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Historiographical Map of Petroleum Scientific Outputs in Science Citation Index (SCI) through 1990-2011

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Abstract

The purpose of this study was to map the structure of scientific outputs of petroleum field in Science Citation Index (SCI) accessible via Web of Science (WOS) during 1990 to 2011 and determine the position of Iran. The used research methods were citation analysis and historiography. The results showed that there were totally 26859 records indexed in the petroleum discipline during 1990-2011 in SCI. USA, 7237 documents (27.28%), was the most collaborative country in this research. Iran with 321 documents ranked 21th country among all countries. The American author, Marshall A.G., with 85 documents ranked top among the most productive authors. In Iran, Kharrat from Petroleum *University* of *Technology* with 8 documents was the most productive Iranian author in petroleum field. Among the institutes and universities, Chinese Academy of Science was the most productive with 530 documents. Among the institutes and universities at national level, Tehran University has the first place with 53 documents. Energy & Fuels, Organic Geochemistry, and Abstracts of Papers of the American Chemical Society were the most important journals in terms of production and citation (both LCS and GCS) in petroleum field. The scientific map of petroleum field was drawn using HistCite™ software. The analysis of the map revealed six thematic clusters including "Analysis and evaluation of compounds and elements of molecular structure of petroleum", "Analysis and evaluation of compounds and elements of molecular structure of petroleum using mass spectrometry", "reviewing and modeling of conditions of production and formation of source rock", "survey of petroleum and its compounds biodegradation by bacteria and algae", "survey of characteristics and history of petroleum reservoir", and "survey of polycyclic aromatic hydrocarbons (PAHs)".

Keywords: Historiography**,** Science Citation Index (SCI), Web of Science (WOS), Citation Analysis, Petroleum, Iran.

Introduction

Advance of science depends upon former scientist's efforts. In the other words, researchers rely on the past knowledge to expedite future advancement of their specialized areas. Information visualization or mapping of science is the one way that helps us to achieve this aim. A map of science is a spatial representation of how disciplines, fields, specialties and individual papers or authors are related to one another as shown by their physical proximity and relative locations, analogous to the way geographic maps show the relationships of political or physical features on the earth (Small, 1999).

In spite of the many mapping and visualization techniques available, none of them were applied to the creation of historiographies. Indeed, none of the many authors on co-citation mapping considered the significant relationship between historical display and its potential role in evaluating the output of searches with Science Citation Index (SCI), Medline, Chemical Abstracts**,** etc. (Garfield, Pudovkin & Istomin, 2002).

Garfield, Pudovkin & Istomin (2003) assume in their work that the basic assumption is that the bibliographic information contained in a collection of published scientific articles is sufficient for the purpose of recapturing the historiographic structure of the field. Because citation indexes utilize the cited works of thousands of authors, it is assumed that collectively they call out the basic works in any field. Gaps may exist in the documentation provided by individual authors, but collectively they produce a fairly complete picture of the historic background of the topic.

Research objectives

The major aim of this research is to visualize the historiographic map of scientific products of petroleum scholars indexed in Science Citation Index (SCI) accessible via WOS during 1990-2009. Other objectives include determining the most productive authors, institutes and universities and countries and important journals during 1990-2011.

To achieve the above-mentioned aims, we will answer the following questions:

1. How is historiographical map of petroleum scientific outputs in SCI during 1990 to 2011?
2. Who are the most productive authors in petroleum scientific outputs in SCI during 1990 to 2011 in international and national levels?
3. What are the most productive institutes & universities and countries in petroleum scientific outputs in SCI during 1990 to 2011in international and national levels?
4. What are the most important journals in which the petroleum scientific outputs in SCI during 1990 to 2011were published?

Review of Literature

Even before the advent of the Science Citation Index in print, the use of citation data to

help write the history of science and scholarship was discussed. Garfield, Sher & Torpie (1964) issued their report on "The use of Citation Data in Writing the History of Science" which included a historiography of DNA's history from Mendel to Nirenberg (Garfield, Pudovkin & Istomin, 2002).

Rabkin & Lafitte-Houssat (1979) choose The American Petroleum Institute (API) Research Project 6 as a model to study the science organization in petroleum chemistry. The quantitative analysis of scientific publications, references, citations and citation lags elucidates the cooperative nature of Project 6.

Osareh & McCain (2008) visualized the structure of Iranian chemistry research using author co-citation technique. A principal component analysis identified seven clusters. Their results revealed that the yearly growth rate of chemistry publication among Iranian authors was 26%. Using author co-citation and applying PFNet software, they also mapped the intellectual Structure of Iranian chemistry research.

