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Top cited articles in adsorption research using Y-index

Hui-Zhen Fu[1,2] and Yuh-Shan Ho[1,2,*]

[1]*Department of Environmental Sciences, Peking University, Beijing 100871, People's Republic of China and* [2]*Trend Research Centre, Asia University, No. 500, Lioufeng Road, Wufeng, Taichung County 41354, Taiwan*
**Corresponding author. E-mail: ysho@asia.edu.tw*

A bibliometric index called Y-index (*j*, *h*) is developed, taking the prominent first author and corresponding author positions into account for evaluation and comparison of scientific productivity. Y-index contained two parameters: publication performance *j*, which is related to publication quantity, and publication character *h*, which describes the proportion of corresponding author publications (RP) to first author publications (FP). The top cited articles with at least 100 citations from 1900 to 2012 were selected to examine the Y-index for the evaluation. Y-index and three indicators, number of total publications, FP and RP, were compared. The main contributors of authors, institutions and countries and their contribution characters were revealed by Y-index. Results showed that the topmost authors were more likely to being designated as the corresponding authors, and their contribution characters varied widely. Most institutions and countries had a balance of FP and RP. Y-index that accredits the important collaborators with weighted and comprehensive credit might be a better choice for the evaluation.

Keywords: bibliometric; Web of Science; Y-index; publication character; publication performance.

1. Introduction

Publications in peer-reviewed journals are a major criterion for evaluating and comparing authors (Nederhof 2008), institutions (Pouris 2007) and countries (Huang, Lin and Chen 2011) as the references of decision-making of policy makers. A person's name should be included as a co-author only if one contributed significantly to the scientific formulation or execution of a study, or to the writing of the article reporting the study (Burman 1982). The International Committee of Medical Journal Editors (1997) proposed that authorship credit should be based on substantial contributions including conception and design, analysis and interpretation of data and the drafting or reviewing of the article. The total number of journal publications is one of the most widely common indicators to evaluate scientific productivity (Rehn, Kronman and Wadskog 2007). Over the past few decades, there has been an increase in the number of multi-author articles within scientific journals (King 2000; National Science Board 2010). Multiple-authorship is becoming the norm (Wren et al., 2007). The proportion of single-author articles had been decreasing, while the percentage of multi-author articles and the number of authors per publication had been increasing from 1945 to 1995 (King 2000). As National Science Board (2010) reported, co-authored articles grew from 40% of the world's total science and engineering articles to 64%, co-authored articles listing authors from different institutions in the same country increased from 32 to 42% and articles from institutions in more than one country grew from 8 to 22% over the period of 1988–2008. Multiple-authorship tended to abrogate responsibility (Anonymous 2008) and dilute accountability (Rennie Yank and Emanuel 1997).

However, the popular indicators, such as number of publications, citation, citations per publication (CPP), *h*-index (Hirsch 2005), g-index (Egghe 2006), A-index (Jin 2006), R-index (Jin et al., 2007) and AR-index (Jin et al., 2007), did not take the authorship into consideration. Some fractional counting by first or corresponding authors was useful for assessment of research productivity and impact (Huang, Lin and Chen 2011). The first author articles have been used as an indicator to characterize the performance of authors in general surgical journals (Paladugu 2002), anesthetic journals (Baltussen and

Kindler 2004), ophthalmology journals (Ohba et al., 2007), rehabilitation (Shadgan et al., 2010), biomedical research (Bissar-Tadmouri and Tadmouri 2009), urology (Hennessey, Afshar and MacNeily 2009) and orthopaedic surgery (Kelly et al., 2010). Number of corresponding author articles was also noted and interpreted as an indicator of research responsibility in Chinese co-authorship (Royle et al., 2007). Recently, some prior attempts have been made using the indicators related to both first author articles and corresponding author articles. The most productive first and corresponding authors were examined in environmental sciences (Ho 2007). Lately, number of first author articles and corresponding author articles have been developed to characterize countries and institutions in a series studies related to medicine (Ho, Satoh and Lin 2010), environment science (Wang, Yu and Ho 2010), risk assessment (Mao, Wang and Ho 2010), desalination (Tanaka and Ho 2011), global climate change (Li, Wang and Ho 2011), comparison of universities (Wang, Fu and Ho 2011) and characteristics of country (Fu et al., 2011). A newly developed indicator related to both first author and corresponding authorship, Y-index (Ho 2012), provided a new appropriate choice for authors', institutions' and countries' evaluation of a field. It has been applied to evaluate the top cited research works in the Science Citation Index Expanded (SCI-Expanded; Ho 2013a) and the independent research of China (Fu and Ho 2012).

