

The State and Trend of Publications in the Sudanese Chemical Engineering Departments

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ABSTRACT

Scientific research plays a major role in industrial and scientific development. The scientific research in the field of chemical engineering and its branches constitute a big part of this important role. In this research, the trends of publications in the field of chemical engineering and its branches published by Sudanese researchers who work in chemical engineering departments in various Sudanese universities were highlighted. This was done through studying the trends, the volume of these researches, and the internal/external cooperation to accomplish them. The preferred journals of researchers plus the geographical distribution of researches were identified in the Sudanese states and around the world. This study uses a sample of (80) researches papers for researchers from chemical engineering departments in the Sudanese universities during the last (12) years (2008 to 2020). These researches were downloaded from Google Scholar and Researchgate sites. A database has been created for these researches samples for study and analysis purposes. Among the most prominent results of this research is the focus of researchers on the water field and its various industries at the expense of other fields and resources. The emergence of the importance of local scientific journals in supporting the scientific research process with the weakness of publication in Arab journals compared to others. The most notable result is the improvement in the production of researchers in chemical engineering departments compared to previous years, with the apparent weakness of research production in general. Meanwhile, the research activities of Sudanese researchers in the chemical engineering departments, as well as regions, vary in different ways. The clarity of the importance of internal cooperation between the researchers in the departments of chemical engineering, in addition to their external cooperation as well. This research provides an opportunity for Sudanese researchers in chemical engineering departments to diversify

and expand their research topics and fields away from focusing on specific fields.

Keywords: Scientific Research, Chemical Engineering, Sudanese Universities, Bibliometric Measurements

I. INTRODUCTION

Scientific research is defined in one of its definitions as a method of collecting reliable information, taking notes, and analyzing it to describe facts through a set of criteria that contribute to adding knowledge. On the other hand, research and innovation is understood as the set of infrastructure and human, financial, institutional, and information resources, projects, and activities organized for scientific and innovation production [1]. Scientific research is divided into theoretical and applied practical research in terms of its nature. The research methods are split into historical research, empirical research, and descriptive research. While, the scientific behaviors such as open-mindedness, viewing events without prejudice, ability to delay the decision until sufficient evidence is collected, and considering, searching, and finding the reasons. Therefore, scientific research methods include the ability to make observations, to interpret, analyze and evaluate objectively [2]. The development of countries in one of its aspects is calculated based on employing scientific research and subjecting problems to study and analysis, which necessarily leads to developed solutions. Through the scientific methodology and closely look at the economic, social, and political indicators, countries can extrapolate and analyze to reach the desired results. Moreover, in many cases, they go beyond the prediction of the future to ensure sustainable development. The establishment of academic institutions and scientific centers for specialized researches is one of the most important solutions for creating scientific national scientists and cadres that contribute to the development of these countries. As depicted in the academic institutions in Africa which is often depend on international

collaborators for their research agenda, scientific support, and funding. Furthermore, the intellectual ownership of the research conducted in Africa has remained with the collaborating institutes, as reflected in the main applicant on grant proposals and key authorship positions in publications [3]. On the economic level, the importance of scientific researches for countries has been throughout the success of solving problems of production processes of the businesses and enterprises. Scientific research is one of the sources that contribute to inventions and innovations. The implication of scientific researches increases as it is involved in the process of developing the economy. Based on the panel data from 65 countries over 36 years (1980 to 2016), the role research output plays in economic growth and shows that the impact of research output occurs mostly through structural changes favoring the industrial sector. Moreover, it proves that academic knowledge constitutes an input to produce other goods and applied in a broad set of industries, such as engineering and technology [4]. The most crucial factors affecting the development of scientific researches in countries summarized as production and the accompanying need for product development, partnerships between state institutions such as universities and the big projects to increase mutual expertise and transfer the latest technology, high rates of public and higher education to provide scientific research cadres, support the researchers, stability of political systems, development of universities to be advanced research centers. On the contrary, there is a large role for faculty members, due to faculty member, who is not sufficient in the field of research, becomes a self-repetitive person due to lack of personal and professional development. Hence, besides, to transfer information to their students, they should also be researchers to raise individuals who can question the information they receive [5]. Countries relegated into two classifications, countries that spend generously on scientific research and that spend fewer amounts on research, which will reflect in their economies. The percentage of what the Arab world spends on scientific research activities amounts to (0.2-0.4%) of the total national income, while this percentage reaches more than (3%) in the United States of America, Japan, and some European countries [6]. In addition to that, The Chinese government allocated 65.5 billion yuan to institutions of higher learning in 2009, and the 10-year growth rate was as high as 135% to 153.7 billion yuan in 2017, with an average annual growth rate of 13.5% [7]

