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A Systematic Review of the Trends Research Synthesis of Magnetic Properties of Natural Iron Sand Materials (2015-2024)

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Abstract: The use of iron sand in Indonesia is currently limited to use only as an additional material in cement factories. Iron sand is generally exported in raw material form, even though iron sand can be further processed so that its use becomes more effective and efficient and the selling price is higher. This research aims to identify and analyze research trends in the synthesis of magnetic properties of natural iron sand materials. This research method is descriptive and analytical. The data used in this research was obtained from documents indexed by Google Scholar from 2015-2024 using Publish or Perish and Dimension.ai. Research procedures use PRISMA guidelines. The data identified and analyzed are the type of publication, publication source, and the title of research on synthesis of magnetic properties of natural iron sand materials that is widely cited. The data analysis method uses bibliometric analysis assisted by VOS viewer software. The results of the analysis show that the trend of research on the synthesis of magnetic properties of natural iron sand materials indexed by Google Scholar experienced varying increases and decreases. It experienced an increase from 2015 to 2018. However, it experienced a decreased in 2019 before increasing again in 2020. Unfortunately, the research trend decreased again until 2023. There are many documents in the form of articles, edited books, proceedings and preprint that discuss about synthesis of magnetic properties of natural iron sand materials. Key words that are often used in research of conceptual mastery are magnetic nanopartiecle, characteristic, impurity, magnetic mineral, etc.

Keywords: Magnetic properties; Natural iron sand material; Review; Synthesis

Introduction

Iron sand is a source of iron whose utilization is still not optimal (Susilawati, Doyan, & Muliyadi, 2020). The use of iron sand in Indonesia is currently limited to use only as an additional material in cement factories. Iron sand is generally exported in raw material form, even though iron sand can be further processed so that its use becomes more effective and efficient and the selling price is higher (Doyan, Hadisaputra, et al., 2023; Haryanto et al., 2021; Morley et al., 2022).

There is a lot of iron sand in Indonesia. Almost all areas in Indonesia have the potential for iron sand. This is inseparable from active volcanic activity which always releases the mineral material it contains. According to Nengsih (2018) the distribution of iron sand in Indonesia is found on the islands of Sumatra, Java, Kalimantan, Sulawesi and Papua. Studies have been carried out on the presence of iron sand in Aceh Province to predict the content of mineral compounds such as iron sand in Lampanah, Aceh Besar Regency, Mon Keulayu Bireuen, White River Channel, Gayo Lues Regency, Aloe Dawah, Aloe Camcung and Aloe Udang, Southwest Aceh Regency. Apart from that, iron sand is also found on the coast of Syiah Kuala, Aceh Besar Regency, Anoe Hitam and Keneke, Sabang Regency, Beungkah, Dakota, Ierhob and Ceurapi, North Aceh Regency, Tangse, Aceh Pidie Regency.

The identification of metal compounds in iron sand in Aceh province in the Lampanah area of Aceh Besar Regency and Mon Keulayu Bireuen Regency has been studied and it is known that they predominantly contain

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the same compounds, namely hematite (Fe_2O_3), Silica (SiO_2) Alumina (Al_2O_3) and rutile (TiO_2) (Sayuti et al., 2018). Based on ESDM data for Aceh Besar Regency, it is known that the potential for iron sand based on magnetic geophysical surveys and sand sampling on the coast has quite large reserves.

Several reasons for the low use of iron sand in industry include the high level of impurities in iron sand and the inhomogeneous grain size of iron sand. This makes the efficiency of iron sand in industry low (Septiyan, 2010). However, you need to know that iron sand contains minerals with high added value such as magnetite, ilmetite, rutile, hematite and so on. Many studies show that the high mineral content in iron sand is magnetite (Jalil et al., 2014). Magnetite is known to have the strongest magnetic properties among other iron oxides (Bustamante-Torres et al., 2022; Cursaru et al., 2020; Susilawati, Doyan, Taufik, et al., 2020).

