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Science mapping for concrete composites as radiation shielding: A review

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A R T I C L E I N F O

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A B S T R A C T

This paper provides a comprehensive bibliometric analysis to better understand the evolution of concrete composite as a radiation shielding research from when it was first published in 1949 to October 26, 2022. This study was conducted based on the Scopus database, and the publications analyzed a total of 541 documents. The data in this paper is visualized using the VOSviewer and Tableau to perform bibliometric analysis and scientific mapping. The analysis results show that published documents have continued to increase in recent years and are dominated by articles. Some countries show productivity and influence in their country/region with the broadest range of partners. This study presents the most contributed journals and the most frequently cited documents. In addition, keyword analysis was carried out to find the hotspots on this research topic. This paper helps scholars to understand the evolution of concrete composite as a radiation shielding research from a bibliometric perspective and inspires them to develop new concrete composite with high stability absorption properties from waste or natural material to replace concrete Lead (Pb)-based.

1. Introduction

The application of electromagnetic waves since discoveries was contributed and provided convenience tools for humans in many ways and reach civilization in every level. Recently, some scientist was reported the applications of radiation was covered various subject area including medical, agriculture, power generation, manufacturing, science, and telecommunications (Abdullah et al., 2022; Ardiansyah et al., 2022; Khazaalah et al., 2022; Mahmoud et al., 2020; More et al., 2021). In addition to its benefits, radiation has significant harm to living organisms. Because radiation is an emission produced by the disintegration of unstable atoms that can cause biological, chemical, and physical changes in living organisms depending on the type, intensity, and exposure time (Ardiansyah et al., 2022; Jaha et al., 2022). With so many impacts, radiation shielding technology continues to be developed for limiting the exposure dose below a particular threshold value; the risk of harmful effects is prevented and kept at acceptable levels (Akbulut et al., 2015; Gholamzadeh et al., 2022; Piotrowski, 2021).

Concrete-based radiation shielding is the most widely developed form of radiation shielding because, in addition to its low cost, concrete can be easily handled and moulded into complex shapes as desired (Ban et al., 2021). Several studies were reported that concrete added with other materials with different characteristics in the form of composite concrete shield, has a significant effect on the ability against ionizing or non-ionizing radiation (Al-Ghamdi et al., 2022; Baalamurugan et al., 2021; Gharissah et al., 2022; Heniegal et al., 2022; Jaha et al., 2022; Singh and Singh, 2021; Zeyad et al., 2022). The ionizing radiation that hits matter will cause several types of interactions that depend on the energy of the ionizing radiation itself, namely: the photoelectric effect, photon-electron scattering, and electron-positron pair production, each of which becomes the dominant interaction mechanism at the energy of 0.01 MeV–0.5 MeV, $>$0.5 MeV, and $\geq$ 1.02 MeV (L'Annunziata, 2020). In contrast to ionizing radiation, a non-magnetic or magnetic shield wall exposed to non-ionizing radiation will experience a different response, as shown in Fig. 1. Electromagnetic waves' electric and magnetic field components influence the difference in response. Non-magnetic

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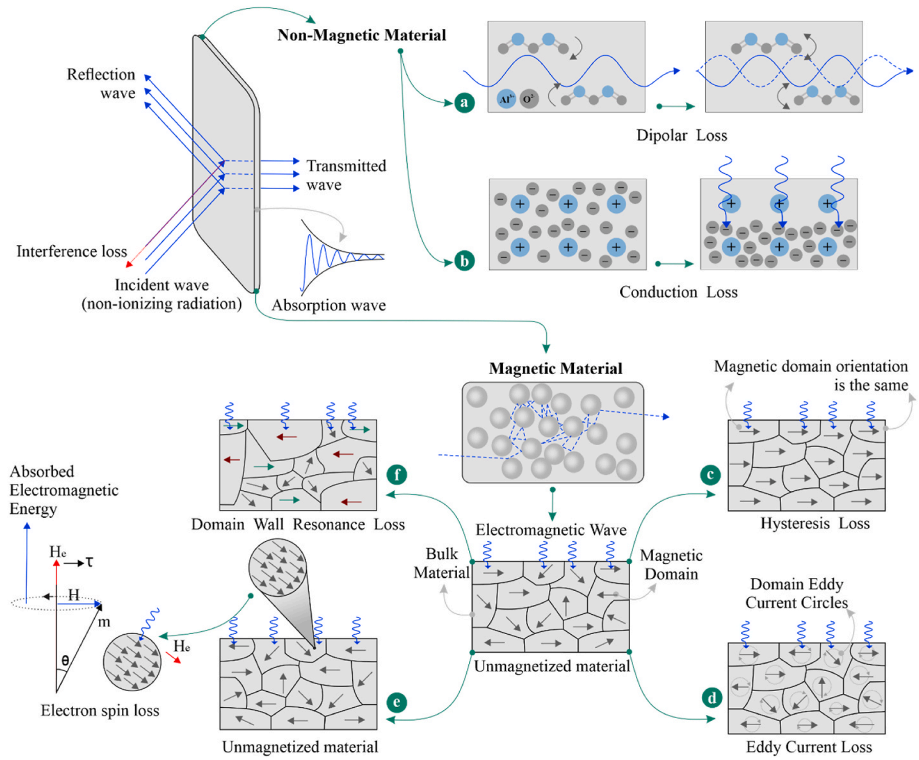

Fig. 1. (a–b) The two main loss mechanisms for non-magnetic materials, and (c–f) The four main loss mechanisms for magnetic materials.

