

Bibliometric Analysis of Adsorption Technology in Environmental Science

Yuh-Shan Ho*

Department of Environmental Sciences, College of Environmental Sciences, Peking University, Beijing, 100871, People's Republic of China

Abstract

A bibliometric analysis based on Journal Citation Reports (JCR) published by the Institute of Scientific Information (ISI) was carried out on adsorption-related studies published in any ISI subject category of environmental sciences from 1995 through 2004. Our results reveal that yearly production of adsorption-related scientific articles increased steadily over the investigation period. The United States produced 49% of all pertinent articles, followed by Germany with 11%, and UK and France with 9% respectively. English was the dominant language. About 25% each of all articles had 2, 3, or 4 authors; the average number was 3.4 authors per article, and the maximum was 25 authors on one article. An analysis of international collaborations is provided. Summaries of the most prolific first and corresponding authors, the most frequently used keywords, and the most frequently cited articles are presented. Environmental Science & Technology, which has one of the highest impact factors in the field of environmental science journals, and contained the most adsorption-related manuscripts, published 7 of the 10 most frequently cited articles.

Keywords: Scientometrics, Adsorption, Science Citation Index (SCI), Citation Frequency

JEPS (2007), Vol. 1, pp. 1 – 11.

Introduction

Research on the adsorption of gases on a solid phase has a long history, and many pertinent theories have been advanced (1–3). Early applications of the adsorption process were mostly related to sewage and waste treatment (4–6) and the environmental factors that influence sorption of atmospheric ammonia by soils (7). Additional applications of adsorption science included uranium recovery (8) and removal of sulfur dioxide from polluted air (9). Today, adsorption research is more concerned with the assessment of environmental pollution and the improvement of environmental quality. Biosorption, process-simulation tools that involve both the equilibrium and the dynamic aspects of the adsorption process have been summarized (10). The following factors that are integral to the overall sorption performance are thought to be important in the design of biosorption column systems: sorption equilibrium,

sorption solution chemistry, biosorption mechanisms, mass transfer, fluid flow, and the shape of the column breakthrough curve (10). Furthermore, the regeneration of biosorbent materials and the testing of immobilized raw biomasses with real industrial effluents suggest that further investigation is needed for modeling biosorption processes (11).

Bibliometrics is a research method used in library and information sciences. This methodology utilizes quantitative analysis and statistics to describe distribution patterns of articles within a given topic, field, institute, or country. A common approach to bibliometric research includes the use of Science Citation Index (SCI), an index that tracks the impact of publications and is published by the Institute for Scientific Information (ISI). Evaluating the performance of each research topic is necessary in order to determine the impact and contribution of authors in their respective fields. Bibliometric methods have been used to investigate topics such as the growth and trends of fullerene research (12, 13)

*Address correspondence to Dr. Yuh-Shan Ho, Tel: 0086-10-62751923; Fax: 0086-10-62751923; Email address: dr_ysho@hotmail.com

in the fields of science and engineering, the productivity of research in environmental psychology in Mexico (14), and the scientific impact of the journal *Solid State Communications* as judged by ISI citation data (15).

The purpose of this study was to gain insight into the framework of adsorption-related research in the field of environmental science. Data from SCI were analyzed to determine the quantitative characteristics of adsorption research in environmental science, including year of publication, authorship, international collaborations, and keyword trends.

Methodology

The 2004 edition of ISI's Journal Citation Reports (JCR) lists a total of 5,968 journals that are covered in SCI. Of these, the 134 journals in the field of environmental science were analyzed in this study. A keyword search was performed to identify adsorption-related studies published between 1995 and 2004, using the following terms: "adsorption," "sorption," and "biosorption." Articles originating from England, Scotland, Northern Ireland, and Wales were reclassified as being from the United Kingdom. The reported impact factor (IF) of each journal was obtained from the 2004 JCR. The IF of a given journal is defined by JCR as the number of citations all articles published in the previous two years received, divided by the total number of articles published in those years. It is a measure of the frequency with which the average article in a journal has been cited in a particular year. The IF is used to evaluate a journal's relative importance, especially when compared with other journals in the same field. Note that the AIHA Journal recently changed its name to *Journal of Occupational and Environmental Hygiene*, and thus this analysis used the 2004 IF of 0.53 rather than the 2003 IF of 0.61 for the AIHA Journal.

