Research performance and knowledge mapping of King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia: A bibliometric analysis of literature indexed in Web of Science (2011-2020)

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Abstract

Purpose: King Fahd University of petroleum and minerals is one of the best universities in Saudi Arabia and the Gulf region. The primary goal of this study is to analyze research output and mapping knowledge of King Fahd University of petroleum and minerals, Dhahran, Saudi Arabia, between 2011 and 2020.
Methodology: The present study employed the bibliometric method to explore the research performance of the King Fahd University Petroleum and Minerals between 2011 and 2020. The study focused on bibliometric parameters such as annual research growth and its citation impact over the years, the prolific researcher, authorship pattern, relevant sources, subjects-wise research and level of collaborations by authors and countries, etc.
Results: The results show that out of 12494 papers, the highest research was 928 papers published in 2020. The majority of the 9906 publications were published as journal articles, and the *"Arabian Journal for Science and Engineering"* ranked first with 256 articles. B.S. Yilbas identified the most prolific author with 342 papers, and the three authorship (3509) papers were the most preferred authorship pattern. Moreover, the subject 'Engineering' has the highest number of published papers. Furthermore, the most commonly used author's keywords are *adsorption, Corrosion, Laser, Laser, Solar, corrosion inhibition, and nanoparticles* between 2011 and 2020. The results also show Saudi Arabia vs. the United States was most the collaborative country for KFUPM

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research with 1365 publications, followed by Pakistan and India, and the collaboration index noted as 1.42. The study also recommends some valuable suggestions to accelerate and produce more research in KFUPM.

Keywords: King Fahd University of Petroleum and Minerals; KFUPM; Bibliometric; Scientometric, Research assessment, Literature review

1. Introduction and Profile of the University

King Fahd University of Petroleum and Minerals (KFUPM) was founded by royal decree on 23rd September 1963. It is a public university located in Dhahran, Eastern Province, Saudi Arabia. Initially, it was called the 'College of Petroleum and Minerals (CPM).' A year later, the first batch of 67 students enrolled in it on 23rd September 1964. Since then, the University enrollment has grown to more than 8,000 students. The purpose of establishing KFUPM as an institution to prepare the Saudi youth to lead the increasing development back there in the 60s when Saudi Arabia became an indispensable petroleum producer in the world. The significant change came in 1975 in its academic status when the CPM became the University of Petroleum & Minerals. In 1986, the University was again renamed as "King Fahd University of Petroleum & Minerals." Over the years, KFUPM became the national pride of Saudi Arabia when it achieved the fourth rank globally according to the annual ranking of the US National Academy of Inventors and Intellectual Property Owners for universities in 2019. KFUPM extended its area of study and research by including more different branches of engineering other than petroleum, including Business Studies also in its programs. In October 2008, Times Higher Education-QS (THE-QS) World University Rankings (WUR) gave KFUPM 338th rank amongst the top 400 universities worldwide (KFUPM, 2021). KFUPM is the first and the only University in the Middle East ever to enter this ranking. Its engineering and business programs are accredited by various technical accrediting agencies such as the 'Accreditation Board for Engineering and Technology (ABET)' and 'National Commission for Academic Accreditation and Assessment' (NCAAA).' The KFUPM presently doing great in producing high-quality research and working professionals in engineering and business studies (KFUPM, 2021). King Fahd University of Petroleum & Minerals is one of the 27 Saudi Universities that, alongside the Council of Higher Education, KFUPM, like other Saudi Universities, has a board. The President serves as the deputy chairman of the board. Membership of the Board, the Vice Presidents, the deans, and three external members. This board is responsible for all the university operations, it grants degrees to students, approves programs and curricula of existing departments, and makes recommendations to the Council of Higher Education in other matters. The President of the University is the chief academic and executive officer of the University. He also represents the University in contacts with outside

organizations. The President is assisted by three Vice Presidents (Vice President for Academic Affairs, Vice President for Graduate Studies & Scientific Research, and Vice President for Applied Research) and two supervisors (the General Supervisor and Supervisor for Technology Transfer, Innovation, and Entrepreneurship). The Vice is assisted by Deans, Directors of the Centers in the Research Institute, Academic Department Chairs, the Director of the Information Technology Center (ITC), Director Generals and Directors of the administrative units (KFUPM, 2015).

The academic organization of the University includes the Preparatory Year Program, seven academic colleges, and the Deanship of Graduate Studies. The Preparatory Year Program is designed as a bridge between the level a student attains upon graduating from the secondary schools of the Kingdom and the academic and language requirements of each of the six-undergraduate degree-offering academic colleges. Although the great majority of students admitted to the University begin their studies in the Preparatory Year Program, a small number of high achievers may, upon passing a qualifying examination, enter the college of their choice directly. The six1undergraduate colleges are the College of Applied Engineering, offering degrees in Applied Chemical, Applied Civil, Applied Electrical, and Applied Mechanical Engineering; the College of Engineering Sciences, offering degrees in Aerospace, Chemical, Civil, Electrical, Mechanical, and Petroleum Engineering; the College of Sciences, offering degrees in Chemistry, Geology, Geophysics, Mathematics, Physics, Statistics & Actuarial Science; the College of Environmental Design, offering degrees in Architecture, Architectural Engineering, and City Planning; the College of Industrial Management, offering degrees in Accounting, Finance, Information Systems, Marketing, and Operations Management; the college of Computer Sciences & Engineering, offering degrees in Computer Science, Software Engineering, Computer Engineering, Industrial & Systems Engineering, and Systems & Control Engineering, and the College of Applied and Supportive studies that offers service courses in Islamic and Arabic Studies, English, Physical Education, and General Studies.

The Deanship of Graduate Studies awards Master of Science (M.S.) degrees in 23 major fields, namely: Aerospace, Architectural, Chemical, Civil, Computer, Electrical, Industrial and Systems, Systems & Control, Mechanical, Petroleum, Software, Telecommunication Engineering, as well as in Applied Statistics, Chemistry, Computer Networks, Computer Science, Construction Engineering Management, Environmental Sciences, Geology, Geophysics, Mathematics, Physics, and Security & Information Assurance. The Deanship of Graduate Studies also awards Master of Engineering (M.Eng.) in Architectural, Civil, Industrial, Oil & Gas Surface Facilities & Systems, Systems & Control, and master's degrees in Accountancy, Business Administration (M.B.A.), Executive Business Administration (E.M.B.A.), City & Regional Planning, Engineering Management, Geology, Geophysics, Medical Physics, and Supply Chain Management. Doctoral programs are offered in thirteen specializations:

Chemical, Civil, Electrical, Industrial & Systems, Mechanical, Petroleum, Systems, and Control Engineering, as well as in Chemistry, Computer Science, Computer Engineering, Geology, Mathematics, and Physics (KFUPM, 2015).
KFUPM has a huge library setup equipped with the latest technologies to support its academic and research activities. The library has a rich collection of electronic resources, including 67 online databases and membership of many professional societies, providing full access to more than 40,000 journals. The library is also a member of the prestigious Saudi Digital Library consortia, one of the pioneering projects of the National Center for E-Learning, Ministry of Higher Education, Saudi Arabia. Most electronic resources, including online databases, can be accessed online remotely from on/off-campus. In addition to providing online access to its digital collection to the KFUPM community, it also provides borrowing privileges and other select services to local government agencies and private institutions. (KFUPM, 2015).

