Visual Analysis for the Domestic and Overseas Research on the Disposal of Construction Wastes

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ABSTRACT

The disposal of construction waste has great significance for social modernization and is a vital issue during urbanization, an inevitability to realize a circular economy and emphasize ecological benefits. This paper illustrates co-occurrence as well as year-over-year change graphs based on keywords of the disposal of construction wastes and studies the spatial distribution from the co-occurrence graphs by institutions and individuals through CNKI and the Web of Science as search engines for kinds of literature. Using the literature between the years of 2000 and 2020 as sample data, the technique and tools of Cite Space to conduct a visual analysis of the data searched and filtered. Besides, this paper offers some proposals concerning more scientific and systematic research on focuses, perspectives, and analytical tools in this field in the future.

Keywords: disposal of construction wastes, domestic and overseas, visual analysis, knowledge graph

1. INTRODUCTION

Construction wastes, of which 80% of them are harmless solid waste, are materials produced during the process of construction, renovation, and demolition of a building. This includes concrete, rebars, packaging, and bricks, which occupy around 30% to 40% of the total urban wastes. Domestic and overseas researches prove that the disposal of utilizing construction wastes is a crucial issue in a circular economy, which accelerates its recycling. Countries find themselves confronted by practical, urgent, and massive issues concerning "whom to cope with" as well as "how to cope with" wastes. Thus the full development of a circular economy, the establishment of creating the awareness of utilizing wastes, and encouragement and guidance of recycling wastes. This results in the inevitable need to dispose of wastes and importance to promote urban construction. Particularly in China, advanced concepts can industrialize the disposal of wastes, enhance its techniques, optimize processes, facilitate the coordination of its disposal, and study during the new period of improvement of infrastructure construction and urban-rural integration [1-3]. In the new normal of China's economy, the disposal of construction of wastes is gradually showing its tendency and results in the building field closely related to social development.

Foreign countries such as Britain, America, France, Germany, etc. already formed a systematic plan of disposal. Domestic scholars also give considerable attention to this based on the fact that there is a buoyant demand in infrastructure construction, renovation, the real estate market, and renewal and demolition of old residential areas, and the fact of high production of wastes.

To avoid the one-sidedness of traditional research literature, this study adopts the tool of information visualization from Cite Space to systematically analyze and explore the developing path of domestic and overseas study and experiences through the literature on construction wastes. Besides, this study provides further reference theoretically and practically.

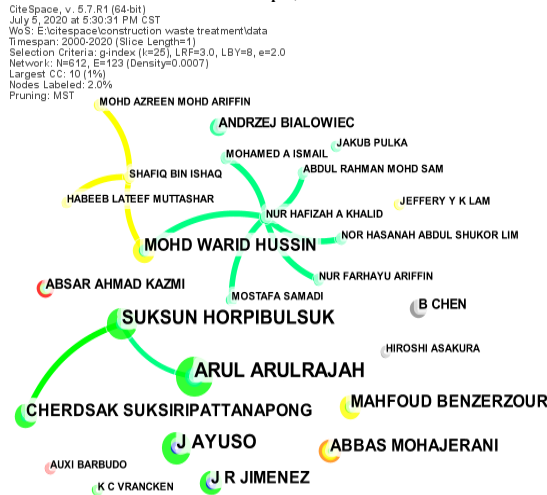## 2. SOURCE OF DATA AND RESEARCH METHODS

According to the database from CNKI and the Web of Science, this study sorts out domestic and overseas research on disposal of construction wastes, popular topics, and the orientation of its study. By the advanced search of "disposal of construction wastes" in the CNKI database, 762 kinds of literature and 62 core theses from the year 2000 to 2020 have been found [4-6]. By reading the abstracts, some inconsistent results as booklists, the minutes of meetings, professional advertising, and news reports have been taken out. Eventually, 376 journal kinds of literature have been selected as samples of the study of disposal in the recent 20 years. By the search of "construction waste treatment" as the topic in the WOS database from 2000 to 2020, 1892 kinds of literature have been found, in which each has the record of the author, institution, and keywords. Eventually, 1462 pieces of literature have been selected as the samples in WOS in the recent 20 years without conference literature, editorials, book reviews, and comments of articles. Through Cite Space, this study illustrates visual graphs, combining the quantitative analysis with qualitative analysis. It also has further analysis of the graphs, explores the crucial pieces

of literature and the evolutionary dynamic, and finds the tendency and the popular topics.