Pashootanizade & Osareh (2009) by reviewing 22,617 records indexed between 2000 and 2008 in the Web of Science database and employing citation analysis methods attempted to identify key authors and institutes and their degree of collaboration, core journals, rate of scientific output, publishing forms and languages and leading countries in the field of Agriculture. They also attempted to draw a historiographic outline of the agricultural science. The average annual growth in publications for the period studied was shown to be seven percent. Total of 22,617 records were presented in 15 different formats in 25 languages. 173 countries were involved. All agricultural articles retrieved from WOS had been submitted from 14,852 institutes and published in 3252 journals. 51,655 authors were identified who had cited 658381 sources. The clusters formed in the historiographic outline based on LCS and GCS also included five clusters.

Mansouri & Osareh (2010) in their study surveyed the scientific outputs of Islamic countries in WOS during 1994-2008. Their results showed that 643429 documents were indexed by Islamic countries in WOS. They also drew historiographical maps of these outputs by HistCite^{TM}. Four thematic clusters were identified that 3 clusters were formed by Iranian researchers in Chemistry and 1 cluster was formed by Lebanese researchers in Immunology.

Osareh & zareh (2010) studied academic scientific output of the University of Tehran (UT) in the Web of Science during 1989-2009 using a scientometric approach. The purpose of their study was to identify the rank of UT among Iranian universities. The key authors and influential journals, types of documents, the rate of yearly output and the annual growth rate were also identified. They also specified the countries UT academic members collaborated with their scholars during the studied period. In addition, they drew and analyzed two historiographical maps of UT based on Local Citation Score (LCS) and Global Citation Score (GCS).

To visualize the structure of Iranian scientific output in Science Citation Index (SCI) accessible via Web of Science (WOS) during 2000-2006, Osareh & Keshvari (2010) used scientometric techniques and HistCite software. The number of Iranian documents indexed in SCI during the study period was 24,480. The results of this study showed that in the study period a total of 8 clusters have been formed on the two levels (GCS and LCS): Clusters 1 and 2 (with 3 sub-clusters) in GCS and clusters 3, 4, 5, 6, 7, and 8 in LCS. The subject area of whole clusters was Chemistry, but there were different areas of this discipline. The prominent subject area in our study was Organic Chemistry. The most effective document in this study was an article by Zolfigol with 123 global citations and 71 local citations. The subject category of cluster 1 was analytical chemistry and membrane electrodes. Cluster 2 consists of 3 sub-clusters (sub-cluster 1 hydrocarbons, sub-cluster 2 in the field of oxidation and nitrogen, and sub-cluster 3 catalysts). Cluster 4 was crystal structure, cluster 5 electrochemical analyses, cluster 6 macro cycles, cluster 7 aliphatic and aromatic complexes and the 8^{th} cluster was polymers.

Review of literature showed that no work was done on the historiographical map of the field of Petroleum. It also showed that though Iranian authors were active in various fields, they did not participate in the maps of sciences.

Research Methodology

Scientometric approach was used as the method of this study. By searching Petroleum keyword in the topic field of the Web of Science database (Science Citation Index) data were gathered. 26859 records were extracted and stored in plain text files format. In the next step data were added to HistCite™ software for analyzing and drawing the historical map. Also MS Excel was utilized for data analysis.

Data Analysis

Historiographical Map

We selected the 100 most cited documents to draw the historiographical map. With HistCite software, we can draw two kinds of map based on Local Citation Score (LCS) and Global Citation Score (GCS). The local citation score or frequency is the number of times an item is cited in the retrieved collection. The GCS is the global score, the number of citations in the entire Web of Science. We drew historiographical map of petroleum field based on LCS. This map is shown in Figure1.