Collaboration type was determined by the addresses of the authors, where the term "single country" was assigned if the researchers' addresses were from the same country. The term "international collaboration" was designated to those articles that were coauthored by researchers from multiple countries.

Results and Discussion

The document types identified by ISI, ranging from journal articles to discussions, were analyzed. Journal articles were the most frequent document

type, comprising 97% (9,058 articles) of the total production of 9,304 documents on the topic under study, followed distantly by reviews (144; 1.6%). Letters (54; 0.58%), editorial materials (32; 0.34%), corrections (11; 0.12%), notes (11; 0.12%), addition corrections (5; 0.054%), discussions (4; 0.043%), and meeting abstracts (3; 0.032%), which were of minor significance compared with articles and reviews. Because journal articles represented the majority of documents that were also peer-reviewed within this field, only journal articles were considered for further evaluation; a total of 9,058 relevant journal articles were identified and analyzed in this study. The predominant language for journal articles within the field of environmental science was English, with 24 (0.26%) and 23 (0.25%) articles being published in German and French, respectively.

Publication Output

From 1995 through 2004, the annual number of journal articles published and the number of pages devoted to adsorption research in environmental science increased more than fivefold, *i.e.*, the number of articles increased from 566 in 1995 to 1,283 in 2004, with a similar increase in total pages (Table 1). The average article length fluctuated slightly, showing a maximum of 10.5 pages in 1997 and a minimum of 9.5 pages in 2004, with an overall average length of 10.1 pages. The numbers of journals and authors also increased from 1995 through 2004 (Table 1). The average number of authors per article also exhibited some variation over the years, from a minimum of 3.1 authors per article in 1995 and 1996 to a maximum of 3.7 in 2003 and 2004; the overall average was 3.4 authors per article. About 11 pertinent articles were published per journal in 1995, compared to 18 papers per journal in 2004, with the numbers varying through the years; the overall mean was 14 articles per journal.

Figure 1 shows the cumulative progression in the number of articles from 1995 through 2004, and its representation by a logarithmic model. The double logarithmic plot of the data revealed a significant linear relation with a high coefficient of correlation ($r^2 = 0.999$) in the period 1995 to 2004. The fact that a logarithmic regression model fit the data best indicates that a constant growth rate was sustained for yearly articles. Comparable quantitative trends in the relationship between the cumulative number of articles and cumulative years of publication were also observed previously in evaluations of methodological

Table 1. Characteristics of journal articles on adsorption in the SCI subject categories of environmental sciences, 1995–2004.

PY	A	PG	PG/A	AU	AU/A	J	A/J	NR	NR/A
1995	566	5913	10.4	1771	3.1	54	10.5	14,881	26
1996	698	7277	10.4	2181	3.1	63	11.1	19,159	27
1997	772	8140	10.5	2492	3.2	53	14.6	21,904	28
1998	807	8348	10.3	2746	3.4	59	13.7	22,753	28
1999	911	9379	10.3	2977	3.3	62	14.7	26,314	29
2000	845	8462	10.0	2871	3.4	60	14.1	24,676	29
2001	1009	9671	9.6	3431	3.4	71	14.2	29,260	29
2002	968	9582	9.9	3456	3.6	73	13.3	28,505	29
2003	1199	12,172	10.2	4385	3.7	73	16.4	35,693	30
2004	1283	12,152	9.5	4700	3.7	72	17.8	39,786	31
Totals	9058	91,096		31,010				262,931	
Averages			10.1		3.4	64	14.0		29

PY: publication year; A: number of articles; PG: total page count; AU: number of authors; J: number of journals; NR: number of references cited; NR/A: number of references cited per article

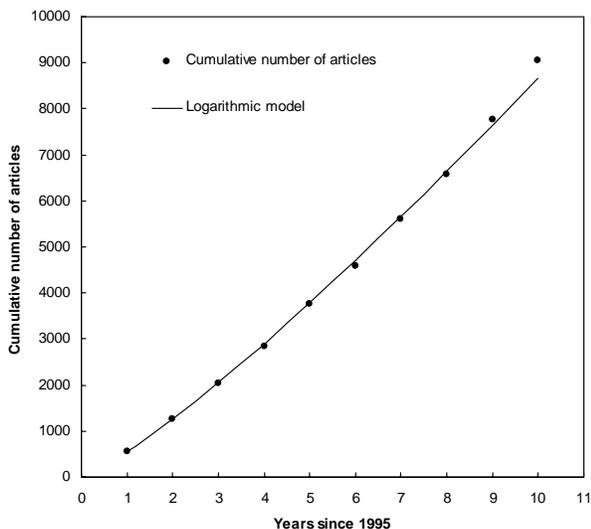


Figure 1. Cumulative number of publications by year.

research for the surgical treatment of patent ductus arteriosus (16) and homeopathy research (17).