2. Literature Review

Bibliometric have been used to assess and evaluate the research productivity of individual authors/faculty members, academic/technical universities, states in various research studies across the globe. Rahaman et al. (2020) derived the scientometric profile of Banasthali University, Rajasthan, India, by examining its faculty members' overall performance in research productivity and publications from 2000 to 2020. The study focused on the average number of citations per document, top-ranked subjects, authors, most prolific author, authorship patterns (single, multiple), top-ranked publications, degree of collaboration, etc. They investigated 2764 from 1196 Sources (journals, books, etc.) during the mentioned study period. Also, M. S. Rahaman et al. (2021) have conducted a similar study for Imam Abdulrahman Bin Faisal University (IAU), Saudi Arabia, to assess the research output between 2010 and 2020. Biblioshiny, Vosviewer, and Scientopy (the bibliometric analysis software) were used for data analysis. The results show that the productivity of scientific writing has increased, and IAU authors have considerable national and worldwide cooperation. Baykal A found as the prolific author with 128 papers and 1,635 citations. Regional collaboration is the highest (2,716 papers), and international collaboration found the highest with Egypt (312 papers). The majority of the researchers preferred to publish their work as journal articles, and the most important author's keywords were *Saudi Arabia* and *Synthesis*. Mukundan & Narayanan (2020) studied the researches produced at Khalifa University, Abu Dhabi, UAE, indexed it in SCOPUS. They found an average citation of research studies conducted at KU. 20% of KU publications could attract 80% of the total number of citations, and the rest 80% of its publications could get a limited number of citations. An interesting study (Doulani, 2020) analyzed the scientific publications of Alzahra University, Iran, during 1986–2019. He found that most of the researches conducted at Alzahra University had International collaborations, mostly made with universities in the United States,

Canada, and Germany. 70% of highly cited articles were published in various high-ranked journals. Utama et al. (2019) evaluated the publications of the SCOPUS database during 2014-2018. They used the very catchy term "World Class University" in their research. They claimed that Diponegoro University publications improved remarkably in the last five years and achieved the fastest publication rateation (up to 471%) during research period. Mulimani & Hadagali (2018) have analyzed research output by the Indian Institute of Toxicology Research during 1993 to 2017 from the Web of Science. The study included different scientometric parameters such as most cited articles, collaboration pattern at the national and international level, degree of collaboration, prolific authors, most favored journal, citation impact of the publication, and most repeated author keywords. The study revealed that most of the researchers preferred to published in the International Journals, 5.73% of publications of IITR scientists remain uncited, 99 % publications contributed by multi-Authors and only 0.86% contributed by single authorship,86 % literature collaborated domestically. In comparison, 13% collaborated with the international level. Analysis of author keywords showed that the most active research areas are Oxidative Stress, Apoptosis, DNA Damage, Lipid Peroxidation, etc. Pradhan & Ramesh, (2018) have analyzed publication data of 72940-research papers contributed by six Indian Institute of Technology from 2006 to 2015 indexed in the Scopus database. The study examined that relative citation impact of IIT Bombay and IIT Roorkee are more than IITs of other regions. The papers of IIT Kharagpur found more cited than other IITs. Highly used Journals used by the researcher of IITs are *Physics of Plasma, Journal of Applied polymer Science* and *RSC advances*. Kumar, (2018) carried out bibliometric mapping of research performance of TIRF Mumbai during 2001 to 2015 indexed in the web of science database. The study explored the total research output of TIRF in comparing its astronomical research output during the year of 2001 to 2015. It includes the growth of research publication, type of documents, total citation received most preferred journal, collaborating institutions, collaborating countries, and research funding agencies. The study also highlighted publication pattern, CAGR, degree of collaboration, h-index, and nature of research work carried out by members of TIRF Mumbai. Marisha et al. (2017) have explored the research output of the central universities in India. The study examined the research productivity of India's 39 central's universities from 1990 to 2014 as data covered in the web of Science database. The publications analyzed to identify research productivity, productivity per capita, productivity per crore rupees grant, the growth rate of research, authorship pattern, and the pattern of collaboration, citation impact, and subject-wise distribution of papers. The research productivity of the central universities guaged and compared with world top most universities such as 'The University of Cambridge' and 'Stanford University.' The study also found that the well-established universities (the University of Delhi and Banaras Hindu University) contributed more research output than newly established universities. The

combined research of all central universities is less than 'The University of Cambridge 'or' Stanford University The study also examined the subject-wise distribution of publications of all the central universities. Haq & Fouzan, (2017) studied the research productivity of 'King Saud bin Abdul Aziz University for Health Sciences (KSAU-HS)' from its beginning till the end of 2015 by retrieving data from ISI - Web of science. They found that 15.35 articles were written on medicine as subject. 94% of the total research work done by collaborative efforts. 61.29% of principal authors were from KSAI-HS. 64.65% research work was collaboratively done mainly with United States organizations followed by Canada and Pakistan. Yadav et al., (2020) evaluated the research productivity of the 'Mizoram University' during 2004-2017 based on Indian Citation Index. Focus of the study was to analyze the research performance of the faculty members of 'Mizoram University'. They discussed the co-authorship index, and collaborative index, degree of collaboration, collaboration coefficient, modified collaboration coefficient, most productive author, top-ranked subjects and top-ranked publications. They found that the research output was average of 18.93 research papers per year. U.K Sahu found as the most prolific author with 25 publications. *Current science* was on top as highest rank publication with 16 research papers. The 'Biological Science' subject with 54 publications produced highest number of research. Ul Haq et al. (2020) discussed the research output of 'Army Medical College, Pakistan,' between 1977 to 2018 and found 417 papers published during the period with the average of 9.92 papers per year. 68% Papers were published on medicine. Abdul Khaliq Naveed found as the most prolific author and Journal of *College of Physicians and Surgeons Pakistan* and *Journal of Pakistan Medical Association* noted as the most relevant journal with 84 and 82 publications. The authors are mostly collaborated with the 'National University of Sciences and Technology' within Pakistan followed by 2 Saudi Arabian Universities. (R et al., 2020) made scientometric profile of the 'University of Madras's' research publications from 2009 to 2018, indexed in Web of science. They found fluctuating trend in research growth rate, the average references for each article was 10.89 and h-index of the university was 65 during the study period. *ACTA Crystallographica Section E Structure Reports* considered as the top-ranking journal with 165 papers. Dr. V. Narayanan was found highly productive author in terms of contributions with an impressive h-index, and the research productivity of the University of Madras was much recognized at the international level. Meera & Sahu, (2014) analyzed the research performance of 'University College of Medical Science (UCMS)' India, during 1975 until November 2013. They stated that slightly more than 25% of UCMS research works were collaborated by three authorships, with the degree of collaboration 0.92. The authors of the research preferred collaborative work, and most of the authors preferred to collaborate with the authors US universities.

3. Research Objectives

The main objective of this study was to analyze the research productivity of King Fahd University of petroleum and minerals (FKUPM) literature indexed in Web of science between 2011 and 2020. Besides the main objectives, the other objectives of this study are mentioned below.

- What are the annual publication trends and its citation structure of KFUPM between 2011 and 2020?
- What the most crucial research areas of the KFUPM in terms of total publications
- Who are the most prolific authors, and what the trends of authorship patterns are among the researchers of KFUPM?
- What is the most favored source by the researchers of KFUPM?
- What are the most used author's keywords and general's keywords in the literature of KFUPM?
- Who is the most collaborator of research in terms of authors and country with KFUPM?
- What is the major theme of research, and what are the most cited publications in KFUPM?

4. Research Methodology

The bibliometric method has been applied to analyze King Fahd University's petroleum and minerals research productivity between 2011 and 2020. Using statistical techniques to analyze any form of research publication such as books, conferences, journal articles, etc., is known as bibliometrics; it is a widely used library and information science method. Bibliometrics involves quantitative means of investigating scholarly publishing practices, publishing trends, productive authors, country, organization, etc. The required literature of KFUPM Publications was retrieved from the 'Web of Science' core collection as of 15 June 2021 at King Fahd University of petroleum and minerals. Web of Science is one of the most extensive peer-reviewed indexing and abstracting literature databases. The targeted data searched in the advanced search box by selecting field tags (OG=King Fahd University of Petroleum and Minerals). The following search query is involved in the Web of Science database (Clarivate Analytics, 2020).

- OG= ("king Fahd university of petroleum & minerals" OR "KFUPM")
- Refined by: PUBLICATION YEARS: (2020 OR 2019 OR 2018 OR 2017 OR 2016 OR 2015 OR 2014 OR 2013 OR 2012 OR 2011)
- Refined by excluding] LANGUAGES: (CHINESE OR ITALIAN OR TURKISH OR RUSSIAN)
- Refined by excluding] DOCUMENT TYPES: (LETTER OR BIOGRAPHICAL ITEM OR CORRECTION OR DATA PAPER OR RETRACTED PUBLICATION)

- Timespan: All years. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI, CCR-EXPANDED, IC.

