A bibliometric study on the usage of isotope in hydrogeological studies in Indonesia

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### Contribution to the field

Identifying research gap is one of the biggest problems prior to proposing novel research. The bibliometric technique has been long used to map research based on large-scale data. Using such a technique, this article would contribute to the mapping of research using isotopes in Indonesia. It presents the constellation of countries involving in research collaboration, especially hydrogeological research. This should help not only earth scientists but also policymakers to determine the future steps in developing research and higher education in Indonesia.

Abstract

Background: Hydrogeology education has been inserted into undergraduate geology education. In fact, since the early 1990s, postgraduate programs in Indonesia have been established specifically to study hydrogeology and its applications. We conducted a bibliometric review to identify advances in hydrogeological research using isotopes.

Methods: A total of 68 research articles using isotopes in various regions in Indonesia were extracted from the Scopus database. The corpus data were analyzed statistically with Orange Data Mining and bibliometrically with Vosviewer. We analyzed the relationship of authorship and keyword text mining to identify research groups, research funding flows, and the intensity of research collaboration that has occurred.

**Conclusion:** We found that although most of the research funding comes from the Government of Indonesia, there are many foreign research funders who fund research in Indonesia. This should be an indicator that the geology of Indonesia attracts interests from international researchers. Isotopes have been widely used for tectonics and volcanological studies and less for environmental studies. This is a sign of opportunities to solve environmental problems using isotopes. Various countries from Asia, Europe, America and Africa have collaborated with Indonesian researchers using various types of isotopes. Hydrogeological and environmental isotope research itself is still minimal. This may be related to mainstream focus on the mitigation of natural disasters and the exploitation of natural resources.

# Introduction

Since 1993, there have been more than 200 graduates from the graduate program in hydrogeology. Since 2007, all options in hydrogeology or groundwater studies in ITB have been merged to form the Master Program of Hydrogeology1. However, the advancement of hydrogeological research especially those which utilize isotopes is unknown. Bibliometric study to harvest the metadata of articles has not been conducted. In this paper we explore the state of hydrogeological research using isotopes in Indonesia, based on the available scholarly documents using major databases and open source tools.

# Materials and Methods

We used Scopus scientific databases for this study. Scopus is a commercial database owned by Elsevier, which covers 77 million documents in 20172. The database has been widely used as standard of research quality by Indonesia3. Scopus lists scientific documents in the form of articles, proceedings, reviews etc that are mainly written in English. The access to Scopus was provided by Institut Teknologi Bandung. Search strategy is shown in Table 1 and the procedures are presented in Figure 1.

Search strategies:

Keywords: “isotope”, “Indonesia”

Operators: AND

Inclusion criteria:

Scopus inclusion criteria

In title

journal articles only

Search duration: all time

Search date: March 8th updated on June 5th 2021

Download: metadata download

We analyzed the corpus using:

* Orange Data Mining[4](#v429mkdt7kon), a Python-based open source statistical package created by [Bioinformatics Lab](http://www.biolab.si) at University of Ljubljana, Slovenia, and
* [Vosviewer](https://www.vosviewer.com/), an open source bibliometric visualization app from CTNW Leiden. We used the software to extract the main research themes. The tools of Vosviewer that we used were co-authorship and keywords link visualization. Datasets are stored in the data repository ([link](https://figshare.com/articles/dataset/Dataset_-_On_the_usage_of_isotope_in_hydrogeological_studies_in_Indonesia/14864895)).

The limitation of this study lies in the language used in publishing the research. Scopus does not include articles written in Indonesian. There is a high probability that many hydrogeological studies have used isotopes written in Indonesian.

# Results and Discussions

## The sum of research

We analyze the main research themes related to the use of isotopes. Hydrogeological research using isotopes increased sharply in the 1990s (Figure 2). It is estimated that this is related to the flow of Indonesian researchers who completed their education abroad, especially in France and Germany. Another cause is the increasing intensity of research and higher education funding, both through national funds through the Ministry of Research and Higher Education (currently divided into two ministries: the Ministry of Education and Culture and the National Research and Innovation Agency of the Republic of Indonesia) as well as grants from foreign countries (section 3.2).

