

High-impact papers presented in the subject category of water resources in the essential science indicators database of the institute for scientific information

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Abstract The Essential Science Indicators (ESI) database is widely used to evaluate institutions and researchers. The objective of this study was to analyze trends and characteristics of papers in the subject category of water resources in the ESI database of the Institute for Scientific Information (ISI). Distributions of document type, language of publication, scientific output, and publication of journals are reported in this article. Five indicators (the number and ranking of total papers, first-author papers, corresponding-author papers, independent papers, and collaborative papers) were applied to evaluate country, institute, and author performances. In addition, the numbers of authors cited, numbers of institutes cited, numbers of countries cited, and numbers of subject areas cited were also used to evaluate ESI papers. Results showed that 265 papers, all written in English, were listed in 27 journals in the field of water resources. A review paper was more likely to be included in the ESI than a research paper. *Journal of Hydrology* published the most papers. The USA and UK were the two leading nations. ESI papers published in the US were more likely to involve inter-institutional collaboration than papers published in the UK. The University of Arizona was the most productive institute. Some papers that were almost excluded from the ESI database appear to have consistently received annual high frequencies of citation. Perhaps the 10 year criterion for inclusion in the ESI should be reassessed.

Keywords Indicators · ESI · Number of institutes cited · Number of countries cited · Number of subject areas cited

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Introduction

Numerous studies have pointed out that climate change and increased human population are expected to place significant stress on water resources, and their effects have already been seen in many regions of the world (Vörösmarty et al. 2000; Piao et al. 2010). Studies found that nearly 80% of the global population is exposed to high levels of threat to their water security (Vörösmarty et al. 2010), and the scarcity of water resources is expected to cause conflicts among nations (Barnaby 2009). Research on water resources has taken on greater importance than ever before, and may directly impact the quality of life on a global scale. In the subject category of water resources, research articles that are listed in the Essential Science Index undoubtedly are of important significance. As important as this subject is, no research thus far has conducted a bibliometric analysis of Essential Science Index papers in the subject category of water resources. Therefore, the purpose of this research was to apply a bibliometric analysis to this group of highly cited papers. Hopefully, initial findings from this research can serve to provide directions for improving research performance in this important subject.

The Science Citation Index (SCI)-Expanded was primarily designed to help researchers retrieve relevant publications on specific topics (Garfield and Pudovkin 2003). As the database became available, different criteria were developed to evaluate papers, journals, and subject categories. In 1955, Garfield first reported the idea of an impact factor (IF; Garfield 1955), and in the early 1960s, Sher and Garfield presented the journal IF to help select journals for the SCI-Expanded (Garfield 1999). The IF is calculated through a 2 year citation window, as typical cited articles are most heavily cited during the first 2 years after publication (Garfield 1972). The IF is often used to determine the importance of a specific field of interest of a given journal, and has emerged as a marker of the quality and rank of the journal (Kelly et al. 2010). Citations per publication (CPP) and peak-year citation per publication (PCPP) are also used as citation indicators (Moed et al. 1985; Hsieh et al. 2004; Ho 2008). In 2005, Hirsch presented the *h*-index which was defined as the number of papers with citation numbers $\geq h$ (Hirsch 2005). The *h*-index is a useful index to characterize the scientific output of a researcher. It is also an applicable indicator of the impacts of scientists (Cronin and Meho 2006), institutes (Van Raan 2006), and journals (Schubert and Glänzel 2007). While each of the indicators has its own merits and special purposes, they are not able to permit rapid or convenient identification of important researchers in a subject category. In 2002, the Essential Science Indicators (ESI) was proposed, and it was able to resolve this problem. It can provide information on papers in each field that rank in the top 1% by citation frequency for each year in a 10 year survey period (Garfield 2002). Since its introduction, the ESI database has been widely used to evaluate institutions (Ma et al. 2008) and countries (Csajbok et al. 2007; Ugolini et al. 2001; Ugolini and Mela 2003). Researchers also compare research performances of different subject categories (Nah et al. 2009). Some evaluations of subject category include analyses of bibliographical trends for journals in general (Foo 2009a), comparisons of journal citations (Foo 2009b; Bensman et al. 2010), monitoring of impact factors of journals (Tsigilis et al. 2010), and the performance of highly cited journals (Bould et al. 2010).