Adsorption, with a long history of more than one century (Mülfarth 1900), has been widely applied in recent years (Wang, Yu and Ho 2010; Chuang, Wang and Ho 2011). Many studies have been conducted to motivate the long-term development of the absorption field (Langmuir 1918; Brunauer, Emmett and Teller 1938). Top cited articles were considered as 'classic citations' (Garfield 1987). Various studies have attempted to identify and analyse the 'citation classics', especially medical fields (Terajima and Åneman 2003; Hennessey, Afshar and MacNeily 2009; Brandt et al., 2010). The analysis of top cited articles allows for the recognition of scientific advancement and gives a historic perspective on the scientific progress (Baltussen and Kindler 2004; Ohba et al., 2007). Nevertheless, the most popular *h*-index is limited to analysed top cited articles since the *h*-index of analysed unit is simply equal to the number of publications, when its number of publications is less than the value of citations that select the articles to be top cited articles. *h*-index may undervalue the performance of unit with an intermediate productivity level but a high impact and a great international visibility (Costas and Bordons 2007).

This study not only reviewed related previous studies to consolidate the theoretical foundation of the newly developed indicator Y-index, but also examined this indicator to evaluate the top cited articles with at least 100 citations in the field of adsorption from 1900 to 2012.

2. Y-index

2.1 Theory

The credits of the co-authors listed in an article varied greatly within authors (Goodman 1994; Shapiro, Wenger and Shapiro 1994). In an age of multi-authorship, the popular counting method (whole counting) that gives each collaborator one full credit may not be the best counting method (Huang, Lin and Chen 2011). This increased number of authors in an article is more likely to precipitate various unethical authorship practice including gift authorship (Slone 1996; Dotson and Slaughter 2011). Honorary authorship, also known as gift, guest, unjustified or undeserved authorship, is defined as the inclusion as author of an individual who has not contributed adequately to the project (Bennett and Taylor 2003; Singh 2009). Pressured authorship, also known as coercion authorship, is a variation of gift authorship (Feeser and Simon 2008). This authorship is defined as persons who use their position of authority to apply pressure upon staff more junior to them to include them as an author, even though they do not qualify (Bennett and Taylor 2003). Honorary authorship is widespread and deeply institutionalized in many disciplines. Substantial proportions of articles with gift authorship were prevalent in recent surveys, ranging from 26 to 39% (Mowatt et al., 2002; Hwang et al., 2003; Eisenberg et al., 2011). This prevalent unethical authorship led to obfuscation of authorship credit within bylines (King 2000). Under the condition of a non-alphabetical name order of publications, the order of authors' names usually symbolizes their relative contributions to research (Over and Smallman 1973; Gaeta 1999). Given the central role of author's name in evaluating scientific productivity and the trend towards obfuscation of authorship credit, both the number of authors on an article and their position in the byline need to be taken into account accurately when measuring author contribution (Mattsson, Sundberg and Laget 2011).

The first author was the most prominent authorship position. Principle 5.12-1 of the Ethical Standards of Psychologists of the American Psychological Association (1953) states: 'the experimenter or author who has borne the principal responsibility for a piece of research or writing should be identified as the first author, and those who have made less but significant contributions should appear as junior authors'. The first author has actually made the most contribution, and should receive a greater proportion of the credit (Reisenberg and Lundberg 1990; Yank and Rennie 1999; Engers et al., 1999; Marušić et al., 2004). One reason for the importance of first author is that some landmark studies are known by the name of their first author (Reisenberg and Lundberg 1990). Some studies also provided the evidence that authors with more top cited articles were more likely to be listed as first author (Paladugu 2002; Baltussen and Kindler 2004).

Accordingly, the non-first authors were investigated to make less contribution (Shapiro, Wenger and Shapiro 1994).

However, only the attention on the position of first author is not enough; another prominent authorship position is corresponding author. The honorary authors including Nobel laureates were more likely to be listed last authors on scientific articles, rather than the first author (Zuckerman 1968; Bates et al., 2004). To some extent, they adopt this pattern of visibility increasingly often as they get older, thereby earmarking their contributions without demanding first-authorship (Zuckerman 1968). The corresponding author obviously increases the author's credit for contributions to the study (Bhandari et al., 2004). The designation of corresponding author, also known as responsible author, is important since he supervises the planning and execution of the study and the writing of the article (Burman 1982). Corresponding author responds to these comments and questions of journal before acceptance and publication and the readers about published publication; declares any competing or conflicting interest and explains the presence and order of co-authors (International Committee of Medical Journal Editors 1997); and has the approval of all other listed authors for the submission and publication of all versions of the manuscript (Coats 2009). Corresponding author was the one who contributed the most to the initial conception and supervision (Wren et al., 2007). Corresponding author was more likely to be designed as the first author and the last author (Mattsson, Sundberg and Laget 2011), who was observed to have the second largest contribution (Shapiro, Wenger and Shapiro 1994). By tradition, the first author is usually a junior researcher the final author is the senior researcher (Burman 1982; Reisenberg and Lundberg 1990; Rennie Yank and Emanuel 1997; Drenth 1998). Some scholars have employed the corresponding author for credits rather than the first author (Miettunen and Nieminen 2003; Man et al., 2004; Chiu and Ho 2005; Sombatsompop et al., 2007). In general, it is not appropriate to ignore the obstruction of increasing multiple co-authorship when measuring authors, institutions, and countries. The designation of first and corresponding authors provides a useful method to take account of multiple-authorship.