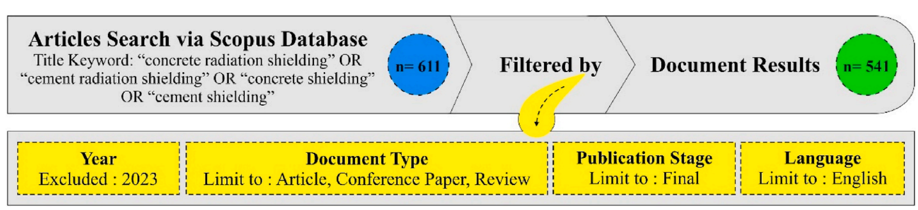

Fig. 2. Document selection scheme for the topic of concrete composite as a radiation shielding.

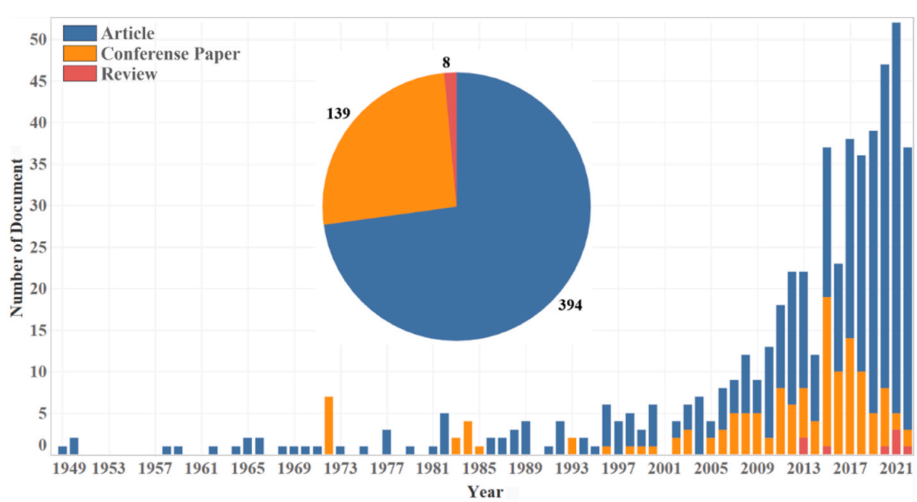

Fig. 3. Distribution of documents on the topic of concrete composites as a radiation shielding published by Scopus from 1949 to October 26, 2022.

materials are only affected by electric elements, while magnetic materials are affected by electric and magnetic field components. The influence of the electric element on non-magnetic materials will result in dipolar and conduction losses. Dipolar loss occurs when an oscillating electric field changes the orientation of the molecular dipoles during the interaction of a photon with the matter, as illustrated in Fig. 1a. The conduction loss mechanism occurs when free electrons move towards an external electric field with a certain speed during the interaction of

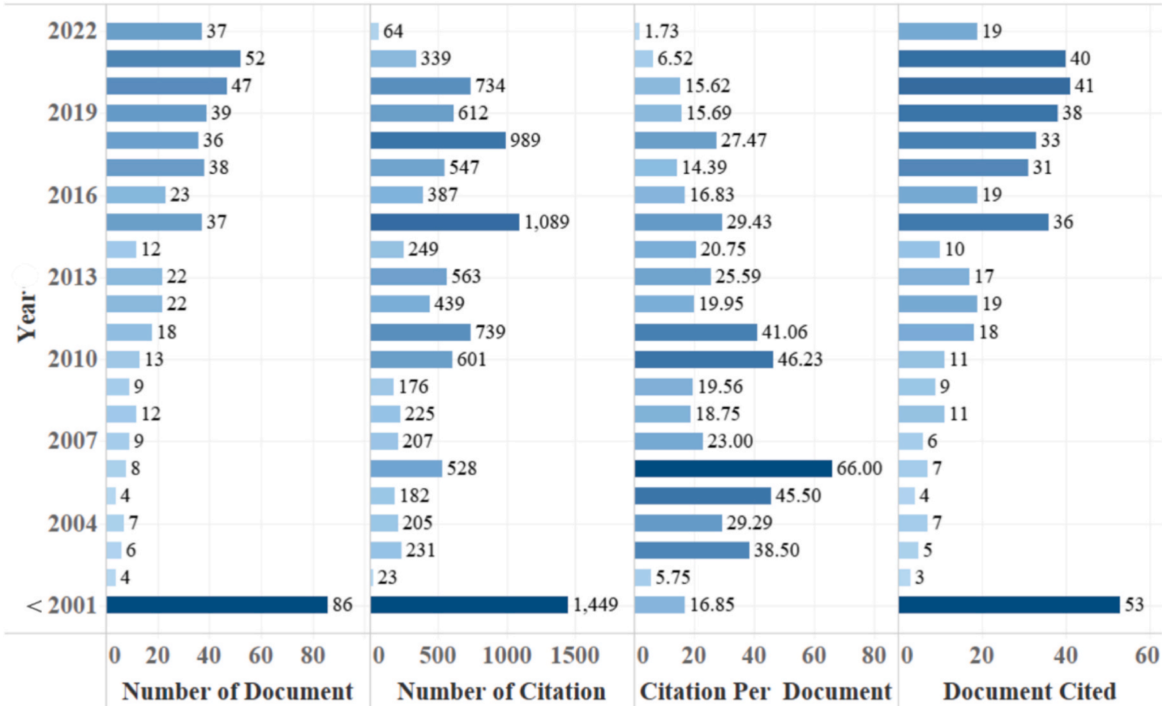

Fig. 4. Publication growth of studies on concrete composite as radiation shielding at Scopus until October 26, 2022.