The purpose of this paper was to analyze ESI papers in the subject category of water resources. In this paper, five indicators were used to compare country, institute, and individual author performances: the total number of papers, number of first-author papers, number of corresponding-author papers, number of independent papers, and number of collaborative papers. These indicators have not been used before in comparing the top 1%

of papers. To compare individual paper performance, five indicators were used: the number of authors citing the paper, number of institutes citing the paper, number of countries citing the paper, number of subject areas citing the paper, and number of times being cited since its publication to 2009. This is the first time these indicators were applied to the top 1% of papers.

Methods

Data for this research was extracted from the online version of the SCI-Expanded, Web of Science. The SCI-Expanded is a multidisciplinary database collected from the Institute for Scientific Information (ISI), Philadelphia, PA, USA. According to *Journal Citation Reports* (JCR), it indexed 6,620 major journals with citation references across 173 scientific disciplines. Sixty journals were listed in the subject category of water resources in SCI 2008. All documents published in the water resources field and listed in the ESI database of the ISI were collected according to data of “ESI updated as of March 1, 2010 to cover an 11 year period of January 1, 1999 to December 31, 2009”. Downloaded information included the names of authors, contact addresses, title, year of publication, keywords, name of the journal publishing the article, and times cited each year. Cited times of each of the most frequently cited articles in each year were collected since an article was published to 2009. The total number of times cited was recorded as TC2009. The records were downloaded into spreadsheet software, and additional coding was manually performed using Excel to obtain the frequency distributions and percentages. IFs and 5 year IFs were taken from the JCR published in 2008. Papers originating from England, Scotland, Northern Ireland, and Wales were reclassified as being from the United Kingdom (UK). Papers from Hong Kong were included with China. Contributions of different institutes and countries were classified according to the affiliation of at least one of the authors to the publications. The collaborative type was determined by the addresses of the authors, where the term “single-country paper” was assigned if the researchers’ addresses were from the same country. The term “international collaborative paper” was given to those articles coauthored by researchers from more than one country. The term “single-institute paper” was assigned if all researchers’ addresses were from the same institute. The term “inter-institutional collaborative paper” was assigned if authors were from different institutes.

Results and discussion

In the ESI database, 265 papers belonged to the category of water resources. A bibliometric analysis of these papers was carried out to identify the leaders in this field. ESI papers were investigated to identify trends, leading journals, institutions, and countries. Furthermore, leading articles, authors and citation trends were identified.

Document type and language of publication

Of the 265 papers in the ESI database, most of them were articles (204; 77%), followed by reviews (42; 16%), and papers of proceedings (19; 7.2%). All of these papers were published in English, with none in any other language. Of 71,965 papers published in the category of water resources during the same period (1998–2009), 55,132 (77%) were

articles, 8734 (12%) were papers of proceedings, and 994 (1.4%) were reviews. Compared to articles, the relative odds ratio for being included in the ESI for reviews and papers of proceedings were 11.9 and 0.6, respectively. This implies that a review paper was 11.9 times more likely than an article to be included in the ESI database, while papers of proceedings were only 0.6 times as likely to be included. A review paper, which mostly likely would include background information and a comprehensive summary on the current status of a research topic, provides a quick and easy way for a researcher to obtain up-to-date information and to familiarize him/herself with the topic. This probably explains why a review paper is likely to have more citations than an article. Unlike a research article that advances knowledge by providing innovative and original ideas, a review paper shortens the time for a researcher to obtain information on the current state of research. It is important in the sense that it speeds up the research process as opposed to offering new ideas.

