Bibliometric Analysis of The Relationships Between Glass, Buildings and Radiation: A VOSviewer Examination of Web of Science Data

İlhami AY [1]*, Sema BEKLER [2], Barış BEKLER [3], Murat DAL [4]

ORCID 1: 0000-0002-3506-3234, **ORCID 3:** 0009-0002-5908-6390

ORCID 2: 0009-0002-2152-2767, **ORCID 4:** 0000-0001-5330-1868

[1] *Hakkari University, Çölemerik Vocational School, Department of Architecture and Urban Planning, 30000, Hakkari, Türkiye.*

[2, 3] *Munzur University, Institute of Postgraduate Education, Department of Cultural Arts Management, 62000, Tunceli, Türkiye.*

[4] *Munzur University, Faculty of Fine Arts, Design and Architecture, Department of Interior Architecture Design, 62000, Tunceli, Türkiye.*

* e-mail: ilhamiay@hakkari.edu.tr

Abstract

This study conducts a bibliometric analysis of academic works obtained from the Web of Science (WoS) database using the keywords "radiation," "glass," and "building." Utilizing the VOSviewer software, the study identifies the distribution of these articles by year, language, publication type, and the most influential authors, countries, institutions, and sources. Based on data from 913 articles, the keyword analysis reveals the most commonly used concepts in the field and the relationships between them. The evolution of these key terms over time is also examined. According to the analysis, "solar radiation", "window", and "glass" emerged as the most frequently used terms, closely related to topics such as energy efficiency, thermal performance, and natural ventilation. This research highlights the development of academic literature focused on the relationships between radiation, glass, and buildings and identifies the key research trends in this domain. The findings suggest a growing interest in scientific research on energy efficiency and building materials.

Keywords: Bibliometric analysis, building, glass, radiation, VOSviewer.

Cam, Binalar ve Radyasyon Arasındaki İlişkilerin Bibliyometrik Analizi: Web of Science Verilerinin VOSviewer İle İncelenmesi

Öz

Bu çalışma, Web of Science (WoS) veri tabanından "radyasyon", "cam" ve "bina" anahtar kelimeleri kullanılarak elde edilen akademik çalışmaların bibliyometrik analizini yapmaktadır. VOSviewer yazılımını kullanan çalışma, bu makalelerin yıllara, dile, yayın türüne ve en etkili yazarlara, ülkelere, kurumlara ve kaynaklara göre dağılımını belirlemektedir. 913 makaleden elde edilen verilere dayanan anahtar kelime analizi, alanda en sık kullanılan kavramları ve bunlar arasındaki ilişkileri ortaya koymaktadır. Bu anahtar terimlerin zaman içindeki gelişimi de incelenmiştir. Analize göre, "güneş radyasyonu", "pencere" ve "cam", enerji verimliliği, termal performans ve doğal havalandırma gibi konularla yakından ilişkili olarak en sık kullanılan terimler olarak ortaya çıkmıştır. Bu araştırma, radyasyon, cam ve binalar arasındaki ilişkilere odaklanan akademik literatürün gelişimini vurgulamakta ve bu alandaki temel araştırma eğilimlerini tanımlamaktadır. Bulgular, bilimsel araştırmalarda enerji verimliliği ve yapı malzemelerine yönelik ilginin zaman içinde arttığını göstermektedir.

Anahtar kelimeler: Bibliyometrik analiz, bina, cam, radyasyon, VOSviewer.

1. Introduction

Glass materials have been used in many areas from the past to the present. The reason for this is the transparency of glass, its acid resistance to attack, reasonable resistance to thermal shocks, high mechanical strength, and recycling (Akyildirim et al., 2020; Bagheri et al., 2017; Kavaz et al., 2019). In addition, easy access to raw materials, flexibility in composition, and advanced melting and forming techniques have encouraged glass researchers to conduct further studies on radiation shielding needs (Karasu et al., 2017; Kaur et al., 2016; Kumar et al., 2020; Kurtulus et al., 2021).

Glasses offer unique advantages such as transparency, easy synthesis, and a wide variety of compositions. Glass-ceramics are materials that combine the properties of both glass and ceramics. In the crystallization process of the main glass system, the temperature rises above the crystallization temperature. The name of the glass-ceramic material is given depending on the type of glass used in its production (for example, when silicate glass is used, a silicate glass-ceramic system is formed) (Mahmoud et al., 2019; Sayyed et al., 2022; Shang et al., 2021).

High-performance concrete and its varieties, developed in the last few decades, are widely used among other protective materials. However, neither concrete nor lead are required for certain applications. Since it can provide transparency, this has led to the development of glass protective materials (Aygun et al., 2021; Gokce et al., 2018; Obaid et al., 2018)

With developing technology, the number of applications in which radiation sources are used has increased (Al-Buriahi et al., 2020; Al-Hadeethi & Sayyed, 2020b; Sayyed et al., 2019). Space travel, agriculture activities, sterilization facilities, non-destructive testing methods and medical centers that are, radiation intensive are among the main areas where it is used (Abdel Maksoud et al., 2022; D'Souza et al., 2020; Deliormanlı et al., 2021; Sallam et al., 2020). However, radiation carries serious irreversible risks makes for human health. Depending on factors such as intensity, duration and distance, skin burns, cell damage, gene mutations and even dangers such as cancer may arise (Al-Hadeethi & Sayyed, 2020a; Ashok et al., 2018; Malidarre et al., 2020; Tekin et al., 2019). Therefore, balancing the widespread use of radiation with health risks the use of protective materials is mandatory. In this context, scientists have been using X-rays and the search for high-performance absorbing materials that can attenuate photon energies such as gamma-rays (Al-Hadeethi et al., 2019; Sayyed et al., 2018; Sayyed et al., 2020). In this context, the use of glass materials as a potential radiation shielding solution has attracted great interest over the last ten years.

The study used metadata from academic studies on radiation, building and glass. Conducting bibliometric analysis constitutes the main purpose of the study. This approach is based on the keywords, journals, and publications by examining how it is addressed in the literature from a broad perspective, provides an in-depth analysis of variables such as authors and collaborations. This type of bibliometric analysis aims to identify existing gaps in the literature and identify and suggest new ways for future research.

Although there are many academic studies on radiation, structure and glass in the literature, a systematic bibliometric analysis of these studies appears to be lacking. Our work fills the gap and makes the existing knowledge in the field more organized and accessible.

Radiation is a current issue and has an interdisciplinary field of study. Due to its interactions with different materials, it constantly emerges as a research topic. It was emphasized that the subject of the study remains current and will continue to be important in the future, and both theoretical and it also offers valuable contributions from a practical perspectives.

In this study, academic studies on radiation, building and glass were examined. Web of Science database was used as the data set in the review and scanning was done without any index and year restrictions. In the search, the terms "radiation" and "glass" and (building or buildings) terms were searched in the Advanced Search section in the title, abstract and topic tap determined by the authors. The data in the Web of Science database was accessed on 08.09.2024, and studies added to the database after that time were not included. In the study, the data obtained from the data set were processed using the VOSviewer analysis program to determine the relationships between the studies,

and visualizations were obtained. When looking at the whole study, publication type analysis, article numbers by year, writing language of the articles, keyword analysis, most effective authors, sources, articles, countries and institutions were analyzed, their relationships with each other were specified and visualization was performed. The studies in the data set were examined and the studies with relevant keywords included radiation, glass and building. Although there are many studies on the subject, bibliometric analysis studies that include these terms together are lacking. The absence of this has encouraged researchers to study this issue.

2. Material and Method

Bibliometrics is the quantitative study of information sources and the analysis of published data. It is a widely used interdisciplinary science. Compared to alternative techniques, it is more reliable, and bibliometric approach, which is widely recognized to be unbiased (Li et al., 2022), systematic, transparent and a significant understanding of the characteristics and structure of a given area through a repeatable procedure (Aria & Cuccurullo, 2017; Liu et al., 2022). Bibliometric techniques are used to analyse provides a quantitative evaluation of the development of research (Akatlı & Dinç Kalaycı, 2024; Dal et al., 2023; van Raan, 2005). It is not possible to analyse all the academic literature of scientific disciplines by classical methods. This bibliometric analysis and visualisation methods in the context of the epistemological and intellectual framework are an effective approach for quantitatively analysing the academic literature that can shed light on the development of offers (Anaç et al., 2023; Gümüşburun Ayalp & Anaç, 2024).

The bibliographic review identifies trends and focal points in academic publications, topics. It is of great importance to examine correlations between keywords and authors. This type of comprehensive analysis provides researchers with valuable insights into the development of previous academic work and sheds light on future developments (Burkut & Dal, 2023; Burkut & Dal, 2024). In order for bibliometric analysis to be carried out a healthy way a number of stages need to be designed and carried out respectively. The design process of the study (Donthu et al., 2021) is as shown in Figure 1.
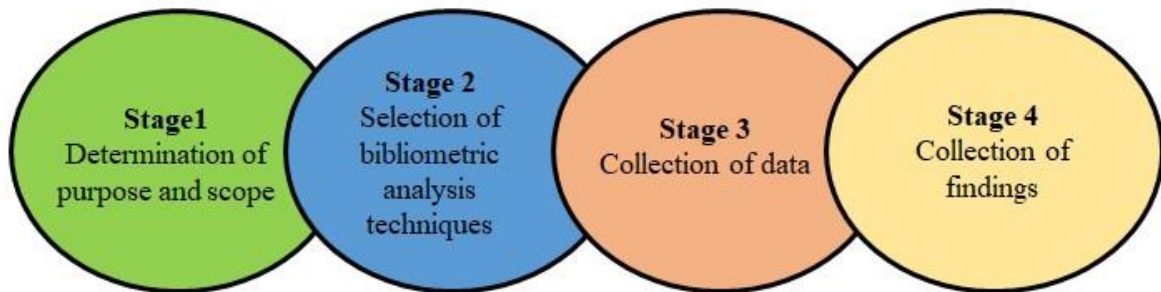
Figure 1. Bibliometric analysis design process (Donthu et al., 2021)

Selection of appropriate visualization software is important in bibliometric analysis. Current visualization and analysis software includes CiteSpace, HistCite, Gephi, SciToo and VOSviewer. VOSviewer is suitable for this study because it can perform self-occurrence, co-occurrence, and clustering analyses of scientific data and clearly present the connections between topics. (Chen, 2006; Chen, 2017). Therefore, visual analysis of the literature was performed with VOSviewer (Burkut & Köseoğlu, 2022).

In the first stage, the aim and scope of the study were determined. The main purpose of this research is to create bibliometric maps by using metadata obtained from studies on 'RADIATION' and 'GLASS' and (BUILDING or BUILDINGS) on variables such as keywords, journals, publications, authors and collaborations in the field. The data analysed within the scope of the study are; publication type distribution, publication language distribution, most effective journals, most effective articles, keyword analysis, most effective countries and institutions, most co-cited sources, journals and authors.

