



Highly cited articles in biomass research: A bibliometric analysis



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ABSTRACT

This study aimed to identify and analyze the characteristics of highly cited biomass articles in the Science Citation Index Expanded that were published between 1900 and 2013. Articles with at least 100 citations from the Web of Science Core Collection were selected, and the following characteristics were recorded: publication year, authors, institutions, countries/territories, journals, Web of Science categories, and citation life cycles. The results show that 3407 highly cited articles were published between 1966 and 2011, and the most highly cited biomass articles were published in *Ecology*. The USA produced 49% of all highly cited articles and contributed the most single, internationally collaborative, first-author, single-author, and corresponding-author articles. All of the top 13 most productive institutions were located in the USA. In addition, the Y-index was successfully applied to evaluate the publication characteristics of authors. Authors' publication intensities for highly cited articles in biomass research and their publication characteristics were analyzed.

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1. Introduction

The number of citations has been widely accepted as an indicator of the impact of an article [1]. In general, the best articles are published in peer-reviewed journals with high impact factors [2]. In recent years, bibliometric indicators of total citations have been broadly applied to evaluate most-cited articles [3], highly cited articles [4], and classic papers [5]. Since Garfield published "Highly Cited Works in Mathematics" in 1973 [6,7], the citation

characteristics of highly cited papers has been analyzed in the fields of water resources [8], chemical engineering [9], environmental sciences [10], wetlands [11], social work [12], adsorption [13], and, in particular, medicine [14–16]. To evaluate countries, institutions, and authors, indicative categories such as independent, collaborative, first-author, corresponding-author, and single-author highly cited articles have been used [9,12]. The citation life cycles of highly cited articles are also important [17]. The citation histories of papers have been used to assess and identify characteristics of articles in water resources [18], chemical engineering [9], social work [12], psychology [19], medicine, and biochemistry [20], as well as to predict future citations on the basis of citation life cycles [21].

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Energy is very important to the world. We rely greatly on non-renewable fossil fuels such as petroleum and coal, but the combustion of fossil fuels causes greenhouse gas emissions worldwide [22]. Development of sustainable energy sources is necessary for our future energy use. The term “biomass” denotes all organic material from plants [23]. Biomass comes from land- and water-based vegetation (trees, crops, and algae) as well as all organic waste. The main components of biomass are the carbohydrate polymers cellulose $[C_6(H_2O)_5]_n$, hemi-cellulose $[C_6(H_2O)_4]_n$, and lignin $[C_{10}H_{12}O_3]_n$ [24]. Green plants convert CO_2 and H_2O to plant material with the help of sunlight through the process of photosynthesis. This process stores solar energy in the form of chemical energy in biomass. Because biomass is abundant and environment-friendly, it is extremely promising as a potential renewable energy resource.

Early biomass research began with the sea [25,26]. Biomass can produce biofuels, such as biodiesel and bioethanols. Biodiesel is produced by triglyceride feedstock from both plant and animal sources, such as vegetable oils, waste oils, and fat, through the transesterification process [27], and bioethanol is produced from starchy feedstock (including sugar) and lignocellulosic feedstock. Biomass as an alternative energy source has received considerable attention [23] because it is renewable [28].

In this study, all biomass-related journal articles with at least 100 total citations from time of publication to the end of 2013 in the Science Citation Index Expanded (SCI-EXPANDED) from 1900 to 2013 were selected and analyzed for the following characteristics: publication year, authors, institutions, countries/territories, journals, Web of Science categories, and citation life cycles. Five bibliometric indicators were used to evaluate publications from specific countries and institutions. A new indicator, the Y-index, was used to evaluate the performance and contributions of individual authors with highly cited articles.