Scientific output

Table 1 shows the characteristics of ESI papers in the water resources field. The year that had the most number of ESI papers was 2002 with 33 papers. In 2009, even 11 papers were included, despite having been published only 1 year earlier. ESI papers were quite evenly distributed over the years, contrary to what might be expected. Interestingly, the length of time since publication did not appear to have increased the probability of being included in the ESI. Such a finding is important in that it provides some supporting evidence that publication time is not necessarily an important factor for inclusion in the ESI database.

The average number of authors per paper appeared to be on the rise, probably indicating more-frequent collaboration on recent ESI papers. The number of pages and references per paper showed wide variations with no particular time trend. The average number of citations for articles, papers of proceedings, and reviews were 42, 78, and 156, respectively.

Table 1 Characteristics of papers published in the water resources field and listed in the Essential Science Indicators database

Year	TP	AU	AU/TP	PG	PG/TP	NR	NR/TP
1998	3	7	2.3	43	14	78	26
1999	14	47	3.4	218	16	540	39
2000	29	70	2.4	441	15	1,728	60
2001	21	64	3.0	314	15	1,345	64
2002	33	101	3.1	581	18	2,841	86
2003	27	91	3.4	484	18	1,846	68
2004	26	103	4.0	483	19	1,614	62
2005	26	111	4.3	429	17	1,251	48
2006	29	96	3.3	403	14	1,602	55
2007	23	96	4.2	369	16	1,451	63
2008	23	106	4.6	328	14	1,460	63
2009	11	35	3.2	150	14	785	71
Total	265	927		4,243		16,541	
Average			3.5		16		62

TP number of papers listed in the Essential Science Indicators, *PG* page count, *NR* cited reference count, *PG/TP* average page count per paper, *NR/TP* average cited reference count per paper

Publication of journals

Papers were published by 27 journals. Table 2 shows the 14 journals which published at least two ESI papers. The *Journal of Hydrology* topped the list with 96 papers, followed by *Water Research* (71) and *Advances in Water Resources* (40). These three journals alone published 78% of ESI papers. According to the JCR in 2008, the IFs of *Journal of Hydrology*, *Water Research*, and *Advances in Water Resources* were 2.305, 3.587, and 2.235, respectively ranking third, first, and fourth in this subject category. However, other journals with a high IF, such as *Water Resources Research* and *Hydrology and Earth System Science*, ranked second and fifth, but combined to publish only 11 papers in the ESI database. Not all journals with a high IF had a high number of papers in the ESI database. One of the reasons could be the time frame difference in the calculation of the IF and the selection of ESI papers. While the IF is calculated based on data from the past 2 years, ESI papers are selected based on citations from the last 10 years. Therefore, some papers published in top journals, although with higher visibility, may lack a lasting impact. This is even more so in a field in which innovative techniques and ideas frequently sprout up. ESI papers in the journal *Hydrology and Earth System Science* were published in 2001, 2007, and 2009, while for *Water Resources Research*, it only had ESI paper in 1999–2003.

Publication performances: countries and institutes

Of the 265 ESI papers published, 186 (70%) were single-country publications and 79 (30%) were international collaborative publications. In total, papers were published from 45 countries, including 19 European countries, 15 Asian countries, 7 countries from the Americas, 2 African countries, and 2 Oceania countries. Table 3 displays the numbers and percentages of total papers, first-author papers, corresponding-author papers, single-country papers, and international collaborative papers for countries with at least five ESI

Table 2 Distribution of Essential Science Indicators papers in journals listed under water resources