3. KNOWLEDGE GRAPH AND ITS ANALYSIS

3.1. Spatial Distribution Graphs

To be aware of the core authors in this field, the graphs illustrate their collaborative relationships, in which the size of the label represents its centrality and lines represent the relationship. The type of the node in this study is the author. Domestically 424 author nodes and 181 lines form a co-occurrence visual graph in the density of 0.002. Yang Xiaohua and Chen Jialong, who have published more literature, focus on "the disposal of construction wastes". Overseas 612 author nodes and 123 lines form a co-occurrence visual graph in the density of 0.0007. Arul Arulrajah and J Ayuso have published more literature. (Figure 1)
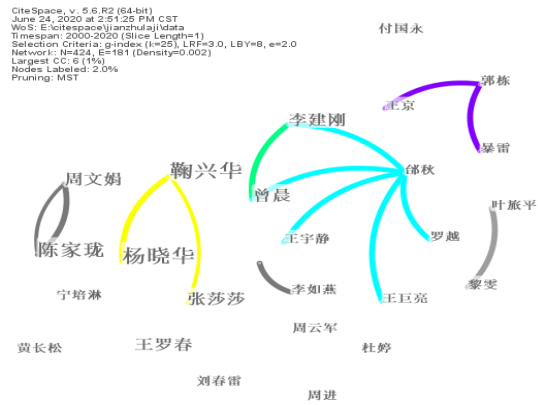

Figure 1 Graphs of collaborative relationships of domestic and overseas authors (Main Part)

To further study the relationship between institutions, the graph illustrates it. (Figure 2) Domestically, 325 nodes and 60 lines in the density 0.0011 represent China has rather less co-operation in this field with scattered groups and has not formed a cohesive scientific research group. Overseas, 570 nodes, and 192 lines in the density of 0.0012 indicate a similar result to China [7]. Within the scope of the whole global periodicals, the Chinese Academy of Sciences ranks the first with 24 pieces of literature published, successively followed by the Hong Kong Polytechnic University, Tongji University, University of Cordoba, Hunan University, and Technical University of Denmark, of which their numbers of published pieces of literature are all over 10. China has more institutions from the picture and it tops the graph in the volume of published literature. Both China and foreign countries occupy 4 institutions in the top eight research institutions.

Figure 2 Graphs of collaborative relationships of domestic and overseas research institutions (Main Part)

3.2. Popular Topics

From the angle of the flow of knowledge, relative popular topics spring up, in which the keywords indicating the topic appear repeatedly. Therefore, high-frequency "keywords" are the sign of related research. The theory of co-word analysis believes the bigger are the nodes of keywords in the co-occurrence graph, the more are the researches in this field, also the more important. As picture 3 shows, domestically high-frequency keywords related to the disposal of constructions wastes are "construction wastes", "utilizing", "recycling", "recycling construction wastes", "recycled aggregate", "circulating utilization", "reduction", etc. in the density of 0.0071. Overseas literatures mainly focus on "construction", "management", "system", "sustainability", "behavior", "concrete", "solid waste", "wastewater treatment" is the density of 0.0015. Domestically, the nodes in high centrality are "construction", successively followed by "utilizing", "recycling", "recycled aggregate", "circulating utilization", etc. compared with "construction", followed by "wastewater treatment", "management", "system", "sustainability", "behavior", etc. By contrast, domestic