2.2 Mathematical expression

The Y-index (j, h) is related to numbers of first author publications (FP) and corresponding author publications (RP), and might be applied to evaluate authors, institutions and countries, as defined (Ho 2013b):

$$j = FP + RP \tag{1}$$

$$h = \tan^{-1}\left(\frac{RP}{FP}\right) \tag{2}$$

where, j is publication performance, which is a constant related to publication quantity, and h is publication character, which can describe the proportion of FP to RP. j is the sum of FP and RP. The greater j is, the more contribution the analysed unit makes. Different values of h stand for different proportions of RP to FP. $h > 0.7854$ means more RP; $h = 0.7854$ means the same quantity of FP and RP; $0 < h < 0.7854$ means more FP. When $h = 0$, j = number of first author articles, and when $h = \infty$, j = number of corresponding author articles.

Y-index is useful, especially in an era of increasing multiple-authorship when the contribution of authors was diluted. Y-index considered two prominent authorships: first author and corresponding author. It could not only reveal the major contributors, ignoring unethical authors, such as gift authors, but also provide deep insight into the features of contribution. For example, the authors with more RP ($h > 0.7854$) usually conducted more supervision and initial conception work (Wren et al., 2011). Furthermore, some popular indicators were limited to analyse the contributors of top cited articles, such as h-index. Y-index without such limitation could provide one reasonable choice to characterize the size and feature of contribution by authors, institutions and countries in top cited articles in one field.

3. Data collection and pretreatment

Top cited articles in the field of adsorption were selected as an example, and Y-index could be useful for other scientific disciplines as well. Data used in this study were retrieved from SCI-Expanded database of the Web of Science from the Thomson Reuters. According to Journal Citation Reports of 2011, it indexes 8,336 journals with citation references across 174 scientific disciplines in science edition. The detailed data collection process is illustrated in Fig. 1. Adsorption, sorption and biosorption were searched in terms of topic (including title, abstract, author keywords and *KeyWords Plus*) within the publication year limitation from 1900 to 2012 based on SCI-Expanded (updated on 21 November 2012). Total 325,615 documents in 20 document types were therefore

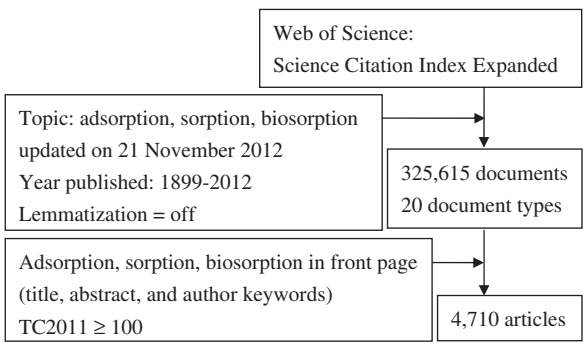

Figure 1. Schematic for searching the top cited articles.

found. Only document type of article (301,826 articles including 26,347 proceedings papers and 29 book chapters) was considered. Another two filters, *TC2011* and the front page, were employed to retrieve articles. $TC2011 \geq 100$ selected the articles as the top cited articles. The total number of times article cited from its publication to 2011 was recorded as *TC2011* (Wang, Fu and Ho 2011; Chuang, Wang and Ho 2011). The advantage of this indicator was its invariance, not updating as time goes on (Fu, Wang and Ho 2012). Another filter, the front page, meant only the articles with the searching keywords in their front page including article title, abstract and author keywords were preserved (Fu, Wang and Ho 2012). *KeyWords Plus* provides search terms extracted from the titles of articles cited in each new article listed in *Current Contents* (Garfield 1990). The articles that can only be searched out by *KeyWords Plus* were excluded. Finally, top 4,710 articles (1.6%) of the total articles were regarded as the top cited articles.