Nano-sized iron sand has ferrimagnetic properties and has very wide application opportunities (Elmahaishi et al., 2021). The application of nano particle sized iron sand is an alternative that is needed to meet the need for industrial raw materials in the electronics sector which is in development and needs are increasing (Darvina et al., 2019; Mohajerani et al., 2019; Nengsih, 2018). Nano-sized iron sand has potential applications in high density information storage, image formation with magnetic resonance, delivery systems for drugs, absorbents and in medical diagnosis (Abu Bakar et al., 2007). Apart from that, it is also applied to cover magnetic drug targets (James et al., 2014).

Magnetite is a material that has great opportunities in industry, this is because magnetite has interesting physical, biological and chemical properties when the size of the material reaches the nanometer scale. The following are several parameters that influence the properties of magnetite such as shape, size, surface area, crystallinity, composition and morphology (Bahadur et al., 2017). Control of these parameters makes magnetite nanoparticles more flexible for use in heavy metal removal, making it easier to separate the adsorbent from solution (Susilowati et al., 2017) and also as a heterogeneous catalyst because it has a large surface area (Puspasari et al., 2012).

The characteristics of nanoparticles are related to their high surface energy, low toxicity, good biocompatibility with the environment, superparamagnetic abilities, high absorption capacity and ability to transfer electrons (Amoozadeh et al., 2015; Mishra et al., 2016; Saragi et al., 2018).

By changing the size of iron sand to nanometer scale, it has caused changes in chemical and physical properties compared to its size. This property is influenced by control of particle size, regulation of chemical composition, surface modification and control of interactions between particles. The magnetic properties of nanoparticles are strongly influenced by their size and surface effects. The size effect results from electrons being trapped quantumly while the surface effect is related to the change in symmetry of the crystal structure at the boundary plane of each particle (El-Yadri et al., 2023; Farag et al., 2020; Jakhmola et al., 2021; Klimchitskaya et al., 2019; Saragi et al., 2018; Upadhyay et al., 2016).

Therefore, this research wants to know the research trends in the synthesis of magnetic properties of natural iron sand materials. It is hoped that this research can become a reference in developing further research related to the synthesis of magnetic properties of natural iron sand materials.

Method

This research method is descriptive and analytical, which aims to understand and describe research trends in the synthesis of magnetic properties of natural iron sand materials. The data used in this study was obtained from information sources indexed by Google Scholar using analytical tools such as Publish or Perish and Dimension.ai. To carry out a search on Google Scholar, keywords related to research trends on the synthesis of magnetic properties of natural iron sand materials.

In this research, an analysis was carried out on 1,000 documents that had been indexed by Google Scholar between 2015 and 2024. The Google Scholar database was chosen as a place to search for documents because Google Scholar applies consistent standards in selecting documents to be included in its index, and Google Scholar displays more documents than the top others databases, especially research in the field of education (Hallinger et al., 2019, 2020). To filter data that has been collected via Publish or Perish, researchers used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Result and Discussion

This research aims to describe research trends in the synthesis of magnetic properties of natural iron sand materials conducted from 2015 to 2024. Research documents are taken from documents from 2015 to 2024. Figure 1 is presented below regarding research trends in the synthesis of magnetic properties of natural iron sand materials.

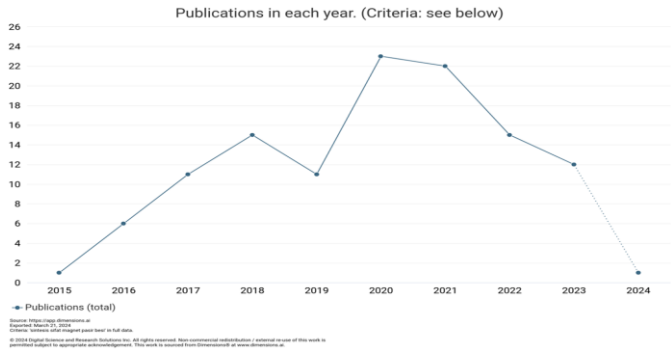

Figure 1. Research trends in the synthesis of magnetic properties of natural iron sand materials

Figure 1 shows that the trends in the synthesis of magnetic properties of natural iron sand materials from 2015 to 2024 experienced varying increases and decreases. It experienced an increase from 2015 to 2018. However, it experienced a decreased in 2019 before increasing again in 2020. Unfortunately, the research trend decreased again until 2023.