In the second stage, the analysis techniques to be applied in the bibliometric study were selected and designed. The study started with a search process that focused on identifying databases that would

comprehensively cover all relevant studies rather than limiting it to specific journals. Accordingly, Web of Science (WoS) was preferred to analyse the research area. WoS is considered to be the gold standard in bibliometric analysis (Enshassi et al., 2019), covering almost all important publications and offering advanced analytical capabilities to generate representative numbers (Yu et al., 2020). Furthermore, WoS has superior citation matching algorithms compared to Scopus (Valderrama-Zurian et al., 2015), making it a valuable data source for our study.

In the third stage of the study, data sets were created using the Web of Science database for analysis. Four steps were followed in this process: keyword identification and screening, data extraction according to various parameters, evaluation of the relevance of the studies to the subject matter, and export of the obtained data. Figure 2 shows the process of creating the data sets prepared in the Web of Science database.

In the fourth and final stage, the data obtained were analyzed and visualized, and the results were reported. The VOSviewer analytical tool (version 1.6.20) was used to visualise and report the data. The rationale for choosing VOSviewer lies in its capacity to provide a more objective assessment and thus increase the scientific rigour of the research (van Eck & Waltman, 2010). Co-developed by Dutch academics van Eck and Waltman, VOSviewer is a visualisation analysis tool designed to create maps based on network data and then visualize and explore these maps. Furthermore, visual interpretation of relevant literature with VOSviewer allows for the identification of emerging common themes and relationships between elements. In the discipline of glass radiation in buildings, VOSviewer has been successfully used to analyse and visualise keyword mapping, author collaboration networks, featured output maps, country collaboration networks and research clusters.
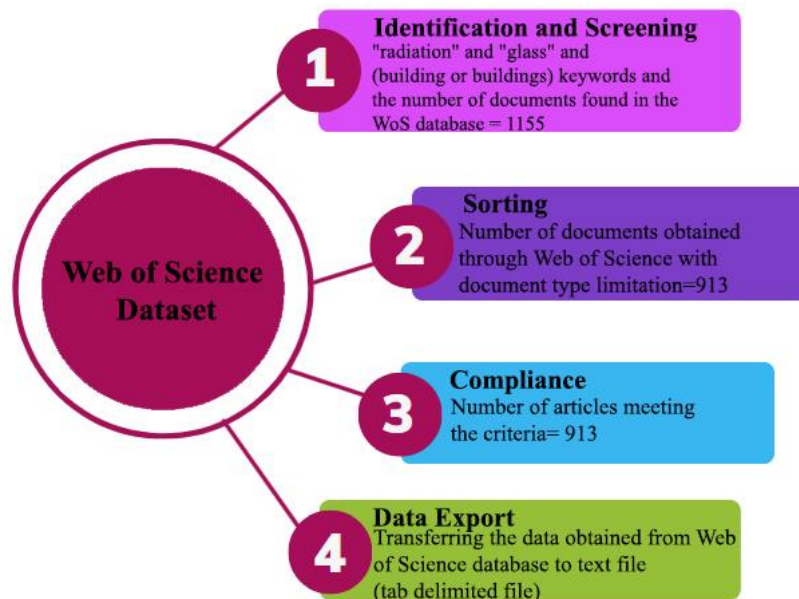

Figure 2. Preparing a data set in Web of Science database (Authors)

In VOSviewer, circles usually represent literature, authors, keywords or other entities; each circle refers to a separate item or entity. The size of the circle reflects the importance or relevance of the entity in the network, so larger circles usually indicate more important entities. Lines represent the relationships or connections between entities. In literature networks, these links reflect elements such as citation relationships, collaboration relationships and topic relevance. The thickness, colour and other attributes of the lines may indicate the strength, type or other characteristics of the relationship. Additionally, different clusters are represented by different colours.

In this study, to determine the relationships between the concepts of 'radiation', 'glass' and 'building' and to identify the trends in the field, the keywords 'RADIATION' and 'GLASS' and (BUILDING or BUILDINGS) were used by selecting the Topic tab in the Advanced Search section of the Web of Science database on 29.08.2024. In the Topic tab, a search including the title, abstract and keywords of the articles was performed and a total of 1155 documents on the subject were reached, 931 of which were

identified as articles. Only articles were included in the study and analyses were made on these articles; other academic literature was excluded from the study.

3. Findings and Discussion

According to the relevant search result in the Web of Science database on 08-09-2024, a total of 1155 documents, including 913 articles, were reached. When we look at the distribution of academic studies, apart from articles, we found papers (196), review articles (25), early access (14), book chapters (5), and editorial material (1). The publication type distribution of academic studies belonging to the relevant keywords is shown in Figure 3.
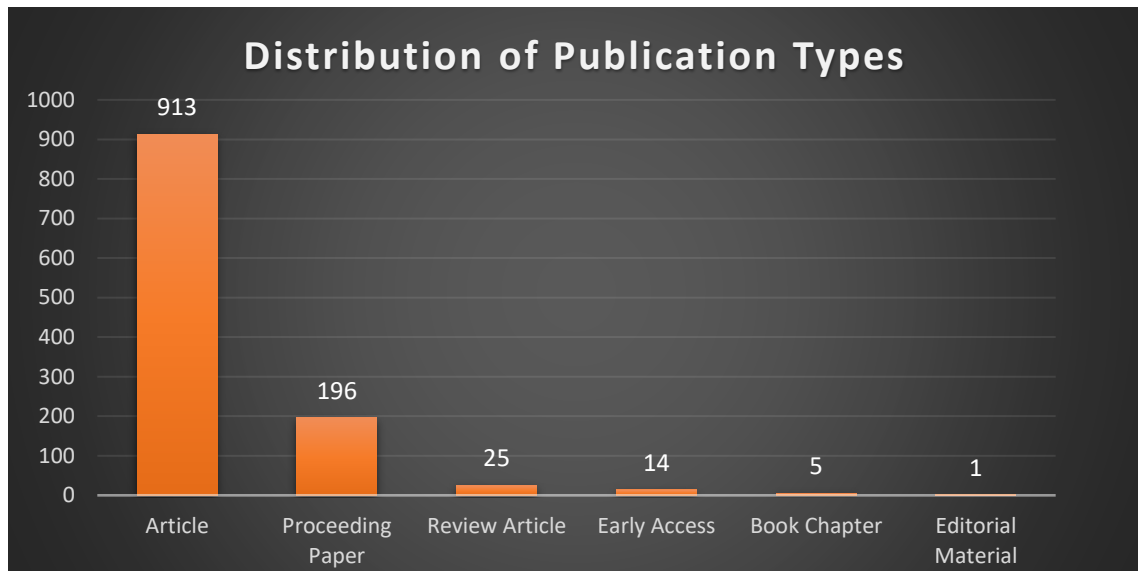
Figure 3. Academic publication type distribution (Authors)

When looking at the distribution of studies by years, it was observed that the first study on the relevant subject was the study titled "Surface Radioactivity Resulting From The Deposition Of Rn-222 Daughter Products" written by Lively and Ney (1987). When examining the number of relevant academic studies, it can be observed that the number of academic studies has increased since 2014 and peaked in 2022 (113 articles). The number of articles by year is shown in Figure 4.
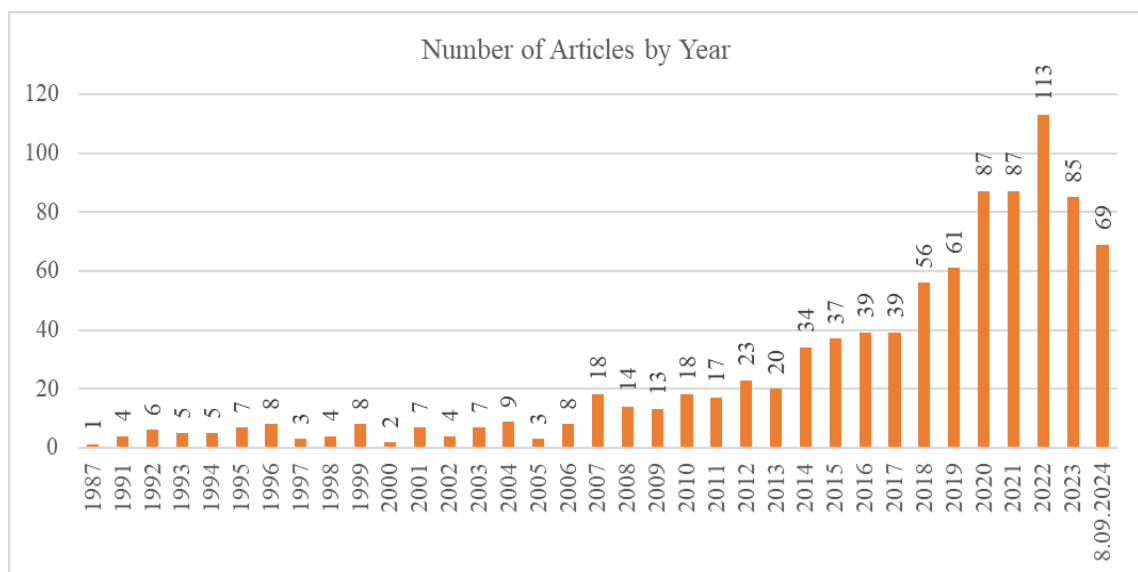

Figure 4. Number of articles by year (Authors)

