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Bibliometric Analysis on CO_2 Capture Research from 2007 to 2018

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Abstract

A scientometric analysis about CO_2 capture publications from 2007 to 2018 was conducted. HistCite was used to analyze the data collected from Web Of Science during the period mentioned. The results show that scientific articles have increased over the years in the last decade, between 2010 and 2010, and a large number of publications have been published. China is the country with the highest number of publications and the International Journal Of Greenhouse Gas Control is the magazine with the highest number of publications. The authors with the greatest impact are Anthony EJ, Rochelle GT and Manovic V.

Keywords: Bibliometric, CO_2 capture, CAC, research results, visualization of analysis

1. Introduction

The use of carbon dioxide has become a global problem due to its impact on the environment, such as the greenhouse effect [1]. The technique of removing carbon dioxide from the atmosphere has become popular because of the large reduction in CO_2 emissions into the atmosphere in a modern power plant compared to a plant

without this technique, according to the IPCC, could mitigate total carbon emissions by 10% to 55% by 2100 [2].
Traditionally, there are three main options for capturing CO_2, which are solvent based chemisorption [3], carbonate loop technology [4] and the oxyfuel process [5], which have their advantages and disadvantages [6]. As many of these techniques can also produce CO_2 that cannot be controlled, the use of ionic liquids as solvents to dissolve and capture CO_2 [7] has been studied, as well as taking the CO_2 and using it to manufacture polymers, chemicals, among others [6]. As one of the main options, there are different ways to capture CO_2 with chemisorption, for example, using lithium oxosilicate (LI_8SiO_6), which can be done over a wide temperature range, capturing a 52.1 wt% by weight of CO_2 and obtaining a ΔH equal to 53.1 KJ/mol [8], as well as, using sodium metasilicate (Na_2SiO_3), trapping water and CO_2 using N_2 as carrier gas, producing two distinct phases and capturing up to 8.5 mmol of CO_2 per gram of ceramic [9]. Other carbon capture and storage methods are used in different applications, such as absorption by MEA [10], for which parametric analyses have been performed with AMP to define the coefficient between CO_2 and monoethanolamine (MEA) at 313K [11], Statistical analysis for parametric interaction and empirical correlations of CO_2 performance in processes mixed with MEA/MDEA [12], mass transfer analysis and absorber height indicator for MEA-AMP mixture, obtained using a constant flow and CO_2 amine concentration of 0.35 mol/mol [13], up to corrosion analysis in a CO_2 capture unit using MEA-piperazine mixtures [14]. The second law of thermodynamics is an essential tool for the analysis of exergy and the application of its concepts and the destruction of exergy[15], for which the modifications of the design of capture equipment could reduce inefficiencies, improving their performance and reducing costs, which is why the second law of thermodynamics was applied for the capture of CO_2 from post-combustion, oxycombustion and pre-combustion [16]. The materials composed of amino-silica for the capture of post-combustion CO_2 are known to absorb a lot of CO_2 at low concentrations of it, for which, its preparation and characterization components of the absorber at dry temperatures and humidity at different partial temperatures are analyzed [17]. The capacity and kinetics of CO_2 capture with Na_2CO_3 was studied to determine how it is the capture under environmental conditions, for which it was analyzed that the formation of Na_2CO_3 bicarbonate in two ways, for which its fundamental properties of reaction formation are studied [18]. In Norway, a project with CCS was implemented since 1996, and from there, it was implemented much more in the industry and allowed to know the CO_2 storage operations, the CO_2 capture tests and how to improve that [19]. For the capture and storage of carbon dioxide, a large amount of energy is required for the process to take place, with which an energy-saving system was built that used waste heat to capture CO_2 using low-temperature steam, tested in banks of a mobile roof system that successfully captured 3.1 tpd of CO_2 from the exhaust gases and a feasibility study of the system where the waste heat from the gas engine was 1.3 GJ/t-CO_2, demonstrating that the mobile bed system is an effective means of capturing carbon dioxide [20]. In this research, publications and citations are reviewed

using the HistCite tool to assess trends and current status of published work in this area.