The initial search by the organization (OG) retrieved 22,503 published documents in the web of Science, then the data refined by 'Publication years (2011-2020)' that retrieved 12,578 records, then refined by language and recovered 125,73 and final refined by 'type of documents and retrieved 12,494 records. The total items screened to achieve an accurate sample for data analysis are 10,009 records. Therefore, 12,494 documents were considered for final analysis during 2011-2020. It is also important to mention that this is the first bibliometric study about KFUPM. All the research data was downloaded in BibTeX, Tab-Delimited (win), plain text, and analyzed with Bibexcel (Persson, O., R. Danell, 2009), Biblioshiny (Aria & Cuccurullo, 2017), and VOSviewer (van Eck & Waltman, 2010)

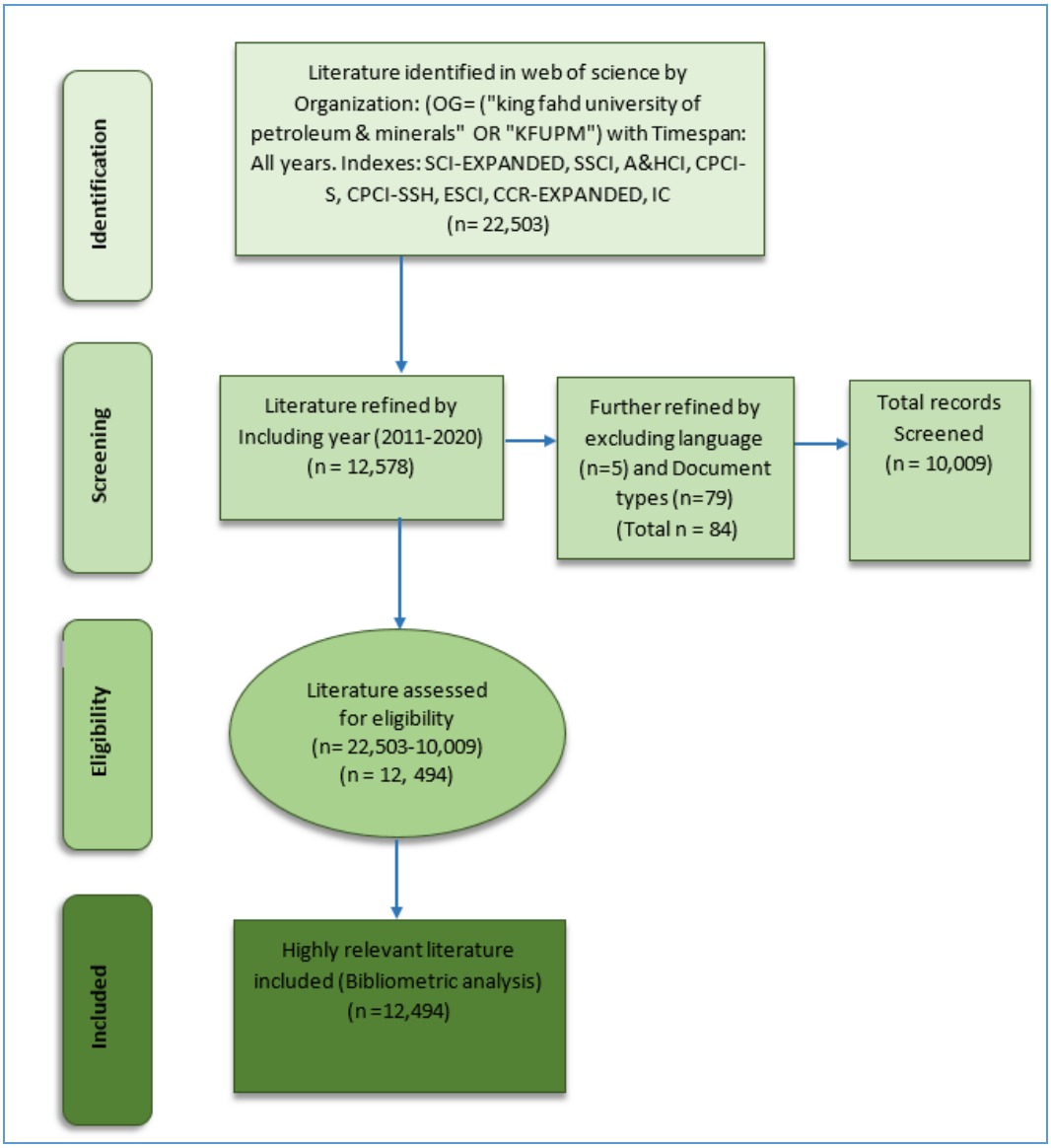


Figure (1) PRISMA flow chart of research data extraction of KFUPM

5. Analysis of results

Table (1) reveals that 16378 authors produced 12494 research papers for KFUPM, which appeared in 3053 sources between 2011 and 2020. The table also shows the average years from publication (4.64), average citations per document (15.4), and authors' keywords (29486). 336500 references have been consulted to yield 12494 publications by the researcher of KFUPM. Single-authored documents were 1304 publications. Hence, there is a greater degree of collocation among the researchers of KFUPM. Collaboration Index was 1.42. For details about the results of this analysis, refer to table (1).

Table (1): Main information of about data

Description	Results
Timespan	2011:2020
Sources (Journals, Books, etc)	3053
Documents	12494
Average years from publication	4.64
Average citations per document	15.4
Average citations per year per doc	2.851
References	336500
Document Contents	
Keywords Plus (ID)	18729
Author's Keywords (DE)	29486
Authors	
Authors	16378
Author Appearances	50222
Authors of single-authored documents	507
Authors of multi-authored documents	15871
Authors collaboration	
Single-authored documents	1304
Documents per Author	0.763
Authors per Document	1.31
Co-Authors per Documents	4.02
Collaboration Index	1.42

5.1. Yearly research productivity of KFUPM during 2011 and 2020

Table 2 shows the annual research growth and citation structure of KFUPM between 2011 and 2020. An evident and regular boost in research productivity can be seen every year throughout the study period. The growth was a little low in the early years, but it increases in the later years rapidly. The highest number of records, 1928, noted in the year 2020, followed by 1664 in 2019 and 1486 in 2018. There were big jumps in the years 2015, 2019, and 2020. It was clear from the table that 2011 recorded the least number of publications during the study period with 712 papers. The total number of citations was highest, 29099 in 2015, followed by 23232 in 2018 and 22573 in 2016, respectively.2020 received very low citations. The year 2015 recorded the highest h-index (H-index=72), since 2015 received maximum number of citations, followed by 2016 (H-Index=68).

Table (2): Annual research growth and citation structure of KFUPM between 2011 and 2020

Year	NP	% Of 12494	TC	Citation sum within h-core	h-index
2011	712	5.699	19214	11756	58
2012	752	6.019	17063	9504	54
2013	915	7.324	19351	10093	62
2014	973	7.788	15551	6566	53
2015	1304	10.437	29099	13136	72
2016	1324	10.597	22573	8911	68
2017	1436	11.494	21164	7805	62
2018	1486	11.894	23232	10117	61
2019	1664	13.318	16218	5659	52
2020	1928	15.431	8504	2344	35

NP=Number of publications, TC=Total citations

5.2. Type of research conducted in KFUPM

Table 3 describes the forms of the research done by KFUPM faculty members. Most of the research, 9906 published as journal articles followed by 1800 proceedings and 552 reviews. This research got the maximum number of citations 154456 in the form of journal articles followed by reviews 32527 and proceeding papers 5171**.** Book review (NP=1) and Book chapters were the least preferred type of research in the KFUPM. On the other hand, the article

(TC=154456) received the maxim number of citations, followed by review (TC=32527) and proceeding papers (TC=5171).