The records were downloaded into spreadsheet software, and additional coding was manually performed using Microsoft Excel 2007 for calculation. Articles originating from England, Scotland, Northern Ireland and Wales were reclassified as being from the UK (Chiu and Ho 2005). Federal Republic of Germany (Fed Rep Ger or Fed Rer Ger), German Democratic Republic (Ger Dem Rep), West Germany, Bundes Republik, East Germany and Germany were reclassified as being from Germany (Ho 2012). USSR and Russia were also reclassified as being from Russia (Ho 2012). France and Fraance were also reclassified as being from France. Similarly, articles from Hong Kong published before 1997 were included in the China category (Chuang, Wang and Ho 2011). In the SCI-Expanded database, the corresponding author is labeled as the reprint author. In this study, this person is referred to as the corresponding author. In a single-author article where authorship is not specified, the author is classified as both the first author and the corresponding author (Ho 2012). In a multi-author article where authorship is not specified, the first author is classified as the corresponding author (Ho 2013b). As for the author, if one author was assigned as the first author of one publication, the publication was considered as 'first author publication' of the author; and if one author was assigned as the corresponding author of one publication, the publication was considered as 'corresponding author publication' of the author. In terms of country/territory or institution, the term 'first author publication' was assigned if the first author was from the country/territory or institution for analysis, and the term 'corresponding author publication' was assigned if the corresponding author was from the country/territory or institution for analysis. *TP*, *FP* and *RP* are 'the number of total publications', 'first author publications' and 'corresponding author publications' for a country/territory, an institution or an author, respectively.

There were 4,710 top cited articles with $TC2011 \geq 100$ in SCI-Expanded database. Only articles with both first author and corresponding author information were used to evaluate the performance. The records of authors and their addresses where institution and country are identified were independently generated from the database, and therefore the quantity with information of author, institution and country was not equal. As for authors, 4,710 articles having both first and corresponding author information were evaluated by Y-index. With respect to institutions and countries, 4,347 articles with the affiliated address information of both corresponding author and first author were abstracted for the following evaluation.

4. Results and discussion

4.1 Publication outputs

The 4,710 top cited articles ($TC2011 \geq 100$) were published in a long period of 95 years from 1916 to 2010. The Fig. 2 illustrates publication outputs and *CPP* by decades. The publication outputs of decades increased during 1910–80s smoothly, and sharply increased to a peak of 1,994 articles in 1990s, but then dropped in last two decades. The two most productive decades were 1990s (1,994; 42%) and 2000s (1,564; 33%), while the three least productive decades were 1910s, 1920s and 2010s with a total number of 11 articles. The mean number of *CPP* was 184. The *CPPs* of the 11 decades ranged from 1,309 to 146. The 1910s with three articles and 1930s with 18 articles had the much higher *CPPs* of 1,309 and 729, respectively, which can be attributed to the articles by Langmuir with *TC2011* = 3,627 in 1918 and Brunauer et al. with *TC2011* of 9,963 in 1938. These two top cited articles are famous

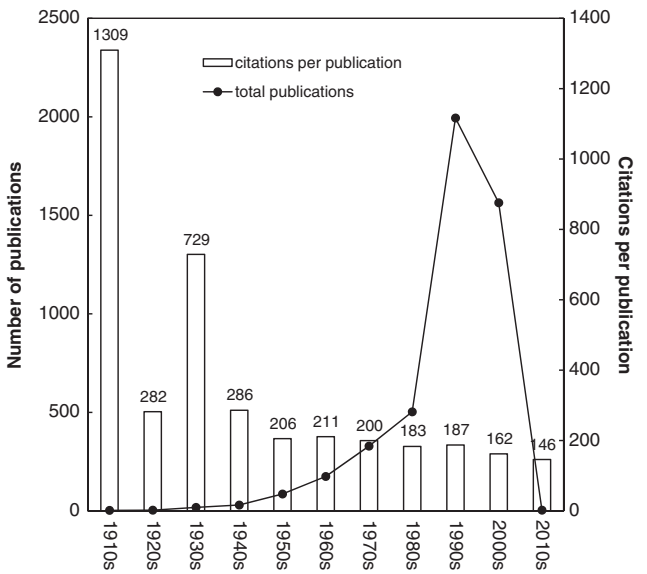

Figure 2. Number of articles and citations per article by decades.

and widely applied in the field of adsorption (Fu, Wang and Ho 2012). One is the first theoretic adsorption isotherm, named the Langmuir isotherm (Langmuir 1918), and the other one is the well-known multilayer adsorption isotherm so-call the BET (Brunauer, Emmett and Teller) (Brunauer, Emmett and Teller 1938).