2. Methodology

Publications on CO_2 capture were collected using Web Of Science (WoS). The search was made using "CO_2 capture", "Carbon capture", "CAC" and "Carbon-dioxide capture", obtaining 4532 documents, including articles, reviews, letters, minutes, among others. Therefore, the information was imported into the HistCite tool and then analyzed. Relevant data such as year, country, institution and type of article were taken into account, and high-impact papers, high-impact authors and research trends were also analyzed.

3. Results and Discussion

3.1 Document type, language and annual research output

Nine types of documents are identified in the 4532 publications. Many of these documents are articles (82.9%) indicating that the basic model for this type of research in this area. Meeting abstract and Proceeding paper are two important models for publishing academic findings in this field of research. The documents were written in nine languages, where English has the highest percentage with 99.2%, because of the vast majority of documents indexed by WoS are published in English. Figure 1 shows the research output for each year from 2007 to 2018, according to information collected on June 14, 2018. During this period, the trend has increased considerably since 2011 and has continued to grow steadily over the following years.

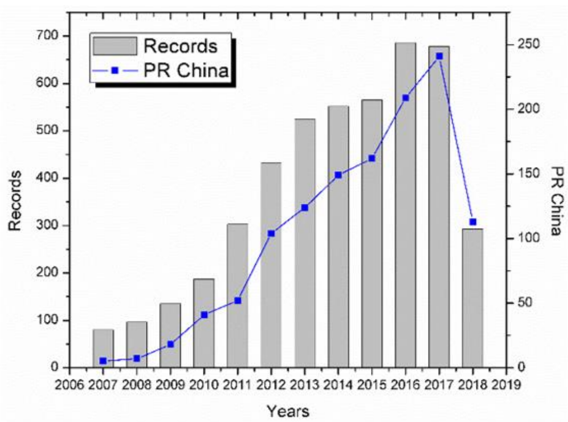

Figure 1. Annual CO_2 Capture research product from 2007 to 2018

Analysis of the research-based distribution helps to understand the capacity of a country to investigate the issue in relation to others, where a total of 73 countries contributed to the research, indicating that it is a global problem. In additions, Table 1 shows that the top five countries contributing the most are China, the United States, the United Kingdom, South Korea and Australia, whose publications represent 68.9% of total scientific production in this area. Using the local citation score (TLCS) it was found that the USA has the highest number of citations, a total of 6104 citations representing 23.1% of the total citations, and that China is the second with 6047 citations, 22.9% of the total, and United Kingdom, Canada and Spain present 2551, 2486 and 2412 citations respectively, representing 28.1% of the total citations.

Table 1. Ranking of citation score (TLCS) and TLCS/results for each country.

Country	TLCS	Country	TLCS/Records
USA	6104	CANADA	10.27
PR CHINA	6047	SPAIN	9.45
UK	2551	UK	7.39
CANADA	2486	AUSTRALIA	7,34
SPAIN	2412	USA	6.33

TLCS represents the total academic influence of a country, but cannot indicate the individual influence of the published articles. However, the average number of items cited is used as an indicator to analyze the influence of the items. Countries with more than 140 published articles were taken to show the influence, a total of 12 countries were chosen to calculate the average number of citations per article.
The selected countries are ranked according to the average number of items cited in descending order, where the Table 1 shows the top five countries with the highest number of TLCS. The country with the highest TLCS is the United States, with a total of 6104, representing 23.1%, but its are 6.73, being the fifth country in this item. Canada, Spain and the United Kingdom have high average citations per item, with 10.27, 9.45 and 7.39 respectively. Compared to other countries, the articles from the first five countries showed a good academic impact, influencing the academic trend in this area, showing in time an important increase with respect to the total publications by country from 2007 to 2018 as shown in Figure 2.