Table (3): Form of research by KFUPM faculties

Rank	Types of research	NP	TC	Citation sum within h-core	h-index
1	Article	9906	154456	35435	132
2	Proceedings Paper	1800	5171	1750	42
3	Review	552	32527	20983	89
4	Meeting Abstract	157	2	1	1
5	Editorial Material	72	193	153	6
6	Book Review	6	1	1	1
7	Book Chapter	1	4	4	1

5.3. Preferred Sources by the researchers of KFUPM

Table 4 is very important in terms of research quality. It shows the top preferred sources (journals, their publishers, and their country of origin) by the KFUPM researchers. As far as the number of publications is a concern, “Arabian Journal for Science and Engineering” (JIF=2.33 with Q3) was top on the list preferred by our researchers with 256 articles followed by “Journal of Molecular Liquids” with 148 articles, “IEEE Access” with 111, and “Energy & Fuels” with 108 articles. “Journal of Molecular Liquids” got more citations leaving others far behind. It has 7508 citations followed by “Renewable & Sustainable Energy Reviews” 4867 citations and “RSC Advances” 4197 citations. In terms of Impact Factor, the “Renewable & Sustainable Energy Reviews” was the top journal with 12.11 impact factor preferred by KFUPM researchers followed by “Energy Conversion and Management” with IF 8.20 and “Journal of Molecular Liquids” with IF 5.06. Five Journals preferred by KFUPM researchers were found in the Q1 category. Three Sources were fallen in the Q2 category. USA and UK were the top countries publishing the journals preferred choices by KFUPM faculty members. Both of them got 3-3 publishers preferred by the KFUPM researchers. Netherlands got two publishers, which KFUPM researchers preferred. Elsevier was found topmost publisher published four journals which KFUPM researchers preferred. Springer, IEEE, Wiley, ACS, RSC, and MDPI published one journal, each preferred by KFUPM Researchers.

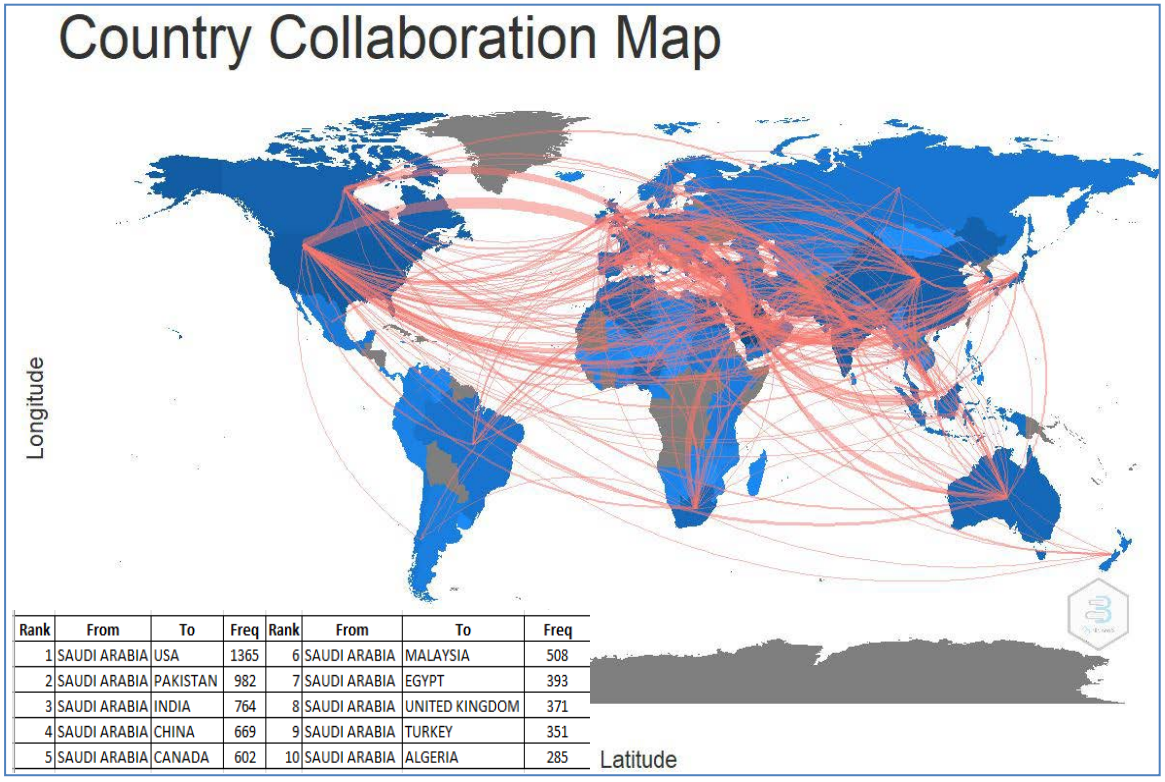
Table (4): To ten most relevant sources

Rank	Source	JIF	Q	Country	Publisher	NP	TC	h_index	g_index	m_index
1	Arabian Journal for Science and engineering	2.33	Q3	Saudi Arabia	Springer	256	1564	19	24	0
2	Journal of molecular liquids	5.06	Q1	Netherlands	ELSEVIER	148	7508	47	82	4.70
3	IEEE access	3.74	Q1	USA	IEEE	111	959	16	25	2.00
4	Energy & fuels	3.42	Q2	USA	ACS	108	995	16	25	1.45
5	Energy conversion and management	8.20	Q1	UK	ELSEVIER	93	3152	32	53	2.91
6	RSC advances	3.11	Q2	UK	RSC	92	4197	29	63	2.90
7	Journal of petroleum science and engineering	3.70	Q1	Netherlands	ELSEVIER	89	1018	16	26	1.45
8	Energies	2.7	Q3	Switzerland	MDPI	72	639	14	19	2.00
9	Renewable & sustainable energy reviews	12.11	Q1	USA	ELSEVIER	71	4867	41	69	3.73
10	Quality and reliability engineering international	1.71	Q3	UK	Wiley	66	1176	20	31	1.82

5.4. Most productive Country collaboration Map/Network

This study examines scientific collaboration and research communities at various levels of aggregation. Figure (2) shows the top ten most collaborative countries with Saudi Arabia (KFUPM). The figure reveals that Saud Arabia vs. the USA was the collaborative county for producing research of KFUPM with 1365 publications, followed by Saudi Arabia vs. Pakistan with 982 publications,

Saudi Arabia vs. India with 764 publications, Saudi Arabia vs. China with 669 publications, and Saud Arabia vs. Canada 602 publications. Saudi Arabia vs. Algeria was the least collaborative country among the top ten list with 285 publications.



Rank	From	To	Freq	Rank	From	To	Freq
1	SAUDI ARABIA	USA	1365	6	SAUDI ARABIA	MALAYSIA	508
2	SAUDI ARABIA	PAKISTAN	982	7	SAUDI ARABIA	EGYPT	393
3	SAUDI ARABIA	INDIA	764	8	SAUDI ARABIA	UNITED KINGDOM	371
4	SAUDI ARABIA	CHINA	669	9	SAUDI ARABIA	TURKEY	351
5	SAUDI ARABIA	CANADA	602	10	SAUDI ARABIA	ALGERIA	285

Figure (2): Country collaboration map

The figure (3) demonstrates networks of top 25 most collaborative country. The selected country was grouped into three clusters. Cluster 1 represents ten countries (Saudi Arabia, USA, Pakistan, China, Malaysia, Canada, Turkey, Egypt, Qatar, and United Arab Emirates). Cluster 2 also includes ten collaborative countries (Algeria, United Kingdom, Australia, Germany, Korea, Spain, France, Ethiopia, Italy, and Japan). Cluster 3 comprises five collaborative countries (India, Iran, South Africa, Nigeria, and Morocco). The figure also shows the most important nodes was Saudi Arabia (Closeness=0.041666667, Page ranked=0.280928), followed by other crucial nodes were USA (Closeness=0.041666667, PageRank=0.072527), and Pakistan (Closeness=0.041666667, PageRank= 0.05641).

