabad, Pakistan	417
25)	State Cement Corporation of Pakistan, Pakistan	7	25)	University of Gujrat, Pakistan	384
26)	PResearch Laboratories, Pakistan	7	26)	Hazara University Pakistan, Pakistan	378
27)	International Islamic University Islamabad, Pakistan	7	27)	University of Engineering and Technology Taxila, Pakistan	356
28)	Natl Inst of Silicon Technology	6	28)	King Saud University College of Science, KSA	326
29)	The University of Sheffield,UK	6	29)	Islamia College, Peshawar, Pakistan	294
30)	University of Leeds, UK	6	30)	Riphah International University, Pakistan	290
31)	University of Cincinnati, USA	6	31)	University of Malaya, Malaysia	285
32)	UNSW Sydney, Australia	6	32)	NED University of Engineering & Technology, Pakistan	285
33)	University of Cambridge, UK	6	33)	University of Engineering and Technology, Peshawar, Pakistan	283
34)	Technical University of Berlin, Germany	5	34)	Lahore University of Management Sciences, Pakistan	271
35)	University of Reading, UK	5	35)	Institute of Space Technology, Islamabad, Pakistan	270

1st Era (1947-2000)			2nd Era (2001-2020)		
S. No.	**Affiliation**	**NoP**	**S. No.**	**Affiliation**	**NoP**
36)	University of Surrey, UK	5	36)	Universiti Teknologi Malaysia, Malaysia	250
37)	Massachusetts Institute of Technology, USA	5	37)	King Fahd University of Petroleum and Minerals, KSA	249
38)	University of Agriculture, Peshawar, , Pakistan	5	38)	Ministry of Education China, China	239
39)	Department of Physics, UOP, Pakistan	5	39)	PCSIR Laboratories, Pakistan	235
40)	Chalmers University of Technology	4	40)	University of Malakand, Pakistan	235
41)	University of Northumbria, UK	4	41)	Mehran University of Engineering & Technology, Pakistan	225
42)	King Fahd University of Petroleum and Minerals, KSA	4	42)	University of Management and Technology Lahore, Pakistan	221
43)	The University of Adelaide, Australia	4	43)	University of Azad Jammu and Kashmir, Kashmir	216
44)	IPCMS Institut de Physique et Chimie des Matériaux de Strasbourg, France	4	44)	Lahore College for Women University, Pakistan	207
45)	Karlsruhe Institute of Technology, Campus North, Germany	4	45)	University of Education, Pakistan	201
46)	Temple University, USA	4	46)	Allama Iqbal Open University, Pakistan	190
47)	University of Hull, UK	4	47)	Air University Islamabad, Pakistan	188
48)	Abdus Salam International Centre for Theoretical Physics, Italy	4	48)	BUITEMS - Balochistan University of Information Technology, Engineering and Management Sciences, Pakistan	186
49)	Sheffield Hallam University, UK	4	49)	Kohat University of Science and Technology KUST, Pakistan	183
50)	NED University of Engineering & Technology, , Pakistan	4	50)	The University of Manchester, UK	177

of Korea (n=427), Alabama Commission on Higher Education (n=392), Ministry of Education of the People's Republic of China (n=315), Ministry of Science and Technology of the People's Republic of China (n=311), Fundamental Research Funds for the Central Universities (n=276), Ministry of Finance (n=240) and Ministry of Science, ICT and Future Planning (n=200). In table 4, the list of top 50 funding sources is described for both eras (1947 to 2000 and from 2001 to 2020).

3.6 International Collaboration

In Pakistan, from 1947 to 2000 the international collaboration was very low. Total 34-countries are noted in publications. Infact, only five countries collaborated in atleast ten publication. For example, United Kingdom (n=142), United States (n=54), Germany (n=37), Japan (n=15) and Australia (n=12). While 29 countries collaborated in less than nine (n=9) publications. From 2001-onwards the collaboration completely changed. One hundred and eight countries collaborated in all publications. The top ten countries in this list China (n=3246), Saudi Arabia (n=2621), United Kingdom (n=1310), South Korea (n=1167), Malaysia (n=1129), United States (n=981), Germany (N=651), Turkey (n=420), Canada (n=402) and Iran (n=333). In table 7, the list of top 50 collaborating countries is described for both eras (1947 to 2000 and from 2001 to 2020). Overall, Pakistan has a low global share (n=0.36%) and holds 38th position in the world (TP=5542484). This highlights that critical future planning and policies are needed to improve the overall research progress.