2. Methodology

The analysis provided in this study is based on the SCI-EXPANDED database of the Web of Science Core Collection from Thomson Reuters (updated on October 31, 2014). According to Journal Citation Reports (JCR) from 2013, it indexes 8539 journals with citation references across 176 Web of Science subject categories in the science edition. The keywords biomass, “bio-mass”, biofuel, “bio-fuel”, bioenergy, “bio-energy”, biogas, “bio-gas”, biooil, “bio-oil”, biohydrogen, “bio-hydrogen”, biomethane, biomethanation, biomethanol, biomethanization, biomethanator, biomethanogenesis, biomethanated, biomethanization, bio-methane, bio-methanated, bio-methanator, bio-methanization, bio-methanol, bio-methanation, bioethanol, “bio-ethanol”, biobutanol, “bio-butanol”, biodiesel, “bio-diesel”, biogasoline, “bio-gasoline”, biorefinery, biorefinement, biorefining, biorefiners, biorefine, biorefining, biorefineries, biorefinary, biorefinely, “bio-refinery”, “bio-refineries”, and “bio-refining” were searched for in the topic field (including title, abstract, author keywords, and *KeyWords Plus*) in the Web of Science Core Collection from 1900 to 2013. We identified a total of 187,407 documents of 19 document types, including articles, proceedings papers, reviews, meeting abstracts, news items, editorial materials, notes, letters, corrections, book chapters, book reviews, reprints, discussions, additional corrections, biographical items, bibliographies, software reviews, and abstracts of published items. *KeyWords Plus* supplies additional search terms extracted from the titles of articles cited by authors in their bibliographies and footnotes in the ISI (now Thomson Reuters, New York) database, and substantially augments title-word and author-keyword indexing [29]. Only the document type “article” was considered. Two additional filters, TC_{2013} [8,18] and

the front page [30], were employed to retrieve articles. Because citations’ invariance will not be updated, TC_{2013} was applied [30]. The articles selected by $TC_{2013} \geq 100$ were deemed highly cited articles. The total number of times an article was cited from its publication until the end of 2013 was recorded as TC_{2013} [8,18]. The other filter, the front page, was used to identify articles with the indicated keywords on their front page, including the article title, abstract, and keyword section [30]. Articles that could be found only through *KeyWords Plus* were excluded. Ultimately, 3407 articles (1.8% of the 187,407 total articles) were selected as highly cited articles. These records were downloaded into spreadsheet software, and additional coding was manually performed using Microsoft Excel 2007 for calculation.

Articles from Hong Kong after 1997 were included in China [8]. Articles from Germany and “Fed Rep Ger” were, after manual inspection, reclassified as being from Germany [9]. Yugoslavia and Serbia were reclassified as Serbia. Czechoslovakia and the Czech Republic were reclassified as the Czech Republic [31]. In the SCI-EXPANDED database, the corresponding author is labeled as the reprint author; in this study, this person is identified as the corresponding author. In a single-author article for which authorship is not specified, the author is classified as both the first author and the corresponding author [9]. Similarly, in a single-institution article where affiliation is not specified, the institution is classified as both the first author’s and the corresponding author’s institution. If one author was assigned as the first author of an article, that article was considered a “first-author article” by that author, and if one author was assigned as the corresponding author of an article, that article was considered a “corresponding-author article” by that author. In terms of country/territory or institution, the term “first-author article” was assigned if the first author was from the country/territory or institution under analysis, and the term “corresponding-author article” was assigned if the corresponding author was from the country/territory or institution under analysis. *TP*, *FP*, and *RP* are the numbers of “total articles”, “first-author articles”, and “corresponding-author articles” for a country/territory, an institution, or an author, respectively.

3. Results and discussion

3.1. Publication year

A total of 3407 highly cited biomass related articles ($TC_{2013} \geq 100$) were published in SCI-EXPANDED. The articles were published between 1966 and 2011. The maximal value of TC_{2013} was 3335, and the average value was 177. Fig. 1 illustrates the distribution of these 3407 highly cited articles over decades, and their citations per publication ($CPP = TC_{2013}/\text{year}$). Time is necessary to accumulate citations. No highly cited articles have yet emerged in the most recent two years (2012–2013). However, only 6.1% of the highly cited articles were published before the 1990s, and 44% and 49% of the highly cited articles appeared in the 1990s and the 2000s, respectively. Thus, time may not be a significant reason that an article is highly cited. In particular, the decade of the 1970s, with 41 articles, had the highest *CPP* (285), which can be attributed to the articles entitled “Physiological method for quantitative measurement of microbial biomass in soils” [32] by Anderson and Domsch in 1978, with a TC_{2013} of 1579, and “Effects of biocidal treatments on metabolism in soil. V. Method for measuring soil biomass” [33] by Jenkinson and Powlson in 1976, with a TC_{2013} of 1498. The *CPPs* of the other five decades ranged from 147 in the 2010s to 285 in the 1970s. The earliest highly cited article, published in 1966, is entitled “Studies on decomposition of plant material in soil. II. Partial sterilization of soil and soil biomass” [34] and has a TC_{2013} of 182. The most recent highly cited article, “Driving forces enable high-titer anaerobic

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