In 2015 there was only 1 publication related to the synthesis of magnetic properties of natural iron sand materials, then this will continue to increase to 15 publications in 2018. However, it experienced a decreased in 2019 with 11 publicatins before increasing again in 2020 with 23 publications. Unfortunately, the research trend decreased again until 2023 to 12 publications. This decreasing research trend shows that researchers are increasingly interested in researching the synthesis of the magnetic properties of natural iron sand materials. This is very unfortunate because in fact the results of the synthesis of the magnetic properties of iron sand have many benefits, for example the application of nano particle sized iron sand is a necessary alternative to meet the need for industrial raw materials in the electronics sector which is in development and needs are increasing (Nengsih, 2018).

Table 1. Trends in Synthesis of Magnetic Properties of Natural Iron Sand Materials Research Based on Publication Types

Publication Type	Publications
Article	112
Edited Book	9
Proceeding	5
Preprint	1

Based on Table 1, it is known that research synthesis of magnetic properties of natural iron sand materials from 2015 to 2024 contained in 3 types of publications. In the form of articles there were 112 documents, edited books as many as 9 documents, proceeding as many as 5 documents and only 1 publications of preprint. Research trends synthesis of magnetic properties of natural iron sand materials in article form is the type of publication that contains the most research synthesis of magnetic properties of natural iron sand materials compared to other types of publications. Meanwhile, the type of publication contains the least amount of research results synthesis of magnetic properties of natural iron sand materials is a preprint. Research conducted by Oltarzhevskyi (2019) states that an article is a complete factual essay of a certain length created for publication in online or print media (via newspapers, magazines or bulletins) and aims to convey ideas and facts that can convince and educate. These articles are usually published in scientific journals both in print and online (Suseno et al., 2020).

Below are also presented top ten (10) sources title trends in research on synthesis of magnetic properties of natural iron sand materials which are often cited by other researchers related to this matter.

Table 2. Top 10 Sources Title Trend on Synthesis of Magnetic Properties of Natural Iron Sand Materials Research in 2015-2024

Name	Publications	Citations	Citations Mean
Jurnal Fisika Unand	13	11	0.85
Komunikasi Fisika Indonesia	11	10	0.91
Journal of Physics Conference Series	5	9	1.80
Journal of Aceh Physics Society	5	1	0.20
Jurnal Fisika dan Aplikasinya	5	7	1.40
JST (Jurnal Sains dan Teknologi)	4	1	0.25
Positron	3	5	1.67
Jurnal Fisika Flux	3	1	0.33
Jurnal Ilmiah Fisika FMIPA Universitas Lambung Mangkurat			
Jurnal Ilmu Fisika | universitas andalas	3	3	1.00
Walisongo Journal of Chemistry	3	5	1.67

Table 2 shows that the most widely published source of research trends on synthesis of magnetic properties of natural iron sand materials is the Jurnal Fisika Unand, namely 15 publications with 11 citations and an average citation of 0.85. Jurnal Fisika Unand (JFU) is a peer-reviewed open access journal on interdisciplinary studies of physics, and is published four times in a year (January, April, July, and October) by Department of Physics, Andalas University Padang. The first issue has been released in 2012 and it is made available in electronic form since October 2019 (Vol. 8, No.4). All edition in this journal are open access. The articles published in them are immediately and

permanently free to read, download, copy & distribute. Below are also presented top ten (10) article title trends in research on synthesis of magnetic properties of natural iron sand materials which are often cited by other researchers related to this matter.

Table 3. Top 10 Citations on Trend on Synthesis of Magnetic Properties of Natural Iron Sand Materials Research in 2015-2024