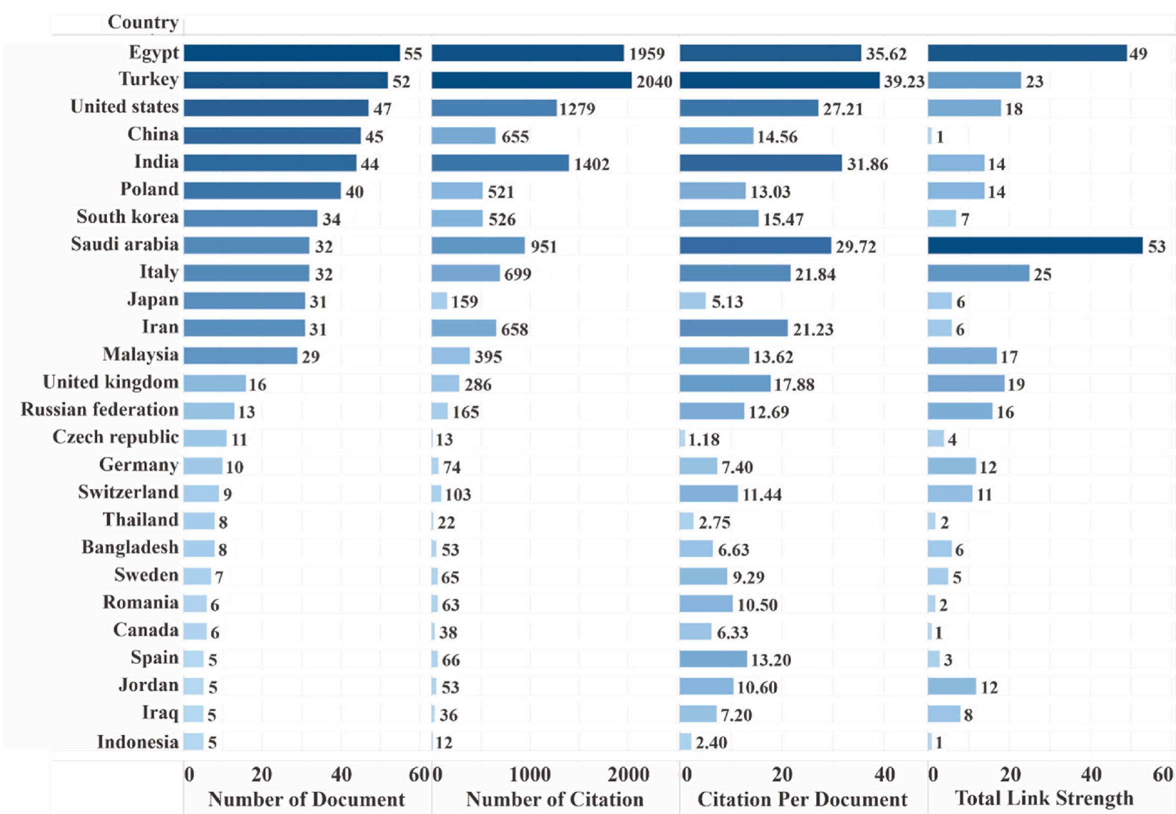

Fig. 5. List of countries that have issued at least five documents on the topic of concrete composite as a radiation shielding.

photons with the matter, as illustrated in Fig. 1b. The effect of electric and magnetic field components on magnetic materials will result in hysteresis loss, eddy current loss, electron spin loss, and domain wall resonance loss. When the magnetic domains align their directions with the external magnetic field, this mechanism is known as hysteresis loss (Fig. 1c). Eddy current loss occurs due to the influence of an external magnetic field which causes eddy currents to be induced in the form of closed loops in all magnetic domains (Fig. 1d). With the influence of the