II. BACKGROUND

The Sudanese Ministry of Higher Education and Scientific Research strives to support scientific research. Their supports appears on the investment in the research field, supporting universities to establishing centers of excellence in research, caring for researchers in all universities, as stated in the objectives of the quarter-century plan (2003- 2027). The plan reflecting the growing interest in scientific research. The Ministry has also established a Scientific Research and Innovation Authority affiliated with the Ministry. The goal of this authority to support scientific research. According to the authority's latest statistics (2013-2014) for the number of faculty members in the field of engineering reached (1173) teaching staff. The number of students in higher education in the field of engineering, in general, was (2132) students. These numbers are the numbers that supposed to work on scientific researches[8]. Many Sudanese universities have designated research centers. The work of these centers appears on separate pages on their websites to support scientific research and its operations [9][10]. It also established many peer-review scientific journals[11]. They strive to excel and raise their quality according to the relevant international standards. Focusing more on the research topic, the Chemical Engineering field is concerned with the design and development of chemical or transformational industrial processes, and processes such as chemical reactions. It also covers transfers of matter, heat, mass, including reactions and multi-stage separation processes. Chemical engineering had its beginnings in dissecting chemical processes into unit processes and unit operations. Unit processes were concerned with the nature of chemical transformations while unit operations focused on physical processes of separation, mixing, and so on. The prevailing view of the early chemical engineer was that of a mechanical engineer, who focused on the manufacture of chemicals. Later Mathematics was inserted to build the scientific base of chemical engineering which form the evolution of chemical engineering science. [12]. Chemical engineering is intertwined with significant sciences such as medical engineering, and pharmacy in addition to environmental engineering. These sciences help countries a lot in the production processes. Developing the area of those scientific research would lead to the raise of Gross Domestic Product. Global trends in chemical engineering research indicate fields such as Optimization, Simulation, Scheduling, Model Predictive Control, Process Synthesis, Process Control, Uncertainty, and

Modelling. As these areas were the most commonly used keywords by the authors in their publications in Computers and Chemical Engineering Journal from 1977 to 2018 [13]. Therefore, there is a general feeling in the chemical engineering community at this time that research activities on chemical product design have been flagging and that there is still no consensus on what needs to be emphasized in teaching. Chemical engineering universality helping with the transition of chemical engineering towards the “knowledge economy” [14]. There are several motivators for the development of scientific research, such as enhancing communication between research centers and researchers, supporting publication in journals, providing references, and subscribing to databases. Some incentives related to the researchers, such as reducing the responsibilities of researchers, increasing researchers’ incentives, training on scientific research skills. Since the developed country like china do, the Chinese colleges and universities provide important talents for scientific research, they have both academic advantages and talent advantages, and how to build a university scientific and technological innovation team and promote its growth has become an important part of university scientific research management [7]. Some motivators concerning the research environment, such as providing advanced, equipped laboratories, providing technicians to support research, increasing the exchange of experiences, and partnerships with counterparts around the world. In this regards, China developed a group of policies such as the Chinese research data privacy protection policy, scientific research achievement transformation policy evaluation, university scientific research innovation policy, and scientific research integrity policy to get more researchers' attention [7].

III. RESEARCH OBJECTIVES

This study aims to explore the state of the publications in the chemical engineering departments in Sudanese universities and their trends. It also shows the nature of the published papers by researchers in the Sudanese chemical engineering departments, the researchers' activity, and their production rates. The research depicts the form of cooperation between researchers of

chemical engineering departments with researchers at the local and global levels. This study paints a geographical map of researchers' universities and the distribution of their participation in research. The research also aims to clarify trends and branches of published papers within the field of chemical engineering. In addition to the preferred scientific journals for researchers in the Sudanese chemical engineering departments.

IV. METHODS

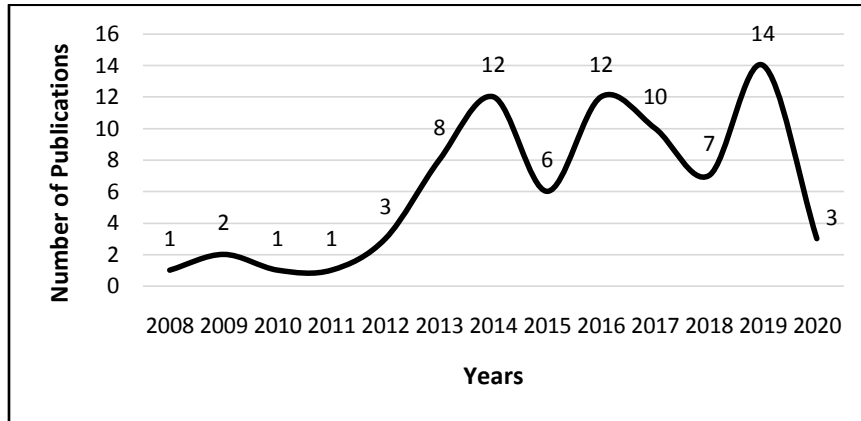
In this study, data were collected from published research papers related to chemical engineering departments in Sudanese universities. These papers were downloaded from Google Scholar and Researchgate websites from 2008 to 2020. A random sample of (80) published scientific papers organize as a database. The abstracts, keywords, journals names, year of publication were summarized, to achieve the study purpose of exploring the state and trends of the published papers in the Sudanese chemical engineering departments. Many graphs, tables, and maps were prepared. In addition to that, many software such as excel and text mining programs were used. To verify the extracted text data VOYANT software was used. The research has focused on three parts; the researchers, research trends in chemical engineering departments in Sudanese universities, and the scientific journals that authors were preferred.