When the publication languages of the articles subject to the study were examined, it was found that 900 articles were written in English. In addition, there are also articles in Chinese (Fei-Ping et al., 2013; Guo-Peng et al., 2023; Xu et al., 2021; Xue-Pei et al., 2016); German (Bernhard et al., 2001; Gregersen

et al., 2021; Haeupl, 2022); Russian (Bagrov et al., 2017; Vichegjanina, 2014). Figure 5 shows the publication language distribution of articles prepared on the relevant subject.
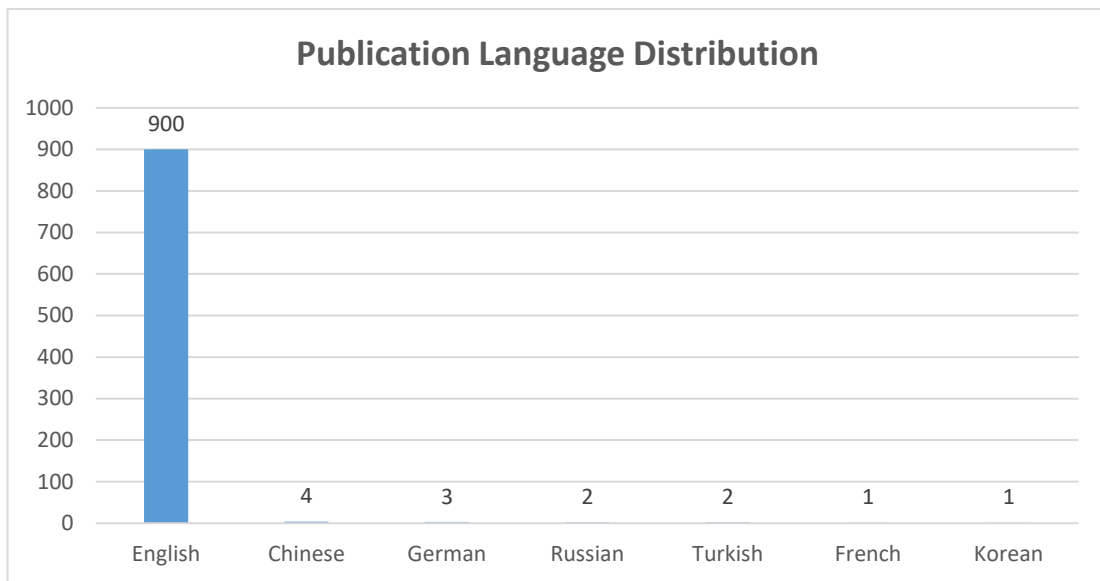
**Figure 5.** Distribution of publication language (Authors)

3.1. Keywords Analysis

Co-occurrence / author keywords analysis via the VOSviewer program was conducted to reveal the structures of the article studies in which the subjects of radiation, glass and building are examined together in the literature, to identify the most effective keywords related to the subject in the literature, to ascertain the concepts on which the study focuses, and to determine the subject contents on which the field has evolved. has been made. It was found that the same key concepts were included in different spellings among the key concepts in the 913 articles that constituted the sample of the study. By performing data cleaning, it was determined that a total of 2878 key concepts were used in the articles in the sample of the study, and are shown in Figure 6.
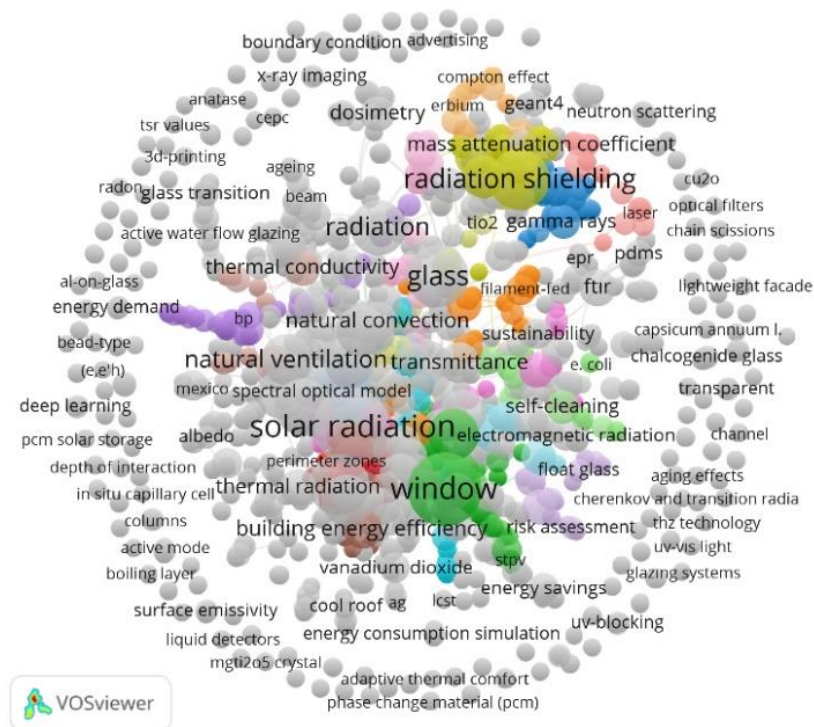
Figure 6. Keyword network analysis (Authors)

In order to identify the most intensively used keywords of the field and to determine the topics of the field, the number of keywords was reduced to 28 key concepts by requiring a keyword to be used at least 8 times, and 28 keywords (items) were mapped by the programme as 5 clusters and shown in Figure 7.
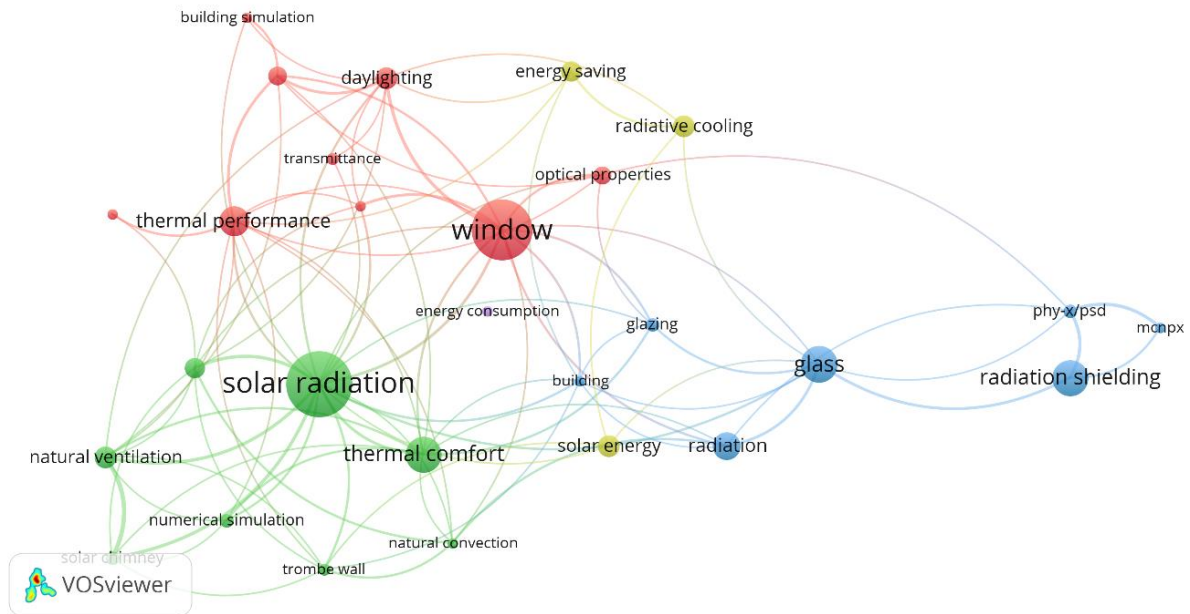

Figure 7. Keyword network analysis visualization (28 keywords) (Authors)

The keywords in each cluster, the most used keyword in the cluster, the number of occurrences and the academic studies in which the keywords were used are shown in Table 1.

Table 1. The most effective keywords according to keyword network analysis

Cluster	Keywords	The most effective keywords	Article Name
1. Cluster (red)	building energy efficiency, building simulation, computational fluid Dynamics, daylighting, energy efficiency, optical properties, thermal performance, transmittance, window	window (44 occurences)	"*Thermal performance of an advanced smart fenestration systems for low-energy buildings*" (Ming et al., 2024)
2. Cluster (green)	heat transfer, naturel convection, naturel ventilation, numerical simulation, solar chimney, solar radiation, thermal comfort, trombe Wall	solar radiation (48 occurences)	"*Numerical simulation of heat transfer of a concentrating solar photovoltaic system*" (Jian & Yanxiang, 2012)
3. Cluster (blue)	building, glass, glazing, mcnpx, phy-x/psd, radiation, radiation shielding	glass (27 occurences)	"*Evaluation of the shielding parameters of alkaline earth based phosphate glasses using MCNPX code*" (Agar et al., 2019)
4. Cluster (yellow)	energy saving, radiative cooling, solar energy	radiative cooling ve solar energy (16 occurences)	"*Exploring energy-saving performance of radiative cooling roofs with a transient heat transfer model*" (Liu et al., 2024)
5. Cluster (purple)	energy consumption	energy consumption (8 occurences)	

Keyword overlay analysis was presented to the reader to determine the relationship between the concepts of radiation, glass and structure and the topics that the field has evolved over time according to the years of publication and is shown in Figure 8.
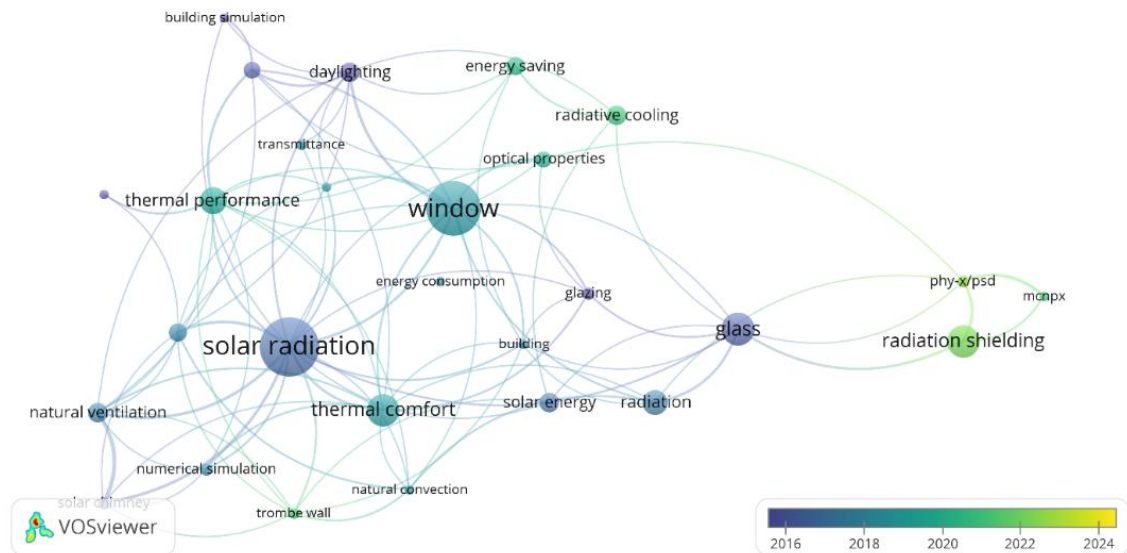
Figure 8. Keyword overlay analysis (Authors)

In the research, the distribution of keywords over time and the average years in which publications in these fields were concentrated were analysed. In 2012, *computational fluid dynamics, glazing*; in 2015, *building simulation, and daylighting*; in 2016, *solar chimney, energy efficiency, glass, solar radiation*. In 2017, topics such as *solar energy, radiation, natural ventilation, heat transfer, building and numerical simulation* took an important place in research. In 2018, topics such as *transmittance, energy consumption, window, natural convection, building energy efficiency and thermal comfort* have been the focus of research. In 2019 and beyond, studies on more technical topics such as *thermal performance, optical properties, energy saving, radiative cooling, mcnpx, trombe wall, radiation shielding and phy-x/psd* have intensified.