4.2 Performance of authors

The authors listed in one publication could be considered as the evidence of contribution (Coats 2009). There were 11,218 authors contributing to 4,710 top cited articles. Within these authors, 6,834 authors (61%) had no first author articles and corresponding author articles ($h = \infty$). Six hundred and sixty-five authors (5.9%) had only corresponding author articles, but no first author articles ($h = \infty$), while 959 authors (8.5%) had only first author articles but no corresponding author articles ($h = 0$). As for the 2,760 authors (25% of all 11,218 authors) published both first author and corresponding author articles: 155 authors (1.4%) had $h > 0.7854$; 2,533 authors (23%) had $h = 0.7854$; and 71 authors (0.63%) had $0 < h < 0.7854$. Except the special authors with $h = \infty$ or $h = 0$, most authors had the same *FP* and *RP*. In terms of *j*, 8,230 (73%) authors had $0 \leq j < 2$; 2,769 (25%) authors had $2 \leq j < 5$; 148 (1.3%) authors had $5 \leq j < 8$; and only 71 (0.63%) authors had $j \geq 8$.

Table 1 shows the comparison of the top 17 authors who had $j \geq 14$ by four indicators including Y-index (*j*, *h*), *TP*, *FP* and *RP*. Different indicators result in widely different rankings. The top 17 authors' ranks ranged from 1st to 21st by *RP*, from 1st to 117th in *TP* and from 1st to 632nd in *FP*, respectively. Ten top authors V.K. Gupta ($Rank_{TP} = 21$), C. Namasivayam ($Rank_{TP} = 19$), T.L. Hill ($Rank_{TP} = 80$), Z. Aksu ($Rank_{TP} = 51$), G.B. Sukhorukov ($Rank_{TP} = 27$), P.E. Laibinis ($Rank_{TP} = 27$), J.G. Yu ($Rank_{TP} = 66$), Y.H. Li ($Rank_{TP} = 98$), R.M. Barrer ($Rank_{TP} = 117$) and B.A. Manning ($Rank_{TP} = 117$), would drop out of top authors list by rank of *TP*. In particular, G.M. Whitesides, who had 41 articles in total ($Rank_{TP} = 1$) and 13 corresponding author articles ($Rank_{RP} = 4$) but no first author articles, would be omitted in terms of *FP*. Moreover, the difference between *FP* and *j* is the greatest, followed by *TP* and *RP*. If only one indicator of *TP*, *FP* or *RP* was conducted, the top list could miss some important authors who made a large contribution to adsorption field. Generally, Y-index (*j*, *h*), which takes the first author articles and corresponding author articles into consideration, could provide more fair information for evaluation.

Table 1. Comparison of top 17 authors ($j \geq 14$) using Y-index, number of total articles, first author articles and corresponding author articles

Author	Rank (*j*)	Rank (*TP*)	Rank (*FP*)	Rank (*RP*)	*h*
Ho, Y.S.	1 (31)	9 (21)	1 (21)	8 (10)	0.4444
Caruso, F.	2 (29)	6 (22)	4 (9)	2 (20)	1.148
McKay, G.	3 (26)	3 (27)	23 (5)	1 (21)	1.337
Gupta, V.K.	4 (25)	21 (15)	2 (12)	4 (13)	0.8254
Lvov, Y.	5 (22)	12 (19)	2 (12)	8 (10)	0.6947
Norde, W.	6 (18)	15 (17)	4 (9)	11 (9)	0.7854
Namasivayam, C.	6 (18)	19 (16)	4 (9)	11 (9)	0.7854
Hill, T.L.	6 (18)	80 (9)	4 (9)	11 (9)	0.7854
Hammer, B.	9 (17)	6 (22)	15 (6)	6 (11)	1.071
Aksu, Z.	9 (17)	51 (11)	8 (8)	11 (9)	0.8442
Yaghi, O.M.	11 (15)	4 (23)	632 (1)	3 (14)	1.499
Sukhorukov, G.B.	11 (15)	27 (14)	15 (6)	11 (9)	0.9828
Laibinis, P.E.	11 (15)	27 (14)	15 (6)	11 (9)	0.9828
Yu, J.G.	11 (15)	66 (10)	10 (7)	19 (8)	0.8520
Li, Y.H.	15 (14)	98 (8)	10 (7)	21 (7)	0.7854
Barrer, R.M.	15 (14)	117 (7)	10 (7)	21 (7)	0.7854
Manning, B.A.	15 (14)	117 (7)	10 (7)	21 (7)	0.7854

TP: number of total articles; *FP*: number of first author articles; *RP*: number of corresponding author articles; N/A: not available.