V. RESULTS

• Researchers of chemical engineering departments and their publications

Figure (1) shows the sample of (80) publications distributed over the years. In 2019, authors in the Sudanese chemical engineering departments had published and participated in the publication of (14) published papers, while the sample shows they have one paper in the years 2008, 2010, and 2011. Generally, the random sample shows the development of publications in chemical engineering departments in Sudanese universities.

Figure (1): Number of Publications vs. Years of Publication (Nov. 2008 – May. 2020)



The nationalities of the involved researchers in the study sample vary between Sudanese (80%) and others (20%). The percentage of Sudanese female researchers was (28%)

compared to the male (72%). The percentage of main females authors were (41%) compared to (59%) for males as shown in Table (1).

Table (1): Genders and Nationalities of the Authors

Variable	Number	Percentage
Sudanese Authors' Gender		
Female	33	28%
Male	84	72%
Total	117	100%
Gender of the Sudanese Main Author		
Female	30	41%
Male	44	59%
Total	74	100%
Authors Nationality		
Sudanese	117	80%
Others	29	20%
Total	146	100%

From Table (2), the authors' publication varies, as authorsno. (1), has participated in (11) publications with a participation rate of (14%) in publications of the study sample. This is compared

to authorsno. (6),(7),(8),(9), who participated in (4) publications with (5%). Noting that (90) authors have participated in only one publication during a period of the sample which is twelve years.

Table (2): Authors Production in the study sample

Author	Number of Publication	Percentage*
Author 1	11	14%
Author 2	9	11%
Author 3	8	10%
Author 4	7	9%
Author 5	6	8%
Author 6	4	5%
Author 7	4	5%

Author 8	4	5%
Author 9	4	5%

*percentage of the number of publication divided by the total number of the sample (80)

Most of the research is published with co-authors. The study sample shows that (27) researches were published by (3) researchers.

While (12) papers were published by one researcher. With the observation of small numbers of publications published by a group of researchers, as in Figure (2).

Figure (2): Co-publication between the authors

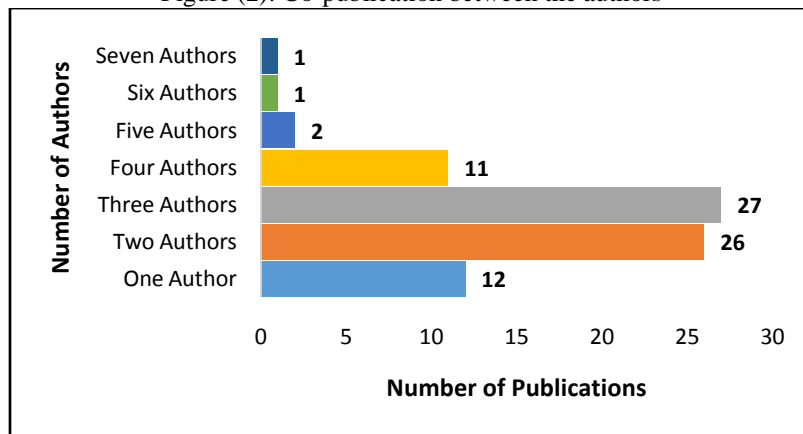
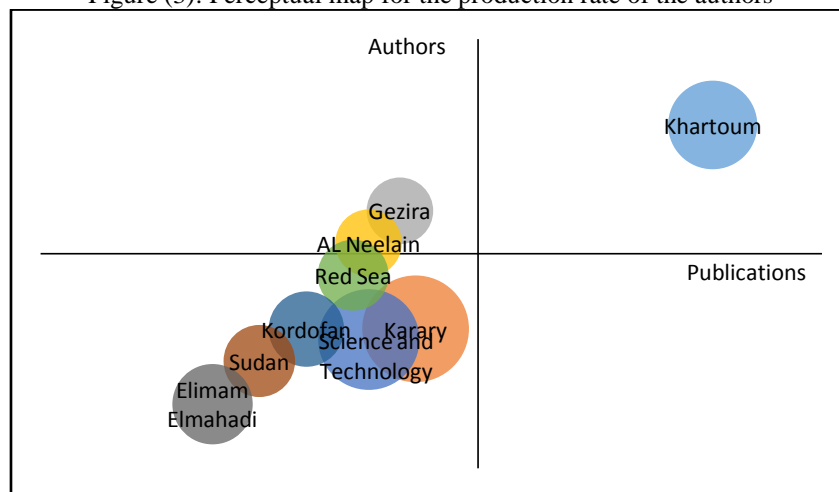


Figure (3) demonstrates the relationship between the number of researchers in chemical engineering departments in Sudanese universities and the number of scientific articles published by them with the support of their universities. As the University of Khartoum leads the number of researchers with (27) researchers and they have published (33) researches. On the other hand, the

number of researchers publishing research papers in most Sudanese universities is smaller compared to the University of Khartoum. The size of the circle increases in the case of Karary University because of the high production rate of (8) researchers who published and participated in (14) research.