Journal	TP	%	IF (rank)	IF5
Journal of Hydrology	96	36	2.305 (3)	2.868
Water Research	71	27	3.587 (1)	4.274
Advances in Water Resources	40	15	2.235 (4)	2.44
Agricultural Water Management	8	3.0	1.646 (12)	1.829
Water Resources Research	7	2.6	2.398 (2)	2.801
Journal of Hydraulic Engineering-ASCE	6	2.3	1.272 (20)	1.885
Hydrology and Earth System Sciences	4	1.5	2.167 (5)	2.131
Journal of Irrigation and Drainage Engineering-ASCE	4	1.5	0.822 (43)	1.264
Journal of Hydrologic Engineering	4	1.5	1.007 (33)	1.431
Water International	3	1.1	0.315 (56)	0.652
Water Science and Technology	3	1.1	1.005 (34)	1.091
Hydrological Sciences Journal-Journal des Sciences Hydrologiques	2	0.75	1.216 (22)	1.876
Hydrogeology Journal	2	0.75	1.1 (30)	1.597
Desalination	2	0.75	1.155 (26)	1.394

TP total number of ESI papers, IF impact factor, IF5 5-year impact factor, Rank rank among 60 journals listed under water resources

papers. The leading countries in total papers were the US (98), followed by the UK (42), Germany (29), Australia (26), and The Netherlands (18). Among them, the US and UK had high percentages of single-country papers, respectively reaching 58 and 55%, much higher than Germany, Australia, and The Netherlands. Countries with the highest percentage of single-country papers were Taiwan (83%), Turkey (80%), and India (71%). Despite having fewer papers in the ESI, they published most of their work independently.

Less than half of the papers were single-institution papers. In total, 119 ESI papers (45%) were single-institution papers, while 146 (55%) were multi-institution papers. Table 4 lists the institutions with at least four ESI papers, ordered according to the number of total papers. The University of Arizona topped the list with nine papers. Among the 21 institutes listed, 11 institutions were in the US and four institutions were in the UK. The others were in Australia, Denmark, The Netherlands, Spain, and Switzerland. ESI papers produced by UK institutions were more likely to be single-institution papers, while papers produced by US institutions were more likely to be multi-institution collaborative papers. Furthermore, UK and Australian institutions were also more likely to be the first or corresponding author in their ESI papers. To sum up, US institutions published more ESI papers and were more likely to collaborate with other institutions in publishing their papers. UK and Australian institutions were more likely to work independently.

Distribution of authorship

The average number of authors per ESI paper in the water resources field was 3.5. The 265 ESI published papers were authored by 801 authors, among which 703 authors (88%) contributed only one paper, 79 authors (10%) contributed two papers, and 19 authors

Table 3 Top eighteen countries ranked by total number of Essential Science Indicators papers

Country	TP	FA (%)	RP (%)	SCP (%)	ICP (%)
USA	98	77 (79)	78 (80)	57 (58)	41 (42)
UK	42	32 (76)	31 (74)	23 (55)	19 (45)
Germany	29	14 (48)	15 (52)	10 (34)	19 (66)
Australia	26	21 (81)	21 (81)	10 (38)	16 (62)
The Netherlands	18	14 (78)	14 (78)	7 (39)	11 (61)
Italy	14	9 (64)	8 (57)	7 (50)	7 (50)
China	14	11 (79)	11 (79)	7 (50)	7 (50)
France	13	9 (69)	8 (62)	7 (54)	6 (46)
Canada	13	9 (69)	9 (69)	9 (69)	4 (31)
Denmark	10	7 (70)	7 (70)	4 (40)	6 (60)
Switzerland	10	8 (80)	8 (80)	3 (30)	7 (70)
Japan	8	2 (25)	2 (25)	2 (25)	6 (75)
Spain	8	7 (88)	6 (75)	5 (63)	3 (38)
India	7	6 (86)	6 (86)	5 (71)	2 (29)
Taiwan	6	5 (83)	5 (83)	5 (83)	1 (17)
Austria	6	3 (50)	3 (50)	3 (50)	3 (50)
Sweden	5	2 (40)	3 (60)	2 (40)	3 (60)
Turkey	5	4 (80)	4 (80)	4 (80)	1 (20)

TP total number of papers, *FA* number of first-author papers, *RP* number of corresponding-author papers, *SCP* number of single-country papers, *ICP* number of international collaborative papers