These data show that issues such as energy efficiency, thermal performance, radiation and natural ventilation have become increasingly important in the field of research over the years.

Data regarding the relevant study and the 10 most effective keywords are shown in Table 2.

Table 2. Data on the 10 most active keywords

| Keyword	Co-Occurence	Total Link Strength	Average Year of Publication	Average Number of Citations
Solar radiation	48	29	2016,83	26,00
Window	44	20	2018,50	19,64
Glass	27	14	2016,52	16,89
Thermal comfort	26	15	2018,81	18,27
Radiation shielding	26	7	2021,92	20,96
Thermal performance	22	11	2019,41	11,59
Radiation	20	7	2017,50	21,10
Naturel ventilation	16	18	2017,69	22,06
Daylighting	16	13	2015,31	25,88
Radiative cooling	16	5	2020,94	28,31

When the most effective key concepts of the study were analysed; Solar Radiation was found to be the most effective key concept with 48 co-occurrences and 29 link strengths. It was determined that the average publication year of Solar Radiation key concept was 2016.83 and the average number of citations was 26.00. The 2nd most effective key concept of the study was window with 44 co-

occurrences and 20 total link strength, and the 3rd most effective key concept was glass with 27 co-occurrences and 14 total link strength.

3.2. The Most Efficient Authors Analysis

Citation/authors analysis was conducted with the data obtained from the Web of Science database in order to reveal the most influential authors who received the most citations on the specified date with the relevant keywords. In the 914 articles that constitute the sample of the study, it was observed that 24 authors among the 1000 most active authors determined by VOSviewer were included in the list with different spellings, and after data cleaning, the authors were combined under the same name and shown in Figure 9.
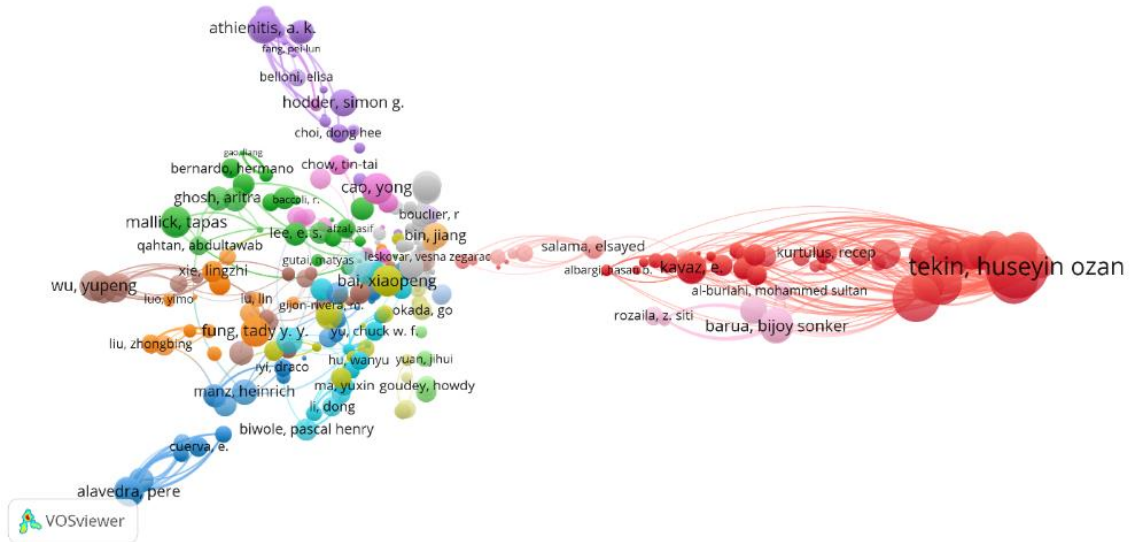
Figure 9. Network analysis of the 1000 most effective authors (Authors)

After the data cleaning, it was determined that there were 3521 authors in 914 articles and it was reduced to 19 authors with the condition that an author should publish at least 5 documents and at least 50 citations, and 12 related authors (items) were mapped as 2 clusters by the programme and shown in Figure 10.
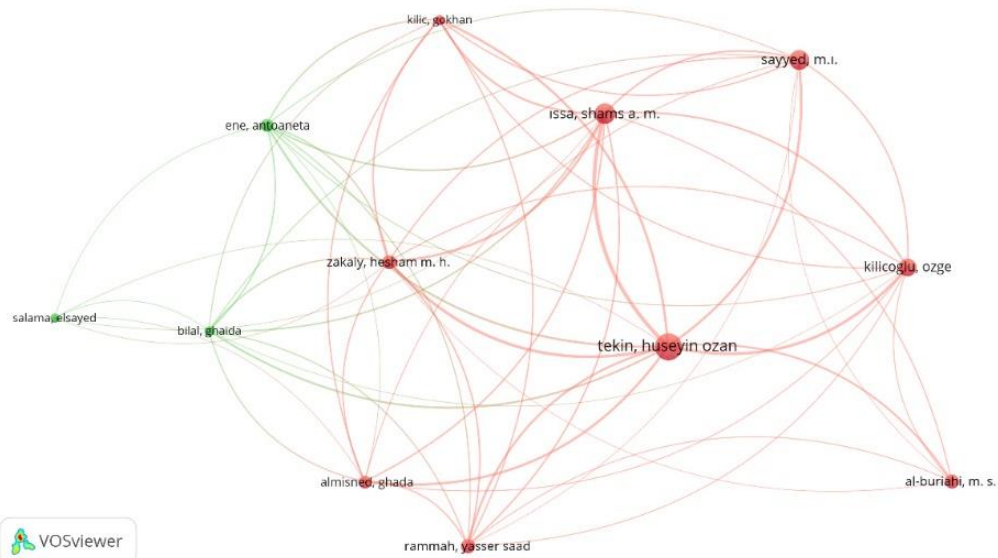
Figure 10. Analysing the most effective interrelated author network (Authors)

The 5 most effective authors of the research topic according to the citations they received are presented in Table 3.

Table 3. The most active authors with the subject of study

Author Name	Citation Count	Average Citation Number	Average Year of Publication	Number of Documents	Total Link Strength
Tekin, Huseyin Ozan	1090	43,60	2020,64	25	134
Issa, Shams	578	38,53	2020,60	15	87
Sayyed, M.I.	570	57,00	2020,40	10	38
Kilicoglu, Ozge.	438	73,00	2019,50	6	42
Al- Buriahi, M.S	260	37,14	2021,00	7	17

According to the number of citations related to the study subject, it was determined that the most active author was Tekin, Huseyin Ozan. Tekin, Huseyin Ozan has 25 documents with the related subject. Tekin, Huseyin Ozan is followed by Issa, Shams and Sayyed, M.I. respectively.

3.3. The Most Efficient Sources Analysis

Citation / Sources analysis was performed to determine the most effective sources according to the number of citations in which the article studies containing radiation-glass-structure topics together. Based on the data obtained from the Web of Science database, 372 sources on the subject were identified and shown in Figure 11.
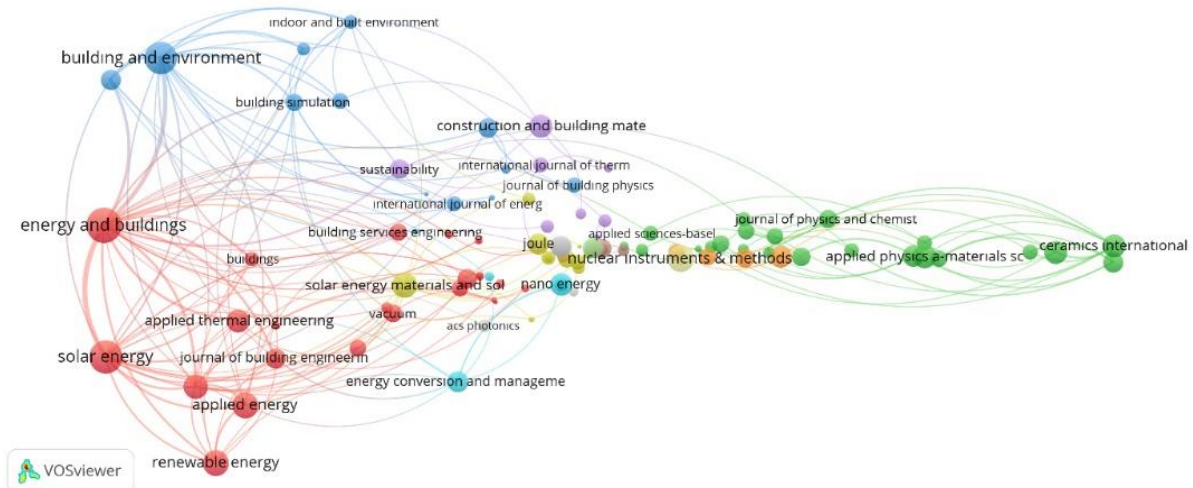
Figure 11. Most efficient resource network analysis (Authors)

In order to identify the most effective sources and to present the cooperation between them to the reader, the 372 sources identified on the subject were reduced to 29 sources with the conditions of publishing at least 5 documents and receiving at least 50 citations, and 22 interconnected sources (items) were visualised by VOSviewer as 3 clusters and shown in Figure 12.
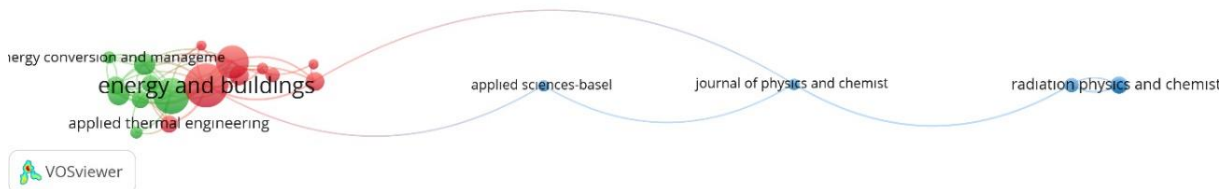
Figure 12. The most effective interrelated sources (Authors)

In cluster 1 (red), Energy and Buildings journal with 1864 citations; in cluster 2 (green) Solar Energy journal with 1353 citations and in cluster 3 (blue) Applied Physics A: Materials Science and Processing journal, which received 330 citations in cluster 3 (blue), were the most effective sources of the clusters.

When 372 sources including 913 articles that constitute the sample of the research are evaluated according to the number of citations; the most cited sources are presented to the reader in Table 4.