Table 5. The top fifty journals or sources in two eras (20th Century) and (21st Century). NoP= Number of Publications

1st Era (1947-2000)			2nd Era (2001-2020)		
S. No.	**Source Title**	**NoP**	**S. No.**	**Source Title**	**NoP**
1.	Journal Of Materials Science Letters	67	1.	IEEE Access	1502
2.	Journal Of Materials Science	53	2.	Acta Crystallographica Section E Structure Reports Online	1360
3.	Polymer Degradation And Stability	32	3.	Ceramics International	436
4.	Optics Communications	30	4.	Journal Of Molecular Liquids	432
5.	Physica Status Solidi A	30	5.	Materials Research Express	422
6.	Journal Of Materials Engineering And Performance	26	6.	Journal Of Alloys And Compounds	399
7.	Solid State Communications	24	7.	Optik	353
8.	Journal Of Physics D Applied Physics	21	8.	Journal Of Magnetism And Magnetic Materials	297
9.	Inorganica Chimica Acta	15	9.	Journal Of Materials Science Materials In Electronics	265
10.	Materials Science And Technology United Kingdom	15	10.	Applied Sciences Switzerland	261
11.	Materials Letters	13	11.	Applied Nanoscience Switzerland	220
12.	Superconductor Science And Technology	13	12.	European Journal Of Scientific Research	209
13.	Journal Of Applied Polymer Science	12	13.	Physica B Condensed Matter	209
14.	Physica Status Solidi B	12	14.	Applied Surface Science	199
15.	Journal Of Materials Science And Technology	11	15.	Journal Of Superconductivity And Novel Magnetism	171
16.	Kolloid Zeitschrift	11	16.	Materials Chemistry And Physics	158
17.	Materials Science And Technology	10	17.	Construction And Building Materials	157
18.	Fresenius Zeitschrift Fur Analytische Chemie	9	18.	Journal Of Electronic Materials	153
19.	Journal Of Physics E Scientific Instruments	9	19.	Applied Physics A Materials Science And Processing	133
20.	Philosophical Magazine A Physics Of Condensed Matter Structure Defects And Mechanical Properties	9	20.	Pakistan Journal Of Scientific And Industrial Research Series A Physical Sciences	133
21.	Semiconductor Science And Technology	9	21.	Journal Of Computational And Theoretical Nanoscience	132
22.	Thin Solid Films	9	22.	Journal Of Applied Polymer Science	129
23.	Journal Of Physics Condensed Matter	8	23.	Pakistan Textile Journal	129
24.	Main Group Metal Chemistry	8	24.	Materials	123
25.	Solar Energy	8	25.	Journal Of Porous Media	117
26.	Journal Of Electromagnetic Waves And Applications	7	26.	Materials Letters	117
27.	Magnetic Resonance In Chemistry	7	27.	SN Applied Sciences	113
28.	Surface Science	7	28.	Carbohydrate Polymers	112
29.	Cement And Concrete Research	6	29.	New Journal Of Chemistry	108
30.	Colloid And Polymer Science Kolloid Zeitschrift Zeitschrift Fur Polymere	6	30.	Digest Journal Of Nanomaterials And Biostructures	107
31.	European Polymer Journal	6	31.	Microwave And Optical Technology Letters	107
32.	International Journal Of Fatigue	6	32.	ACS Applied Materials And Interfaces	105
33.	Journal Of Colloid And Interface Science	6	33.	Materials Science In Semiconductor Processing	103
34.	Journal Of Non Crystalline Solids	6	34.	Polymer Plastics Technology And Engineering	93
35.	Optica Applicata	6	35.	Optics Communications	92
36.	Physica B Condensed Matter	6	36.	Computers Materials And Continua	90
37.	Physica C Superconductivity And Its Applications	6	37.	Journal Of Coordination Chemistry	90
38.	Radiation Effects And Defects In Solids	6	38.	Solar Energy	89
39.	British Corrosion Journal	5	39.	Journal Of The Textile Institute	79
40.	Carbon	5	40.	Materials Science And Engineering C	79
41.	International Journal Of Engineering Science	5	41.	Journal Of Colloid And Interface Science	78
42.	Materials Chemistry And Physics	5	42.	Journal Of Physics D Applied Physics	78
43.	Materials Science Forum	5	43.	Materials Research Bulletin	78
44.	Oxidation Of Metals	5	44.	Polyhedron	78
45.	Textile Research Journal	5	45.	Inorganica Chimica Acta	77
46.	Colloid Polymer Science	4	46.	Current Applied Physics	76
47.	Engineering Failure Analysis	4	47.	Journal Of Materials Science	75

