



Characteristics and trends of research on waste-to-energy incineration: A bibliometric analysis, 1999–2015



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ARTICLE INFO

Article history:

Received 6 February 2015

Received in revised form

21 March 2016

Accepted 1 July 2016

Keywords:

Bibliometrics

Incineration

Statistical analysis

Co-words analysis

Waste-to-energy

ABSTRACT

This study aims to provide an up-to-date contemporary bibliometric view of the waste-to-energy incineration literature and a correlative analysis of this field. Based on the bibliometric method, a statistical analysis was undertaken on papers published from 1999 to 2015 in Science Citation Index (SCI) and the Social Science Citation Index (SSCI). There were 4348 publications in the field of waste-to-energy incineration. The number of publications per year has increased steadily since 2009. China produced 15.71% of all pertinent articles followed by Japan with 11.37% and USA with 7.97%. China has played a key role in the collaboration network of 30 most productive countries and regions. In addition, the co-operation within the European countries was notable. However, China ranked first in all aspects except h-index. This means China's impact (number of citations) in this field could be further strengthened though its quantity (number of publications) was the highest. Five clusters were identified from key-words networks, i.e. Central Cluster node ("combustion"), Cluster(I) (central nodes were "fly ash", "heavy metal(s)" and "bottom ash"), Cluster(II) (central nodes were dioxin-related substances), Clusters(III) (central nodes focused on waste management), and Cluster(IV) "chemistry methods". These findings are useful for the future endeavor of waste-to-energy incineration academic research.

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1. Introduction

Renewable energy has attracted a growing attention due to global warming and rapid depletion of natural resources [1,2]. It is well recognized that municipal solid waste (MSW) is a source of renewable energy due to its composition, e.g. wood or food as biomass materials [3,4]. As one of most popular approaches, waste-to-energy incineration helps to reduce the amount of waste sent to the landfill [5,6]. Waste-to-energy incineration can not only deal with the rapid growing amount of MSW arguably due to the expansion of the population but also satisfy the demand for energy by means of heat and electricity [7,8]. This indeed forms part of renewable energy production strategies [9,10].

Last decades have witnessed the rapid advancement of waste-to-energy incineration technologies from simple open pit burning in the 1950s to waste-to-energy plants with energy recovery as current practices which is highly efficient [11].

Major concerns to waste incineration plants include the air pollutants such as dioxins and heavy metals [3]. Indeed, there were no new WTE facilities in the USA since 1996 for a decade due to environmental and political pressure [3]. However, recently waste-to-energy incineration is receiving a growing attention in many countries due to the promotion of renewable energy developments and pressure on efficient land use. In Europe, the EU waste framework directive (2008/98/EC) emphasizes energy recovery from waste [5]. Waste incinerators play a critical role for the energy supply in several northern European countries [11]. The waste-to-energy incineration was used to treat more than 30% MSW in Germany. In Asia, in the Chinese government put forward “The 12th Five-Year Plan (2011–2015)”, which specified that electricity generated from the waste incineration technologies will grow by 10%, reaching a proportion of 30% of the total energy mix in 5 years [12]. In Japan, approximately 80% of MSW is incinerated, where energy recovery has been included in a certain proportion of waste incineration plants [13]. In South Korea, the amount of energy generated from mixed wastes (incineration) contributed to more than 23% of the renewable energy production [4].

With the advancement of waste incineration and emissions control technologies, the related body of literature has grown substantially. Therefore, it is necessary to assess the development and growth of research related to the waste-to-energy incineration, especially during the past decade.

Bibliometrics provides a useful tool which quantitatively analyzes the development and growth of any specific research field [14–16]. Mathematical and statistical methods can be employed to examine various characteristics of publications such as the distributed architecture and variation patterns, which in turn reflect the status quo of the underlying science and technology [17]. Bibliometrics technique has been adopted in various energy-related fields such as alternative energy research [14], solar energy [18], and energy efficiency [19], however not on the waste-to-energy incineration. The objective of this study is to present a comprehensive analysis of publications related to waste-to-energy incineration by means of bibliometric method. As Municipal solid waste (MSW) is regarded as an important source of renewable energy, these results not only provide a better understanding of global hotspots in the specific research related to the waste-to-energy incineration, but may also provide useful information for

the broader research area of renewable energy.

2. Methods

Multiple methods were employed in order to analyze the trends and characteristics of researches related to waste-to-energy incineration. These methods are: bibliometric, social network analysis, and h-index.

2.1. Bibliometric analysis

Bibliometric method is a combination of quantitative and qualitative of analysis which involves three typical models: Bradford literature dispersion law, Lotka's law, Zipf's Law [20–22]. It adopts statistical and mathematical methods to research the distributed architecture, mathematical regularities, varying pattern and quantitative management of the information, and subsequently investigates the structure, characteristics and patterns of the underlying science and technology [23]. As one of the most important methods in the researching of library and information science and a newly developing discipline, the bibliometric technique has become one of most commonly adopted method to measure the progress in a specific scientific field [15]. The research objects can be all kinds of literatures themselves and the characteristics they reveal such as topics, authors, publication dates references, contents and so on.

Bibliometrics provides a useful tool to map the literature around a research field. It includes quantitative and visual processes to identify patterns and dynamics in scientific publications [24]. Bibliometric analysis has been guided by the objective of revealing global trends in certain areas of research [25]. The aspects of body of literature by Bibliometric method include both quantitative information (e.g. annual outputs, mainstream journals, leading countries and institutions) and qualitative data (e.g. hotspots and future research methods directions) [26].

2.2. Social network analysis (SNA)

Social network, which stems from graph theory, is a regulation or a method of analyzing social relations, focusing on the structure of relationships, ranging from casual acquaintance to close bonds [27,28]. Social network analysis is designed to model the dynamics between focus and relationships which has been employed in bibliometric related studies. SNA has been employed to highlight the relationships between various nodes in the networks. In the context of bibliometrics analysis, these nodes present countries, institutions, authors and keywords related to a specific research field. Data visualization plays a crucial role in network research. A variety of software are available to achieve the data visualization. Pajek and Gephi are two of powerful visualization tools for SNA. In this study, the academic collaboration among different countries and institutes were analyzed by using the Pajek software, and the clustering analysis of keywords were analyzed by using the Gephi software.

2.2.1. Co-word analysis

Co-word is one of the content analysis methods, which is

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