researches focus more on the present situation of the disposal of construction wastes, utilizing, recycling, and circulating utilization in an external view. Overseas researchers focus more on the disposal itself in an internal view of the node naming as "management", "system", "behavior". Different views signify they have different logical initial points, with the supply side domestically and the demand side overseas. Compared with studying authors and institutions, the co-occurrence network of keywords has structurally changed dramatically with a low density and a loose structure
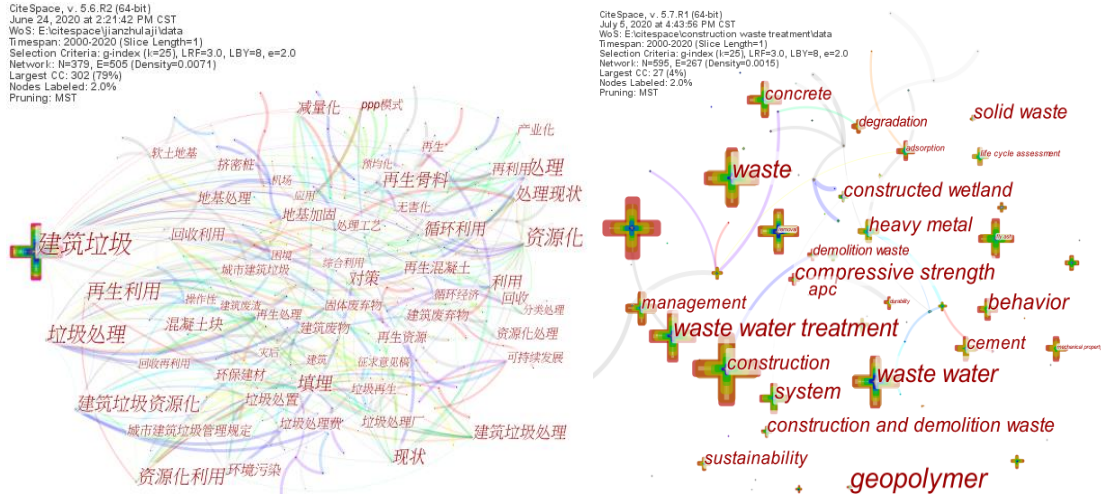
Figure 3 Graphs of the co-occurrence frequency of domestic and overseas key words

3.3. Leading Edge and Tendency

In the domestic researches of disposal of construction wastes from 2000 to 2020, the keywords with the highest degree of emergence are "disposal of wastes", followed by "resource utilization" and "present situation of disposal". Overseas it is "system" and "management", etc., which indicates the attention degree of the inevitable industry of "systematism" and "management" ability during the social modernization as for the disposal, which is also identical with the research of internal view previously mentioned.

To get a better understanding of the research tendency of the disposal of construction wastes, the keywords time zone view illustrates the tendency of the popular topics of the disposal in the recent 20 years and further shows the development pattern of literature. In the graphs, the bigger is the radius nodes, the higher is the frequency.

The development path of the researches of disposal of construction wastes is as follows: first, from 2002 to 2006, is in the embryo and outbreak stage, involving landfill, circulating utilization, and utilizing. The second stage, from 2006 to 2012, involves a component analysis of construction wastes, business management, and reduction. Simultaneously it continued early study, including recycling and utilizing construction wastes. The third stage is from 2013 to 2016. From 2013 to 2014 the study mainly focused on utilizing and urban construction wastes, which had dense matches, representing the close research relationship. The fourth stage is from 2017 to 2020, involving industrialization, green buildings, the PPP pattern, dehydration, informatization management, etc. which indicates the technical progress of disposal of construction wastes, the change of concepts of the disposal, the use of the information technology, etc. These four stages have not only witnessed the development of the field of the disposal of construction wastes but also shown the elementary process of the research of "disposal of construction wastes". Along the path, the study has experienced from the initial stage of a rough landfill to the stage of the macro utilizing and circulating utilization under the national strategy, and to the specific micro practice as treatment techniques, sorting treatment and reduction from the source. Especially after 2013, the study focused on utilizing and reduction, i.e. construction wastes themselves, and industrialization, information management, and green buildings, in a trend gradually from study topics to the internal view.