Publication Patterns

Of the 134 journals covering the subject of environmental science, 107 journals published articles relating to adsorption. Among these, 17 journals (16%) contained only 1 article, and 20 journals (19%) contained more than 100 articles. Table 2 shows the 20 journals that published more than 100 articles on adsorption from 1995 through 2004, including the IFs and associated rankings among all environmental science journals, the number of articles, and the respective percentages of total articles published in the field. Environmental Science & Technology published the most adsorption-related articles (1,419; 16%), followed by Applied Catalysis A-General (959; 11%), Water

Research (760; 8.4%), Chemosphere (581; 6.4%), and Journal of Environmental Quality (477; 5.3%). The distribution of articles by reference to the IF of the journal in which they were published was as follows: 16% of all articles had an IF of >3; 33% had an IF of 2–3; 26% had an IF of 1–2; and 24% had an IF of <1. Interestingly, only one adsorption-related article was published in *Global Change Biology*, which has the highest IF (4.333) in the category of environmental sciences.

Country of Publication

Author address information was not provided in 30 articles (0.33%) in the ISI Web of Science. For this reason, only 9,028 articles were included in this analysis. Table 3 shows the 20 countries most productive in publishing adsorption science articles from 1995 through 2004. Among the articles with author address information published from 1995 through 2004, international collaborations accounted for 22% of the articles, while 78% of the articles

Table 2. Ranking of the top 20 journals with the most articles on adsorption by number of articles published between 1995 and 2004, percentage of total articles published in adsorption science, impact factor, and impact factor rank

Journal	A (%)	IF	IF Rank
Environmental Science & Technology	1419 (16)	3.557	4
Applied Catalysis A-General	959 (11)	2.378	11
Water Research	760 (8.4)	2.304	14
Chemosphere	581 (6.4)	2.359	12
Journal of Environmental Quality	477 (5.3)	1.617	33
Water Science and Technology	435 (4.8)	0.586	106
Environmental Toxicology and Chemistry	302 (3.3)	2.121	18
Journal of Contaminant Hydrology	299 (3.3)	0.861	83
Water Air and Soil Pollution	275 (3.0)	1.058	69
Environmental Technology	273 (3.0)	0.707	96
Journal of Hazardous Materials	247 (2.7)	1.433	44
Water Resources Research	220 (2.4)	1.530	39
Journal of Environmental Engineering–ASCE	213 (2.4)	0.845	85
Science of the Total Environment	197 (2.2)	1.925	24
Journal of Environmental Science and Health Part A-Toxic/Hazardous Substances & Environmental Engineering	165 (1.8)	0.501	116
Fresenius Environmental Bulletin	138 (1.5)	0.480	118
Environmental Pollution	125 (1.4)	2.205	15
International Journal of Environmental Analytical Chemistry	112 (1.2)	0.156	132
Atmospheric Environment	107 (1.2)	2.562	10
Journal of Environmental Science and Health Part B-Pesticides Food Contaminants and Agricultural Wastes	105 (1.2)	0.569	107

A (%): number of articles (percentage of all articles published in the field)

IF: impact factor

originated in one country. Adsorption-related papers with single-country affiliation were authored by investigators representing 98 different countries. Most articles originated in the United States (3,519; 50%), followed distantly by Germany (892; 13%) and the United Kingdom (723; 10%). This result is not unusual, as the United States is the top article producer in most research fields. Sixty-seven countries produced articles exclusively by way of

international collaboration, while 31 countries produced no international collaborations at all in the field of adsorption science. Twenty-four countries contributed only one or two single-country articles. Twenty-two countries contributed only one or two collaborative articles. The United States also had the most-frequent partners accounting for 50% of the international collaborative articles followed by Germany with 13%, and 10% collective contribution by France, United Kingdom, and Canada.