Cites/year	Year	Author	Title
13.00	2020	A Taufiq, A Nikmah, A Hidayat, S Sunaryono, N Mufti, N Hidayat, H Susanto	Synthesis of magnetite/silica nanocomposites from natural sand to create a drug delivery vehicle
9.50	2016	EA Setiadi, P Sebayang, M Ginting, AY Sari, C Kurniawan, CS Saragih, P Simamora	The synthesization of Fe3O4 magnetic nanoparticles based on natural iron sand by co-precipitation method for the used of the adsorption of Cu and Pb ions
6.60	2019	M Rianna, M Situmorang, C Kurniawan, AP Tetuko, EA Setiadi, M Ginting, P Sebayang	The effect of Mg-Al additive composition on microstructure, magnetic properties, and microwave absorption on BaFe12−2xMgxAlxO19 (x = 0–0.5) material synthesized from natural iron sand
6.50	2018	F Malega, IPT Indrayana, E Suharyadi	Synthesis and Characterization of the Microstructure and Functional Group Bond of Fe3o4 Nanoparticles from Natural Iron Sand in Tobelo North Halmahera
6.14	2017	A Taufiq et al.	Studies on Nanostructure and Magnetic Behaviors of Mn-Doped Black Iron Oxide Magnetic Fluids Synthesized from Iron Sand
5.67	2018	MR Fahlepy, VA Tiwow	Characterization of magnetite (Fe3O4) minerals from natural iron sand of Bonto Kanang Village Takalar for ink powder (toner) application
2.50	2018	M Arsyad, VA Tiwow, MJ Rampe	Analysis of magnetic minerals of iron sand deposit in Sampulungan Beach, Takalar Regency, South Sulawesi using the x-ray diffraction method
2.00	2022	AMS Sebayang, M Rianna, LPS Sagala, NS Asri, AP Tetuko, EA Setiadi, LF Nurdiyansah	Nano-structures and magnetic properties of Zn1-xCux/2Nix/2Fe2O4 (x = 0-0.4) synthesized from natural iron sand
1.67	2021	AN Syahida, H Sutanto, I Alkian, FDD Irianti, AA Wibowo, P Priyono	Synthesized and characterization nanosized synthesis Fe3O4powder from natural iron sand
1.20	2019	Abraham Laurens Rettob	Characterization Of Iron Sand Magnetic Materials Coated With 2-Aminobenzimidazole Modified Silica

Table 3 shows that research on the synthesis of magnetic properties of natural iron sand materials that is widely cited by other researchers is about "Synthesis of magnetite/silica nanocomposites from natural sand to create a drug delivery vehicle" which is 13.00 (Taufiq et al., 2020). Then the research entitled "The synthesization of Fe_3O_4 magnetic nanoparticles based on natural iron sand by co-precipitation method for the used of the adsorption of Cu and Pb ions" was cited 9.50 times per year (Setiadi et al., 2016). Research by Rianna et al. (2019) entitled "The effect of Mg-Al additive composition on microstructure, magnetic properties, and microwave absorption on $BaFe_{12-2x}Mg_xAl_xO_{19}$ (x = 0–0.5) material synthesized from natural iron sand" is also widely cited by other researchers, namely 6.60 per year. Malega et al. (2018) in their research entitled "Synthesis and Characterization of the Microstructure and Functional Group Bond of Fe3o4 Nanoparticles from Natural Iron Sand in Tobelo North Halmahera" was cited 6.50 per year.

This research data is comparable to data on the increasing trend of research on the synthesis of magnetic properties of natural iron sand materials from 2015 to 2024. This means that in that year, research related to the synthesis of magnetic properties of natural iron sand materials was continuously cited by other researchers. In the articles researched and written by these researchers, there are many terms/keywords related to the synthesis of magnetic properties of natural iron sand materials. Below are presented ten (10) popular keywords related to it.

Table 4 shows that the keywords that often appear related to research on the synthesis of magnetic properties of natural iron sand materials are magnetic nanoparticle 30 times with a level of 0.92. This indicates that many research discuss about magnetic nanoparticle,

for example, research conducted by Taufiq et al. (2017) which examined Studies on Nanostructure and Magnetic Behaviors of Mn-Doped Black Iron Oxide Magnetic Fluids Synthesized from Iron Sand.