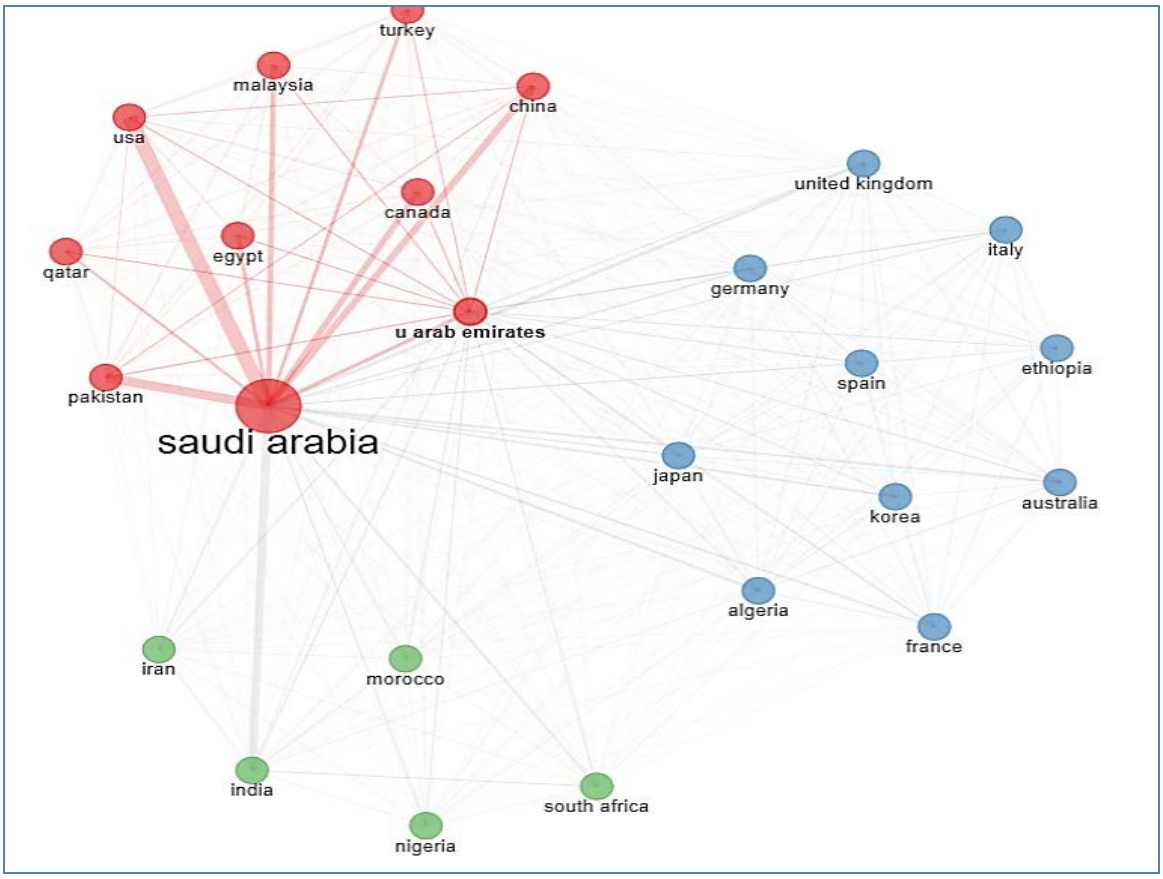


Figure (3): Top 25 country collaboration networks

5.5. Author collaboration network

Figure (4) illustrated the top 39 author's collaboration networks. Only the topmost 39 authors, out of 16378 authors, appeared to have collaborated with the same research group more than once, and they are grouped in 7 clusters.
Cluster 1 comprises six authors (Gondal MA, Muraza O, Yamani Zh, Hakeem AS, Aziz MA, and Laoui T).
Cluster 2 includes four authors (mahmoud m, elkatatny s, kamal ms, and al-harthi ma).

Cluster 3 represented six authors (riaz m, ahmad s, ahmad I, isab aa, ali s, and maslehuddin m). Cluster 4 consists of three authors (saidur r, al-sulaiman fa, and sait sm).
Cluster 5 contains eight authors (saleh ta, gupta vk, obot ib, ali sa, hossain mm, al-saadi aa, quraishi ma, and basheer c).
Cluster 6 has only two authors, namely zerguine a and zummo sa.
Cluster 7 comprises ten authors (yilbas bs, rehman s, ali h, zubair sm, al-aqeeli n, sahin az, al-naffouri ty, arif afm, ali hm and Akhtar ss).
The figure also reveals the highest betweenness of Gonadal MA (181.623966490547) and Saleh, ta (151.943626128442). Hakeem As have maximum closeness (0.0117647058823529) and Yilbas, BS with highest PageRank (0.0913206277313704)

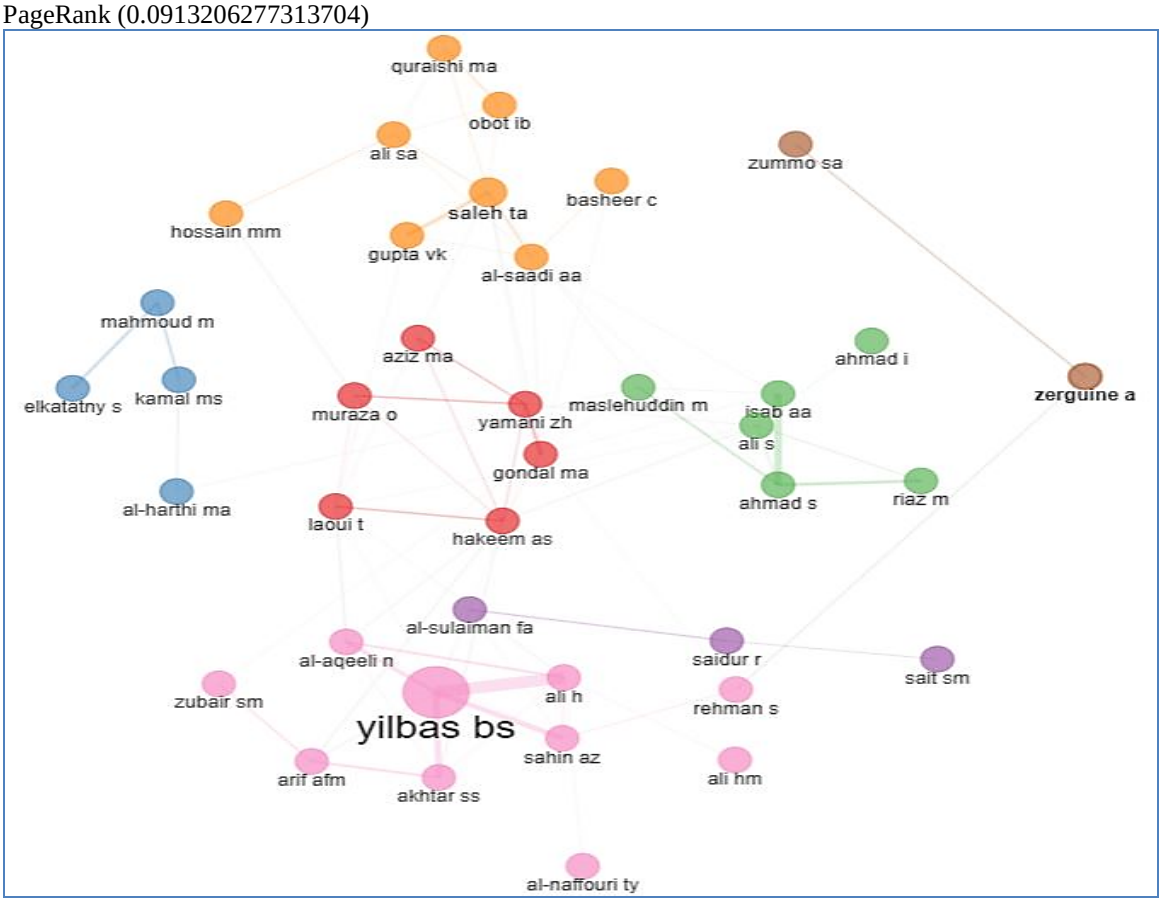


Figure (4): Top 40 author's collaboration networks

5. 6. Prolific authors of KFUPM

Table 5 shows the top 10 most prolific authors of KFUPM that produce a maximum number of research. It was clear from the table that all the top ten authors produced more than 100 research papers ranging from 118 to 342 publications. Yilbas, B.S. was found the most prolific author in terms of the number of publications. He produced 342 kinds of research, followed by Saleh, T.A with 220 publications, and Gondal, M.A with 192 publications. Obot IB was at the bottom of the list, with 118 publications and 5065 citations. Gupta, V.K. was found far ahead of everyone else as far as the total number of citations is concerned. He got 22425 citations, followed by Saleh, T.A, with 15435 citations.