Table 3. The 20 countries producing the most adsorption-related articles from 1995 through 2004

Country	IA	% of all IA	CA	% of CA	A	% of all A
United States	3519	50	916	46	4435	49
Germany	892	13	83	4.2	975	11
United Kingdom	723	10	76	3.8	799	8.9
France	721	10	65	3.3	786	8.7
Canada	701	10	53	2.7	754	8.4
Japan	646	9.2	75	3.8	721	8.0
China	631	9.0	83	4.2	714	7.9
Taiwan	538	7.7	63	3.2	601	6.7
Spain	527	7.5	45	2.3	572	6.3
Italy	480	6.8	39	2.0	519	5.7
India	465	6.6	52	2.6	517	5.7
Netherlands	433	6.2	38	1.9	471	5.2
South Korea	350	5.0	34	1.7	384	4.3
Turkey	323	4.6	59	3.0	382	4.2
Switzerland	332	4.7	13	0.65	345	3.8
Australia	324	4.6	18	0.90	342	3.8
Sweden	280	4.0	19	0.95	299	3.3
Denmark	259	3.7	20	1.0	279	3.1
Hong Kong	190	2.7	18	0.90	208	2.3
Belgium	198	2.8	9	0.45	207	2.3

IA: single-country articles

CA: international collaborative articles

A: total articles

Note: Only the 9,028 journal articles that contained author address information were included in this analysis.

Authorship

The vast majority of adsorption science papers published from 1995 through 2004 had between 1 and 6 authors; the average number was 3.4, and the maximum was 25 authors (Figure 2). The 9,058 published articles were authored by 18,720 authors, of which 13,488 authors (72%) contributed only one article, 2,830 (15%) authored two articles, 1,038 (5.5%) authored three articles, 507 (2.7%) authored four articles, and 259 (1.4%) authored five articles. Table 4 shows the top 10 contributors to articles in adsorption science. P. Le Cloirec at the École des Mines de Nantes, France, contributed to 40 adsorption-related articles from 1995 through 2004, followed by W. J. Weber at the University of Michigan, United States, with 33 articles, and A. Kettrup at GSF - National Research Center for Environment and Health, Germany, with 31 articles. A potential bias in analysis of authorship might occur when different authors have the same name or when authors used different names over time in their articles. Another potential confounder arises when an author moves from one affiliation to another. One possibility to establish an unambiguous association of each author with his/her articles would be to create an “international publication identity number” that is assigned to each author on the publication of his/her first paper in an ISI-listed journal.

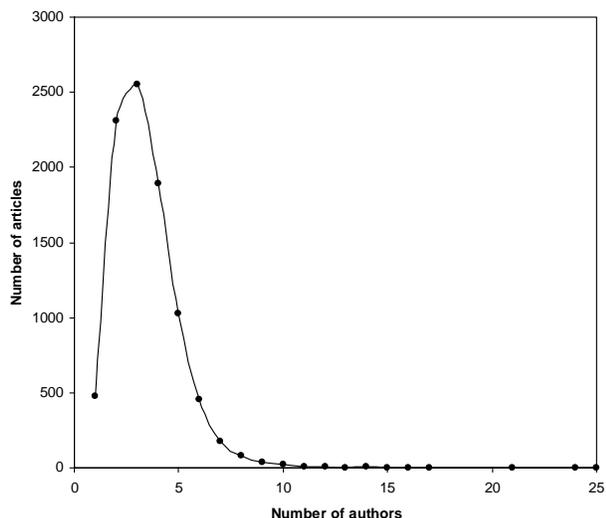


Figure 2. Relationships between the number of authors and their articles.

For the purpose of this analysis, the assumption was made that corresponding (or “reprint”) authors are the ones who acquire the funding and are responsible for the resulting articles. An analysis of corresponding authors from a total of 8,360 articles with appropriate records in the ISI Web of Science was conducted. There were 8,058 articles from 5,389 corresponding authors who were from 82 countries. Of the 82 countries from which articles on adsorption originated, 11 countries produced only one article with single-country corresponding authors. Seventy-three percent (3,950) of the corresponding authors published only one article. Fifteen percent (792) of the corresponding authors contributed only two articles. Table 5 shows the 13 most productive corresponding authors from 1995 through 2004. Six corresponding authors were from the United States, six were from Canada, Taiwan, and Hong Kong (2 per country), and one from India. S. H. Lin from Taiwan dominated the field as the corresponding author on 23 articles, followed by I. M. C. Lo from Hong Kong, who was corresponding author on 18 articles. Twenty-nine percent (2,439) of the corresponding authors were from the United States, 5.4% (453) from Germany, and 4.8% (400) from China. Furthermore, corresponding authors from the G7 nations (United States, Japan, Germany, United Kingdom, France, Italy, and Canada) provided 55% (4,557) of all published articles in adsorption science.