Table 4. Keywords on Trend of Synthesis of Magnetic Properties of Natural Iron Sand Materials Research in 2015-2024

Terms	Occurrences	Relevance
Iron sand magnetic material	13	6.15
Silica	19	3.74
Magnetic susceptibility	18	2.33
Magnetic mineral	27	1.73
Fe_2O_3	11	1.55
Crystal structure	11	1.46
External magnetic field	11	1.46
Magnetic nanoparticle	30	0.92
Characteristic	24	0.62
Impurity	27	0.60

Table 4 also shows that characteristic is also a keyword that appears frequently in research trends on the synthesis of magnetic properties of natural iron sand materials, namely 24 times with a relevance of 0.62. This indicates that synthesis of magnetic properties are often researched together with characteristic of iron sand, for example, research conducted by Syahida et al. (2021) which examined Synthesized and characterization nanosized synthesis Fe3O4powder from natural iron sand.

Below are the visualization is accomplished by generating a landscape map, which offers a visual representation of subjects related to scientific studies. The outcomes of bibliometric mapping for the co-word network in articles related to the topic on synthesis of magnetic properties of natural iron sand materials are illustrated in Figure 2.

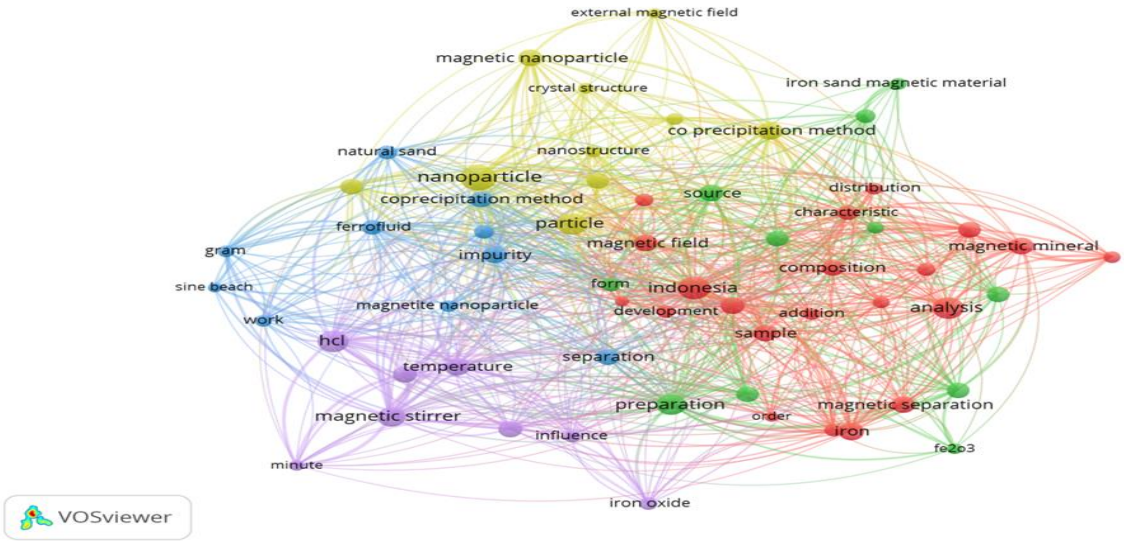

Figure 2. Network visualization on trend synthesis of magnetic properties of natural iron sand materials learning research

Figure 2 shows the results of bibliometric keyword mapping on research trends on synthesis of magnetic properties of natural iron sand materials. In Figure 2 there are 3304 terms and 60 keyword items that are often used in research on the synthesis of magnetic properties of natural iron sand materials from 2015 to 2024. Figure 2 also contains 5 clusters, where the first cluster is colored red and consists of 21 keyword items, namely characteristic, composition, indonesia, iron sand sample, magnetic mineral, magnetic susceptibility, etc. The second cluster in green consists of 11 keyword items, namely extraction, Fe_2O_3, silica, magnetic particle, etc. The third cluster in blue consists of 10 keyword items, namely coprecipitation method, ferrofluid, impurity, magnetic nanoparticle, etc. The fourth yellow cluster consists of 10 keyword items, namely crystal structure, external magnetic field, nanostructure, nanoparticle, etc. The fifth purple cluster consists of 8 keyword items, namely iron oxide, magnetic stirrer, temperature, etc.

Figure 2 above also shows that network visualization shows the network between the terms being visualized. Keywords classified into five clusters are arranged in a color chart showing the divisions/clusters that are connected to each other. The results of this analysis can be used to determine keyword research trends in the last year. This analysis shows several keywords that are often used in research on synthesis of magnetic properties of natural iron sand materials. The more keywords that appear, the wider the visualization displayed. Below are also presented keywords regarding the synthesis of magnetic properties of natural iron sand materials based on overlay visualization.