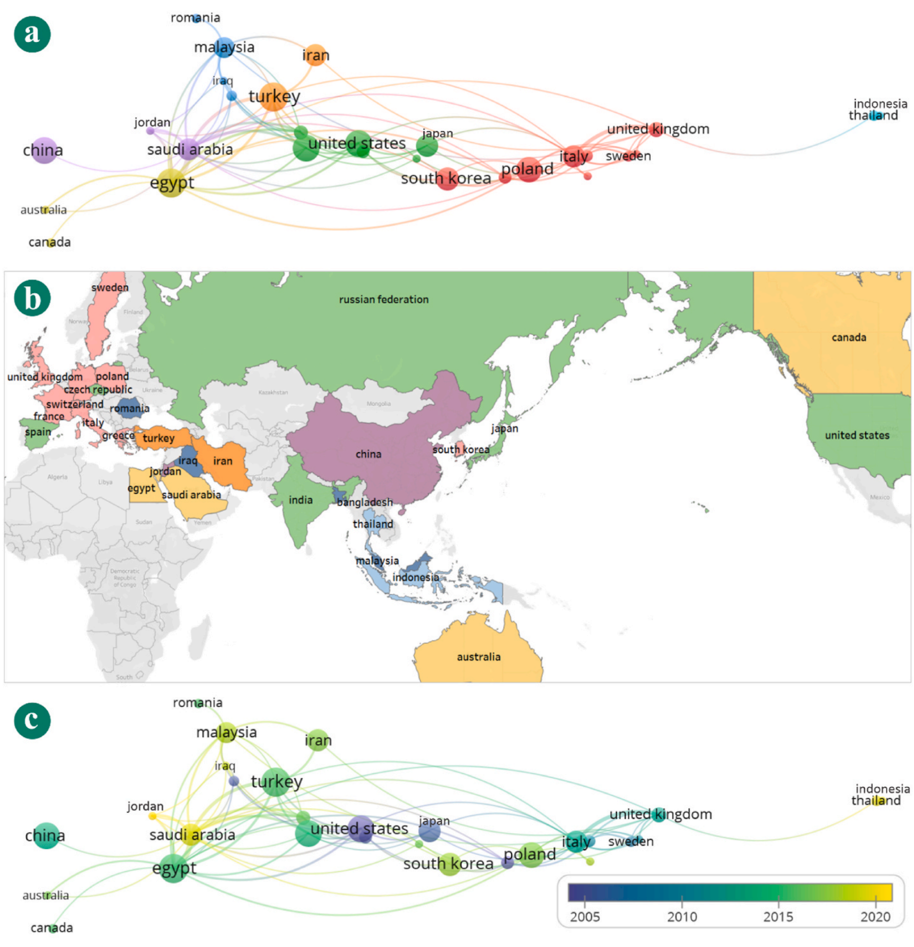

Fig. 6. (a) The visualization of the network of partnerships between countries (b), Global geographical distribution, and (c) Overlay visualization map of countries that have contributed to the topic of concrete composite as a radiation shielding with a minimum productivity of five documents.

external magnetic field (H) due to electromagnetic waves, the internal magnetic field (H_e) and angular momentum (m) will form an angle which will have an impact on the absorption of electromagnetic wave energy, this mechanism is known as electron spin loss (Fig. 1e). The direction of the external magnetic field affecting the magnetic domain area is known as the domain wall resonance loss (Fig. 1f) (Mishra and Sharma, 2016). However, since this topic was first published on Scopus, there has been no literature analysis investigating the development of concrete composites as radiation shielding over time.

The analytical method widely used to analyze published data on certain topics is bibliometric analysis. A bibliometric analysis of shielding has been performed previously on reference (Kilicoglu and Mehmetcik, 2021), the paper was created using the keyword "radiation shielding" to collect documents from the Web of Science (WoS) database. With these keywords, radiation shielding documents based on concrete, polymer, steel, and glass are discussed simultaneously so that a bibliometric analysis of more specific radiation shielding materials is also needed: for example, especially in concrete composites. Bibliometric analysis is a systematic approach to science mapping that includes various statistical methods for quantitatively analyzing big scientific data and its evolution over time, such as performance analysis and scientific mapping analysis (Kilicoglu and Mehmetcik, 2021; Kinnin et al., 2019; Lu et al., 2022; Pei et al., 2022). Activity analytics relies on performance metrics to measure the productivity and impact of publications by analyzing items (country/region, organization, author, etc.). Baseline characteristics can be measured by several recognized biometric metrics, including publication count, citation count, and average citation count per publication (Ding and Zeng, 2022; Zhang et al., 2022).

Based on the description above, this article was written to provide important insights about the scientific development of concrete composites as radiation shields by focusing on: (1) the development of research interest in this field by observing the number of documents published from year to year, (2) contributions countries on the development of research on the topic from year to year along with its network of cooperation with other countries, (3) the journals that publish the most articles on the application of composite concrete as radiation shields and the quality of these journals reviewed based on Scopus metrics (CiteScore, SNIP, and SJR), (4) the documents most often used as references in doing new writings, and (5) the focus of research studies on radiation shielding from concrete composites from year to year. Based on the information that will be obtained from these objectives, this paper can help researchers to understand and development of concrete composite research as a radiation shield from a bibliometric perspective, making it easy for them to find reliable, newest, and quality references. In addition, this paper can even make it easier for researchers to determine the most suitable countries to serve as partners for developing this research topic.

2. Material and methods

Literature searches and data collection was carried out from the Scopus database on October 26, 2022, with the scheme (Fig. 2). The keywords used to get the desired title was "concrete radiation shielding" OR "cement radiation shielding" OR "concrete shielding" OR "cement

Table 1
Journals contributing to concrete composite as a radiation shielding with five minimum number of publication.