Based on the assumption that the first author of an article performs most of the research, a distribution of first authors was undertaken. Three articles without first author address information on the ISI Web of Science were excluded from the analysis. The analysis comprised a total of 9,055 articles with 6,429 first authors. Among these first authors, 4,948 (77%) published only one article and 931 (14%) authors published only two articles as first author. Table 6 shows the most productive first authors between 1995 and 2004. Four first authors were from Taiwan, three from the United States, and two from India. S. H. Lin, Taiwan, was the most prolific first author with 23 articles, followed by I. M. C. Lo, Hong Kong, with 18. The fact that the same authors ranked the highest in both first and corresponding author analysis is of interest.

Table 4. Top 10 authors with the highest numbers of adsorption-related articles in research in environmental sciences

Rank	Author	Institute	Country	A
1	Le Cloirec, P	École des Mines Nantes	France	40
2	Weber, WJ	University of Michigan	United States	33
3	Kettrup, A	GSF - Natl Res Ctr Environ & Health	Germany	31
4	Brusseau, ML	University of Arizona	United States	30
5	Hermosin, MC	CSIC, Inst Recursos Nat & Agrobiol	Spain	28
6	Cornejo, J	CSIC, Inst Recursos Nat & Agrobiol	Spain	27
7	Sparks, DL	University of Delaware	United States	27
8	Lin, SH	Yuan Ze University	Taiwan	25
9	van Riemsdijk, WH	Wageningen University	Netherlands	25
10	Juang, RS	Yuan Ze University	Taiwan	24

A: total number of articles

Table 5. The 13 corresponding authors with the most adsorption-related articles from 1995 through 2004

Rank	Corresponding author	A	Country
1	Lin, SH	23	Taiwan
2	Lo, IMC	18	Hong Kong
3	Juang, RS	17	Taiwan
3	Valsaraj, KT	17	United States
5	Brusseau, ML	15	United States
5	Pignatello, JJ	15	United States
5	Weber, WJ	15	United States
8	Li, ZH	14	United States
8	McKay, G	14	Hong Kong
10	Namasivayam, C	13	India
10	Reddy, KR	13	United States
10	Viraraghavan, T	13	Canada
10	Volesky, B	13	Canada

A: total number of articles

Table 6. The 14 first authors with the most adsorption-related articles from 1995 through 2004

Rank	First author	A	Country
1	Lin, SH	23	Taiwan
2	Lo, IMC	18	Hong Kong
3	Cornelissen, G	14	Sweden
4	Li, ZH	13	United States
4	Namasivayam, C	13	India
6	Cox, L	11	Spain
7	Ho, YS	10	Taiwan
7	Shen, YH	10	Taiwan
7	Tsai, WT	10	Taiwan
10	Aksu, Z	9	Turkey
10	Gupta, VK	9	India
10	Low, KS	9	Malaysia
10	Saiers, JE	9	United States
10	Zhang, YQ	9	United States

A: total number of articles

Distribution of Keywords

An analysis of keywords was undertaken for a total of 5,983 articles with records that included keywords in the SCI database between 1995 and 2004. There were 31,817 keywords listed, 9,902 (31%) of which were used only once, and 2,928 (9.2%) keywords were used twice. Figure 3 shows the 20 most frequently used keywords. “Adsorption” (used 1,037 times) headed the list followed by “sorption” (535 times), “heavy metals” (238 times), “activated carbon” (228 times), and “desorption” (218 times). Figure 4 shows a regression analysis of the number of times a keyword was used and the number of articles where this occurred; there was a highly significant ($r^2 = 0.978$) inverse logarithmic correlation between these two bibliometric parameters.