Table 4. The most effective journals according to the number of citations

Journal Name	Citation Count	Document Count	Total Link Strength
Energy and Building	1864	60	58
Solar Energy	1353	42	38
Building and Environment	1249	37	23
Nuclear Instruments & Methods in Physics	534	9	0
Applied Energy	513	13	17
Renewable Energy	468	18	15
Solar Energy Materials and Solar Cells	428	12	7
Energy	381	12	18
Applied Physics A-Materials Science Processing	330	9	2
Ceramics International	297	9	8

According to the table, based on the number of citations received by the journals, it is observed that the most effective journal is Energy and Buildings with 1864 citations. Energy and Buildings is followed by Solar Energy (1353 citations) and Building and Environment (1249 citations).

3.4. The Most Efficient Article Analysis

Citation / document analysis was performed to determine the most effective articles according to the number of citations in which the keywords radiation, glass and building were used together. Through VOSviewer, the 913 articles (items) constituting the sample of the study were visualised as 913 clusters. Only the first authors are indicated in the visualisation and shown in Figure 13.
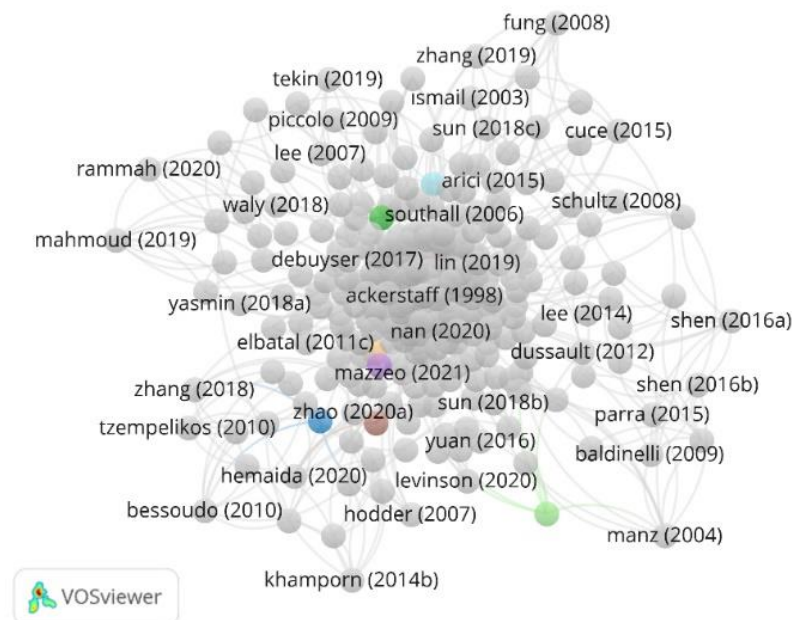
Figure 13. Most active articles network visualisation (Authors)

In order to present the most effective articles of the study and the relationships between them to the reader, the analysis was repeated with the condition that an article study should have at least 90 citations and visualised as 33 items and 30 clusters by VOSviewer and presented to the readers in Figure 14.
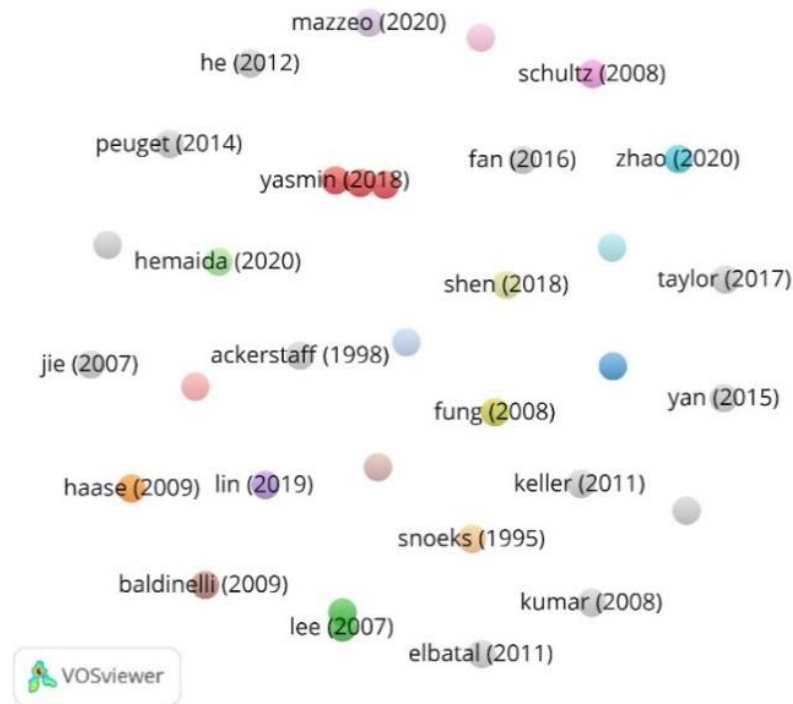
Figure 14. The most effective interrelated article network visualisation (Authors)

When the article studies with at least 90 citations were analysed in the study, it was seen that there was collaboration only in the studies of Yasmin et al., (2018), Mahmoud et al., (2019) and Tekin et al., (2018) in the red cluster and it is shown in Figure 15.

Figure 15. Network analysis of co-operating authors (Authors)

The 10 most effective articles according to the number of citations received by the studies are presented in Table 5.

Table 5. The most effective articles according to the number of citations

Author Name (Year)	Article Name	Published Source	Number of Citations	Total Link Strength
Ackerstaff et al. (1998)	The HERMES spectrometer	Nuclear Instruments & Methods In Physics Research Section A- Accelerators Spectrometers Detectors and Associated Equipment	392	0
Lin et al. (2019)	Direct spray-coating of highly robust and transparent Ag nanowires for energy saving windows	Nano Energy	194	1
Sun et al. (2018)	Heat-Insulating Multifunctional Semitransparent Polymer Solar Cells	Joule	186	3
Fung & Yang (2008)	Study on thermal performance of semi-transparent building-integrated photovoltaic glazings	Energy And Buildings	185	9
Keller & Messenger (2011)	On the origins of GEMS grains	Geochimica Et Cosmochimica Acta	152	0
Hodder & Parsons (2007)	The effects of solar radiation on thermal comfort	International Journal of Biometeorology	151	6
Yasmin et al. (2018)	Studies of ionizing radiation shielding effectiveness of silica-based commercial glasses used in Bangladeshi dwellings	Results In Physics	151	4
Tekin et al. (2018)	Gamma radiation shielding properties of the hematite-serpentine concrete blended with WO_3 and Bi_2O_3 micro and nano particles using MCNPX code	Radiation Physics and Chemistry	133	2
Kumar & Bai (2008)	Performance study on solar still with enhanced condensation	Desalination	133	0
Jie et al. (2007)	Study of PV-Trombe wall assisted with DC fan	Building and Environment	126	3

3.5. The Most Efficient Countries Analysis

A citation / countries analysis was conducted to determine the countries that contributed to the literature by receiving the most citations with publications on radiation, glass and building. When the outputs of the data obtained from the Web of Science database were analysed, it was determined that 5 countries were written in different ways and included in the application as different countries, and different spellings were combined under the same roof by data cleaning. After data cleaning, it was determined that there were 82 countries conducting studies, and as shown in Figure 16.
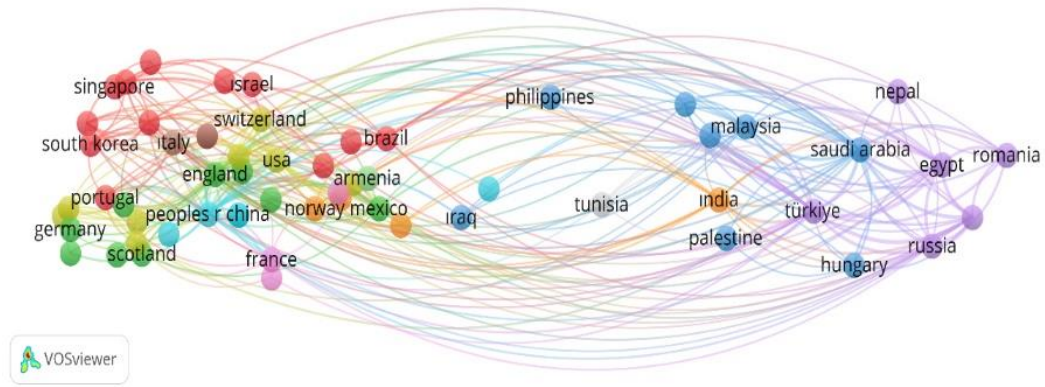
Figure 16. Most Efficient countries network analysis (Authors)

In order to determine the most effective countries based on the number of citations they receive, 82 countries were reduced to 25 countries that meet the conditions of publishing at least 10 documents and receiving 200 citations and mapped as 2 clusters by VOSviewer and shown in Figure 17.
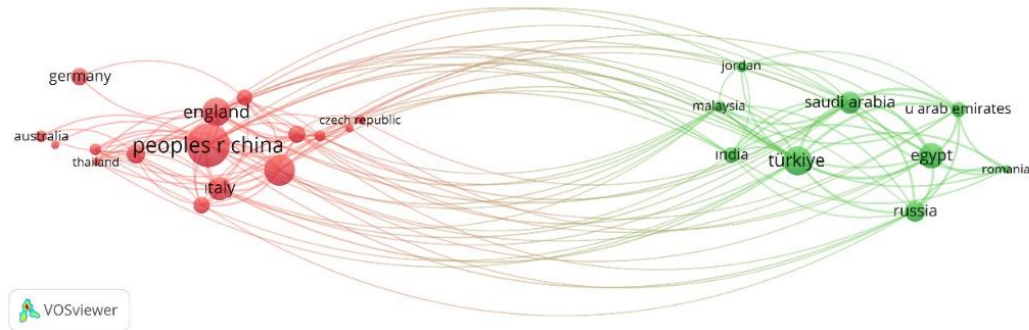
Figure 17. The most effective countries network analysis (Authors)

In cluster 1 (red), Peoples Republic of China with 4087 citations and in cluster 2 (green), Turkey with 2084 citations were determined as the most effective countries of the clusters.

Considering the number of citations received by the documents, the 10 most effective countries of the research topic were determined and shown in Table 6.

Table 6. The most effective countries according to the number of citations

Country Name	Citation Count	Number of Documents	Average Citation Number	Total Link Strength	Ave. Year of Publi. of Doc.
Peoples Republic of China	4087	202	20.23	152	2019.71
USA	2270	92	24.67	56	2014.05
Turkey	2084	58	35.93	256	2019.86
England	1988	54	36.81	83	2015.63
Egypt	1623	67	24.22	201	2019.04
Italy	1424	52	27.38	53	2015.83
Saudi Arabia	1303	60	21.72	209	2020.95
Russia	1149	32	35.91	104	2015.97
Canada	944	24	39.33	32	2015.33
Germany	876	39	22.46	4	2015.79

It is seen that Peoples Republic of China is the most active country with 202 documents and 4087 citations. Peoples Republic of China is followed by USA (92 documents and 2270 citations) and Türkiye (58 documents and 2084 citations).