Source Title	Number of Document	Percentage (%)	Number of Citation	Publisher	Publication Type	Cite Score	SJR 2021	SNIP 2021
Construction and Building Materials	53	9.80	1292	Elsevier	Journals	10.6	1.777	2.36
Progress in Nuclear Energy	33	6.10	1245	Elsevier	Journals	3.8	0.712	1.38
Radiation Physics and Chemistry	18	3.33	634	Elsevier	Journals	4.5	0.524	1.01
Annals of Nuclear Energy	14	2.59	1479	Elsevier	Journals	3.5	0.875	1.38
Nuclear Engineering and Design	13	2.40	312	Elsevier	Journals	3.5	0.879	1.47
Materials	12	2.22	92	MDPI	Journals	4.7	0.604	1.14
Applied Radiation and Isotopes	10	1.85	269	Elsevier	Journals	2.7	0.422	0.95
Advanced Materials Research	9	1.66	25	Trans Tech Publications	Book Series	NA	NA	NA
Journal of Building Engineering	9	1.66	113	Elsevier	Journals	6.4	1.164	2.15
Acta Physica Polonica A	8	1.48	104	Polish Academy of Sciences	Journals	1.3	0.218	0.34
American Concrete Institute, ACI Special Publication	8	1.48	11	American Concrete Institute	Conferences and Proceedings	NA	NA	NA
Journal of Nuclear Science and Technology	8	1.48	15	Taylor and Francis	Journals	3.1	0.625	1.25
Key Engineering Materials	8	1.48	9	Trans Tech Publications	Book Series	0.9	0.2	0.28
Nuclear Instruments and Methods in Physics Research, Section B: Beam Interactions with Materials and Atoms	8	1.48	181	Elsevier	Journals	2.7	0.426	0.71
Nuclear Instruments and Methods in Physics Research, Section A: Accelerators, Spectrometers, Detectors and Associated Equipment	7	1.29	60	Elsevier	Journals	3.1	0.629	0.94
Nuclear Technology	7	1.29	64	American Nuclear Society	Journals	2.5	0.653	1.00
AIP Conference Proceedings	6	1.11	21	American Institute of Physics Inc.	Conferences and Proceedings	0.8	0.189	0.26
Cement and Concrete Research	5	0.92	487	Elsevier	Journals	19.3	5.408	3.82
European Physical Journal Plus	5	0.92	4	Springer Verlag	Journals	5.0	0.611	1.10
Journal of Hazardous Materials	5	0.92	201	Elsevier	Journals	14.7	1.991	2.06

shielding" and 611 documents were obtained. Furthermore, documents published in 2023 are excluded, and the types of documents are limited to articles, conference papers, and reviews. In addition, all journal articles that are not in English are also excluded. Finally, 541 articles were obtained for analysis. The analysis we carried out to answer the purpose of this study focused on the document type, publication by years, country and journal contributions, highly cited papers, and the relationship of the most frequently used keywords in the research topic of concrete composite as a radiation shielding. In addition, CiteScore, SCImago Journal Rank (SJR), and Source-normalized Impact per Paper (SNIP) for 2021 from the top ten journals were taken from Scopus, Journalindicators, and Scimagojr, respectively. The data visualization software we use is Tableau and VOSviewer. The software has been widely used to represent bibliographic maps graphically (Chen et al., 2021; Ding and Zeng, 2022; Kilicoglu and Mehmetcik, 2021; Lu et al., 2022; Pei et al., 2022).

3. Results

3.1. Document type

The selected types of documents are articles, conference papers, and reviews, each of which amounts to 394, 139, and 8, which are shown in the form of a pie chart in Fig. 3. Fig. 3 also shows that the first document on this topic was first published in 1949 in the form of an article and only one. Publication in the form of a conference paper was first published in 1972 as many as seven documents. The review paper for this topic was first published in 2013 and consists of 2 documents. Since it was first published on Scopus, there have been several years in which this topic was not found, namely 1951–1957, 1963, 1967, 1974, 1976, 1978, 1980, 1990, and 2001. For this reason, documents published from 1949 to 2001 are written with the label <2001 for further data visualization.

3.2. Publication by year

The number of publications on cement composites as radiation shields published by Scopus until October 26, 2022, is presented in Fig. 4. In this figure, it can be seen that the number of publications from 1949 to 2001 was only 86 documents or 1.58 documents per year. In the period 2002–2007, the number of documents issued never reached ten documents per year. 2008 was the first year the number of documents issued exceeded ten, and the highest number of documents were issued, namely in 2021, with a total of 52 documents. The number of citations per document is also shown in Fig. 4. The highest number of citations per document occurred in 2006, as many as 66.00 citations per document, whereas in that year, eight documents were published, and seven of them were cited with a total of 528 citations.

3.3. Geographical distribution of paper

Documents on concrete composite as radiation shielding from 1949 to October 26, 2022, obtained from Scopus, are contributed by authors from 67 countries. Countries that issued at least five documents can be seen in Fig. 5. The country with the highest number of publications is Egypt, with a total of 55 documents, followed by Turkey with 52 documents, the United States with 47 documents, China with 45 documents, and so on. For total citations and number of citations per document, turkey took the top spot with 2040 citations and 39.23 citations per document, respectively.

Collaboration between countries that publish at least five documents is visualized using VOSviewer, as shown in Fig. 6a. The circle's diameter indicates the level of the number of documents published. The same colour indicates that the countries are in the same cluster. The picture shows seven different colours, which means that there are seven clusters. South Korea, Poland, Italy, Sweden, and the United Kingdom form one cluster, while Egypt, Australia, and Canada form another cluster. In full, the distribution of countries can be seen on the map presented in Fig. 6b. The similarity in colour of the countries on the map indicates

Table 2
The top 10 most cited document on concrete composites as radiation shielding.