Table (5): Top ten most productive authors in KFUPM

Rank	Author	NP	TC	h_index	g_index	m_index	PY_start
1	Yilbas BS	342	4051	26	43	2.36	2011
2	Saleh TA	220	15435	56	120	5.09	2011
3	Gondal MA	192	3785	32	50	2.91	2011
4	Riaz M	171	2681	29	39	0.00	NA
5	Gupta VK	130	22425	63	130	5.73	2011
6	Sharawi MS	130	1794	24	37	2.18	2011
7	Mahmoud MS	124	1850	22	36	2.00	2011
8	Ahmad S	123	1243	19	27	0.00	NA
9	Muraza O	123	2541	26	43	2.89	2013
10	Obot IB	118	5065	39	67	3.90	2012

5.7. Pattern of authorship

Amongst KFUPM authors, three authorship patterns found the most productive pattern in terms of both numbers of publications and total numbers of citations. Three thousand five hundred nine publications yielded by a three-authorship

pattern and have 47009 citations. Two authorship patterns have got 2414 publications and begged 27937 citations. In contrast, four authorship patterns produced 2243 pieces of research and got 36416 citations for these research. Single authorship pattern published 1304 research articles and gained 10077 citations. Five, six, and seven authorship patterns also contributed by publishing 1233, 769, 465 papers and captured 25351, 16657, 10616 citations, respectively, for their publications. Interestingly 882 authorship patterns and 896 authorship patterns got 2290 and 1386 citations, respectively, for their one publication each. The analysis reveals that researchers have a greater tendency to work in collaboration with other researchers.

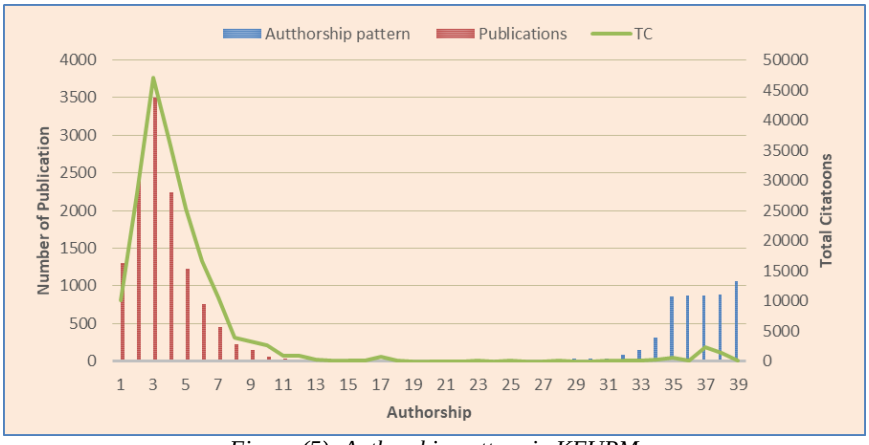


Figure (5): Authorship pattern in KFUPM

5.8. Most important research Area

Table 6 shows the top ten most important areas of research made by research scientists of KFUPM. Four thousand four hundred fifty-six research articles were published in 'Engineering' and scored 60822 citations, followed by 'Chemistry' with 2134 publications & 54874 citations and 'Material Science' with 1516 publications & 31109 citations of these publications, respectively. The 'Computer science' scored 1403 publications and 10994 citations. Remarkably Energy & Fuels, other topics of Science & Technology, Physics research areas published 1381, 1164, 1155 papers and got 27012, 23664, 20243 citations out these publications respectively.

Table (6): Top ten most important areas of research

Rank	Research Area	NP	TC	Citation sum within h-core	h-index
1	Engineering	4456	60822	17939	96

2	Chemistry	2134	54874	22892	96
3	Materials Science	1516	31109	14283	77
4	Computer Science	1403	10994	3314	45
5	Energy & Fuels	1381	27012	9857	74
6	Science & Technology - Other Topics	1164	23664	12263	74
7	Physics	1155	20243	8873	62
8	Mathematics	1147	9318	2697	39
9	Telecommunications	814	5735	2275	35
10	Thermodynamics	599	11201	5022	53

5.9. Mapping co-occurrence keywords

To analyze the keywords, a minimum of 80 co-occurrences were considered; therefore, 100 keywords, out of 42790 keywords, fulfill the criteria. These 100 keywords are grouped in five clusters and represented with different colors.

The first cluster contains 38 keywords (algorithm, classification, desalination, design, diffusion, dynamics, efficiency, energy, enhancement, existence, fixed point, flow, general decay, generation, heat-transfer, impact, management, model, models, Nanofluid, networks, oil, optimization, parameters, performance, performance analysis, permeability, power, prediction, renewable energy, Saudi Arabia, simulation, solar energy, stability, stabilization, system, systems, and transport).

The second cluster includes 27 keywords (alumina, behavior, carbon nanotubes, coatings, composite, composites, degradation, evolution, fabrication, films, graphene, growth, laser, mechanical-properties, microstructure, morphology, nanocomposite, nanocomposites, nanoparticles, optical-properties, oxide, resistance, sensor, size, strength, temperature, and thin-films).

The third cluster comprises 14 keywords (acid, aluminum, carbon-steel, complexes, copper, corrosion, corrosion inhibition, derivatives, dft, iron, mechanism, mild-steel, steel, and surface)

The fourth cluster represents 11 keywords (activated carbon, adsorption, aqueous-solution, aqueous-solutions, carbon, equilibrium, kinetics, removal, sorption, wastewater, and water).

The fifth cluster consists of 10 keywords (average run length, carbon dioxide, catalysts, conversion, efficient, hydrogen, oxidation, reduction, separation, and tio2).

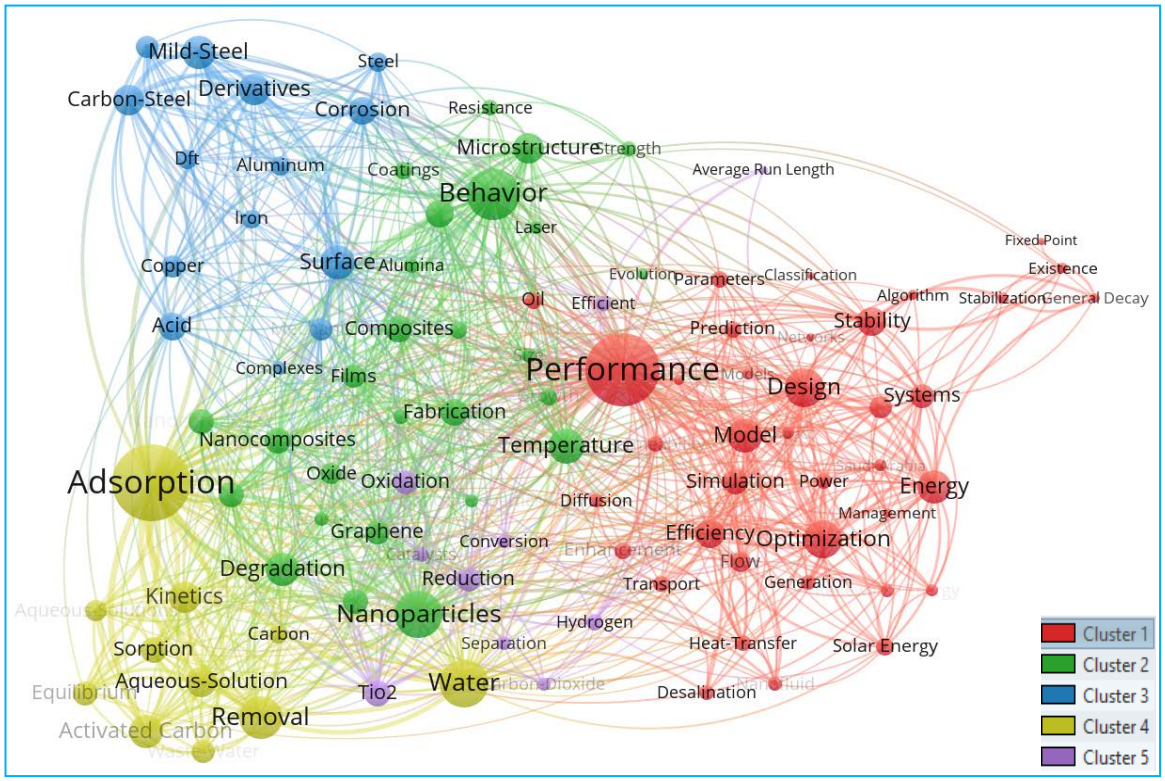


Figure (6): Keyword's analysis used by Vosviewer Software

The top **20** most occurred keywords used by the researcher of KFUPM are performance (freq=823), adsorption (freq=563), design (freq=514), behavior (freq=474), optimization (freq=428), model (freq=407), nanoparticles (freq=384), water (freq=368), stability (freq=307), temperature (freq=290), systems (freq=282), energy (freq=269), system, simulation, removal, microstructure, surface, mechanical-properties, flow and derivatives).