Figure (3): Perceptual map for the production rate of the authors



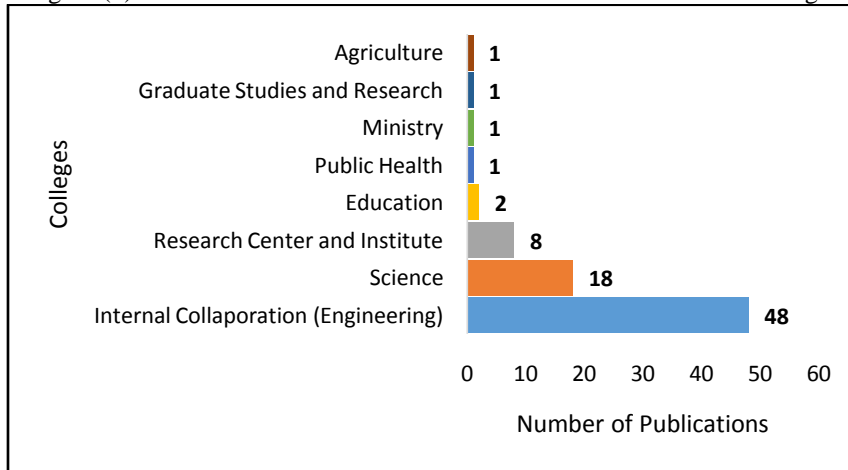
• Collaboration of the researchers with the various Sudanese faculties' members

Collaboration between researchers to produce research is a usual thing. In Figure (4),

patterns of cooperation appear between internal cooperation in the engineering departments (48) researches. The cooperation with colleges of science was (18) and (8) joint research with

research centers, with smaller numbers in other colleges.

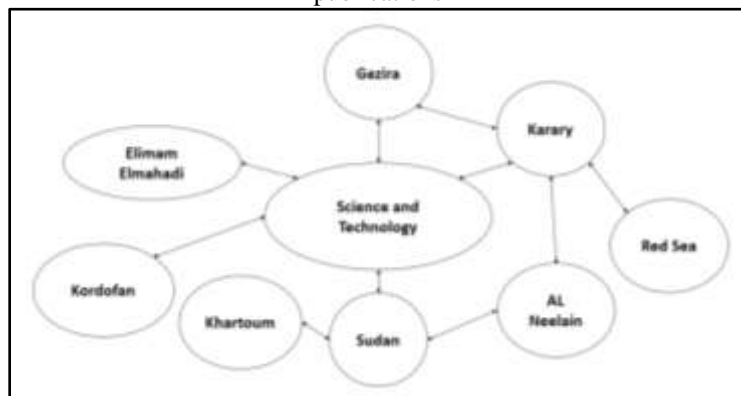
Figure (4): The collaboration of authors with authors from different colleges



Researchers in Sudanese universities work together to publish researches. Figure No. (5), represents the form of cooperation between these universities and the variation in cooperation between one university and another. For example, the researchers from the University of Science and

Technology have collaborated with (5) universities, unlike researchers from Imam Mahdi University, Kordofan University, University of Khartoum, and the University of the Red Sea, who have collaborated with only one university to publish chemical engineering publications.

Figure (5): Cooperation between authors in the Sudanese universities to publish chemical engineering publications



On the international level, it's founded that (5) Sudanese universities have cooperated with researchers from different universities around the world. The University of Khartoum took the lead in

this regard, followed by the University of Gezira and the University of Karary, as shown in Figure (6).

Figure (6): Cooperation between authors in the Sudanese and international universities to publish chemical engineering publications

