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A historical review and bibliometric analysis of research on lead in drinking water field from 1991 to 2007

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ABSTRACT

A bibliometric analysis based on Science Citation Index (SCI) published by Institute of Scientific Information (ISI) was carried out to identify the global research related to lead in drinking water field from 1991 to 2007 and to improve the understanding of research trends in the same period. The results from this analysis indicate that there have been an increasing number of annual publications mainly during two periods: from 1992 to 1997 and from 2004 to 2007. United States produced 37% of all pertinent articles followed by India with 8.0% and Canada with 4.8%. *Science of the Total Environment* published the most articles followed by *Journal American Water Works Association* and *Toxicology*. Summary of the most frequently used keywords are also provided. "Cadmium" was the most popular author keyword in the 17 years. Furthermore based on bibliometric results four research aspects were summarized in this paper and the historical research review was also presented.

1. Introduction

It is well known that lead (Pb), as a kind of heavy metals, is a dangerous and important environmental pollutant. Lead has been used for thousands of years and its poisoning effects have been recognized for several centuries. Lead can cause pathophysiological changes in several organ systems including central nervous, renal, hematopoietic, and immune system (Goyer, 1986; Beliles, 1994). Among these damages, a very important issue is that lead can strongly affect intelligence development of children. Many studies indicated that neurodevelopment (Fulton et al., 1987; Needleman, 1991; Chiodo et al., 2004; Surkan et al., 1993) and cognitive development (Bellinger, 1991; Garavan et al., 2000; Troesken and Geddes, 2003; Fewtrell et al., 2004) of children were adversely affected by low level lead exposure. For example, Canfield et al. found a decrease of 4.6 intelligence quotient (IQ) point corresponding to every 10 μg/dL increase in blood Pb level (Canfield et al., 2003). Lanphear et al. (2000) also found that deficits in cognitive and academic skills associated with lead exposure occurred at blood lead concentrations lower than 5 μg/dL.

The lead sources in daily life are mainly lead paint and dust (Kaplan and Shaull, 1961; Baker et al., 1977), leaded gas (Nriagu and Pacyna, 1988; Nriagu, 1990) and lead in drinking water (Dudi et al., 2005; Triantafyllidou et al., 2007). Among them, lead in drinking water is a very important lead source. In fact, for instance, in USA, the average national contribution of drinking water to blood lead is currently believed to be on the order of 7%–20% (Shannon and Graef, 1989; Guidotti, 2004).

For decades, the research related to lead in drinking water field has become a multidisciplinary field which covers a wide spectrum including studies in environmental sciences (Wasserman et al., 2004), toxicology (Adonaylo and Oteiza, 1999), water resources (Gharaibeh et al., 1998), pharmacology and pharmacy (Cohn et al., 1993), and biochemistry and molecular biology (Sewerynek et al., 1995). Although serious problems with lead pollution of drinking water were largely considered historical, some lead problems still emerged in recent years (Edwards and Dudi, 2004). Therefore, it is urgent to portray the global trend of research on lead in drinking water field in order to sustain human life.

Bibliometrics refers to research methodology employed in library and information sciences, which utilizes quantitative analysis and statistics methods to describe distribution patterns of articles with a given topic (Almind and Ingwersen, 1997), field (Campanario et al., 2006), institute (Moed et al., 1985), or country (Schubert et al., 1989). These methods have been used to investigate research trends of

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specific fields recently (Vergidis et al., 2005; Falagas et al., 2006; Kumari, 2006). In order to analyze global trends of research productivity in tropical medicine, Falagas et al. studied the contribution of different world regions to research published in main journals of tropical medicine during the period of 1995–2003 (Falagas et al., 2006). Rajendram et al. used statistic methods to describe the worldwide alcohol-related research from 1992 to 2003 (Rajendram et al., 2006). An assumption is made in these studies that the research publications of a country in a certain scientific subfield reflects its commitment to the state of science and is a reasonable indicator for research and development efforts in that field. However, traditional bibliometrics analysis in scientific research fields has two universal deficiencies: first, the original data are usually insufficient. Many studies only select several journals or categories to represent global research trends related to a certain topic (Mela and Cimmino, 1998; Klein and Hage, 2006). Second, the change in citations or publication counts of countries and organizations cannot completely indicate the development trend or future orientation of research field (Chiu and Ho, 2007). More information, closely related to research itself, i.e. source title, author keyword, keyword plus, and abstracts have also been introduced in study of research trend (Xie et al., 2008; Li et al., 2009; Zhang et al., in press).