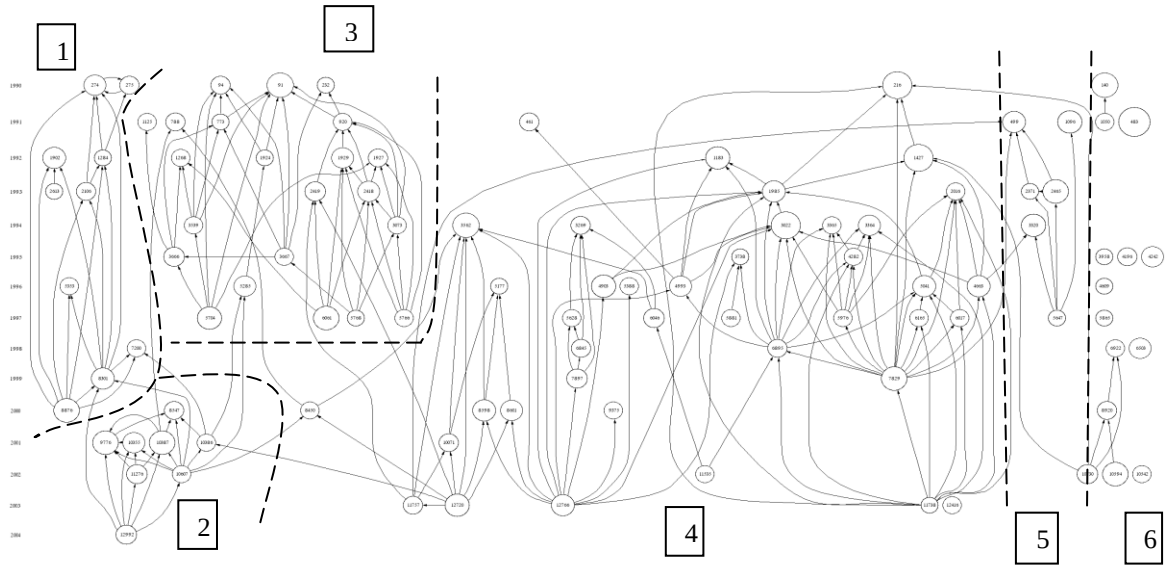

Figure 1. Historiographical maps of petroleum outputs indexed in SCI during 1990 to 2011

As shown in Figure 1, petroleum outputs formed six thematic clusters. Cluster 1 includes 10 documents that formed from 1990 to 2000. Survey of documents in this cluster showed that subject area of these documents is about "Analysis and evaluation of compounds and elements of molecular structure of petroleum" by methods as X-Ray Photoelectron-Spectroscopy, X-Ray Absorption-Spectroscopy et al. In this cluster, document with number 8876 is the most cited (LCS=84 & GCS=187). This document is an article from Groenzin & Mullins entitled "Molecular size and structure of asphaltenes from various sources" that was published in Energy & Fuels in 2000. As we can observe in Figure 1, cluster 2 is formed from cluster 1 during 2000-2004 and subject area of this cluster is also about "Analysis and evaluation of compounds and elements of molecular structure of petroleum" but using new methods especially using mass spectrometry. In this cluster documents 10387 and 9776 are the most cited articles. These documents are from Qian et al. as other documents in this cluster are published in the various volumes of Energy & Fuels in 2000. Survey of documents in cluster 3 showed that subject area of this cluster was "reviewing and modeling of conditions of production and formation of source rock" formed from 1990-1997. Document 91 with 88 LCS and 123 GCS is the most cited document in this cluster that was published in Organic Geochemistry in 1990.

Review of documents in cluster 4 released that this cluster is about "survey of oil and its compounds biodegradation by bacteria and algae". This cluster formed from 1990 to 2003 and included the most records. Most of documents in this cluster are published by Nature. In this cluster document 216 is one of the most cited (LCS= 109 & GCS=149) with which this cluster started. This document is an article by Gough & Rowland that is about "Characterization of Unresolved Complex-Mixtures of Hydrocarbons in Petroleum" and

was published in 1990 by Nature.

Cluster 5 and 6 are the smallest clusters of this map. Cluster 5 with 6 documents formed from 1991 to 1997 is about "survey of characteristics and history of petroleum reservoir". Cluster 6 includes 4 documents and was formed from 1998 to 2003 and subject of this cluster is about "survey of polycyclic aromatic hydrocarbons (PAHs)".

The most productive countries, authors, institutes & universities

Analysis of data showed that 26859 records retrieved in this study were done by collaboration of 155 countries. USA with 7237 documents (27.282% of the total) was the most productive country. Five of the most productive countries in Petroleum filed indexed in SCI during 1990 to 2011 are showed in Table 1. These 5 countries have 55.33 % of the total documents for themselves. Iran with 321 documents ranked 21th among all countries.

Table 1

The Most Productive Countries in Petroleum in SCI during 1990 to 2011

Rank	countries	Documents	Records
1	USA	7237	27.282
2	China	2610	9.839
3	Canada	2020	7.615
4	India	1494	5.632
5	France	1317	4.965
Total of 5 countries		14678	55.333
Other countries		12181	44.637

Marshall, A.G., the American author, ranked top among the authors. Five of the most productive authors are listed in Table 2.