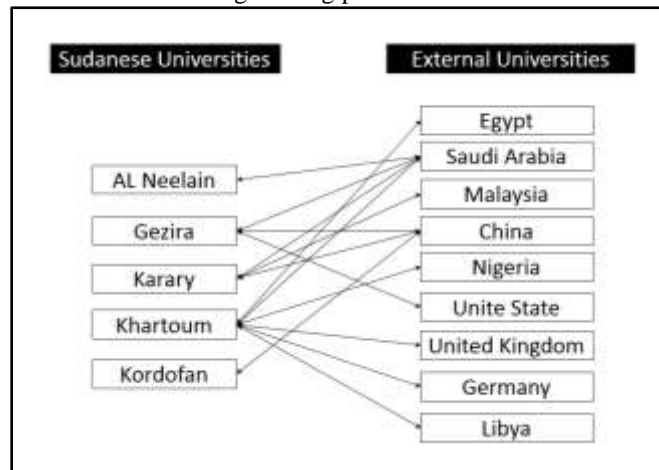
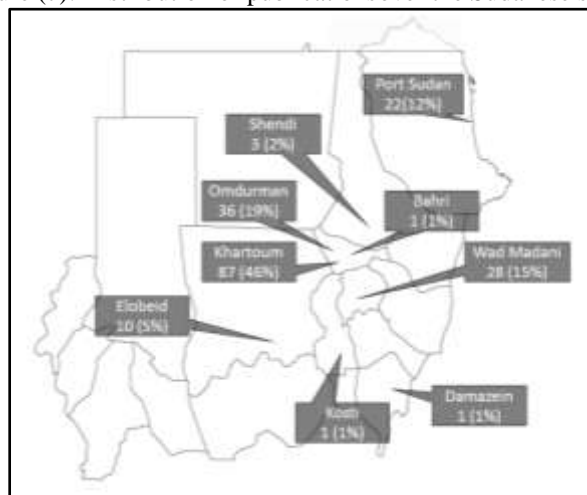


Figure (7) shows the distribution of published research at the level of the Sudanese states, as Khartoum State, in its three governorates, Khartoum, Bahri, and Omdurman, obtained (66%) of the published research from the chemical

engineering departments in Sudanese universities. As for the peripheral states such as Blue Nile State (Blue Nile University) and White Nile State (Imam Al Mahdi University), it scored (1%).

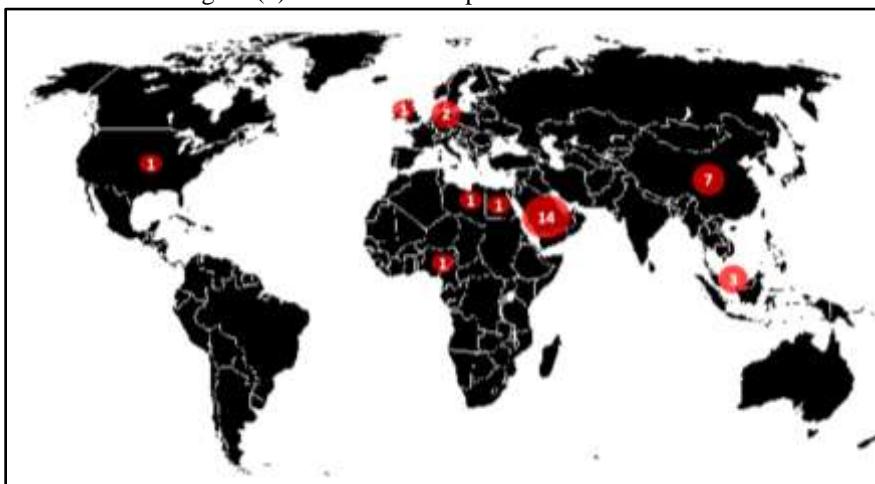
Figure (7): Distribution of publications over the Sudanese states.



The published researches are distributed among participating researchers in different countries of the world, as in Figure (8), where researchers from Saudi Arabia universities participating with researchers from chemical engineering departments in Sudanese universities

with (14) participants in researches. This was followed by the participation of researchers from a Chinese university, with (7) participation in the research. Participation in the research was limited by researchers from the United States of America, the United Kingdom, Egypt, Libya, and Nigeria.

Figure (8): Distribution of publications worldwide



• Trends of the published research by the chemical engineering departments in Sudanese universities

Table No. (3) shows the branches and fields of published research by the researchers of