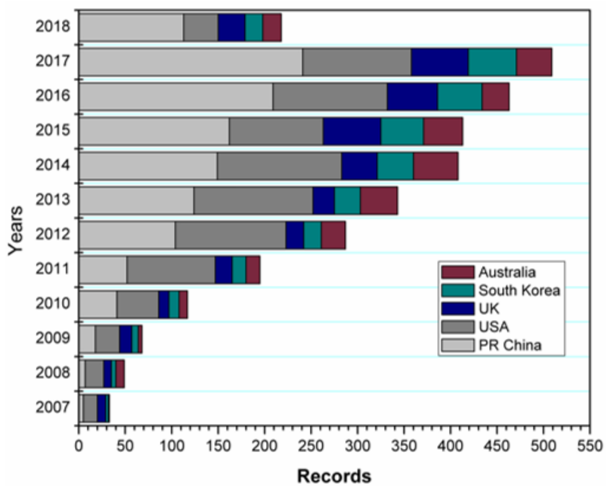

Figure 2. Total publications by country from 2007 to 2018

3.2 Distribution of central journals and quotations

4532 publications have been published in 522 journals in the area of CO_2 capture. In terms of published articles, the International Journal of Greenhouse Gas Control has 469 published articles, with a percentage of 10.3% of the total number of journals. In reference to TGCS, the overall total citation score, the International Journal of Greenhouse Gas Control also leads with a score of 10417, a percentage of 10.1% of the overall citation score. Although there are many journals with a large number of articles published as shown in Table 2, they are not guaranteed to have a local impact. Analyzing the TLCS score, Abstracts of the Papers of the American Chemical Society has 299 articles, but does not have TLCS scores, not as much as the Industrial & Engineering Chemistry Research magazine that has the second best TLCS score with 2661. In addition to these two journals, Energy & Fuels and the Chemical Engineering Journal are the fourth and fifth place of articles with 1570 and 1056 respectively. These journals, with a high TLCS, have a great influence on the development of CO_2 capture research.

Table 2. Classification of the top five journals of published papers TLCS and TGCS

Journal	Records	TLCS	TGCS
INTERNATIONAL JOURNAL OF GREENHOUSE GAS CONTROL	469	3154	10417
ABSTRACTS OF PAPERS OF THE AMERICAN CHEMICAL SOCIETY	299	0	2
INDUSTRIAL & ENGINEERING CHEMISTRY RESEARCH	291	2661	7862
ENERGY & FUELS	186	1570	3634
CHEMICAL ENGINEERING JOURNAL	159	1056	3634

The highest average citations per item is in the Industrial & Engineering Chemistry Research articles, which contain approximately 9 citations per item, followed by Applied Energy and Energy & Fuels, which have citations per item are 8.52 and 8.44 respectively as shown in Table 3.

Table 3. Classification of the first five journal with average citations by papers.

Journal	Records	TLCS	TLCS/Records
INDUSTRIAL & ENGINEERING CHEMISTRY RESEARCH	291	2661	9.14
APPLIED ENERGY	153	1263	8.52
ENERGY & FUELS	186	1570	8.44
INTERNATIONAL JOURNAL OF GREENHOUSE GAS CONTROL	469	3154	6.72
CHEMICAL ENGINEERING JOURNAL	159	1056	6.64

3.3 High-impact papers and authors

Authors and high impact articles have been selected using TLCS. From Table 4, it can be seen that 20 authors have written these, and the high impact articles have been published in five different journals. Given that two of the high impact articles were published in Energy & Environmental Science, where 45 articles have been published and two of the high impact articles have been published there, where it is concluded that to be a high level journal, an important factor is regarding the impact of the articles. The high-impact articles were published between 2009 and 2011, indicating that at that time, the research trend on the topic gained acceptance and visibility.

Table 4. Classification of the top five high impact articles.

Author	Title	Journal	Year	TLCS
Rochelle GT	Amine Scrubbing for CO_2 Capture	Science	2009	462
Wang QA, Luo JZ, Zhong ZY, Borgna A	CO_2 capture by solid adsorbents and their applications: current status and new trends	Energy & Environmental Science	2011	227
Samanta A, Zhao A, Shimizu GKH, Sarkar P, Gupta R	Post-Combustion CO_2 Capture Using Solid Sorbents: A Review	Industrial & Engineering Chemistry Research	2012	215
MacDowell N, Florin N, Buchard A, Hallett J, Galindo A, et al.	An overview of CO_2 capture technologies	Energy & Environmental Science	2010	212
Wang M, Lawal A, Stephenson P, Sidders J, Ramshaw C	Post-combustion CO_2 capture with chemical absorption: A state-of-the-art review	Chemical Engineering Research & Design	2011	170

As Table 5 shows, the author with the highest TLCS is Anthony EJ, who has 58 articles and a TLCS of 1427. The second and third authors are Rochelle GT and Manovic V, who have TLCS of 892 and 797 respectively.