Figure 3 displays the distribution of the top 28 authors ($j \geq 12$) with Y-index. These 28 authors were considered to be the main contributors to the top cited articles in adsorption, who made the most contribution including conception and design, analysis and interpretation of data and the drafting or reviewing of the article (International Committee of Medical Journal Editors 1997; Wren et al., 2007). Each dot represents a Y-index (*j*, *h*). The authors who contributed the most to adsorption were Y.S. Ho ($j = 31$), followed by F. Caruso ($j = 29$), G. McKay ($j = 26$), V.K. Gupta ($j = 25$) and Y. Lvov ($j = 22$). Publication character *h* could help obtain the different proportion of first author articles to corresponding author articles. It is helpful especially when *j* of authors is too close to distinguish the different contribution of authors. For example, the *j* of J.G. Yu, G.B. Sukhorukov, P.E. Laibinis and O.M. Yaghi were all 15, but their *h* were different of 0.8520, 0.9828, 0.9828 and 1.499, respectively. Of these four authors, O.M. Yaghi had the greatest proportion of corresponding author articles to total articles. Within these 28 authors, only two authors: Y.S. Ho ($h = 0.4444$) and Y. Lvov ($h = 0.6947$) had more first author articles than the corresponding author articles. Eleven authors had $h = 0.7854$, on the boundary of 0.7854 line owning the same quantity first authors articles and corresponding author articles. The *h* of G.M. Whitesides ($j = 13$) was ∞, representing no first author articles. On this occasion, the value of *j* was equal to *RP* of Whitesides. Except this special author, 14 authors had more corresponding author articles than first author articles ($h > 0.7854$). Most top authors had more corresponding author articles than first author articles. This indicated that topmost authors contributing to the top cited articles were more likely to be designed as the corresponding authors, who probably contributed more to the initial conception and supervision of study (Wren et al., 2007).

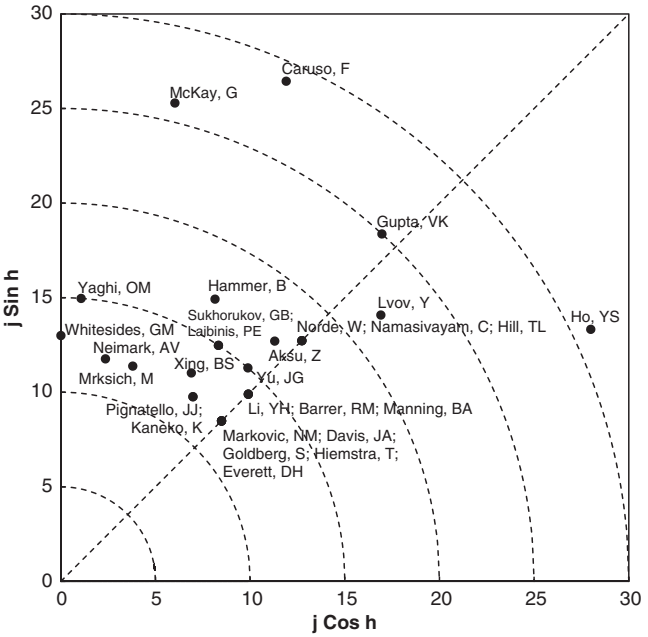

Figure 3. Distribution of top 28 authors who had $j \geq 12$.

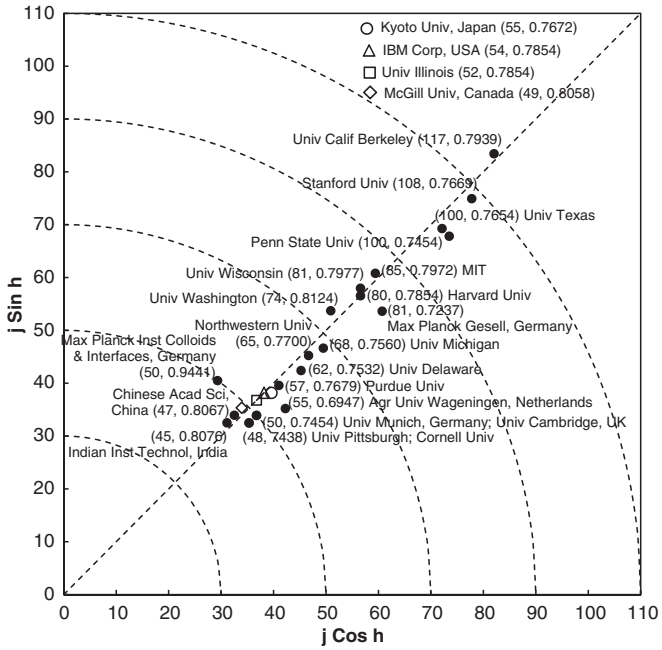

Figure 4. Top 25 institutions with the highest publication performance $j \geq 45$.

4.3 Performance of institutions

There were 1,489 institutions contributing to 4,347 articles with author affiliations in Web of Science. Within these institutions, 133 (8.9%) institutions had only corresponding author but no first author articles ($h = \infty$); 66 (4.4%) institutions had $\infty > h > 0.7854$; 999 (67%) institutions had $h = 0.7854$; and 161 (11%) institutions had $0 < h < 0.7854$. More than a half of the total institutions had the same *FP* and *RP*. With respect to *j*, 112 (7.5%) institutions had $j = 0$, with no first author articles and corresponding author articles; 1,162 (78%) institutions had $1 \leq j < 10$; 161 (11%) institutions had $10 \leq j < 30$; and 54 (3.6%) institutions had $j \geq 30$.