3.6. The Most Efficient Institutions Analysis

Citation / organisations analysis was conducted to determine the most cited institutions with the documents published in the literature on the research topic. In the analysis, the nodes take different dimensions in proportion to the citation size. In order to determine the most effective institutions of the study, mapping was carried out over the size of the number of citations and shown in Figure 18.
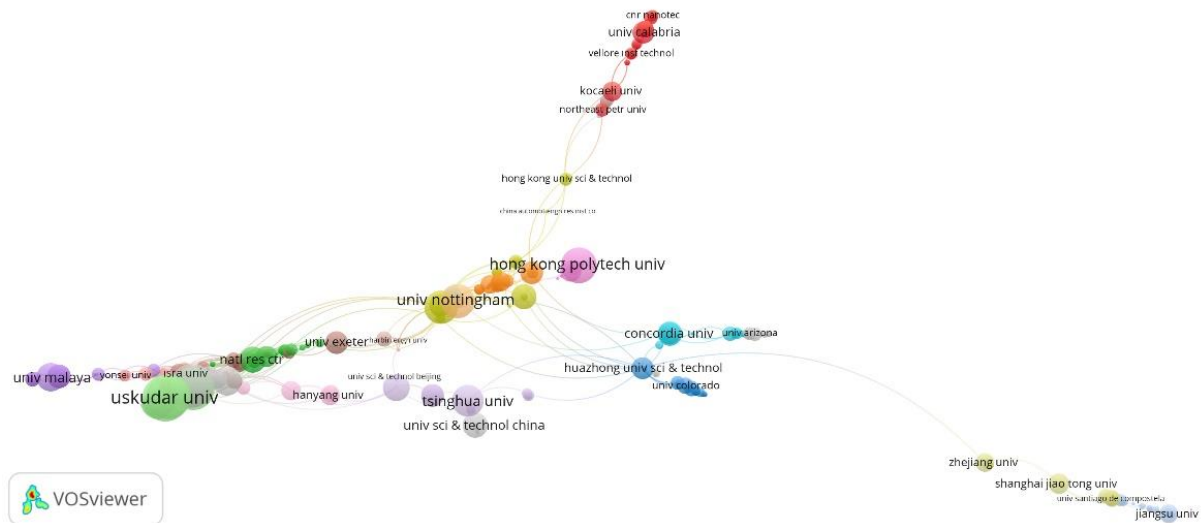
Figure 18. Network visualisation of the most active institutions according to the number of citations (Authors)

In order to identify the most effective institutions and the relationships between them, the number of institutions was reduced to 25 (items) with the condition of publishing 5 documents and visualised as 3 clusters and presented in Figure 19.
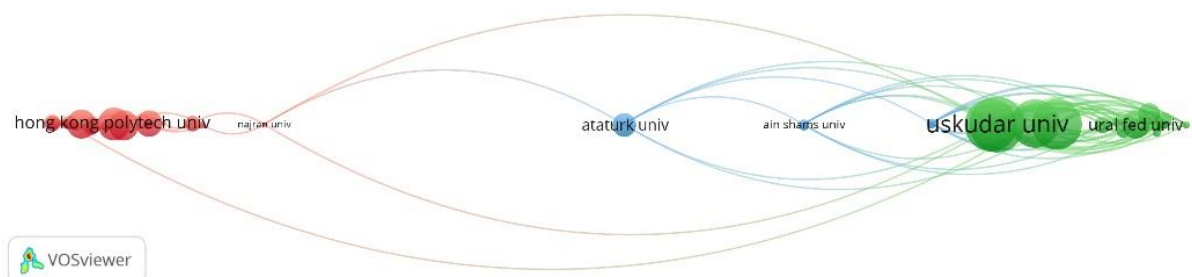
Figure 19. The most active institution network visualisation (by number of citations) (Authors)

In cluster 1 (red) Hong Kong Polytech University with 479 citations and 8 documents; in cluster 2 (green) Üsküdar University with 800 citations and 16 documents; and in cluster 3 (blue) Atatürk University with 344 citations and 7 documents.

The 5 most effective institutions according to the number of citations among the studies on the subject are shown in Table 7.

Table 7. The most effective institutions according to the number of citations

Organization	Citations	Documents	Average Citation Number	Total Link Strength
Uskudar University	800	16	50,00	143
University of Tabuk	761	17	44,76	138
Al Azhar University	726	23	31,57	161
University of Sharjah	691	23	30,04	176
Hong Kong Polytech University	479	8	59,88	10

Uskudar University is the most active institution with 16 documents and 800 citations, followed by University of Tabuk (17 documents and 761 citations) and Al Azhar University (23 documents and 726 citations).

4. Conclusion and Suggestions

This study was conducted on 08-09-2024 following the data obtained from the Web of Science database. In the creation of the database, the Advanced Search tab was used in the article title, article to be scanned in the abstracts and in the content of keywords determined in line with the authors' preferences. The search words 'RADIATION' AND 'GLASS' AND (BUILDING OR BUILDINGS) were written in the Topic section. As a result of the search, 1155 documents, 913 of which were articles, were reached. In the study, the articles constituted the material of the research and determined the limits of the study. Apart from the article limitation, limitations such as index, year, language were not made. In the study, it is aimed to determine how the field has evolved in the face of the latest developments in the field of radiation, glass and building over the years. The data obtained from the database were analysed using VOSviewer version 1.6.20 application. The results obtained at the end of the study are as follows;

Distribution and Types of Publications: At the end of the keyword search, a total of 1155 documents were reached. These documents were observed to be articles (913), proceeding papers (196), review articles (25), early accessions (14), book chapters (5) and editorial material (1). It was observed that the first article related to the study was written in 1987 and the most articles were written in 2022 (113 articles). The fact that there are different types of studies shows that the related subject has attracted a wide interest in the academic field and an important knowledge accumulation has been formed in this field.

Publication Language: According to the data obtained, it is seen that the subject of radiation, glass and building has a global interest. Although the majority of the articles are written in English, the fact that there are publications in German, Chinese, Russian, Turkish, French and Korean languages shows that the relevant subject is not specific to a specific geographical region or language, on the contrary, it is a universal subject and constitutes a global research field.

Keywords: In line with the data obtained in the study, it was observed that the most effective keywords were 'solar radiation', 'window' and 'glass'.

Looking at the distribution of keywords over the years, it was observed that there was an increasing interest in topics such as energy efficiency, thermal performance and natural ventilation in the 2012-2019 period. After 2019, more technical topics, especially 'radiation shielding' and 'radiative cooling', came to the fore. These results show that the energy performance of buildings and radiation issues are gaining more and more importance in academic studies.

The Most Effective Authors: According to the results of the author analysis, the authors who received the most citations and published the most documents were identified. Accordingly, Tekin, Hüseyin Ozan (25 documents and 1090 citations) was found to be the most active author. Tekin, Hüseyin Ozan is followed by Issa, Shams (15 documents and 578 citations) and Sayyed, M. I. (10 documents and 570 citations).

The Most Effective Sources: Among the most effective sources the Energy and Buildings journal was determined as the most cited journal with 60 documents and 1864 citations. It is among the most effective sources with Solar Energy (42 documents and 1353 citations) and Building and Environment (37 documents and 1249 citations).

The Most Effective Articles: According to the relevant screening data results, it was observed that the most cited study among the prepared articles was "The HERMES spectrometer". The relevant study ranks first in the list of the most effective articles, receiving 392 citations. The studies "Direct spray-coating of highly robust and transparent Ag nanowires for energy saving windows" with 194 citations and "Heat-Insulating Multifunctional Semitransparent Polymer Solar Cells" with 186 citations are among the most influential articles.

The Most Effective Countries: The most effective countries were determined according to the citation ranking of the countries where the studies were conducted. With 4087 citations and 202 documents the People's Republic of China was determined as the most effective country. It is among the most active countries with the USA (92 documents and 2270 citations) and Turkey (58 documents and 2084 citations).

The Most Effective Institutions: In the light of the data obtained by scanning the relevant keywords, the most effective institutions with the most citations were determined. Accordingly, Uskudar University was determined to be the most effective institution with 16 documents and 800 citations. It is among the most active institutions with University of Tabuk (17 documents and 761 citations) and Al Azhar University (23 documents and 726 citations).

Based on the bibliometric analysis conducted on the intersection of radiation, glass, and building-related research, several recommendations can be proposed for future studies and practical applications. These suggestions aim to guide researchers, institutions, and policy-makers toward more comprehensive and collaborative scientific efforts.

Expand the Scope of Data Sources: This study was limited to the Web of Science (WoS) database. Future research should incorporate additional databases such as Scopus, IEEE Xplore, and Google Scholar to ensure a broader and more inclusive representation of the literature. This would allow for more robust comparative analyses and a more complete overview of global research trends in the field.

Promote Interdisciplinary Approaches: Radiation shielding using glass materials is inherently interdisciplinary, involving fields such as materials science, engineering, architecture, physics, and healthcare. Future research should promote interdisciplinary collaborations to develop holistic solutions, especially in applications related to radiation safety, energy-efficient building design, and medical shielding technologies.

Support the Development of Advanced Shielding Materials: The increasing prominence of keywords such as "radiation shielding" and "glass" suggests a growing interest in transparent and eco-friendly shielding materials. Therefore, R&D initiatives should be encouraged to design innovative, sustainable, and high-performance glass-based composites that can effectively block harmful radiation without compromising visibility or aesthetics.

Enhance Regional and Institutional Collaborations: The analysis revealed that countries like China, Turkey, and the USA, and institutions such as Üsküdar University and the University of Tabuk are among the most productive. However, global cooperation remains limited. To address this, international partnerships, joint research projects, and cross-border academic events should be fostered to enhance knowledge exchange and collaborative innovation.

Identify and Explore Emerging Research Themes: Recent trends show a shift towards technical and sustainability-oriented themes such as radiative cooling, thermal performance, and energy saving. Future studies should align with these trends by focusing on climate-responsive architecture, passive energy systems, and smart glass technologies. Such focus areas hold the potential for both high academic impact and real-world application in sustainable development.

Acknowledgements and Information Note

The article complies with national and international research and publication ethics. Ethics Committee approval was not required for the study.

Author Contribution and Conflict of Interest Declaration Information

All authors contributed equally to the article. There is no conflict of interest.