Most research funders are from Indonesia, especially from the Ministry of Education and Culture and several major universities such as the Bandung Institute of Technology, Padjadjaran University and the University of Indonesia, and several state research institutions such as BATAN and LIPI. This means most of the research funding are coming from the government. Since 2012, even more government funding for research and capacity building were allocated under LPDP scheme. In 2020, the allocation was attaining IDR 2 Trilyun (equal to USD 138 million) (<https://www.lpdp.kemenkeu.go.id/api/Medias/b0f5ad9e-e2d4-4acc-9dca-19d16e3fe167>).

Other top 3 research funding comes from Japan through the Japanese Ministry of Education, from universities such as Kumamoto University, and from research institutes such as the Japan Society for the Promotion of Science (Figure 3). Those funding were given through Master and/or PhD student scholarships (<https://www.id.emb-japan.go.jp/sch.html>). Funding also comes from China (<http://id.china-embassy.org/eng/whjy/lxxx/t1728025.htm>), Germany (<https://www.daad.id/en/find-funding/daad-scholarships-for-indonesia/>), Australia (<https://www.australiaawardsindonesia.org>), and United States of America (<https://www.aminef.or.id>). Unfortunately, we couldn’t find the annual recapitulation of funding from those governments.

## Research collaborations

Such pattern in funding sources connected with the situation of research collaboration as were reflected by co-authorship at researcher, organization, and country level. The connections are presented by co-authorship and keywords mapping from VosViewer, known as knowledge mapping (refs: <https://link.springer.com/article/10.1007/s10462-021-09980-4>, <https://arxiv.org/pdf/2001.09006.pdf>, <https://link.springer.com/article/10.1007/s10660-020-09410-7>). Such graphs could be used as the basis to assess the status of research collaboration and networking in various subjects between individuals, organizations, and countries (refs: <https://www.jstage.jst.go.jp/article/bst/advpub/0/advpub_2021.01061/_pdf>, <https://www.sciencedirect.com/science/article/pii/S0165032720308211?casa_token=EcC9TRcglLsAAAAA:fTyTKwvCdmnNfJlt1ZEMTCdSqkIEpKEV_zIrYF-biXonMuLKH1juYlOXD3D669VypJ3G5uV9XL9W>, <https://pdfs.semanticscholar.org/47c1/edf9ec91791744b9114978227b365714b82b.pdf>, <https://jscires.org/article/103>).

The authors come from 20 countries from six continents. This reflects the collaboration that occurs among researchers. Researchers from Indonesia still dominate, followed by Japan, the United States, and European countries. Researchers from China are ranked 8th. The least is cooperation with researchers from Africa. This situation shows that cooperation among Asian countries is more and more strengthened. Collaboration with countries on the African continent is also starting to appear (Figure 4a and Figure 4b). Similar patterns of collaborations between South East Asia countries and other countries are also shown by other studies (refs: <https://peerj.com/preprints/936.pdf>, <https://link.springer.com/article/10.1186/gm556>, <https://arxiv.org/pdf/1712.06513.pdf>).

Of the 261 authors (Figure 5a and 5b) coming from 197 institutions (Figure 6a), only 51 coming from eight research institutions have strong relationships (Figure 6b). Those eight institutions are based in Japan and Indonesia. Figure 7 presents most collaborations by country. Other new strong research and development have been built by Chinese organizations since mid 2000’s, to support their industries and entrepreneurship as their economy went vastly stronger (refs: <https://www.orfonline.org/wp-content/uploads/2019/11/OP223.pdf>, <https://www.tandfonline.com/doi/abs/10.1080/08985626.2014.999718>).