5.10. Analysis of author keywords

Figure (7) examined the top ten author keywords used by KFUPM researchers. Adsorption was the most frequently used author's keyword between 2011 and 2020, with a total frequency of 209 and 51 H-Index, followed by Saudi Arabia (161 times and 25 h-index), optimization 137 times with 23 h-index, Corrosion 137 times, Laser 130 times, laser (freq=95), Solar energy (freq=90), corrosion inhibition (freq=88), and nanoparticles (freq=86). The author's keyword fixed point (freq =85) was the tenth-most-frequently-appearing keyword on the list.

The words adsorption, optimization, and corrosion have appeared the most in the last two years (2019-2020).

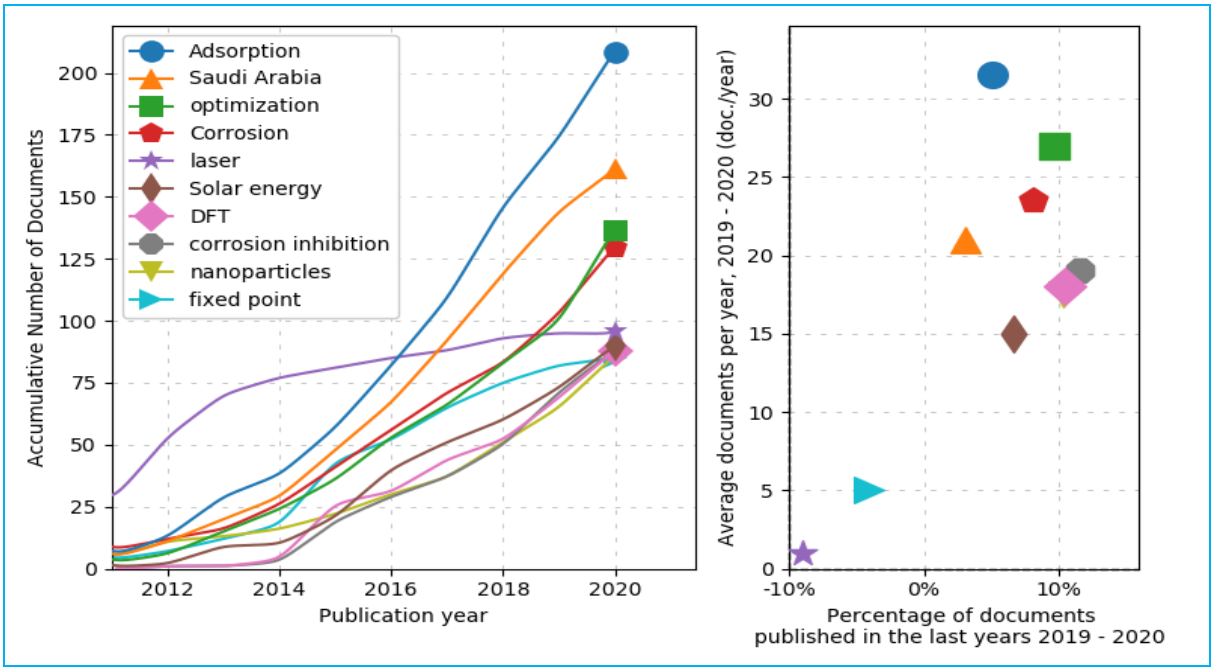


Figure (7): Analysis of top then author's Keywords used by Scientopy software

5. 11. Exploring the thematic map of KFUPM Researcher's Publications

Figure 8 displays four alternative typologies of themes that have been visualized using the thematic map by Biblioshiny software. The thematic parameter considered as title selected for filed, number of words selected 120, Unigram selected for the graph, min cluster frequency (5), number of levels for each cluster (3), and level size (0.3).

1. The motor theme is water effect properties, which have shown in cluster 3. This cluster is represented by 48 keywords, namely, water, effect, properties, synthesis, thermal, surface, laser, applications, characterization, oil, review, application, gas, heat, flow, phase, nanoparticles, oxide, temperature, effects, detection, enhanced, low, characteristics, composite, metal, graphene, influence, structure, mechanical, thin, conditions, organic, liquid, transfer, films, catalytic, single, optical, nanocomposites, pressure, activity, catalysts, concrete, porous, nanocomposite, induced and materials.

2. The basic theme is Based on analysis performance which is represented by cluster 4. This cluster includes 46 keywords (based, analysis, performance, system, systems, energy, control, model, design, power, approach, solar, modeling, networks, time, optimization, method, efficient, hybrid, multi, process, antenna, stability, assessment, development, network, data, nonlinear, algorithm, type, estimation, impact, optimal, generation, wind, mimo, production, equation, monitoring, mixed, equations, integrated, wireless, models, dynamic and sensor).
3. The niche theme is Study carbon corrosion placed in cluster 2. This cluster includes 23 keywords (study, carbon, corrosion, steel, experimental, evaluation, investigation, acid, removal, solution, behavior, modified, studies, electrochemical, adsorption, molecular, comparative, solutions, aqueous, numerical, chemical, simulation, and mild).
4. The emerging or declining theme is Saudi Arabia Potential represented by cluster 1and composed of three keywords (Saudi, Arabia, and potential).

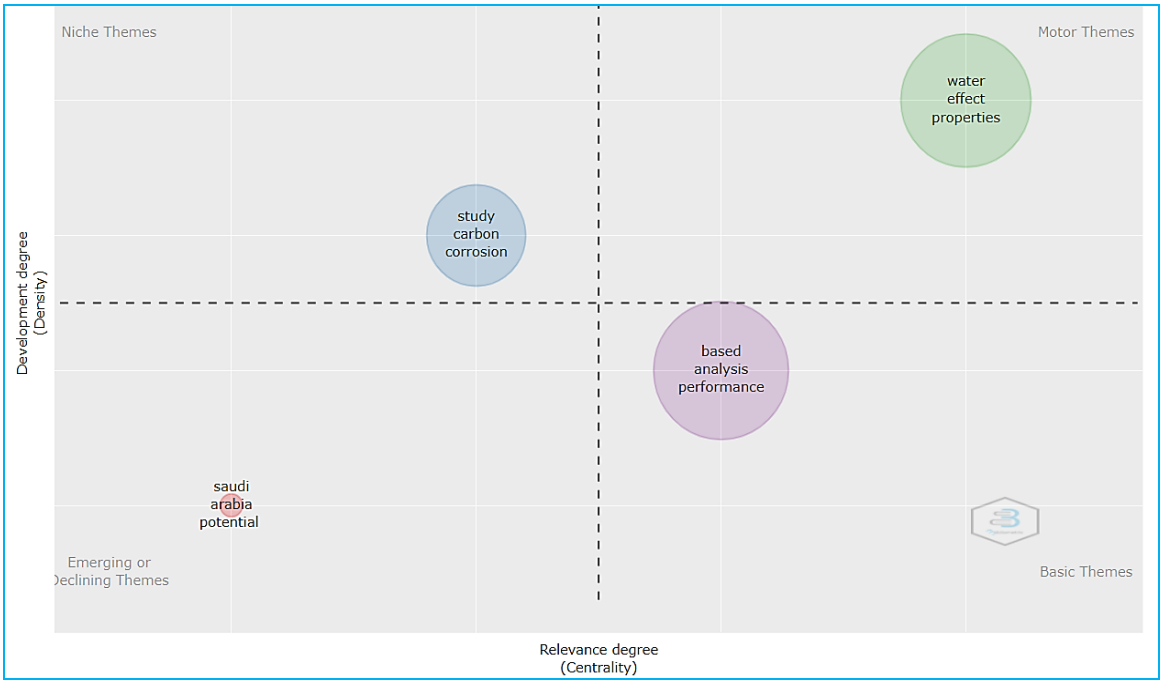


Figure (8): Thematic map used by Biblioshiny software

5.12. Most cited research paper by the researcher of KFUPM

Table 7 establishes the top 10 most cited publications locally and globally too during the research period. 'A new nonlocal trigonometric shear deformation theory for thermal buckling analysis of embedded nanosize FG plate' published in "*Structural Engineering & Mechanics*" noted as the most locally cited publication. It was published in 2017 and got 57 citations locally (Khetir & Mohamed Bachir Bouiadjra, Mohammed Sid Ahmed Houari, 2017), followed by "*Adsorption Behavior of Glucosamine-Based, Pyrimidine-Fused Heterocycles as Green Corrosion Inhibitors for Mild Steel: Experimental and Theoretical Studies*" published by "*The Journal of Physical Chemistry C,*" got 54 citations locally in 2016 (Verma et al., 2016).