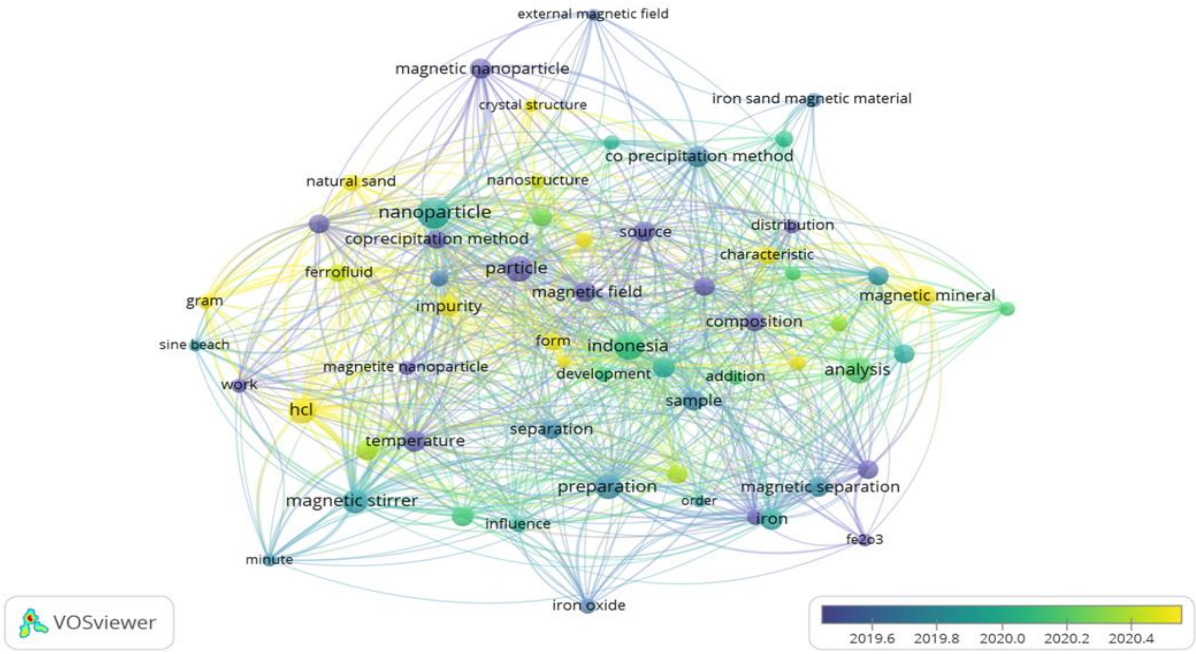

Figure 3. Overlay visualization on trend synthesis of magnetic properties of natural iron sand materials research

Figure 3 shows the trend of keywords related to research on synthesis of magnetic properties of natural iron sand materials in Google Scholar indexed journals from 2015 to 2024. Trends in the themes of writing articles related to the synthesis of magnetic properties of natural iron sand materials from the oldest to the newest year are marked with purple, blue themes, turquoise, dark green, light green and yellow. In the picture above you can see that the magnetic nanoparticle, temperature, iron oxide, Fe_2O_3, composition, etc are purple colored. This shows that these keywords were widely used by researchers in 2019. In early 2020, the keywords that frequently appeared were indonesia, silica, local iron sand, analysis, magnetic mineral, etc. While in end of 2020 with yelloe colored, the keywords that frequently appeared were crystal structure, impurity, ferrofluid, characteristic, nanostructure, etc.

Research on synthesis of magnetic properties of natural iron sand materials is one area of research that has developed rapidly in recent years. The following also presents keywords for conceptual mastery in physics learning research based on density visualization.

