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PAPER

MODERN RESEARCH AND ANALYSIS OF WATER-COAL ALTERNATIVE FUELS

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Abstract

This article analyses scientific publications related to alternative fuels obtained from biomass pyrolysis and coal-water fuel technologies, using the Web of Science international database and the keywords "alternative fuel" and "coal-water fuel". The search queries "Alternative Fuels AND Coal-Water Fuel" and "Coal AND Water AND Fuel AND Alternative Fuels" were used to identify scientific articles published or scheduled for publication between 1988 and 2027. The types of articles, the leading authors in terms of publication activity, the contributing countries and the main research directions were determined, and the dynamics of scientific and practical activity in this field were analysed. The results show that the number of scientific publications on alternative fuels derived from biomass pyrolysis has increased significantly over the past decade, indicating active research by leading countries and authors. Additionally, coal-water fuel technologies, including their preparation methods, efficient combustion processes, and potential use as environmentally friendly energy sources, were identified as promising areas of research.

Key words: Alternative fuels, Biomass pyrolysis, Coal-water fuel, Bibliometric analysis, Energy efficiency.

Introduction

The role of coal in ensuring national energy security is currently being reassessed worldwide. An increased proportion of coal in the fuel–energy balance is seen as a stabilising factor in the event of severe energy crises. However, the environmental challenges associated with conventional coal combustion mean that energy-efficient, environmentally friendly, coal-based alternative fuels must be developed and implemented. In this context, coal-water slurry fuel offers a promising approach [1-5]. At the same time, introducing hybrid autonomous heat supply systems based on renewable energy sources is an effective alternative to conventional autonomous heating systems. Ensuring the continuous supply of such systems with combined coal–water alternative fuels is also

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important to address existing challenges, as this can enhance reliability, energy efficiency, and environmental performance [6-9].

Materials and methods

Scientific publications using the keywords "alternative fuels" and "coal-water fuel" were identified and analysed from the Web of Science database. At the same time, additional publications were identified using the keywords "coal", "water", "fuel" and "alternative fuels" to find articles dedicated to new research approaches (20.02.2026). Based on the collected data, the number of publications, the countries and authors contributing to this field and the types and areas of publications were analysed. Additionally, alternative fuels obtained from biomass pyrolysis, technologies and methods for preparing coal-water fuel, the combustion process and its energy efficiency, and the associated types, advantages and disadvantages were identified. A "Literature Analysis" was then conducted on the selected articles.

Results and discussions

Figure 1 presents the results of the analysis of data identified through an open search of the Web of Science database. It shows the number of publications identified by keywords such as "Alternative Fuels and Coal-Water Fuel", the authors who published the most research papers, and the percentage share of countries researching alternative fuels obtained from biomass pyrolysis between 1988 and 2027. The bar chart illustrates the growth trend in the number of publications over the years, primarily comprising scientific research conducted between 1988 and 2027. According to the analysis results, the number of articles on alternative fuels has increased sharply since 2004 and has grown rapidly since 2010. The pie chart in Figure 1 shows the distribution of publications by type: articles account for 71% (48,165) and proceedings papers for 15% (10,136). Between 1988 and 2027, a total of 64,862 articles and other publications on alternative fuels obtained from biomass pyrolysis were published or are planned to be published by scientists worldwide.

Figure 2 shows the authors who have published the most scientific research papers on the topic

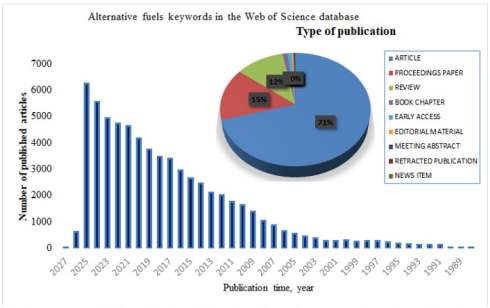


Figure 1. Articles published in the Web of Science database for alternative fuels and their types (between 1988 and 2027).

of "Alternative Fuels" in the Web of Science database, along with the number of articles they have published.

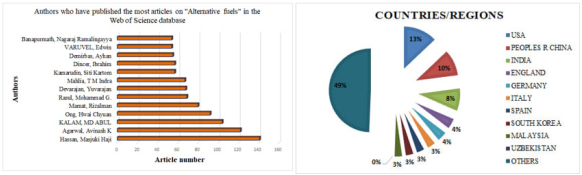


Figure 2. Ranking of authors and countries that published the most scientific articles on the topic of "Alternative fuels" in the Web of Science database (1988-2027).

Figure 2 shows the scientific contributions of researchers from different fields related to "alternative fuels", based on Web of Science database data. The analysis shows that Hassan Masjuki Haji is one of the most active authors in the field of alternative fuels derived from biomass pyrolysis, leading with 141 published scientific articles. He is followed by Avinash K. Agarwal (122 publications), Md Abul Kalam (104 publications), Hwai Chyuan Ong (92 publications) and Rizalman Mamat (80 publications).