Rank	Authors	Title	Year	Cites	Cites Per Year	Ref.
1	Bashter I.I.	Calculation of radiation attenuation coefficients for shielding concretes	1997	581	23.24	Bashter (1997)
2	Singh A.P., Gupta B.K., Mishra M., Govind, Chandra A., Mathur R.B., Dhawan S.K.	Multiwalled carbon nanotube/ cement composites with exceptional electromagnetic interference shielding properties	2013	239	26.56	Singh et al. (2013)
3	Akkurt I., Basyigit C., Kilincarslan S., Mavi B., Akkurt A.	Radiation shielding of concretes containing different aggregates	2006	230	14.38	Akkurt et al. (2006)
4	Guan H., Liu S., Duan Y., Cheng J.	Cement based electromagnetic shielding and absorbing building materials	2006	223	13.94	Guan et al. (2006)
5	Singh A.P., Mishra M., Chandra A., Dhawan S.K.	Graphene oxide/ ferrofluid/cement composites for electromagnetic interference shielding application	2011	204	18.55	Singh et al. (2011)
6	Obaid S.S., Gaikwad D. K., Pawar P. P.	Determination of gamma ray shielding parameters of rocks and concrete	2018	170	42.50	Obaid et al. (2018)
7	Akkurt I., Akyildirim H., Mavi B., Kilincarslan S., Basyigit C.	Gamma-ray shielding properties of concrete including barite at different energies	2010	160	13.33	Akkurt et al. (2010)
8	Wen S., Chung D.D.L.	Electromagnetic interference shielding reaching 70 dB in steel fiber cement	2004	155	8.61	Wen and Chung (2004)
9	Akkurt I., Basyigit C., Kilincarslan S., Mavi B.	The shielding of γ-rays by concretes produced with barite	2005	152	8.94	Akkurt et al. (2005)
10	Yilmaz E., Baltas H., Kiris E., Ustabas I., Cevik U., El-Khayatt A.M.	Gamma ray and neutron shielding properties of some concrete materials	2011	146	13.27	Yilmaz et al. (2011)

that the countries are in the same cluster. Then, the connecting line between the circles shown in Fig. 6a shows the line of cooperation where the total link strength can be seen in Fig. 5. The countries with the highest number of link strengths are Saudi Arabia, with 53 total link strengths and the least are China, Canada, and Indonesia with one total link strength. Countries that dominate publications in a given year are shown in Fig. 6c. In the figure, it can be seen that United States publications dominated in the years before 2005. For the latest research, Jordan, Indonesia, Thailand, and Saudi Arabia dominated.

3.4. Preferred journals

Table 1 shows a list of journals that publish at least five documents from 1947 to October 26, 2022. The journal that publishes the most documents is Construction and Building Materials, with the number of publications of 53 documents or 9.80%, the second position is Progress in Nuclear Energy, with a number of publications of 33 documents or 6.10%, and the third is Radiation Physics and Chemistry with a total of 18 documents or 3.33% publications. The highest number of citations was Annals of Nuclear Energy with 1479 citations, followed by Construction and Building Materials with 1292 citations, then Progress in Nuclear Energy with 1245 citations. Other information provided in Table 3 for each journal is CiteScore, SJR, and SNIP in 2021. CiteScore is the number of citations a journal received in one year for documents published in the last three years divided by the number of documents indexed in Scopus published in the same three years. The SCImago Journal Rank (SJR) Index is a size-independent measure of a journal's academic prestige. It ranks journals based on citation weighting scheme and eigenvector centrality (González-Pereira et al., 2010). Source-normalized Impact per Paper (SNIP) is a field-normalized assessment of journal impact. The SNIP score is the ratio of the source's average citation frequency to the number of citations the journal is expected to receive in its subject area (García-Villar and García-Santos, 2021). The journal with the highest citeScore, SJR, and SNIP is Cement and Concrete Research, with five documents and 487 total citations.

3.5. Highly cited document

The top 10 documents with the highest number of citations are shown in Table 2. The article entitled "Calculation of radiation attenuation coefficients for shielding concretes" by Bashter I.I (Bashter, 1997) is the most cited article, with a total of 581 citations and a number of citations per year, as many as 23.24 citations. The article with the highest number of citations per year is entitled "Determination of gamma-ray shielding parameters of rocks and concrete" by Obaid S.S., Gaikwad D.K., Pawar P.P. with 42.50 citations per year (Obaid et al., 2018). Broadly speaking, Table 2 is divided into two main topics: cement composites for gamma-ray shielding and cement composites for EMI shielding, which are tabulated in Tables 3 and 4.

Table 3 shows some parameters of gamma irradiation, namely LAC, MAC, and HVL. An article was written by Bashter I.I in 1997 discussed theoretical calculations and experiments of linear attenuation coefficients, and mass attenuation coefficients for ordinary, hematite-serpentine, ilmenite-limonite, basalt-magnetite, ilmenite, steel-scrap, and steel-magnetite concretes. Overall, Bashter I.I concluded that the higher the atomic number of a constituent or concrete composite material, the more effective the material's ability to shield against radiation. In Table 3, it can also be seen that the materials natural aggregates used in the articles is the most frequently cited. This is because, in recent years, concrete composites have focused on using heavy natural aggregates such as barite or magnetite (Abdullah et al., 2022). The use of heavy natural aggregates was also reported by El-Samrah et al., in 2022 in the form of coarse barite, dolomite, ilmenite, and celestite. Their results show that, the concrete mix containing barite and celestite can attenuate emitted gamma rays in narrow and wide beam (El-Samrah et al., 2022). In 2022, Al-Ghamdi et al., in 2022 was reported concrete by added WO_3 and barite, and show that the highest WO_3 composition had a radiation protection efficiency (RPE) value of 99% at 0.122 MeV (Al-Ghamdi et al., 2022). In 2021, Singh and Singh's was reported green concrete composites which were reinforced with natural heavy aggregates in the form of hematite mixture of ordinary portland cement (OPC) and fly ash as a shield against gamma-ray radiation (Singh and Singh, 2021).