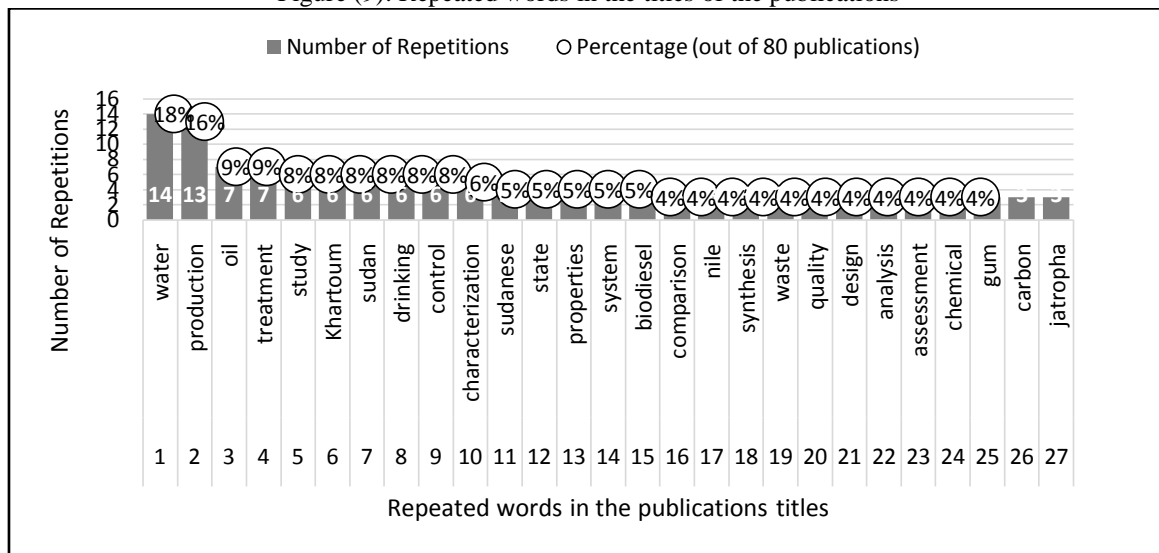
the chemical engineering departments. Where researches directed by “water” as the rate (19%) of the total sample. While the “biotechnology”, which is takes 10%, while one percent of the researches is devoted to the field of “energy”.

Table (3): Research branches published from researchers of chemical engineering departments

Fields of Publications	Frequency	Percentage	Fields of Publications	Frequency	Percentage
1. Water	15	19%	8. Pharmaceuticals	3	4%
2. Inorganic Chemicals	13	16%	9. Oil	3	4%
3. Process Control	10	13%	10. Organic Chemicals	3	4%
4. Biotechnology	8	10%	11. Polymers	3	4%
5. Food	7	9%	12. Air	2	3%
6. Petrochemicals	6	8%	13. Energy	1	1%
7. Safety	6	8%	Total	80	100%

By tracking the words in the research titles as shown in Figure (9), it’s founded that the word "water" was mentioned in (14) research (18%). Compared to the word "oil", which was mentioned in (7) research (9%).

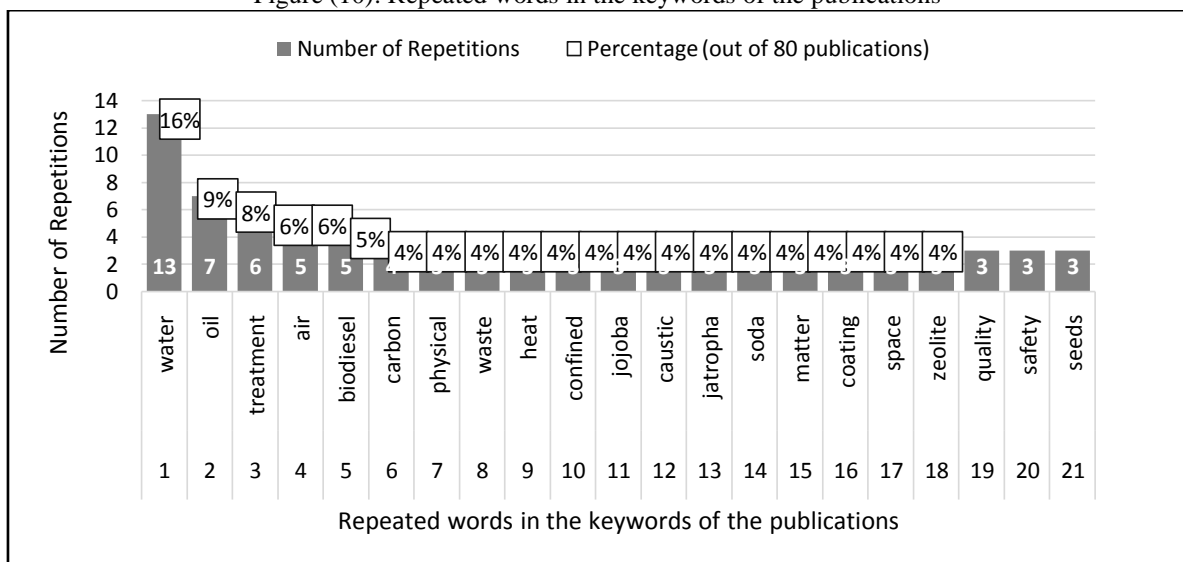
Figure (9): Repeated words in the titles of the publications



To increase the conformity more, the frequency of the mentioned words in the keywords of the published researches were tracked as shown in Figure (10). The highest percentage of the word

was "water" which is mentioned (13 times) at a rate of (16%) compared to the word "oil" which was mentioned in (7) researches at a rate of (9%).

Figure (10): Repeated words in the keywords of the publications



From the sample study, it was confirmed that (30%) of the published research of chemical engineering departments in Sudanese universities are related to local companies, factories, tanneries, hotels, refineries, stations, and universities. In contrast (70%), which were independent and done in laboratories, workshops using some software programs related to chemical engineering and others.