Significant contributions have also been made by Rasul Mohammad, Devarajan Yuvarajan, Mahlia T. M. Indra, Siti Kartom Kamarudin, Dincer Ibrahim, Ayhan Demirbas, Edwin Varuvel and Nagaraj R. Banapurmath, whose research activities have substantially advanced the field.

Figures 1 and 2 illustrate that research on 'alternative fuels' has been recorded in the Web of Science database since 1988. The United States leads in terms of country contributions with 13% (11,356 publications), followed by China with 10% (8,854 publications), India with 8% (7,436 publications), the United Kingdom with 4% (3,451 publications) and Germany with 4% (3,234 publications). Uzbekistan accounts for 0.0007% (43 publications), while other countries collectively

contribute 49% (43,473 publications).

Figure 3 presents the analysis of data obtained through an open search in the Web of Science database. This includes publications identified using the keyword 'coal-water fuel' between 1988 and 2026. The analysis focuses on research related to coal–water slurry fuels containing biomass-derived alternative fuels, various mixtures, coal powder, water, plasticisers, oil sludge and waste oils at different concentrations. The figure provides information on the number of publications, the most productive authors, and the distribution of contributing countries as a percentage.

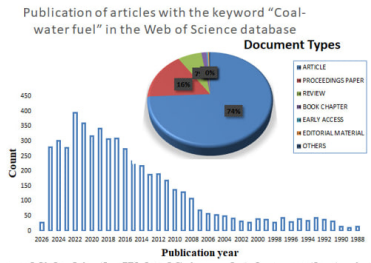


Figure 3. Articles published in the Web of Science database on the topic "Coal-water fuel" and their types (between 1988 and 2026).

Figure 3 shows an increasing trend in the number of publications over the years, mainly covering the period from 1988 to 2026. According to the analysis, the number of publications related to "coal-water fuel" began growing in 2008, showing a particularly sharp increase after 2014. However, a decline in the number of published studies can be observed after 2022. Figure 3 also shows a pie chart illustrating the distribution of publications by type. Journal articles account for 74% (4,171 publications), while proceedings papers account for 16% (918 publications). A total of 5,279 scientific publications and related documents on coal-water fuel were published worldwide between 1988 and 2026.

Figure 4 presents information from the Web of Science database on the authors who have published the greatest number of scientific papers on coal-water fuel, as well as the countries in which these studies were conducted and published.

Figure 4 illustrates the scientific contributions of researchers from various fields related to the topic of "coal-water fuels", based on data from the Web of Science database. The analysis indicates that Strizhak Pavel A. is one of the most active authors

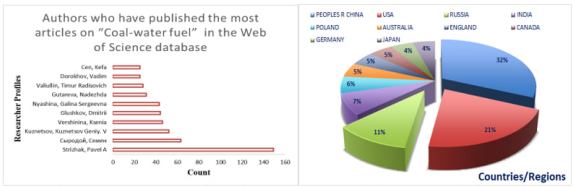


Figure 3. Ranking of authors and countries that published the most scientific articles on the topic "Coal-water fuel" in the Web of Science database (between 1988 and 2026).

in the field of coal–water slurry fuels, which are composed of alternative fuels derived from biomass pyrolysis, various mixtures, coal powder, water, plasticisers, oil sludge and waste oils in different concentrations. He leads with 149 published scientific articles. He is followed by Syrodoy Semyon (63 publications), Kuznetsov Geniy (52 publications), Vershinina Ksenia (46 publications) and Glushkov Dmitrii (44 publications).

Figures 3 and 4 show that research on "coal-water fuels" in the Web of Science database has primarily been conducted since 1988. In terms of country contributions, China is in the lead with 32% (1,360 publications), followed by the United States with 21% (905 publications), Russia with 11% (471 publications), India with 7% (319 publications) and Poland with 6% (249 publications).

Conclusions

Analysis of publications indexed in the Web of Science database on the topics of "alternative fuels" and "coal-water fuels" indicates that alternative fuels obtained from biomass pyrolysis, as well as coal–water slurry fuels prepared from coal, water, alternative fuels, plasticisers and various mixtures with different concentrations, represent an important and rapidly developing area of scientific and industrial research. Research findings demonstrate that developing such fuels and their production technologies significantly improves the efficiency of energy systems, facilitates the recycling of waste materials and creates environmentally sustainable "green" energy sources.

In future, this area of research is expected to prioritise scientific and applied studies aimed at enhancing energy efficiency across relevant industrial sectors, optimising combustion processes and their operational parameters, and developing environmentally safe and resource-efficient technologies.

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