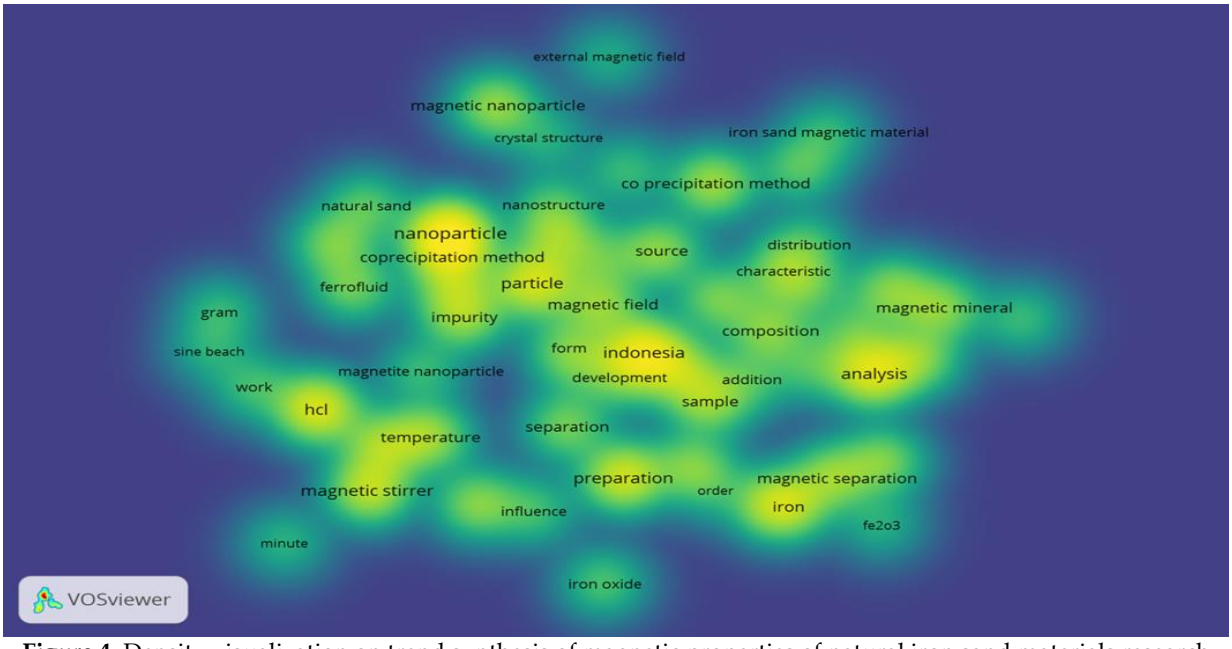

Figure 4. Density visualization on trend synthesis of magnetic properties of natural iron sand materials research

Figure 4 shows density visualization. The density of research themes is shown in bright yellow. The brighter the colors of a theme, the more research is done. The fainter the color means the theme is rarely researched (Kaur et al., 2022; Liao et al., 2018). Faintly colored themes such as iron oxide, magnetite nanoparticle, external magnetic field are dimly colored keywords. This shows that these keywords can be used as a reference for further research. Doyan et al. (2023) and Bahtiar et al. (2023) stated that yellow indicates keywords that are currently and frequently used in research like nanoparticle coprecipitation method.

Overall, research on on synthesis of magnetic properties of natural iron sand materials is important because the results of the synthesis of the magnetic properties of iron sand have many benefits, for example the application of nano particle sized iron sand is a necessary alternative to meet the need for industrial raw materials in the electronics sector which is in development and needs are increasing.

The research trend in on synthesis of magnetic properties of natural iron sand materials is expected to continue to develop in the next few years. This can be done by exploring the potential of natural iron sand materials in Indonesia, especially in NTB.

Conclusion

Research on trends in the synthesis of magnetic properties of natural iron sand materials has urgency high because it has many benefits, for example the application of nano particle sized iron sand is a necessary alternative to meet the need for industrial raw materials in the electronics sector. The research trend on the synthesis of magnetic properties of natural iron sand materials indexed by Google Scholar experienced varying increases and decreases. It experienced an increase from 2015 to 2018. However, it experienced a decreased in 2019 before increasing again in 2020. Unfortunately, the research trend decreased again until 2023. There are many documents in the form of articles, edited books, proceedings and preprint that discuss about synthesis of magnetic properties of natural iron sand materials. Key words that are often used in research of conceptual mastery are magnetic nanopartiecle, characteristic, impurity, magnetic mineral, etc.

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