The overseas time zone graph demonstrates that the extensive study centralized, but the key words varied in a different time. Between 2000 and 2005, the topic words are "behavior", "environment", "management", "leaching", "recycling", "concrete", "construction and demolition waste", etc. From 2006 to 2011 high-frequency words of co-occurrence as "road construction", "aqueous solution", "energy", "strength" occurred. From 2012 to 2016 these topic words gained attention as "reuse", "cycle assessment", "municipal solid waste", "design", "growth", "recycled aggregate", etc. Between 2017 and 2020 topic words as "circular economy", "system", "nanocomposite", "methylene blue", "ion exchange", etc. were popular. Compared with the domestic trend, overseas study shows it from the macro direction to micro implementation before the assessment of the implementation effect, along with the keywords from behavior to management and techniques, and application, from systematic management to assessment, and the policies and techniques. It focused on the design again at the system level, then techniques, and then policy evolvement. Both macro and micro aspects influenced one another and took turns to appear, which is different from the domestic change from macro to micro trend.
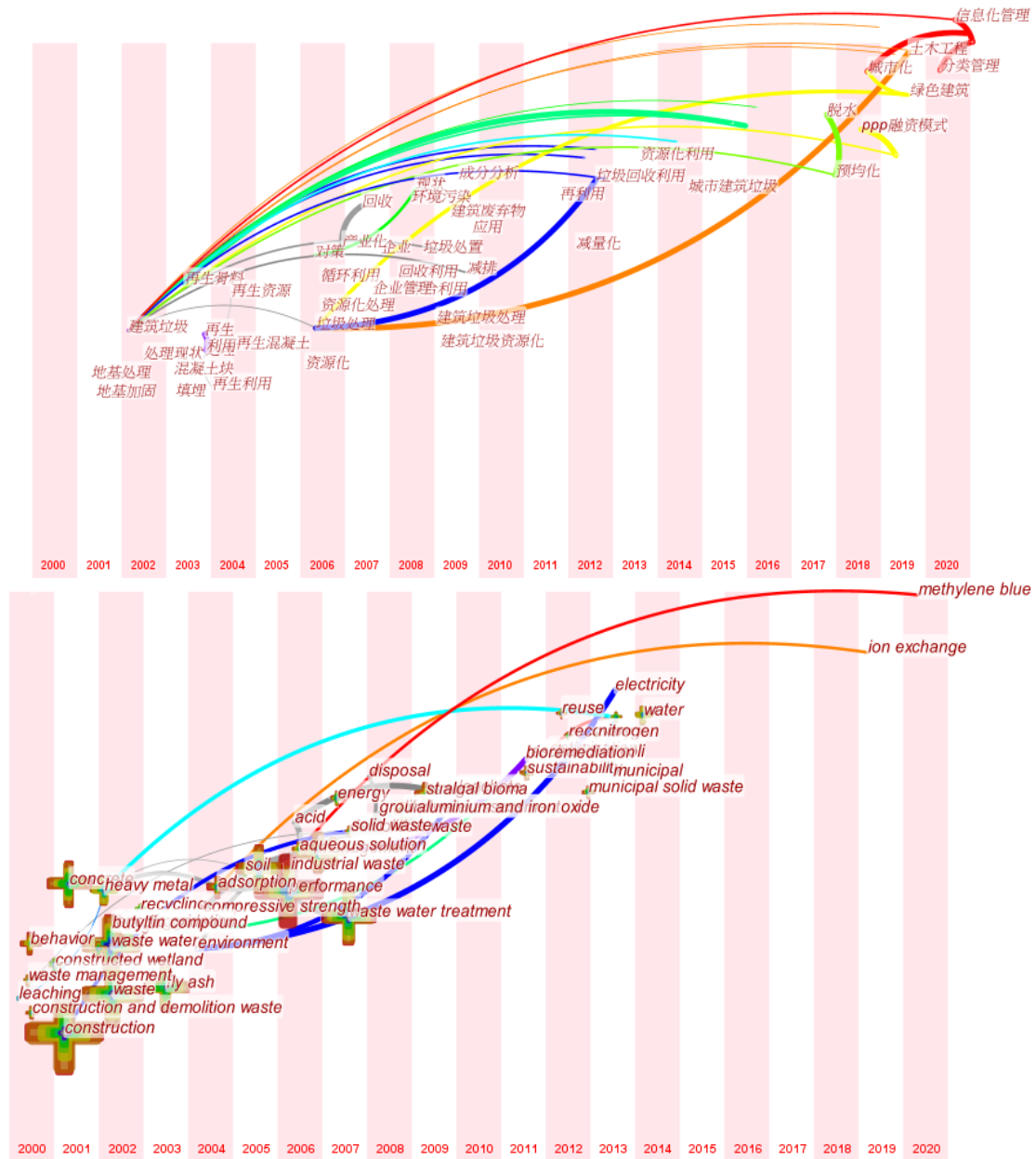
Figure 4 Time zone graph of domestic and overseas key words