The institutions' ranks of *j*, *TP*, *FP* and *RP* showed slightly different orders. With respect to the top 25 institutions based on *j*, the ranks by *TP* ranged from 1 to 35, the ranks by *TP* ranged from 1 to 30 and the ranks by *RP* ranged from 1 to 23. The difference of institutions' ranks by these four indicators was much smaller than that of authors. The top 25 institutions with the highest *j* are revealed in Fig. 4. Sixteen institutions were in the USA, three in Germany, one each in Canada, Netherlands, the UK, China, India and Japan. In comparison with the authors' distribution in Fig. 3, the dots of institutions were more concentrated nearby the 0.7854 line or on the line. University of California, Berkeley ($j = 117$), Stanford University ($j = 108$), University of Texas ($j = 100$) and Pennsylvania State University ($j = 100$) with no less than 100 *j* took the leading positions. It is noticeable that Harvard University, which ranked 8th here was the most productive university by revealing the research performance of adsorption-related articles with no less than 500 citations (Fu, Wang and Ho 2012). This suggested that Harvard University had a remarkable ability to publish studies with greater influence. To be specific, eight institutions with the highest had more corresponding author articles ($h > 0.7854$), while 14 institutions had more first author articles ($h < 0.7854$). The *h* of these 25 institutions ranged from 0.6947 to 0.9441.

4.4 Performance of countries

The 4,347 articles originated from 62 countries. Within these 62 countries, except Nigeria with only one first author article ($h = 0$), and Bangladesh with only one corresponding author article ($h = \infty$), 25 (40%) countries had $h > 0.7854$, 21 (34%) countries had $h = 0.7854$ and 14 (23%) countries had $0 < h < 0.7854$. The geographical global distribution of top cited articles related to adsorption is revealed in Fig. 5 based on publication performance *j*. The 62 countries were divided into five parts. Particularly, 26 countries (42%) had *j* of 1–10, 17 countries (27%) belonged to the second part with 11–50, nine countries (17%) belonged to the third part with 51–200, nine countries (17%) belonged to the fourth part with 201–800 and only one country (the USA), which had *j* of 3,578, belonged to the fifth part with 801–3,600. Although there were only 19 countries that had the value of $j > 50$, these 19 countries contributed to ~95% of total articles.

The difference of country ranks by Y-index (*j*, *h*), *TP*, *FP* and *RP* was the smallest, in comparison with that of authors and institutions. The top 19 countries by different indicators of *j*, *TP*, FP and *RP* were the same. This may be

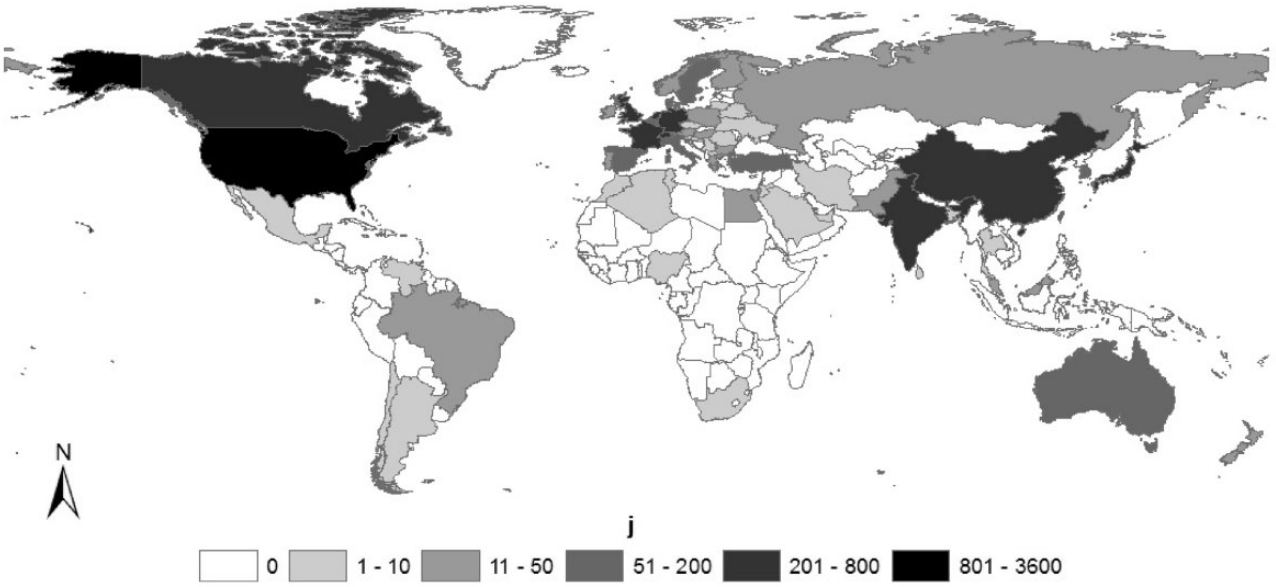

Figure 5. Global geographical distribution of top cited articles by *j*.