Table 2

Five of the Most Productive Authors in Petroleum Indexed in SCI during 1990 to 2011

Rank	Authors	Country	Records	Total percent
1	Marshall A.G.	USA	85	0.32
2	Larter S.R.	Canada	81	0.30
3	Rodgers R.P.	USA	75	0.28
4	Simoneit B.R.T.	Saudi Arabia/USA	72	0.27
5	Huang G.H.	Canada/China	68	0.25
	Total of 5 authors	-	381	1.42
	Other authors	-	26478	98.58

As showed in Table 3, Kharrat from Petroleum *University* of *Technology* with 8 documents is the most productive author among Iranians in this study.

Table 3

The Most Productive Iranian Authors in Petroleum Indexed in SCI during 1990 to 2011

Rank	Authors	Institutes & Universities	Records
1	Kharrat R.	Petroleum *University of Technology*	8
2	Bidhendi G.N.	Tehran university	7
3	Masihi M.	Sharif University	7
4	Mehrdadi N.	Tehran university	7
5	Rahimpour M.R.	Shiraz university	7

In regard to institutes and universities, Chinese Academy of Science with 530 documents is the most productive institute. Five top productive institutes and universities are shown in Table 4.

Table 4

The Most Productive Institutes & Universities in Petroleum Indexed in SCI during 1990-2011

Rank	Institutes & Universities	Country	Records
1	Chinese Academy of Science	China	530
2	Russian Academy of Science	Russia	472
3	US Geological Survey	USA	276
4	University of Alberta	Canada	263
5	*Institute Francais* du Petrole	France	262

Also the most productive institutes and universities in Iran are shown in Table 5. In Iran, Tehran University with 53 documents is the most productive university in Petroleum indexed in SCI during 1990 to 2011. There is a significant difference between numbers of documents in the most productive universities in Iran and the most productive ones in the world.

Table 5

The Most Productive Institutes and Universities in Iran in Petroleum Indexed in SCI during 1990 to 2011

Rank	Institutes & Universities	Records
1	Tehran University	53
2	Sharif University of Technology	33
3	Amirkabir University of Technology	29
4	Shiraz University	28
5	Tarbiat Modarres University	23
6	Petroleum *University* of *Technology*	21
7	*Tehran university* of *medical* sciences	16
8	Isfahan University of Technology	14
9	Islamic Azad University	13
10	Iranian Research Institute of Petroleum Industry	12

The most important journals

2787 journals indexed in SCI published Petroleum documents during 1990 to 2011. Energy & Fuels with 782 documents is the most productive journal and ranked first. Ten of the most productive journals are shown in Table 6. These journals that are almost 0.35% of all journals published 15.98% of all documents.

Table 6

The Most Important Journals in Petroleum Indexed in SCI during 1990 to 2011

Production Rank	Journals	Records	Total percent
1	Energy & Fuels	782	2.94
2	Organic Geochemistry	735	2.77
3	Abstracts of Papers of the American Chemical Society	465	1.75
4	Fuel	444	1.67
5	Petroleum Science and Technology	374	1.41
6	Environmental Science & Technology	307	1.15
7	Marine and Petroleum Geology	292	1.10
8	Bulletin-American Association of Petroleum Geologists(AAPG)	289	1.08
9	Marine Pollution Bulletin	282	1.05
10	Chemistry and Technology of Fuels and Oils	281	1.06
Total of 10 journals		4251	15.98
Other journals		22608	84.02

Discussion and conclusion

Today Petroleum has an important role in economy and politics; furthermore, scientific maps of this discipline can be useful and important. The results showed 26859 records in Petroleum indexed in SCI during 1990 to 2011. USA was the most productive country and Iran with 321 documents ranked 21th. Although Iran is ranking 3 in Petroleum resources in the world, there is a distance between number of documents of the most productive institutes & universities and authors of the world and the most productive ones in Iran; moreover, survey of map showed any Iranian author participated in the historiographical map, hence Iranian authors and institutes & universities should be more active in scientific production in Petroleum. Historiographical map of scientific outputs in Petroleum indexed in SCI during 1990 to 2011 show that 6 thematic clusters are formed. The First and the second clusters are about "Analysis and evaluation of compounds and elements of molecular structure of petroleum" but the second cluster as advance in technology shifted methods to using new methods especially using mass spectrometry. "Survey of oil and its compounds biodegradation by bacteria and algae" that is the subject of cluster 4 attracted much attention of authors in petroleum field because most of authors are in this cluster and also most of documents in this cluster are published by Nature that importance of this journal is clear. Since Energy & Fuels, Organic Geochemistry and Abstracts of Papers of the American Chemical Society are the most productive and cited journals, we can say that these journals are the most important in Petroleum discipline.

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