References

Abdel Maksoud, M. I. A., Kassem, S. M. & Sallam, O. I. (2022). Structural, optical, and radiation shielding features of newly developed BaZrO3/Na2O–B2O3 glass. *Ceramics International*, *48*(20), 30938–30950. doi: https://doi.org/10.1016/j.ceramint.2022.07.051

Ackerstaff, K., Airapetian, A., Akopov, N., Amarian, M., Andreev, V., Aschenauer, E. C., Avakian, R., Avakian, H., Avetissian, A., Bains, B., Barrow, S., Beckhusen, W., Beckmann, M., Belostotski, S., Belz, E., Benisch, T., Bernreuther, S., Bianchi, N., Blouw, J., … Collaboration, H. (1998). The HERMES spectrometer. *Nuclear Instruments & Methods in Physics Research Section A-Accelerators Spectrometers Detectors And Associated Equipment*, *417*(2–3), 230–265. doi: https://doi.org/10.1016/S0168-9002(98)00769-4

Agar, O., Khattari, Z. Y., Sayyed, M. I., Tekin, H. O., Al-Omari, S., Maghrabi, M., Zaid, M. H. M. & Kityk, I. V. (2019). Evaluation of the shielding parameters of alkaline earth based phosphate glasses using MCNPX code. *Results in Physics*, *12*, 101–106. doi: https://doi.org/10.1016/j.rinp.2018.11.054

Akatlı, G. & Dinç Kalaycı, P. (2024). Spatial perception: A critical bibliometric inquiry. *journal of architectural sciences and Applications*, *9*(1), 548–567. doi: https://doi.org/10.30785/mbud.1402794

Akyildirim, H., Kavaz, E., El-Agawany I, F., Yousef, E. & Rammah, Y. S. (2020). Radiation shielding features of zirconolite silicate glasses using XCOM and FLUKA simulation code. *Journal of Non-Crystalline Solids*, *545*. doi: https://doi.org/10.1016/j.jnoncrysol.2020.120245

Al-Buriahi, M. S., Sriwunkum, C., Arslan, H., Tonguc, B. T. & Bourham, M. A. (2020). Investigation of barium borate glasses for radiation shielding applications. *Applied Physics A*, *126*(1), 68. doi: https://doi.org/10.1007/s00339-019-3254-9

Al-Hadeethi, Y. & Sayyed, M. I. (2020a). BaO–Li2O–B2O3 glass systems: Potential utilization in gamma radiation protection. *Progress in Nuclear Energy*, *129*, 103511. doi: https://doi.org/https://doi.org/10.1016/j.pnucene.2020.103511

Al-Hadeethi, Y. & Sayyed, M. I. (2020b). Evaluation of gamma ray shielding characteristics of CaF2–BaO–P2O5 glass system using Phy-X / PSD computer program. *Progress in Nuclear Energy*, *126*, 103397. doi: https://doi.org/https://doi.org/10.1016/j.pnucene.2020.103397

Al-Hadeethi, Y., Sayyed, M. I., Kaewkhao, J., Raffah, B. M., Almalki, R. & Rajaramakrishna, R. (2019). An extensive investigation of physical, optical and radiation shielding properties for borate glasses modified with gadolinium oxide. *Applied Physics A*, *125*(11), 749. doi: https://doi.org/10.1007/s00339-019-3053-3

Anaç, M., Gümüşburun Ayalp, G. & Erdayandi, K. (2023). Prefabricated Construction Risks: A Holistic Exploration through Advanced Bibliometric Tool and Content Analysis. *Sustainability*, *15*(15). doi: https://doi.org/10.3390/su151511916

Aria, M. & Cuccurullo, C. (2017). bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics*, *11*(4), 959–975. doi: https://doi.org/10.1016/j.joi.2017.08.007

Ashok, K., Dong, M. G., Sayyed, M. I., Lakshminarayana, G., Xue, X. X. & Mahdi, M. A. (2018). Gamma-Ray Shielding Effectiveness of Lead Bismuth Germanoborate Glasses. *Glass Physics and Chemistry*, *44*(4), 292–299. doi: https://doi.org/10.1134/S1087659618040089

Aygun, B., Sakar, E., Agar, O., Sayyed, M. I., Karabulut, A. & Singh, V. P. (2021). Development of new heavy concretes containing chrome-ore for nuclear radiation shielding applications. *Progress in Nuclear Energy*, *133*. doi: https://doi.org/10.1016/j.pnucene.2021.103645

Bagheri, R., Khorrami Moghaddam, A. & Yousefnia, H. (2017). Gamma Ray Shielding Study of Barium–Bismuth–Borosilicate Glasses as Transparent Shielding Materials using MCNP-4C Code, XCOM Program, and Available Experimental Data. *Nuclear Engineering and Technology*, *49*(1), 216–223.

doi: https://doi.org/https://doi.org/10.1016/j.net.2016.08.013

Bagrov, A. V, Sysoev, A. K., Sysoev, V. K. & Yudin, A. D. (2017). Modeling of sintering of moon soil imitators by solar radiation. *Letters On Materials-Pis Ma O Materialakh*, *7*(2), 130–132. doi: https://doi.org/10.22226/2410-3535-2017-2-130-132

Bernhard, G., Friedrich, H. & Nitsche, H. (2001). Radiochemistry building for actinides research - Technology, radiation protection, methods. *ATW-Internationale Zeitschrift Fur Kernenergie*, *46*(10), 653+.

Burkut, E. B. & Dal, M. (2023). Systematic literature review and scientific maps on ecological architecture and eco-architecture. *International Journal of Pure and Applied Sciences*, *9*(2), 369–380. doi: https://doi.org/10.29132/ijpas.1365407

Burkut, E. B. & Dal, M. (2024). Analysis of articles on occupational health and safety with scientific mapping techniques in WoS & Scopus database (2000-2023). *Digital International Journal of Architecture Art Heritage*, *3*(1), 1–13.

Burkut, E. B. & Köseoğlu, E. (2022). Mimarlık alanında çocuklarla ilgili yayınların bibliyometrik analizi ve bibliyografik haritaları. *Journal of Architectural Sciences and Applications*, *7*(2), 511–527. doi: https://doi.org/10.30785/mbud.1099993

Chen, C. (2006). CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature. *Journal of The American Society For Information Science and Technology*, *57*(3), 359–377. doi: https://doi.org/10.1002/asi.20317

Chen, C. (2017). Science mapping: A systematic review of the literature. *Journal of Data and Information Science*, *2*(2), 1–40. doi: https://doi.org/10.1515/jdis-2017-0006

D'Souza, A. N., Prabhu, N. S., Sharmila, K., Sayyed, M. I., Somshekarappa, H. M., Lakshminarayana, G., Mandal, S. & Kamath, S. D. (2020). Role of Bi2O3 in altering the structural, optical, mechanical, radiation shielding and thermoluminescence properties of heavy metal oxide borosilicate glasses. *Journal of Non-Crystalline Solids*, *542*, 120136. doi: https://doi.org/https://doi.org/10.1016/j.jnoncrysol.2020.120136

Dal, M., Burkut, E. B. & Karataş, L. (2023). Analysis of Publications on earthquake research in architecture category and analysis with R studio-biblioshiny software. *Journal of Architectural Sciences and Applications*, *8*(Special Issue), 183–197. doi: https://doi.org/10.30785/mbud.1333876

Deliormanlı, A. M., Ensoylu, M., Issa, S. A. M., Elshami, W., Al-Baradi, A. M., Al-Buriahi, M. S. & Tekin, H. O. (2021). WS2/bioactive glass composites: Fabrication, structural, mechanical and radiation attenuation properties. *Ceramics International*, *47*(21), 29739–29747. doi: https://doi.org/https://doi.org/10.1016/j.ceramint.2021.07.146

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N. & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, *133*, 285–296. doi: https://doi.org/10.1016/j.jbusres.2021.04.070

Enshassi, M. S. A., Walbridge, S., West, J. S. & Haas, C. T. (2019). Integrated risk management framework for tolerance-based mitigation strategy decision support in modular construction projects. *Journal of Management In Engineering*, *35*(4). doi: https://doi.org/10.1061/(ASCE)ME.1943-5479.0000698

Fei-Ping, L., Jian-Feng, L. & Shuo, S. (2013). Influence of the functional layer thickness on the light output property of tandem organic light emitting diode: a numerical study. *Acta Physica Sinica*, *62*(24). doi: https://doi.org/10.7498/aps.62.247201

Fung, T. Y. Y. & Yang, H. (2008). Study on thermal performance of semi-transparent building-integrated photovoltaic glazings. *Energy and Buildings*, *40*(3), 341–350. doi: https://doi.org/10.1016/j.enbuild.2007.03.002

Gokce, H. S., Ozturk, B. C., Cam, N. F. & Andic-Cakir, O. (2018). Gamma-ray attenuation coefficients and transmission thickness of high consistency heavyweight concrete containing mineral admixture. *Cement & Contrete Composites*, *92*, 56–69. doi: https://doi.org/10.1016/j.cemconcomp.2018.05.015

Gregersen, D. M., Elsner, P., Wendelmuth, A. & Goetze, S. (2021). Phototherapy in the 'City of Light' Jena. *Hautarzt*, *72*(5, SI), 459–466. doi: https://doi.org/10.1007/s00105-020-04730-z

Gümüşburun Ayalp, G. & Anaç, M. (2024). A comprehensive analysis of the barriers to effective construction and demolition waste management: A bibliometric approach. *Cleaner Waste Systems*, *8*, 100141. doi: https://doi.org/https://doi.org/10.1016/j.clwas.2024.100141

Guo-peng, L., Jing-lin, Y., Jian, W., Xiao-ye, G., Yu-fan, Z., Qing-li, Z. & Song-ming, W. (2023). Application of aerodynamic levitator laser heating technique : Microstructures of MgTi2O5 crystal and melt by in-situ superhigh temperature raman spectroscopy. *Spectroscopy And Spectral Analysis*, *43*(8), 2507–2513. doi: https://doi.org/10.3964/j.issn.1000-0593(2023)08-2507-07

Haeupl, P. (2022). Indoor climate study in the 'heavy' Golden Hall in Nuremberg and in the 'light' glass enclosure of the Busmann Chapel in Dresden. *Bauphysik*, *44*(3), 113–125. doi: https://doi.org/10.1002/bapi.202200008

Hodder, S. G. & Parsons, K. (2007). The effects of solar radiation on thermal comfort. *International Journal of Biometeorology*, *51*(3), 233–250. doi: https://doi.org/10.1007/s00484-006-0050-y

Jian, S. & Yanxiang, W. (2012). Numerical Simulation of heat transfer of a concentrating solar photovoltaic system. *Asia-Pacific Power And Energy Engineering Conference (Appeec)*.