Table 3
Linear Attenuation Coefficient (LAC), Mass Attenuation Coefficient (MAC), and Half Value Layer (HVL) concrete composites as shielding for the most widely cited gamma-ray radiation.

Ref.	Materials	Density (g/cm^3)	LAC			MAC			HVL		
			0.66 MeV	1.33 MeV	1.50 MeV	0.66 MeV	1.33 MeV	1.50 MeV	0.66 MeV	1.33 MeV	1.50 MeV
Bashter (1997)	Portland Cement/sand/graval	2.30	–	–	0.164	–	–	0.071	–	–	4.226
	Portland Cement/hematite/serpentine	2.50	–	–	0.124	–	–	0.049	–	–	5.589
	Portland Cement/ilmenite/limonite	2.90	–	–	0.159	–	–	0.055	–	–	4.358
	Portland Cement/basalt/magnetite	3.05	–	–	0.139	–	–	0.045	–	–	4.986
	Portland Cement/ilmenite	3.50	–	–	0.200	–	–	0.057	–	–	3.465
	Portland Cement/sand/steel scrap	4.00	–	–	0.196	–	–	0.049	–	–	3.536
	Portland Cement/magnetite/steel scrap	5.11	–	–	0.220	–	–	0.043	–	–	3.150
Akkurt et al. (2006)	Cement/fine normal aggregate/coarse barite aggregate	–	0.266	0.132	–	–	–	–	2.605	5.262	–
Obaid et al. (2018)	Portland cement and normal sand	–	–	–	–	0.078	0.055	–	–	–	–
Akkurt et al. (2010)	Portland cement/barite($BaSO_4$)	–	0.299	0.168	–	–	–	–	2.316	4.117	–
Akkurt et al. (2005)	Portland cement/barite($BaSO_4$)	–	0.255	–	–	–	–	–	2.714	–	–
Yilmaz et al. (2011)	Cement/aggregate	2.09	0.175	–	–	0.084	–	–	3.960	–	–
	Cement/aggregate/silica fume	2.07	0.202	–	–	0.098	–	–	3.431	–	–
	Cement/aggregate/Fly ash	2.07	0.182	–	–	0.088	–	–	3.808	–	–
	Cement/aggregate/Blast furnace slag	1.87	0.157	–	–	0.084	–	–	4.414	–	–

Table 4
A brief description of performances of concrete composite-based EMI shields, which is a highly cited paper.

Ref.	Materials	Source	Thickness (mm)	Frequency (GHz)	EMI SE (dB)
Singh et al. (2013)	Multi-walled carbon nanotube (MWCNT)/portland cement (PC) composites	microwave	2	8.2–12.4	27
Singh et al. (2011)	Graphene oxide–ferrofluid–cement nanocomposites	microwave	2.5	8.2–12.4	46
Wen and Chung (2004)	Steel fiber cement	radio wave	–	1.0	77
				1.5	78

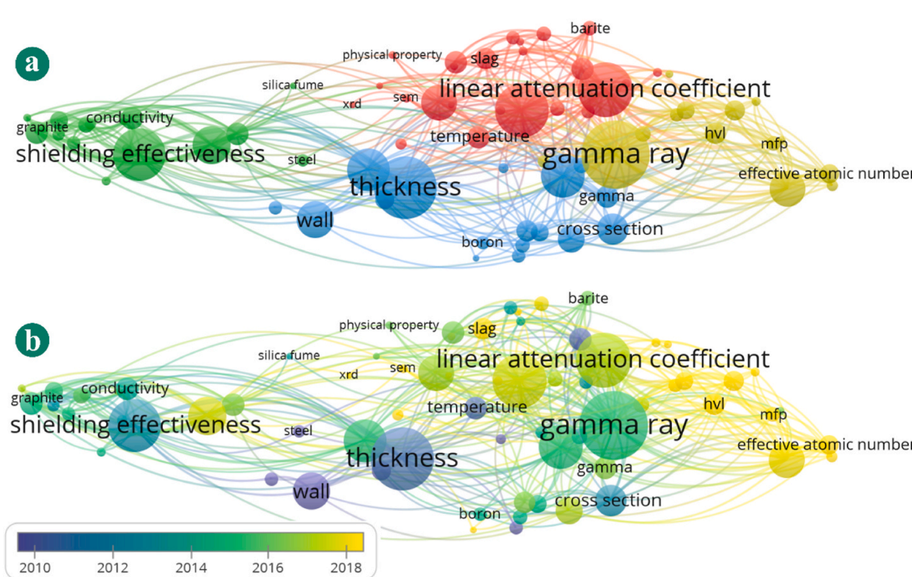

Fig. 7. (a) Keyword map, and (b) Overlay visualization map of the keyword of cement composites as a radiation shielding.