	1st Era (1947-2000)			2nd Era (2001-2020)	
S. No.	**Source Title**	**NoP**	**S. No.**	**Source Title**	**NoP**
48.	IEEE Transactions On Electron Devices	4	48.	Sensors And Actuators B Chemical	75
49.	International Biodeterioration And Biodegradation	4	49.	Journal Of Materials Research And Technology	71
50.	International Journal Of Clothing Science And Technology	4	50.	Physica E Low Dimensional Systems And Nanostructures	70

Table 6. The top fifty funding sponsors in two eras (20th Century) and (21st Century). NoP= Number of Publications

	1st Era (1947-2000)			2nd Era (2001-2020)	
S#	**Funding Sponsor**	**NoP**	**S#**	**Funding Sponsor**	**NoP**
1.	Pakistan Science Foundation, Pakistan	13	1.	Higher Education Commission, Pakistan	1441
2.	Agency for Science, Technology and Research, Singapore	7	2.	National Natural Science Foundation of China	1228
3.	Science and Engineering Research Council, UK	7	3.	Higher Education Commision, Pakistan	789
4.	Pakistan Atomic Energy Commission, Pakistan	6	4.	King Saud University, KSA	638
5.	Quaid-i-Azam University, Pakistan	6	5.	Deanship of Scientific Research, King Saud University, KSA	443
6.	Abdus Salam International Centre for Theoretical Physics, Italy	4	6.	National Research Foundation of Korea	427
7.	National Science Foundation, USA	4	7.	Alabama Commission on Higher Education, USA	392
8.	Deutsche Forschungsgemeinschaft, Germany	3	8.	Ministry of Education of the People's Republic of China	315
9.	Deutscher Akademischer Austauschdienst, Germany	3	9.	Ministry of Science and Technology of the People's Republic of China	311
10.	University Grants Commission, Pakistan	3	10.	Fundamental Research Funds for the Central Universities, China	276
11.	Alexander von Humboldt-Stiftung, Germany	2	11.	Ministry of Finance, Pakistan	240
12.	Australian Research Council, Australia	2	12.	Ministry of Science, ICT and Future Planning, South Korea	200
13.	British Council, UK	2	13.	Chinese Academy of Sciences	142
14.	Department of Education and Training, Australia	2	14.	Pakistan Science Foundation	137
15.	Department of Trade and Industry, Australia	2	15.	European Commission	134
16.	Ministerio de Ciencia y Tecnología, Argentina	2	16.	UK Research and Innovation	133
17.	Temple University, USA	2	17.	National Key Research and Development Program of China	132
18.	University of Karachi, Pakistan	2	18.	Engineering and Physical Sciences Research Council, UK	130
19.	Academy of Sciences Republic of Uzbekistan	1	19.	National University of Sciences and Technology, Pakistan	130
20.	Air Force Materiel Command, USA	1	20.	Ministry of Higher Education, Malaysia	126
21.	Air Force Office of Scientific Research, USA	1	21.	National Basic Research Program of China (973 Program)	120
22.	Bangladesh Council of Scientific and Industrial Research	1	22.	China Postdoctoral Science Foundation	114
23.	Dairy Farmers of Canada	1	23.	King Abdulaziz University, KSA	108
24.	Directorate for Mathematical and Physical Sciences, USA	1	24.	Quaid-i-Azam University, Pakistan	107
25.	Division of Materials Research, USA	1	25.	Ministry of Trade, Industry and Energy, South Korea	94
26.	European Commission	1	26.	National Science Foundation	92
27.	Fonds pour la Formation de Chercheurs et l'Aide à la Recherche, Canada	1	27.	Deanship of Scientific Research, King Faisal University, KSA	90
28.	Ghulam Ishaq Khan Institute of Engineering Sciences and Technology, Pakistan	1	28.	Ministry of Education, Science and Technology, Nepal	88