Table 5. Ranking of the first ten authors with high values of TLCS

Author	Records	TLCS
Anthony EJ	58	1427
Rochelle GT	43	892
Manovic V	42	797
Abanades JC	40	773
Jones CW	35	549
Pevida C	27	522
Zhao CS	28	518
Romeo LM	18	409
Alonso M	19	395
Rubiera F	21	395

3.4 Citation Visualization Analysis

With the help of the HistCite and UCINET software, with the NetDraw tool, a chronological graph of citations is made for the articles related to the research of CO_2 capture. As shown in Figure 3, the first 50 items with LCS are selected to generate the graph. From Figure 3, it can be seen that the articles written by Manovic

V, Merel J, Wang QA and Blamey J have a high correlation factor, compared to other articles such as those written by Wang M, Mrkewitz, Rochelle G, among others. The article written or Wang QA has a great correlation factor with other articles, relating articles from the year 2014 or older. The articles published between 2007-2010 have a strong correlation between them.

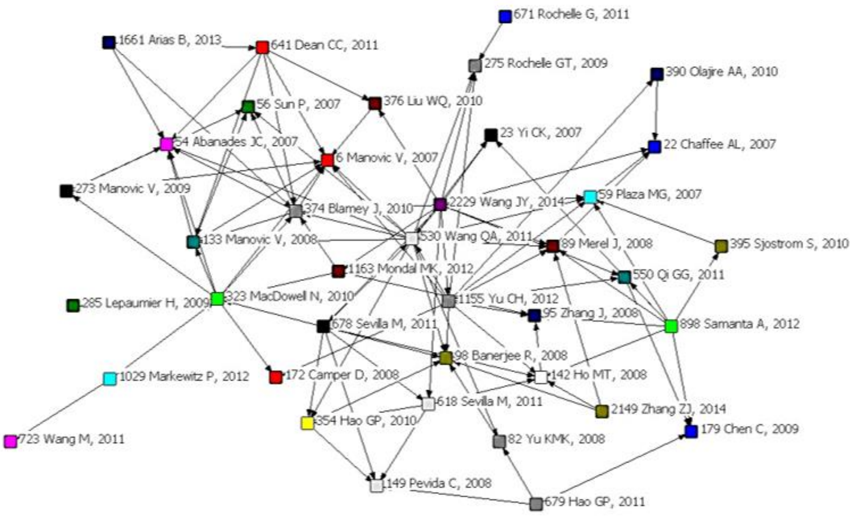

Figure 3. Chronological citation chart for CO2 Capture research.

4. Conclusions

The trend in CO_2 capture research has increased considerably from 2007 to 2018, increasing considerably between the years 2010-2016. These results imply that the problem of CO_2 emissions plays an important role in climate change. As long as the problem of the greenhouse effect and climate change continues, the research trend is expected to continue to increase.

Many articles were published in journals with specific disciplines, such as energy, environment, fuel, chemistry, being the articles accepted in these journals to generate a greater impact and have higher citations, Articles with a high FTA published between 2009 and 2011 have had a greater impact during the next seven years in the research of co2 capture.

The research had two areas of interest between 2007 and 2018. The first one, focused on how to collect and use emissions from gases, engines, among others, using external machines such as chemisorption and carbonate looping to dissolve CO_2, the second one had to do with the innovations of deep capture and analysis methods to evaluate their effectiveness, the amount of co2 captured and possible co2 emissions using these methods. This same area also focused on the economic and energetic impact of using the first methods and the current methods.

CO_2 Capture's research has shown progress and is continuing in its efforts to control and reduce the greenhouse effect, such as helping to control climate change, although no consensus has yet been reached on certain issues.

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