Table 4 Top 21 productive institutions ranked by the total number of Essential Science Indicators papers

Institute	TP	FA	RP	SIP	MIP
University of Arizona, USA	9	4	3	3	6
Oregon State University, USA	7	2	2	1	6
Princeton University, USA	7	4	4	1	6
University of Lancaster, UK	7	6	5	4	3
University of London Imperial College of Science, Technology and Medicine, UK	7	4	4	4	3
Agricultural Research Service (ARS), US Department of Agriculture (USDA), USA	7	4	5	2	5
Pennsylvania State University, USA	6	3	3	1	5
University of California, Davis, USA	6	1	3	0	6
University of Melbourne, Australia	6	6	6	2	4
US Geological Survey, USA	6	3	3	3	3
Delft University of Technology, The Netherlands	5	3	3	1	4
Johns Hopkins University, USA	5	3	3	1	4
ARS, USA	4	3	3	2	2
EAWAG, Switzerland	4	4	4	2	2
Louisiana State University, USA	4	4	4	1	3
National Oceanic and Atmospheric Administration (NOAA), USA	4	2	2	2	2
Technical University of Denmark, Denmark	4	2	2	0	4
University of Aberdeen, UK	4	3	3	1	3
University of Barcelona, Spain	4	4	4	3	1
University of Newcastle upon Tyne, UK	4	2	2	0	4
University of Queensland, Australia	4	3	3	1	3

TP total number of papers, *FA* number of first-author papers, *RP* number of corresponding-author papers, *SIP* number of single-institution papers, *MIP* number of multi-institutional collaborative papers

(2.4%) contributed three or more papers. Table 5 shows the authors with at least three papers. Two authors, Dr. Beven from the University of Lancaster, UK and Dr. McMahon from the University of Melbourne, Australia, had five papers, while five authors, Dr. Bloschl from Vienna University of Technology, Australia; Dr. Ho from Peking University, China; Dr. McDonnell from Oregon State University, USA; Dr. Van Loosdrecht from Delft University of Technology, The Netherlands; and Dr. Western from University of Melbourne, Australia, had four papers. Despite the US dominance, only one of the top seven authors was from an US institution. It was more likely to see an author from countries outside of the US repeatedly publishing in ESI. Among all the authors in Table 5, Dr. Ho had the highest number of first-author papers (four); Dr. Beven, Dr. McKay, Dr. Rodriguez-Iturbe, and Dr. von Gunten had the highest number of corresponding-author papers (three); and Dr. Beven, Dr. Ho, and Dr. von Gunten also had highest number of single-author papers (two). A potential bias in the analysis of authorship might have occurred if different authors had the same name, or authors used different names over time in their articles. 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 upon the publication of his/her first paper in an ISI-listed journal (Ho 2007). Another potential confounder could have arisen if an author had moved from one affiliation to another. In this study, the latter address is presented in Table 5.

Table 5 Top 19 productive authors ranked by the total number of Essential Science Indicators papers

Author	Institute	TP	FA	RP	SAP	CP
Beven, K	University of Lancaster, UK	5	3	3	2	3
McMahon, TA	University of Melbourne, Australia	5	1	1	0	5
Bloschl, G	Vienna University of Technology, Australia	4	0	0	0	4
Ho, YS	Peking University, China	4	4	2	2	2
McDonnell, JJ	Oregon State University, USA	4	0	1	0	4
Van Loosdrecht, MCM	Delft University of Technology, The Netherlands	4	0	0	0	4
Western, AW	University of Melbourne, Australia	4	2	2	0	4
Bastiaanssen, WGM	Water Watch, The Netherlands	3	2	2	1	2
Bouten, W	University of Amsterdam, The Netherlands	3	0	0	0	3
Doerr, SH	University of Wales Swansea, UK	3	2	2	0	3
Doll, P	University of Frankfurt/M., Germany	3	1	1	0	3
Gupta, HV	University of Arizona, USA	3	0	0	0	3
Krajewski, WF	University of Iowa, USA	3	1	1	0	3
McKay, G	Hong Kong University of Science and Technology, China	3	0	3	0	3
Rodriguez-Iturbe, I	Princeton University, USA	3	1	3	1	2
Seo, DJ	National Oceanic and Atmospheric Administration, USA	3	0	0	0	3
Sorooshian, S	University of California, Irvine, USA	3	0	0	0	3
von Gunten, U	EAWAG, Switzerland	3	2	3	2	1
Zhang, L	Ghent University, Belgium	3	2	1	0	3