Although isotope technology has developed rapidly, research on water, climate, and life sciences using isotopes in Indonesia is still far behind compared to research on tectonics, volcanology, and geophysics in general (refs: <https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.669.5231&rep=rep1&type=pdf>, <https://www.sciencedirect.com/science/article/pii/S0012825215300660?casa_token=2cb66mgrgbwAAAAA:G8KeDF3-uMrYiYml8W96zIjDUMNnJt0GdeUH-4jiNN-sPZ0r7iGF_yWg17KCPf9ICiOl4cAk8ER8>, <http://en.earth-science.net/fileDQKXEN/journal/article/jes/2015/5/PDF/20151016105851.pdf>, <https://www.sciencedirect.com/science/article/pii/S001282520400056X?casa_token=N_v26qWM7pkAAAAA:OZmRrbLS_uMdmREFjL2ctpQ9swoOdIAM53CeQxDgdoDvM9uYP88tSYw_URBebqAPjpDVqwwDS_4T>, <https://www.frontiersin.org/articles/10.3389/feart.2017.00112/full>, <https://en.cnki.com.cn/Article_en/CJFDTotal-KCDZ201005008.htm>, <https://www.sciencedirect.com/science/article/pii/S0883292708002072?casa_token=LLvEmx1aqdAAAAAA:6vTHpiKlqwbZ_B0BEFQfG-87bQ7rp4v1eCZzF-etH6b59r-4uUWDxRu1JaTdDSNj8YuCUoqb0evI>, <https://link.springer.com/content/pdf/10.1007/s11430-012-4532-y.pdf>, <https://www.sciencedirect.com/science/article/pii/S0012825214002220?casa_token=fPQArFJrn5wAAAAA:cQ0Cuq2wzv7XnpBbEZ331G7Y9FiHTLW31yDaa1h-DSebbYDJ_ndspf1zg2q77zPgZHY1NfRQ98MZ>). More research funding flows for research themes of physics and chemistry than research on water and life sciences (refs: <https://www.nap.edu/read/10281/chapter/22>, <https://www.nwo.nl/en/description-five-research-communities-rc-physics>, <https://epsrc.ukri.org/research/ourportfolio/themes/physicalsciences/introduction/>, <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/422477/bis-10-1356-allocation-of-science-and-research-funding-2011-2015.pdf>). However, given the situation, there are several ongoing researches in life science, eg a long term research funding from JICA to increase biodiversity data (refs: <https://www.jica.go.jp/indonesia/english/activities/activity15.html>). This could be because research on water, climate, and life sciences requires a longer period of observation and development.

Figure 4a below shows the dominance of research on tectonic and volcanology conducted by several research groups. It is described in more detail in Figure 5b (refs: <https://www.sciencedirect.com/science/article/pii/S1367912006001489?casa_token=yV980sexg7sAAAAA:VS4c9aZj0ONsDtm_QB2nMImcj5CFbDi_HrLWkiHBPoQIkc9B5i2NNDD9WjAuNrnFG2ClRSb5d-7m>, <https://www.sciencedirect.com/science/article/pii/S0016703798002981?casa_token=2m8ftnAjD0EAAAAA:AX_26vxBp34Ry3j6JXnG3BRB8FgVtF4kOKVcKwihG-r57gHOPf1zq7v7kw_FMxpm-ybdG6FTXzGJ>, <https://pubs.geoscienceworld.org/gsa/geology/article-abstract/48/10/1002/587408/Mesozoic-juvenile-crustal-formation-in-the?redirectedFrom=fulltext>). Research on hydrology, including groundwater, surface water, climate, and life sciences, is lagging. However, it should be realized that the Scopus database is exclusive, not all works especially those written in non-English languages are listed in it (Refs: <https://hal.archives-ouvertes.fr/hal-03281168/document>, <https://2021.goldschmidt.info/goldschmidt/2021/meetingapp.cgi/Paper/3367>).