• Scientific journals that have collaborated with researchers of chemical engineering departments

Within the framework of the research publishing process, it was founded that (49) papers (61%) of the published papers of chemical engineering departments in Sudanese universities have been published in international scientific journals compared to (31) papers (39%) which were devoted to Sudanese scientific journals.

Table No. (4) shows the shares of the journals that the researchers from the chemical engineering departments in Sudanese universities were selected. University of Khartoum Engineering Journal was the top with (12) research papers and (15%) of the total number of papers. This was followed by Gezira Journal of Engineering and

Applied Sciences with (6) research papers and (8%) of the total number of published papers. It does not seem that there is a focus on specific journals, on the contrary, the distribution appears on a large group of scientific journals, reach to (43) scientific journals

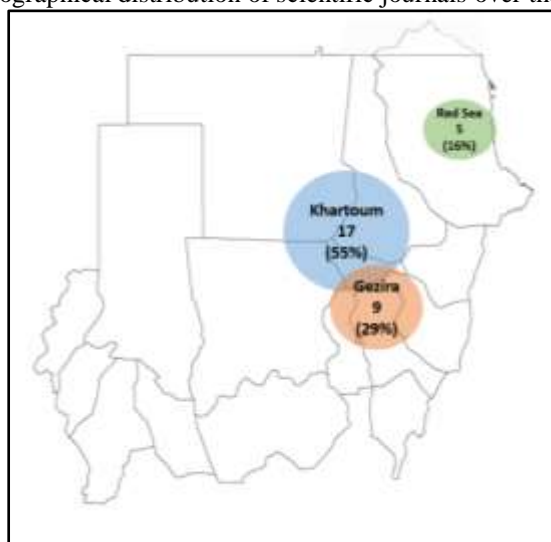
Table (4): Shares of Scientific Journals from the publications

No.	Journal	Number	Percentage
1	University of Khartoum Engineering Journal (UofKEJ)	12	15%
2	Gezira Journal of Engineering and Applied Sciences	9	11%
3	Journal of Applied and Industrial Sciences	4	5%
4	European Journal of Engineering Research and Science (EJERS)	4	5%
5	Red sea university Journal of Basic and Applied Science	5	6%
6	International Journal of Engineering Research & Technology (IJERT)	3	4%
7	International Journal of Engineering and Applied Sciences (IJEAS)	3	4%
8	Sudan Engineering Society Journal	2	3%
9	Open Access Library Journal	2	3%
10	International Journal of Innovative Science, Engineering & Technology	2	3%
11	International Journal of Engineering Trends and Technology (IJETT)	2	3%

Sudanese scientific journals interested in publishing chemical engineering research papers are distributed over three Sudanese states, as shown in figure (11). Scientific journals in Khartoum State have published (17) research papers, representing

(55%) of all research published in Sudanese journals. Compared to (29%) and (16%) for the scientific journal in Gezira State and the Scientific Journal in Red Sea State, respectively.

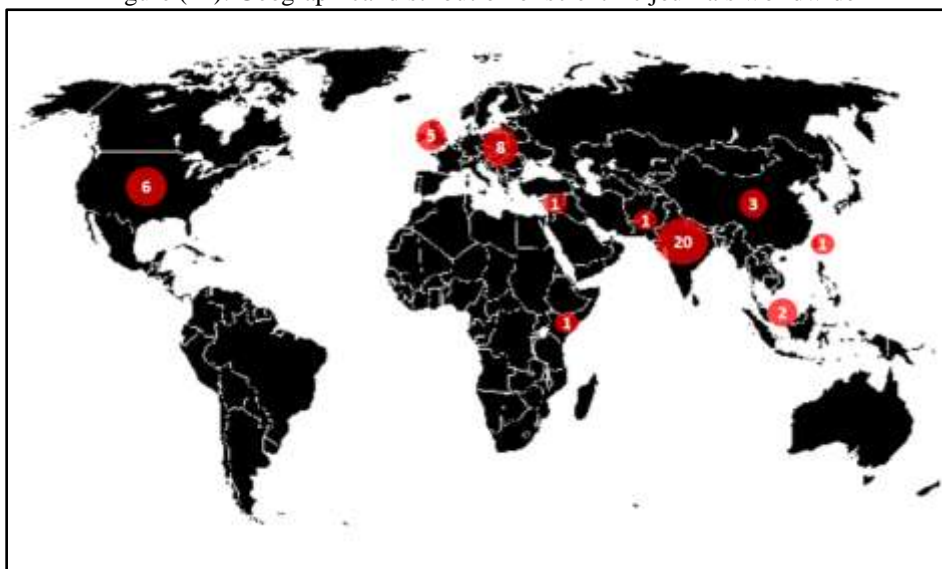
Figure (11): Geographical distribution of scientific journals over the Sudanese states



At the global level, Figure No. (12) shows the geographical distribution of research based on the sample among scientific journals worldwide. As the number of papers published in Indian scientific journals reached (20) researches. While (8) and (6)

researches were published in scientific journals from the European Union and the United States of America, respectively. On the Arab country level, one research was published in a Jordanian scientific journal.