TP total number of papers, FA number of first-author papers, RP number of corresponding-author papers, SAP number of single-author papers, CP number of collaborative papers

Impact of ESI papers

Table 6 shows the 11 papers, including three reviews, seven articles, and one paper of proceedings, that were cited at least 200 times since being published in 2009. Six of the 11 papers were published in *Water Research*, and two were published in *Water Resources Research*. Three of them were published by authors from the US, more than any other country. A review paper, titled “A review of potentially low-cost sorbents for heavy metals”, received the most citations (742). It was published in *Water Research* by Bailey et al. (1999) from Louisiana State University (USA). Further analysis of citations showed that it was cited by 1936 authors from 635 institutions in 69 countries or regions. It was cited in 58 subject areas, and was cited an average of 67 times per year. The next article with the most citations was “The kinetics of sorption of divalent metal ions onto sphagnum moss peat”, published in *Water Research* by Ho and McKay (2000) from Hong Kong University of Science and Technology. It was cited 489 times by 1,008 authors from 342 institutions in 52 countries or regions. Of all the authors listed in Table 6, only Dr. Ho, Dr. Beven, and Dr. McKay are also listed in Table 5, indicating strong performance both in quantity as well as in the impact of their research.

Although Table 6 shows the papers with the highest citations over the last 10 years, it does not provide any information on the future citation impact. To examine this aspect, Fig. 1 was constructed. Instead of looking at papers with the highest accumulated citations from 1999 to 2009, it shows papers with the highest citations in 2009 and charted the annual citations since publication. In total, eight papers, including five articles, two

Table 6 Top 11 papers with highest total citation since publication to 2009

Paper	Document type	AU	IN	CT	SA	C/Y	Journal	Country	TC2009
Bailey et al. (1999)	Review	1936	635	69	58	67	Water Research	USA	742
Ho and McKay (2000)	Article	1008	342	52	45	49	Water Research	China	489
Legates and McCabe (1999)	Article	915	416	48	42	35	Water Resources Research	USA	380
Davis et al. (2003)	Review	800	279	52	57	47	Water Research	Canada	327
Beven and Freer (2001)	Article	627	318	42	33	30	Journal of Hydrology	UK	270
Gujer et al. (1999)	Proceedings Paper	603	247	42	36	24	Water Science and Technology	Switzerland, Denmark, Japan, The Netherlands	261
Beun et al. (1999)	Article	340	109	27	16	20	Water Research	The Netherlands, Germany	218
Lay et al. (1999)	Article	494	163	30	23	20	Water Research	Japan	217
Welch et al. (2000)	Review	680	240	30	46	21	Ground Water	USA	212
Carballa et al. (2004)	Article	618	229	36	30	35	Water Research	Spain, Germany	212
McArthur et al. (2001)	Article	560	239	35	41	23	Water Resources Research	UK, Bangladesh	209

AU numbers of authors cited, IN numbers of institutes cited, CT numbers of countries cited, SA numbers of subject areas cited, C/Y citations/year, TC2009 total number of times cited since the paper was published to 2009