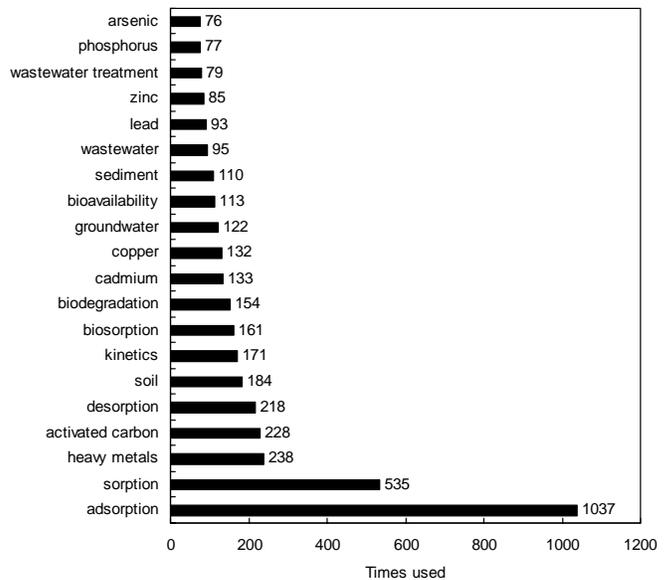


Figure 3. The top 20 most-frequently used keywords.

Citation Frequency

The most frequently cited adsorption science articles for the years 1995 through 2004 are presented in Table 7. Seven of the most frequently cited

articles were published in Environmental Science & Technology. Six of the most frequently cited articles (among them the top five listings) originated in the United States, two in Canada (both with coauthors

Table 7. Most frequently cited articles between 1995 and 2004

C	C/Y	PY	Article	Country	PG
283	28.3	1995	Hatzinger PB, Alexander M. Effect of aging of chemicals in soil on their biodegradability and extractability. <i>Environ Sci Technol</i> ;29:537-545.	United States	9
205	25.6	1997	Gustafsson O, Haghseta F, Chan C, MacFarlane J, Gschwend PM. Quantification of the dilute sedimentary soot phase: Implications for PAH speciation and bioavailability. <i>Environ Sci Technol</i> ;31:203-209.	United States	7
172	19.1	1996	Xing BS, Pignatello JJ, Gigliotti B. Competitive sorption between atrazine and other organic compounds in soils and model sorbents. <i>Environ Sci Technol</i> ;30:2432-2440.	United States	9
159	22.7	1998	Sims JT, Simard RR, Joern BC. Phosphorus loss in agricultural drainage: historical perspective and current research. <i>J Environ Qual</i> ;27:277-293.	United States, Canada	17
102	25.5	2001	Haruta M, Date M. Advances in the catalysis of Au nanoparticles. <i>Appl Catal A-Gen</i> ;222:427-437.	Japan	11
100	16.7	1999	Schauer JJ, Kleeman MJ, Cass GR, Simoneit BRT. Measurement of emissions from air pollution sources. 2. C-1 through C-30 organic compounds from medium duty diesel trucks. <i>Environ Sci Technol</i> ;33:1578-1587.	United States	10
86	17.2	2000	Ho YS, McKay G. The kinetics of sorption of divalent metal ions onto sphagnum moss peat. <i>Water Res</i> ;34:735-742.	Hong Kong	8
52	17.3	2002	Ebinghaus R, Kock HH, Temme C, et al. Antarctic springtime depletion of atmospheric mercury. <i>Environ Sci Technol</i> ;36:1238-1244.	Germany, Canada	7
22	11	2003	Accardi-Dey A, Gschwend PM. Reinterpreting literature sorption data considering both absorption into organic carbon and adsorption onto black carbon. <i>Environ Sci Technol</i> ;37:99-106.	United States	8
9	9	2004	Cornelissen G, Gustafsson O. Sorption of phenanthrene to environmental black carbon in sediment with and without organic matter and native sorbates. <i>Environ Sci Technol</i> ;38:148-155.	Sweden	8

C: number of citations from year of publication through 2004; C/Y: number of citations per year; PY: publication year; PG: page count

from the United States and Germany, respectively), and one each in Sweden, Japan, Hong Kong, and Germany, respectively. The four articles with the most citations (283, 205, 172, and 159) came from Environmental Science & Technology. Of the 10 most frequently cited articles, the ones originating in the United States were cited a total of 941 times, the ones from Canada 211 times, followed by Japan, Hong Kong, Germany, and Sweden with 102, 86, 52, and 9 citations, respectively. An interesting aspect, presented as the second column in Table 7, is the number of citations per year. Although this observation is not consistent, it appears that the number of citations per year tends to increase with the number of years since publication, pointing to a possible snowball effect when it comes to the acceptance of novel research results.