Figure (12): Geographical distribution of scientific journals worldwide



VI. DISCUSSION

The research showed an increase in the publishing of research by researchers of chemical engineering departments in Sudanese universities. The published papers reach (14) researches in the year (2019). This study as well depicts the disparity and weakness of researchers' production of publishing of scientific papers. The best researchers in the sample were published (11) papers within (13) (Years) despite the possibility of promoting researchers academically according to the laws in force in Sudanese universities. The research sheds light on the weakness of the single publications, as only (15%) of the sample were for a single publication, while the researchers of chemical engineering departments in Sudanese universities varied in the publishing rates, as (60%) of universities had a production rate of one research per researcher during (13) as general. On the other hand, the good participation with other colleges other than the colleges of engineering to produce research by researchers has significantly affected, as it reached (40%) of the total research. The apparent cooperation between researchers of chemical engineering departments in Sudanese universities, internally between the nine departments and externally to only five universities, was one of the reasons for the increase in publication. Among the observations on the

results is the correlation of the published researches with the available supporting resources for these researches, as (66%) of the researches were concentrated in the Sudanese capital (Khartoum State). The participation of Sudanese researchers had increased with researchers in Saudi universities to reach (14) researches and this is due to the tendency of researchers from Sudanese chemical engineering departments to migrate to the Kingdom of Saudi Arabia as a possible reason, in addition to that research chairs come to be a tributary and a strong supporter of the pillars of scientific research, and the Kingdom of Saudi Arabia has taken good and vigorous steps in this direction bypassing most Arab countries. The number of research chairs in Saudi universities exceeded (552) research chairs, and the number is increasing [15]. It is evident from this research that many of the published researches tend to be directed to the water researches, manufacture, and treatment of all its branches with (19%) of the study sample, at the expense of other fields such as other natural resources, energy, and oil, whose percentage has decreased. Mind mapping and text mining operations also emphasized the focus of research on water, its manufacture, and treatment at rates (16%) to (18%) in each of the research titles and their semantic words. Sudanese scientific journals have contributed significantly to the increase in

publication, as it constituted (39%) of the total scientific journals which were chosen by the researchers of chemical engineering departments in Sudanese universities, noting the weak distribution of scientific journals in the rest of the Sudanese states. The publication of the researchers for their scientific articles in an Indian scientific journal might be attributed to the lack of publishing fees, ease of publication, and speed, compared to the European and American scientific journals. Since there was a significant difference in time of acceptance between Indian and international journals as a whole. Needless to say, this long interval translates to a considerable loss of time for the authors [16]. Moreover, they were almost absent in publishing in Arab scientific journals.

VII. CONCLUSION

Despite the improvement in the publishing rates of scientific research by researchers of chemical engineering departments in Sudanese universities compared to past years, the rate of publication of scientific research is still weak and needs more support to assume its natural role in solving development problems. The research concludes that whenever sufficient support is provided for scientific research, the effect is clear on the publication of researches, as in the case of the chemical engineering departments at the University of Khartoum, Karary University, and the University of Science and Technology, compared to the rest of the Sudanese universities. Besides, increasing communication between universities, whether internal or external, can help in enhancing and supporting the publishing processes, as in the cases of the University of Khartoum and the University of Science and Technology, and this may be attributed to agreements, memoranda of understanding and others ways of cooperation. The reliance of the research environment on the availability of services and resources that needed for research are evident, with attention to the distribution of researches in the peripheral areas to search for solutions to their problems and support their development. The availability of the enormous natural resources in Sudan makes it imperative for researchers, universities, and the Ministry of Education, Higher Education and Scientific Research to work on distributing and diversifying the fields of research and not focusing on the water field only, and linking research fields in chemical engineering departments and others in Sudanese universities with the development problem in Sudan. The Sudanese scientific journals have played an important role, as they helped in publishing

research by providing the appropriate environment for researchers in the chemical engineering departments in Sudanese universities. Through this research, many opportunities emerge that can be exploited by linking the production and industrial obstacles in Sudan and its states with Sudanese universities to promote and support scientific research, take advantage of laboratories and workshops in Sudanese universities. Governmental institutions, companies, and organizations can also provide data to support their research and development departments with the necessary information to help complete and publish researches in cooperation with Sudanese universities. Finally, the research summarized the reality of the published researches in scientific journals by the researchers of the chemical engineering departments in Sudanese universities and their trends.

VIII. LIMITATION

This research was limited to the published papers on the Google Scholar and ResearchGate website, and it did not cover all the published research on all websites. Moreover, a specific period from Jan. 2008 to June 2020 was dedicated for this study due to the lack of available data before this time. No detailed regional or world level comparisons are made in this research and will be done in future research as per plan.

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