In this study, bibliometric methods were used to quantitatively and qualitatively investigate research trends related to lead in drinking water field. A common research tool utilized by bibliometric practitioners includes the use of Science Citation Index (SCI), a searchable database of publications that is maintained by Institute for Scientific Information (ISI), Philadelphia, USA. Keywords may be inputted to SCI, followed by an evaluation of output to determine the impact of authors, institutes, countries, etc. in a particular discipline. Data is presented regarding the contribution of major regions of the world regarding research productivity, published during a 17-year period in all SCI journals. The results could provide a basis for better understanding the global development of research related to lead in drinking water field. Furthermore, based on bibliometric results, the historical research review was also presented in this study.

2. Data sources and methodology

The data were based on the online version of Science Citation Index (SCI), Web of Science. According to Journal Citation Reports (JCR), it indexes 6426 major journals with citation references across 172 scientific disciplines in 2007. Because before 1991, there is no abstract in articles, in order to use same standard, only articles published in the period beginning 1991 were discussed.

For bibliometric analysis, the online version of SCI was searched with keywords ("drinking water" or "drinking waters" or "drinkable water" or "drinkable waters" or "drinking waterborne" or drinking water or drinking waters) and (lead or Pb or leady or plumbean or plumbum) to compile a bibliography of all articles related to the research on lead in drinking water field. Because "lead" can also be used as a verb besides the meaning of metallic element, the articles were carefully screened to delete those in which "lead" was used as a verb. The final number of articles is 1305. Articles originating from England, Scotland, Northern Ireland, and Wales were reclassified as from United Kingdom (UK). Besides, the reported impact factor (IF) of each journal was obtained from 2007 JCR. Collaboration type was determined by the addresses of authors, where the term "single country" was assigned if researchers' addresses were from the same country and the term "international collaboration" was designated to those articles which were coauthored by researchers from multiple countries.

All articles referring to the research on lead in drinking water field during the past 17 years (1991–2007) were assessed with the following aspects: document type and language of publications, characteristics of publication outputs during 1991–2007, distribution of output in subject categories and journals, publication outputs of countries and institutes and author keywords analysis.

A historical review was also performed in this research. The historical method proposes that historical phenomena can be rich and complex and a better understanding can be gained by reviewing and investigating the time(s), place(s) and context(s) in which events occur and develop. The historical method was employed in investigating the research development of lead in drinking water field as documented in publications in SCI from 1991 to 2007.

3. Results and discussion

3.1. Bibliometric analysis of research on lead in drinking water field

3.1.1. Document type, publication year and language of publications

The distribution of document types identified by ISI was analyzed. Eight document types were found in total 1305 publications during the 17-year period. Article (1113) was the most frequently used document type comprising 85% of total production, followed by proceedings paper (120; 9.2%), and review (43; 3.3%). The others showing less significance were meeting abstract (9), note (8), news item (6), letter (4), and editorial material (2). Because journal articles represented the majority of document types that were also peer-reviewed within this field, only 1113 original journal articles were used for further analysis as the relevant citable items, while all others were discarded. The distribution of annual publication output is shown in Fig. 1. It is obvious that there was an increasing number of publications mainly during two periods: from 1992 to 1997 and from 2004 to 2007.

Ninety-seven percent of all these journal articles were published in English. Several other languages also appeared, containing German (8; 0.72%), French (6; 0.54%), Japanese (6; 0.54%), Spanish (5; 0.45%), Chinese (3; 0.27%), Czech (2; 0.18%), and one for each of Croatian, Polish, Rumanian, and Russian respectively. Garfield and Welljamsdorof (1992) reported that English is the main language of microbiology research, accounting for 90–95% of all SCI papers. English remains the dominant language as it is the main language in many fields (Hsieh et al., 2004; Chen et al., 2005). It could be expected that a higher percentage of English would be used because more journals listed in ISI are published in English (Chiu and Ho, 2007).

3.1.2. Publication distribution of countries and institutes

The contribution analysis of different countries/territories publications was based on journal articles in which the address and affiliation of at least one author were provided. There were 7 articles without any author address information on ISI Web of Science and the total article number for distribution analysis of country and institute publications was 1106. Among 1106 articles with author address, 989 (89%) were independent publications and 117 (11%) were internationally collaborative publications. The top 20 countries/territories were ranked by the number of total publications, including other information i.e. the number and percentage of single country articles and internationally collaborated articles, as well as first author and corresponding author articles (Table 1). The top 10 institutes in 17 year period are displayed in Table 2. USA, India, Canada, Turkey, and Germany are the top 5 most productive countries. However, from Table 2, no institute in Canada and Germany can be found. US EPA, University of North Carolina, and University Rochester are the top three research institutes. Furthermore, there are two Turkey and two India research institutions whose rank is in the top 10 research institutions.

3.1.3. Distribution of output in subject categories and journals

The distributions of subject categories are shown in Table 3. It indicates that "environmental sciences", "toxicology", and "public, environmental & occupational health" are the top 3 most popular