3.6. Keyword analysis

Fig. 7 shows the relationship between keywords used from 1947 to 2022 for the concrete composite as radiation shielding with ten minimum occurrences. In Fig. 7a, the connecting lines between the circles reflect the relationships between keywords. Circles of the same colour indicate that the keywords are usually listed together (Lam et al., 2022). For example, linear attenuation coefficient, SEM (Scanning Electron Microscope), XRD (X-Ray Diffraction), physical property, temperature, barite, and slag usually occur together. As they are within a similar cluster, they have a strong relationship. The figure also shows that the circle for the gamma-ray keyword has the largest size indicating that the keyword is used the most, followed by the keyword's thickness, linear attenuation coefficient, and shielding effectiveness. The keywords used in certain years can be seen in Fig. 7b; the colour in the image ranges from purple to yellow, the purple colour in the image indicates that the keyword is used in previous studies, and the yellow colour indicates that the keyword is used in recent studies. In the latest research, the keywords often used are HVL (half value layer), MFP (mean free path), and effective atomic number.

The effective atomic number (Z_{eff}) keyword is probably often used in recent years because of the Auto-Zeff software that makes it easy to calculate the Z_{eff} value of shielding material (El-Samrah et al., 2022). While HVL and MFP are important information that must be conveyed in research to determine the ability of materials to absorb ionizing radiation such as X-rays, gamma rays, and neutrons. These two parameters can be calculated by entering the value of the linear attenuation coefficient, and one way to determine the linear attenuation coefficient is the Monte Carlo N-Particle transport code (MCNP) simulation (Lee et al., 2022). Low value of HVL and MFP indicated that the concrete composite has good effectiveness as a radiation shield (Cinan et al., 2021; Jaha et al., 2022) which can be determined theoretically by Phy-X/PSD software (Khazaalah et al., 2022).

The equations used to determine the HVL and MFP values based on the experimental results can be seen in equations (1) and (2) (Cinan et al., 2021; Jaha et al., 2022):

$$HVL = \frac{ln\,2}{\mu} \approx \frac{0.693}{\mu} \tag{1}$$

$$MFP = \frac{1}{\mu} \tag{2}$$

where μ is the liner attenuation coefficient which can be calculated using the Lambert-Beer rule (3):

$$\mu = -\left[\frac{ln(I/I_0)}{x}\right] \tag{3}$$

where I_0, I, dan x are the photon intensity values before hitting the material, the photon intensity values after hitting the material, and the thickness of the material, respectively. Then to calculate the effective atomic number (Z_{eff}), equation (4) can be used (Singh and Singh, 2021):

$$Z_{eff} = \frac{\sigma_{t,a}}{\sigma_{t,el}} \tag{4}$$

where $\sigma_{t,a}$ and $\sigma_{t,el}$ are the average atomic cross-section and electronic cross-section, respectively.

4. Conclusion and future research

This paper provides a bibliometric evaluation of relevant publications for concrete composites as a radiation shield from different perspectives, reveals publication trends from year to year, contributions and cooperative relations of countries in the world, the most influential documents, and developments in research topics. In recent years this topic has received great attention; in 2021, the number of published documents reached 52, which were dominated by article-type documents and was the highest number of publications per year since they were first published on Scopus in 1949. Documents that have been published are contributions from various countries. Egypt is the country that has issued the most documents, with a total of 55 documents. The country whose documents received the most citations was Turkey, with a total of 2040 citations. Turkey has the highest number of citations per document, namely, 39.23 citations per document. In developing this research topic, cooperation between countries is also carried out. The country with the most lines of cooperation is Saudi Arabia, followed by Egypt, Italy, and Turkey. The countries that first developed this topic were the United States and Japan, and now publications on this topic are dominated by Jordan, Indonesia, Thailand, and Saudi Arabia.

The journal contributed significantly to developing composite concrete as a radiation shield, namely construction and building materials, with 53 documents. Then the journal with the highest CiteScore, SJR, and SNIP also contributed to developing this research topic, namely cement, and concrete research. Then the most cited article is "Calculation of radiation attenuation coefficients for shielding concretes" by Bashter I.I with a total of 581 citations. The article discusses theoretical calculations of linear and mass attenuation coefficients for ordinary, hematite-serpentine, ilmenite-limonite, basalt-magnetite, ilmenite, steel-scrap, and steel-magnetite concrete.

Keyword analysis shows that research hotspots for concrete composites as radiation shielding focus on gamma-ray, thickness, shielding effectiveness, and linear attenuation coefficient. In recent research, the keywords that are often used are HVL (half value layer), MFP (mean free path), and effective atomic number.

In the future need to be considered, concrete composite filled with waste or natural materials such as iron sand or fiber for safety environment, being both reliable and economical but the important point also is how to project to give rapid, convenient, and easy-to-apply for masses across the globe. The purposes used or waste natural material to be replaced Pb as the best absorber electromagnetic waves including X-rays and γ-rays but should be careful to check compatibility regarding physical and chemical properties. Life cycle assessment for environmental impact and cost analysis of waste or natural materials in concrete should also be studied. The utilization place is also important because the source of waste or natural materials is usually far from the location of utilization means that transportation costs may be disadvantageous for using waste or natural materials. The most important waste to be considered is plastic waste which was a viable alternative to making hydrogen loaded in shielding concrete. By used plastic waste means contributing to the green environment by reducing heavy pollution caused by waste plastics.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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