Jie, J., Hua, Y., Gang, P., Bin, J. & Wei, H. (2007). Study of PV-Trombe wall assisted with DC fan. *Building And Environment*, *42*(10), 3529–3539. doi: https://doi.org/10.1016/j.buildenv.2006.10.038

Karasu, B., Bereket, O., Biryan, E. & Sanoğlu, D. (2017). The latest developments in glass science and technology. *El-Cezeri*, *4*(2), 209–233. doi: https://doi.org/10.31202/ecjse.318204

Kaur, P., Singh, D. & Singh, T. (2016). Heavy metal oxide glasses as gamma rays shielding material. *Nuclear Engineering and Design*, *307*, 364–376. doi: https://doi.org/https://doi.org/10.1016/j.nucengdes.2016.07.029

Kavaz, E., Ekinci, N., Tekin, H. O., Sayyed I, M., Aygun, B. & Perisanoglu, U. (2019). Estimation of gamma radiation shielding qualification of newly developed glasses by using WinXCOM and MCNPX code. *Progress in Nuclear Energy*, *115*, 12–20. doi: https://doi.org/10.1016/j.pnucene.2019.03.029

Keller, L. P. & Messenger, S. (2011). On the origins of GEMS grains. *Geochimica Et Cosmochimica Acta*, *75*(18), 5336–5365. doi: https://doi.org/10.1016/j.gca.2011.06.040

Kumar, A., Gaikwad, D. K., Obaid, S. S., Tekin, H. O., Agar, O. & Sayyed, M. I. (2020). Experimental studies and Monte Carlo simulations on gamma ray shielding competence of (30+x)PbO10WO3 10Na2O – 10MgO – (40-x)B2O3 glasses. *Progress in Nuclear Energy*, *119*, 103047. doi: https://doi.org/https://doi.org/10.1016/j.pnucene.2019.103047

Kumar, K. V. & Bai, R. K. (2008). Performance study on solar still with enhanced condensation. *Desalination*, *230*(1–3), 51–61. doi: https://doi.org/10.1016/j.desal.2007.11.015

Kurtulus, R., Kurtulus, C. & Kavas, T. (2021). Nuclear radiation shielding characteristics and physical, optical, mechanical, and thermal properties of lithium-borotellurite glass doped with Rb2O. *Progress in Nuclear Energy*, *141*, 103961. doi: https://doi.org/https://doi.org/10.1016/j.pnucene.2021.103961

Li, C. Z., Li, S., Li, X., Wu, H., Xiao, B., Tam, V. W. Y. & Asiedu-Kwakyewa, C. (2022). A Scientometric Review of Management of Prefabricated Construction from 2011-2021. *Buildings*, *12*(10). doi: https://doi.org/10.3390/buildings12101515

Lin, S., Wang, H., Zhang, X., Wang, D., Zu, D., Song, J., Liu, Z., Huang, Y., Huang, K., Tao, N., Li, Z., Bai, X.,

Li, B., Lei, M., Yu, Z. & Wu, H. (2019). Direct spray-coating of highly robust and transparent Ag nanowires for energy saving windows. *Nano Energy*, *62*, 111–116. doi: https://doi.org/10.1016/j.nanoen.2019.04.071

Liu, J., Xie, L., Wu, H., Zhang, G., Fang, C. & Gu, J. (2024). Exploring energy-saving performance of radiative cooling roofs with a transient heat transfer model. *Journal of Building Engineering*, *88*. doi: https://doi.org/10.1016/j.jobe.2024.109174

Liu, Y., Yao, F., Ji, Y., Tong, W., Liu, G., Li, H. X. & Hu, X. (2022). Quality Control for Offsite Construction: Review and Future . *Journal of Construction Engineering and Management*, *148*(8). https://doi.org/10.1061/(ASCE)CO.1943-7862.0002317

Lively, R. S. & Ney, E. P. (1987). Surface radioactivity resulting from the deposition of rn-222 daughter products. *Health Physics*, *52*(4), 411–415. doi: https://doi.org/10.1097/00004032-198704000-00001Directions

Mahmoud, I. S., Issa, S. A. M., Saddeek, Y. B., Tekin, H. O., Kilicoglu, O., Alharbi, T., Sayyed, M. I., Erguzel, T. T. & Elsaman, R. (2019). Gamma, neutron shielding and mechanical parameters for lead vanadate glasses. *Ceramics International*, *45*(11), 14058–14072. doi: https://doi.org/10.1016/j.ceramint.2019.04.105

Malidarre, R. B., Kulali, F., Inal, A. & Oz, A. (2020). Monte Carlo simulation of a waste soda–lime–silica glass system containing Sb2O3 for gamma-ray shielding. *Emerging Materials Research*, *9*(4), 1334–1340. doi: https://doi.org/10.1680/jemmr.20.00202

Ming, Y., Sun, Y., Liu, X., Liu, X. & Wu, Y. (2024). Thermal performance of an advanced smart fenestration systems for low-energy buildings. *Applied Thermal Engineering*, *244*. doi: https://doi.org/10.1016/j.applthermaleng.2024.122610

Obaid, S. S., Gaikwad, D. K. & Pawar, P. P. (2018). Determination of gamma ray shielding parameters of rocks and concrete. *Radiation Physics and Chemistry*, *144*, 356–360. doi: https://doi.org/10.1016/j.radphyschem.2017.09.022

Sallam, O. I., Madbouly, A. M., Elalaily, N. A. & Ezz-Eldin, F. M. (2020). Physical properties and radiation shielding parameters of bismuth borate glasses doped transition metals. *Journal of Alloys and Compounds*, *843*, 156056. doi: https://doi.org/https://doi.org/10.1016/j.jallcom.2020.156056

Sayyed, M. I., Ali, A. A., Tekin, H. O. & Rammah, Y. S. (2019). Investigation of gamma-ray shielding properties of bismuth borotellurite glasses using MCNPX code and XCOM program. *Applied Physics A*, *125*(6), 445. doi: https://doi.org/10.1007/s00339-019-2739-x

Sayyed, M. I., Hanfi, M. Y., Mahmoud, K. A. & Abdelaziem, A. (2022). Theoretical Investigation of the radiation-protection properties of the CBS glass family. *Optik*, *258*, 168851. doi: https://doi.org/https://doi.org/10.1016/j.ijleo.2022.168851

Sayyed, M. I., Kumar, A., Tekin, H. O., Kaur, R., Singh, M., Agar, O. & Khandaker, M. U. (2020). Evaluation of gamma-ray and neutron shielding features of heavy metals doped Bi2O3-BaO-Na2O-MgO-B2O3 glass systems. *Progress in Nuclear Energy*, *118*, 103118. doi: https://doi.org/https://doi.org/10.1016/j.pnucene.2019.103118

Sayyed, M. I., Lakshminarayana, G., Moghaddasi, M., Kityk, I. V. & Mahdi, M. A. (2018). Physical properties, optical band gaps and radiation shielding parameters exploration for Dy3+-doped Alkali/Mixed Alkali Multicomponent Borate Glasses. *Glass Physics and Chemistry*, *44*(4), 279–291. doi: https://doi.org/10.1134/S1087659618040119

Shang, W., Peng, Z., Huang, Y., Gu, F., Zhang, J., Tang, H., Yang, L., Tian, W., Rao, M., Li, G. & Jiang, T. (2021). Production of glass-ceramics from metallurgical slags. *Journal of Cleaner Production*, *317*, 128220. doi: https://doi.org/https://doi.org/10.1016/j.jclepro.2021.128220

Sun, C., Xia, R., Shi, H., Yao, H., Liu, X., Hou, J., Huang, F., Yip, H.-L. & Cao, Y. (2018). Heat-Insulating Multifunctional Semitransparent Polymer Solar Cells. *Joule*, *2*(9), 1816–1826. doi:

https://doi.org/10.1016/j.joule.2018.06.006

Tekin, H. O., Kavaz, E., Papachristodoulou, A., Kamislioglu, M., Agar, O., Altunsoy Guclu, E. E., Kilicoglu, O. & Sayyed, M. I. (2019). Characterization of SiO2–PbO–CdO–Ga2O3 glasses for comprehensive nuclear shielding performance: Alpha, proton, gamma, neutron radiation. *Ceramics International*, *45*(15), 19206–19222. doi: https://doi.org/https://doi.org/10.1016/j.ceramint.2019.06.168

Tekin, H. O., Sayyed, M. I. & Issa, S. A. M. (2018). Gamma radiation shielding properties of the hematite-serpentine concrete blended with WO3 and Bi2O3 micro and nano particles using MCNPX code. *Radiation Physics and Chemistry*, *150*, 95–100. doi: https://doi.org/10.1016/j.radphyschem.2018.05.002

Valderrama-Zurian, J. C., Aguilar-Moya, R., Melero-Fuentes, D. & Aleixandre-Benavent, R. (2015). A systematic analysis of duplicate records in Scopus. *Journal of Informetrics*, *9*(3), 570–576. doi: https://doi.org/10.1016/j.joi.2015.05.002

van Eck, N. J. & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, *84*(2), 523–538. doi: https://doi.org/10.1007/s11192-009-0146-3

van Raan, A. F. J. (2005). For Your Citations Only? Hot Topics in Bibliometric Analysis. *Measurement-Interdisciplinary Research and Perspectives*, *3*(1), 50–62. doi: https://doi.org/10.1207/s15366359mea0301_7

Vichegjanina, N. (2014). Ecological factors affecting the provision of optimal quality of the indoor environment in office premises. *National Academy of Managerial Staff of Culture and Arts Herald*, *4*, 112–117.

Xu, Z., Lailin, J., Dong, L., Yanqi, G., Zhan, S., Xiaohui, Z. & Xia, X. (2021). Numerical simulation on third-harmonic generation of super-luminescent light by mixing broadband and narrowband lasers. *Chinese Journal Of Lasers-Zhongguo Jiguang*, *48*(21). doi: https://doi.org/10.3788/CJL202148.2108001

Xue-pei, W., Hong-xia, Z., Song, L. & Qing-hui, L. (2016). Research method and spectral analysis of ancient polychromatic silicate artifacts. *Spectroscopy And Spectral Analysis*, *36*(12), 4045–4051. doi: https://doi.org/10.3964/j.issn.1000-0593(2016)12-4045-07

Yasmin, S., Barua, B. S., Khandaker, M. U., Chowdhury, F.-U.-Z., Rashid, M. A., Bradley, D. A., Olatunji, M. A. & Kamal, M. (2018). Studies of ionizing radiation shielding effectiveness of silica-based commercial glasses used in Bangladeshi dwellings. *Results in Physics*, *9*, 541–549. doi: https://doi.org/10.1016/j.rinp.2018.02.075

Yu, Y., Li, Y., Zhang, Z., Gu, Z., Zhong, H., Zha, Q., Yang, L., Zhu, C. & Chen, E. (2020). A bibliometric analysis using VOSviewer of publications on COVID-19. *Annals of Translational Medicine*, *8*(13), 816. doi: https://doi.org/10.21037/atm-20-4235