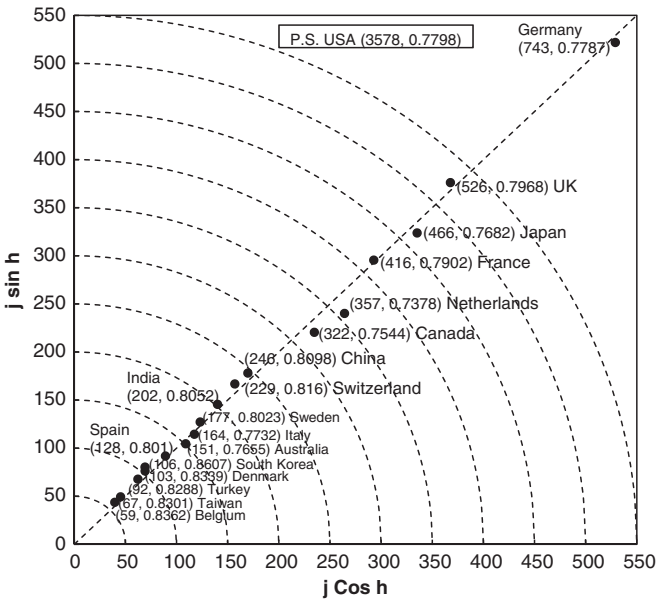

Figure 6. Top 19 countries with the highest publication performance $j \geq 50$.

due to the large size of countries and the fact that countries' outputs differed distantly. The Y-indices of these top 19 countries except the USA are displayed in Fig. 6. The USA with the highest *j* of 3,578 ($h = 0.7798$) took the leading position, followed distantly by Germany ($j = 743$) and other countries. The analysis of top cited articles with no less than 500 citations in adsorption field also found that the USA took an overwhelming majority (Fu, Wang and Ho 2012). The USA authors are more likely to quote articles from USA journals more than other countries, and reviewers tend to evaluate USA articles more favourably (Campbell 1990; Link 1998). The dots of these 19 countries were scattered in order of the number of *j* along the line. Except the USA, the country that conducted the most work is Germany, followed by the UK, Japan and France. However, Japan won the second place following the USA by analysing the adsorption-related articles with no less than 500 citations (Fu, Wang and Ho 2012). The seven major industrialized countries G7, the USA ($j = 3{,}578$), Germany ($j = 743$), the UK ($j = 526$), Japan ($j = 466$), France ($j = 416$), Canada ($j = 322$) and Italy ($j = 164$), ranked in the top 12, accounting for 75% of the total articles over the investigation period. Similarly, G7 accounted for a significant proportion exited in many researches (Fu et al., 2010; Wang, Yu and Ho 2010). The *h* of these 19 countries were in the range of 0.7378 (the Netherlands)–0.8607 (South Korea), which is more centralized than the distribution of institutions and authors. The countries that had higher values of *j* were likely to have more first author articles ($h < 0.7854$), such as the first position the USA with $h = 0.7798$, and the second place Germany with $h = 0.7787$. There were seven countries with more first author countries, while 12 countries had more corresponding author articles.

5. Conclusions

Y-index (*j*, *h*) based on FP and RP, is a helpful index to characterize the scientific output of authors, institutions and countries by being examined in the field of adsorption. By using Y-index, Y.S. Ho, F. Caruso and G. McKay contributed the most to the top cited articles in adsorption. University of California, Berkeley, Stanford University, University of Texas and Pennsylvania State University were the main contributors. Seven major industrialized

countries G7 including the USA, Germany, the UK, Japan, France, Canada and Italy dominated this field, contributing about three-fourths of the total articles, especially the USA. Topmost authors usually had more corresponding author articles, and their number of first author articles differed widely. Based on bigger size of sample than that of authors, the difference between first author articles and corresponding author articles of institutions and countries was much smaller. Single indicators were not suggested to measure the performance alone to avoid being one-sided. Y-index broadens current evaluation system with the consideration of authorship to alleviate the problem of increasing multi-authorship and unethical authorship. This indicator can be applied to examine the important contributors and look further into the contribution characters of authors, institutions and countries of other fields.

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