Whereas article namely "*Synthesis and characterization of alumina-coated carbon nanotubes and their application for lead removal*" published in "*Journal of Hazardous Material*" was found most globally cited publication. It was published in 2011 and got 798 citations globally (Gupta et al., 2011), followed by "*Nanocomposite of carbon nanotubes/silica nanoparticles and their use for adsorption of Pb(II): from surface properties to sorption mechanism*" published in "*Desalination and Water Treatment,*" got 329 citations globally in 2016 (Saleh, 2016).

Table (7): Top ten most cited publications between 2011 and 2020

Rank	**Title**	**Author**	**Source**	**Year**	**LTC**	**GTC**	**LC/GC**	**NLC**	**NGC**
1	A new nonlocal trigonometric shear deformation theory for thermal buckling analysis of embedded nanosize FG plates(Khetir & Mohamed Bachir Bouiadjra, Mohammed Sid Ahmed Houari, 2017)	Khetir H	Struct Eng Mech	2017	57	166	34.34	49.81	11.26

2	Adsorption Behavior of Glucosamine-Based, Pyrimidine-Fused Heterocycles as Green Corrosion Inhibitors for Mild Steel: Experimental and Theoretical Studies (Verma et al., 2016)	Verma C	J Phys Chem C	2016	54	229	23.58	41.74	13.43
3	A refined four variable plate theory for thermoelastic analysis of FGM plates resting on variable elastic foundations (Amina Attia, Abdelmoumen Anis Bousahla, Abdelouahed Tounsi, 2018)	Attia A	Struct Eng Mech	2018	53	147	36.05	37.78	9.41
4	A novel nonlocal refined plate theory for stability response of orthotropic single-layer graphene sheet resting on elastic medium (Miloud Yazid, Houari Heireche, Abdelouahed Tounsi, 2018)	Yazid M	Smart Struct Syst	2018	51	152	33.55	36.36	9.73

5	The influence of treatment temperature on the acidity of MWCNT oxidized by HNO3 or a mixture of HNO3/H2SO4 (Saleh, 2016)	Saleh Ta	Appl Surf Sci	2011	50	278	17.99	34.40	10.30
6	A new quasi-3D sinusoidal shear deformation theory for functionally graded plates (Benchohra, 2018)	Benchohra M	Struct Eng Mech	2018	50	83	60.24	35.64	5.31
7	Synthesis and characterization of alumina-coated carbon nanotubes and their application for lead removal(Gupta et al., 2011)	Gupta VK	J HAZARD MATER-A	2011	48	798	6.02	33.02	29.57
8	Dynamic analysis of nanoscale beams including surface stress effects (Djamel Ould Youcef, Abdelhakim Kaci, Abdelnour Benzair, 2018)	Youcef DO	Smart Struct Syst	2018	48	116	41.38	34.22	7.42
9	Nanocomposite of carbon nanotubes/silica	Saleh TA	Desalin Water	2016	47	329	14.29	36.33	19.30

	nanoparticles and their use for adsorption of Pb(II): from surface properties to sorption mechanism (Saleh, 2016)		Treat						
10	Electrochemical, Theoretical, and Surface Morphological Studies of Corrosion Inhibition Effect of Green Naphthyridine Derivatives on Mild Steel in Hydrochloric Acid (Singh et al., 2016)	Singh P	J Phys Chem C	2016	47	177	26.55	36.33	10.38

5.13 Funding Agencies

Table 8 highlights the top 10 most influential funding agencies of KFUPM. All the research was conducted under the KFUPM affiliation; therefore, King Fahd University of petroleum and minerals, Saudi Arabia, identifies as the topmost significant funding agency and funded 2941 projects leaving other agencies far behind. King Abdelaziz city for Science and Technology KACST, Saudi Arabia, ranked the 2nd largest funding agency, funded for 264 projects, followed by the National Natural Science Foundation of China NSFC, China, funded for 215 projects. NSFC was the top funding agency amongst funding agencies out of Saudi Arabia. NSFC was followed by the National Science Foundation NSF, USA, and Natural Sciences and Engineering Research Council of Canada. These agencies funded 172 and 108 projects, respectively.

Table (8): Top ten most influential funding agencies of KFUPM

Rank	**Funding Agencies**	**Country**	**NP**
1	King Fahd University of petroleum and minerals	Saudi Arabia	2941

2	National natural science foundation of China nsfc	China	215
3	National science foundation nsf	USA	172
4	King Abdelaziz city for science and technology kacst	Saudi Arabia	264
5	Saudi Aramco	Saudi Arabia	119
6	Natural sciences and engineering research council of Canada	Canada	108
7	Higher education commission of Pakistan	Pakistan	95
8	King Abdullah University of Science technology	Saudi Arabia	82
9	King Saud university	Saudi Arabia	76
10	European commission	Belgium	74

Discussion

Bibliometric analysis now widely and increasingly employed to evaluate the progress of various research fields. This study is about King Fahd University of Petroleum and Minerals' research productivity between 2011 and 2020, evident that the research growth was accelerating throughout the study period. It was a little low in the early years of the study period, but it increased in the later years rapidly, which is a good sign for any research-based university. The highest records, 1928, were found in 2020, whereas 2015 was the top productive year in citation number (29099). As an obvious result, most of the research published as journal articles (9906) followed by proceedings (1800). A good amount of research work was published in high impact factors journals or the sources falling in Q1 and Q2 Categories. In terms of Impact Factor, the "Renewable & Sustainable Energy Reviews" was the top journal with a 12.11 impact factor preferred by KFUPM researchers. The study also established that most of the research conducted in 'Engineering' at KFUPM. Four thousand four hundred fifty-six research articles were published in the field of Engineering and scored 60822 citations. After Engineering, a good number of research are produced in Chemistry, Material Science, Computer Science, and Physics. It is also evident that KFUPM, as a base of research, funded many of its projects around 2941.

Moreover, it is observed that KFUPM researchers could attract many foreign funding agencies from the US, Canada, China, and Belgium for their large number of research projects and get the funds from them. National Natural Science Foundation of China NSFC funded 215 projects, followed by National Science Foundation NSF, USA, and Natural Sciences and Engineering Research Council of Canada. These agencies funded 172 and 108 projects, respectively.

Recommendations

The study recommended a few points for KFUPM to boost research output and citations.

- The bibliometric analysis could be conducted for individual colleges or subjects to explore the research trends and assess the research to fulfill the missing gap.
- Encourage faculty to publish their research in Scopus/Web of Science indexed or other ISI indexed sources, bringing more fame and exposure to the university.
- Conduct more research-related workshops, seminars, also provide individual attention to the most active research faculties.
- The college is also required to have a liaison librarian to fulfill their research need as per requirement.
- The university library should start a research support service center.

Conclusion

Saudi Arabia invests a significant amount in higher education as well in the progress of research and development. The aim is to produce high-quality researchers and research to support the vision 2030. The research faculties of the university play as a key indicator to bring success, fame and maintain the good image of the university. As far as KUPM's research output is concerned, the engineering subject contributed the highest number of research in the university, seamless research publication recorded by the researcher of KFUPM between 2011 and 2020. The researcher tends to collaborate nationally and internationally. The United was found as the most popular country for research collaboration, followed by Pakistan and India with KFUPM. The study suggested increasing the number of publications as well as citations. Although citation monitoring databases cannot provide a complete picture of data, this information can be viewed as a comprehensive research sample. The further recommendations from this study are to aid KFUPM in revising its research strategy for the future.

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