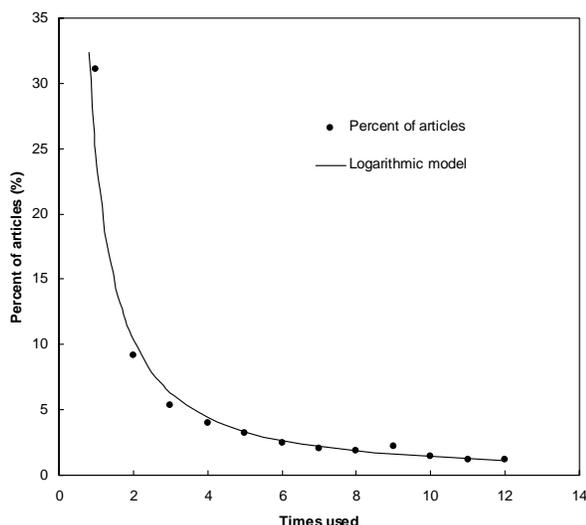


Figure 4. Relationship between the percentage of total articles and the times a keyword was used.

Conclusions

The bibliometrics of adsorption science-related studies in all ISI subject categories of environmental sciences were analyzed over a period of 10 years, 1995-2004. A steady increase was observed for the cumulative number of articles published throughout the observation period. The three top-ranking countries of origin for adsorption science-related articles were the United States, Germany, and France. English was the dominant language in pertinent articles. Small-group collaboration was a popular method of co-authorship. On average, 28% of the

published papers involved international collaborations. A summary of the 10 most frequently cited articles revealed that six originated in the United States, and seven were published in Environmental Science & Technology, which has one of the highest impact factors in the category of environmental sciences. The three journals with the most articles in this category were Environmental Science & Technology, Applied Catalysis A-General, and Water Research.

References

- Mulfarth P. (1900) Adsorption of gases on glass powder. *Ann Phys*;3:328-352.
- Freundlich HMF. (1906) Concerning adsorption in solutions. *Z Phys Chem Stöchiometrie Verwandtschaftslehre*;57:385-470.
- Langmuir I. (1916) The constitution and fundamental properties of solids and liquids. *J Am Chem Soc*;38:2221-2295.
- Ullrich AH, Smith MW. (1951) The biosorption process of sewage and waste treatment. *Sewage Ind Wastes*;23:1248-1253.
- Ullrich AH, Smith MW. (1957) Operation experience with activated sludge-biosorption at Austin, Texas. *Sewage Ind Wastes*;29:400-413
- Stasiak M. (1969) Application of biosorption process for renovation of waste waters at chemical industry. *Przemysl Chemiczny*;48:426-428.
- Hanawalt RB. (1969) Environmental factors influencing sorption of atmospheric ammonia by soils. *Soil Sci Soc Am Proc*;33:231-234.
- Chiu Y, Zajic JE. (1978) Biosorption isotherm for uranium recovery. *J Environ Engin-ASCE*;102:1109-1111.
- Suchecky TT, Walek T, Banasik M. (2004) Fly ash zeolites as sulfur dioxide adsorbents. *Pol J Environ Stud*;6:723-727.
- Volesky B. (2003) Biosorption process simulation tools. *Hydrometallurgy*;71:179-190.

11. Vegliò F, Beolchini F. (1997) Removal of metals by biosorption: a review. *Hydrometallurgy*;44:301-316.
12. Braun T, Schubert AP, Kostoff RN. (2000) Growth and trends of fullerene research as reflected in its journal literature. *Chem Rev*;100:23-38.
13. Schubert A. (1998) The profile of the Chemical Engineering Journal and Biochemical Engineering Journal as reflected in its publications, references and citations, 1983–1996. *Chem Engin J*;69:151-156.
14. Lena MMYL. (1997) Scientific productivity in environmental psychology in Mexico: a bibliometric analysis. *Environ Behav*;29:169-197.
15. Marx W, Cardona M. (2003) The impact of Solid State Communications in view of the ISI citation data. *Solid State Commun*;127:323-336.
16. Hsieh WH, Chiu WT, Lee YS, Ho YS. (2004) Bibliometric analysis of patent ductus arteriosus treatments. *Scientometrics*;60:205-215.
17. Chiu WT, Ho YS. (2005) Bibliometric analysis of homeopathy research during the period of 1991 to 2003. *Scientometrics*;63:3-23.