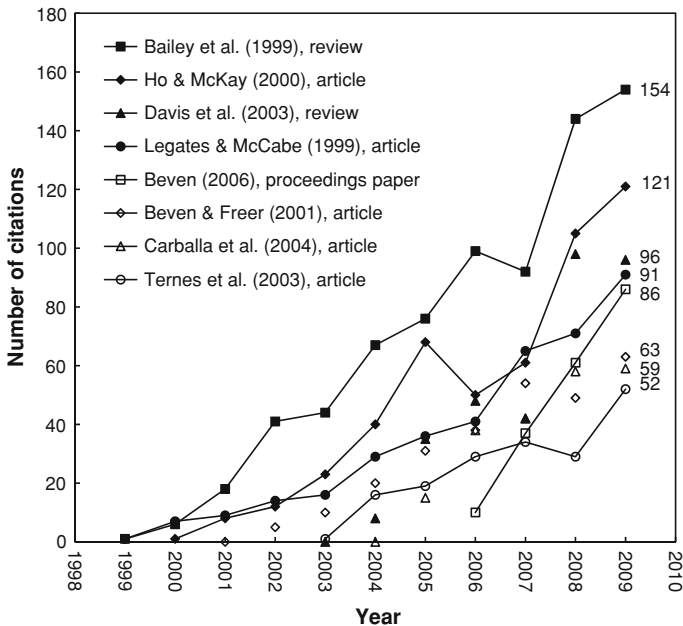


Fig. 1 The life of the ten most frequently cited Essential Science Indicators papers in 2009

reviews, and one paper of proceedings, had more than 50 citations in 2009. The number of times these papers were cited since 1999 was charted. Among them, five papers were published in *Water Research*, two in the *Journal of Hydrology*, and one in *Water Resources Research*. The paper with highest number of citations in 2009 was published by Bailey et al. (1999) with 154 citations in 2009. Its annual number of citations increased since the time of its publication, and it is the only review paper with more than 100 citations in 2009. Overall, it appeared to be going strong and showed no sign of leveling off. The paper with the second highest number of citations in 2009 was published by Ho and McKay (2000) with 121 citations. It was the only article with more than 100 citations in 2009. It had an article life pattern similar to the most frequently cited review paper by Bailey et al. (1999). Overall, it seems that ESI papers in the field of water resources had high consistency between accumulated citations (1999–2009) and 2009 annual citations. Six of the top eight papers in 2009 were among the top 11 papers in accumulated citations.

Conclusions

It was found that 265 papers were written in English, in three document types including articles, reviews, and papers of proceedings, in 27 journals listed in the subject category of water resources in JCR in 2008. They were concentrated in three, not all, high-IF journals: the *Journal of Hydrology*, *Water Research*, and *Advances in Water Resources*. Journals with a high IF but a low number of ESI papers probably have a more-evenly distributed citation pattern among all papers rather than for a few highly cited papers. Review papers have a much higher probability of being included in the ESI database than research articles. More research is needed to verify if such findings exist in other subject categories.

The review function in the field of water resource appears to be highly importance since it shortens the time for a researcher to obtain information on the current state of research. It is important in the sense that it speeds up the research process as opposed to offering new ideas. The US had the most number of papers in water resource category of the ESI database. Findings revealed distinctive patterns of collaboration of the US with other countries. Compared to papers by other countries, US papers tend to have fewer international collaborations but more likely to have multi-institutional collaborations. Therefore, as a nation and as institutions, the US performed very well compared to others, but relatively few US researchers fared as well individually when compared to top researchers from other countries. The University of Arizona had more ESI papers than other institutions, while the University of Lancaster has the most first-author and independent papers. Dr. Beven led in total, first-author, and collaborative papers. Dr. McMahon ranked tops in total and corresponding-author papers. Dr. Ho led in first-author and independent papers. Some of the ESI papers continue to receive a large number of citations annually despite having been published 10 years ago. Some papers that are about to be excluded from the ESI database appear to continue to be receiving a high frequency of citations. Further research is needed to evaluate if such a phenomenon exists in other subject categories. If so, perhaps the 10 year criterion for inclusion in the ESI should be reassessed.

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