	1st Era (1947-2000)			2nd Era (2001-2020)	
S#	**Funding Sponsor**	**NoP**	**S#**	**Funding Sponsor**	**NoP**
29.	Government of Canada	1	29.	Universiti Teknologi Malaysia	80
30.	Hong Kong Baptist University	1	30.	King Fahd University of Petroleum and Minerals, KSA	78
31.	Hong Kong Government	1	31.	Ministry of Science and ICT, South Korea	78
32.	Institute for Applied Ecology, USA	1	32.	Deutsche Forschungsgemeinschaft, Germany	74
33.	King Abdulaziz City for Science and Technology, KSA	1	33.	Universiti Malaya, Malaysia	65
34.	Ministry of Education, Culture, Sports, Science and Technology, Japan	1	34.	Kementerian Pendidikan Malaysia	62
35.	Ministry of Science and Technology, Taiwan	1	35.	Korea Institute of Energy Technology Evaluation and Planning,	62
36.	National Institute of General Medical Sciences, USA	1	36.	COMSATS Institute of Information Technology, Pakistan	61
37.	National Institutes of Health, USA	1	37.	Majmaah University, KSA	60
38.	Natural Sciences and Engineering Research Council of Canada	1	38.	University of Engineering and Technology, Lahore, Pakistan	60
39.	Pennsylvania State University, USA	1	39.	King Khalid University, KSA	59
40.	Rolls-Royce, UK	1	40.	Ministry of Knowledge Economy, South Korea	57
41.	Royal Society, UK	1	41.	University of the Punjab, Pakistan	57
42.	St. Thomas University, Canada	1	42.	China Scholarship Council	52
43.	State of New Jersey Commission on Science and Technology, USA	1	43.	The World Academy of Sciences, Italy	49
44.	Swedish Foundation for International Cooperation in Research and Higher Education	1	44.	Universiti Teknologi Petronas, Malaysia	47
45.	The World Academy of Sciences, Italy	1	45.	NED University of Engineering and Technology, Pakistan	46
46.	U.S. Air Force	1	46.	Deutscher Akademischer Austauschdienst, Germany	43
47.	U.S. Department of Defense	1	47.	Ministry of Education, Culture, Sports, Science and Technology, Japan	43
48.	U.S. Department of Health and Human Services	1	48.	Ministry of Education, Pakistan	42
49.	United Nations Development Programme, USA	1	49.	Alexander von Humboldt-Stiftung, Germany	41
50.	United States Agency for International Development	1	50.	Ministario da Ciancia, Tecnologia e Inovaacao, Brazil	41

Table 7. The top collaborating countries in two eras (20th Century) and (21st Century). NoP= Number of Publications

	1st Era (1947-2000)			2nd Era (2001-2020)	
S#	Country	**NoP**	**S#**	Country	**NoP**
1.	Pakistan	832	1.	Pakistan	19313
2.	United Kingdom	142	2.	China	3246
3.	United States	54	3.	Saudi Arabia	2621
4.	Germany	37	4.	United Kingdom	1310
5.	Japan	15	5.	South Korea	1167
6.	Australia	12	6.	Malaysia	1129
7.	Canada	8	7.	United States	981
8.	France	8	8.	Germany	651
9.	Saudi Arabia	6	9.	Turkey	420
10.	China	5	10.	Canada	402
11.	Italy	5	11.	Iran	333
12.	Sweden	5	12.	Australia	320
13.	Hong Kong	3	13.	India	267
14.	Turkey	3	14.	Italy	258
15.	Algeria	2	15.	Japan	254
16.	Egypt	2	16.	United Arab Emirates	237
17.	India	2	17.	Egypt	233
18.	Iran	2	18.	Sweden	231
19.	Ireland	2	19.	France	220

1st Era (1947-2000)			2nd Era (2001-2020)		
S#	Country	**NoP**	**S#**	Country	**NoP**
20.	Libyan Arab Jamahiriya	2	20.	Viet Nam	196
21.	Nigeria	2	21.	Czech Republic	160
22.	South Korea	2	22.	Austria	158
23.	Bahrain	1	23.	Qatar	151
24.	Bangladesh	1	24.	Hong Kong	132
25.	Belgium	1	25.	South Africa	132
26.	Brunei Darussalam	1	26.	Spain	131
27.	Cyprus	1	27.	Algeria	129
28.	Indonesia	1	28.	Brazil	126
29.	Kiribati	1	29.	Singapore	114
30.	Malaysia	1	30.	Taiwan	114
31.	Poland	1	31.	New Zealand	107
32.	Qatar	1	32.	Thailand	101
33.	Spain	1	33.	Netherlands	97
34.	Switzerland	1	34.	Tajikistan	92
35.	Uzbekistan	1	35.	Romania	91
36.	No Data	No Data	36.	Finland	78
37.	″	″	37.	Ireland	78
38.	″	″	38.	Oman	74
39.	″	″	39.	Nigeria	70
40.	″	″	40.	Switzerland	70
41.	″	″	41.	Iraq	69
42.	″	″	42.	Kuwait	66
43.	″	″	43.	Russian Federation	66
44.	″	″	44.	Mexico	64
45.			45.	Poland	64
46.	″	″	46.	Belgium	61
47.			47.	Bangladesh	56
48.	″	″	48.	Jordan	52
49.			49.	Portugal	46
50.	″	″	50.	Norway	44

4. LIMITATIONS

The major limitation is, we only analyzed the Scopus data. Other databases for examples, Web of Science, Crossref, Dimensions, or PubMed Central were not explored.

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6. CONFLICT OF INTEREST

There is no conflict of interest.

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