4. CONCLUSION AND REFLECTION

This study sorts out the knowledge graphs using the software of Cite Space according to the literature on the disposal of construction wastes between 2000 and 2020. The databases of CNKI and the Web of Science analyzes the data in different layers and dimensions, and concludes as follows:

(1) Visual graphs of co-occurrence of keywords: the popular topic words of the research of the disposal of construction wastes, except the study object construction

waste treatment, have multiple topics, in which macro ones are common domestically, and micro ones are overseas. In future studies, scholars may focus on the concentrated topic to have an intensive study in its field, avoiding scratching the surface.

(2) Visual graphs of spatial distribution: first, many institutions have taken part in the study of the disposal of construction wastes, along with the increasing number of researchers, but without enough cooperation among institutions and influential groups. Thus, researchers and scholars need more cooperation between regions and between IUR. As for the social system engineering of the

disposal of construction wastes, top-level design needs to be combined with the present situation under the guidance of policies. With the long-effect mechanism, the longitudinal focus of the study, full cooperation of research groups, the mainstream research orientation, the study on the disposal will gradually switch from the macro aspect to the micro aspect. Second, domestic research institutions occupied a major proportion in the foreign periodicals, which demonstrates Chinese authors' capacity for scientific research and their demand. In recent 20 years, a large number of infrastructure constructions, urbanization, the renewal of old residential areas, a buoyant demand in the real estate market, and the new rural construction have led to a great number of construction wastes, which cause the synchronous study on the disposal by scholars as society moves on. Last, some foreign periodicals represent the leading edge of a certain field to some extent. Since China has more literature on the field of disposal of construction wastes, in the later stage of studying, they may expedite the implementation of utilization, industrialization, and harmlessness in China based on the advanced concepts and techniques of researchers.

(3) Visual graphs of time zones: the disposal of construction wastes is of great significance theoretically and practically, which can be traced back to the year 2002. After the embryo and outbreak stage from 2002 to 2006, it received more attention from 2013 to 2020 and focused on a few most popular topics. On account of some differences between domestic study and overseas study, from the micro aspect to the macro aspect and then vice versa, they come together and supplement each other. Both domestically and overseas, the visual graphs of timezones illustrate many types of research, but with a single study field, method, and angle.

According to the present research, some problems in the research of the disposal of construction wastes are: the perspective of the content as most studies by scholars are regionally explored. Simple summaries of the present situations, problems, reasons, and methods, don't conform to a specific model as the data is strongly affected by the region. From the data provided, most scholars did not classify the research subject, which led to the one-sidedness of the disposal. When looking at the tools and analysis, general descriptive analysis, and professional technical analysis, the data shows a lack of effective comments on the study of the disposal, as well as the scientific evaluation methodology in the ecological benefits. Thus human resource management and economic development will help with the study and the inter-discipline co-operation to draw more attention to the disposal of waste from scholars of management and economics. In the angle of the content, the new system of the disposal will be realized (by subsidies and tax reduction to attract social capitals; by accelerating the building of the smart research system and adding the disposal of construction wastes into a credit system in companies) with a clear demand of the disposal process, classified treatment from the source, all-round co-governance, the disposal pattern in the view of ecological

benefits, and new concepts of ecological civilization. In the meantime, applying new techniques (as cloud computing and big data) is beneficial to realize a win-win pattern of governance and further enhance the scientific and systematic disposal of construction wastes.

The disposal of construction wastes is an inevitable product as society moves on, of which its study and development need to be combined with China's condition to improve. As the study of the disposal is gradually perfected, a deeper study and application will become a critical topic during China's transformation and development. Thus being more detailed and profound in the future.

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