From 68 articles, 847 keywords were extracted from the title, abstract, and keywords. We picked up the keywords used in three or more different articles. There are 90 keywords, which are classified into four clusters. Each cluster describes a research theme (Figure 8).

We got four themes, each in blue, yellow, red, and green (clockwise). The blue theme is research related to paleoclimate, organic matter, carbon, and biogeochemistry. The yellow theme includes research related to tectonics, plate movement, petrology, and geochemistry. Research on volcanology, petrology, and petrography are highlighted in red. Then the green color contains research on geothermal, environment, groundwater, and surface water. This result is in line with the researchers' focus on the previous images. Those themes are matched with other similar studies by European and Australian researchers to map research themes in earth sciences (refs: <https://ui.adsabs.harvard.edu/abs/2016AGUFMIN33C..07G/abstract>, <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.946.616&rep=rep1&type=pdf>, <https://link.springer.com/article/10.1007/s10784-010-9137-3>, <https://www.iitbmonash.org/wp-content/Resources/Research_Opps_PDFs/IMURA_0716.pdf>).

1. **Conclusions**

From this bibliometric study in which excluding researches written in non-English languages, the use of isotopes in hydrogeological and environmental researches science have been fallen behind other fields of earth sciences. We argue that this would connect with the focus of research funders. More attentions have been developed to physics, chemistry, and material sciences. The focus in earth science research has been narrowed to geological natural disasters and mapping of energy-related and alternative energy reserves[5](#hno558yr6ivi). Research on tectonics and volcanology will be closely related to the prediction of earthquakes and volcanic eruptions, two major geohazards, which are becoming the priorities in many countries.

Research on water and the environment also needs to get a sufficient portion of attention, considering that various current disasters are also closely related to water, such as floods and water contaminations. Moreover, hydrogeological researches could support the increase of water accessibility which has been declared as one of the Sustainable Development Goals is one of the targets that need to be considered together for the benefit of the people.

The flow of research funds from foreign institutions to solve natural problems in Indonesia needs to be maintained so that it does not become "helicopter research" which places Indonesian researchers only on paper or does not involve them at all[6](#vs427o7xhjgu)[7](#idhry2en6bbq)[8](#unmorlw1ngok). The current nature of research that highlights Diversity, Equity, and Inclusivity (DEI) is expected to make collaboration more fluid and benefit all stakeholders involved[9](#qjwuxx8oqkk5)[10](#z3h3b6wt42vq).

The current environmental isotope measurement technique has been very advanced and needs to be supported by the provision of evenly distributed test equipment, not only in universities located on the three main islands (Sumatra, Java and Bali) only. This will make isotope testing faster, more precise, and less expensive.

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# Tables and figures

Table 1 Search strategies

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Databases | Links | Search strategies | Inclusion criteria | Object | Results | Search dates |
| Scopus | Scopus.com | In title “isotope” AND in title “Indonesia” | We used Scopus inclusion criteria[11](#lvkc6c05l22) | To search for articles written in English | 68 | March 8th updated on June 5th 2021 |

Diagram

Description automatically generated

Figure 1 The flowchart of the methods

Chart, bar chart

Description automatically generated

Figure 2 Distribution of published paper by year

Diagram, timeline

Description automatically generated

Figure 3 Distribution of research funders based on continents

Chart, histogram

Description automatically generated

Figure 4a Distribution of authors based on countries

Diagram

Description automatically generated with medium confidence

Figure 4b Distribution of authors based on continents

Diagram

Description automatically generated

Figure 5a Co-authorship based on researchers

Diagram

Description automatically generated

Figure 5b The strongest co-authorship based on researchers

A picture containing timeline

Description automatically generated

Figure 6a Co-authorship based on research organizations (affiliations)

A picture containing text, sky, day

Description automatically generated

Figure 6b Co-authorship with the strongest collaboration based on research organizations (affiliations)

Diagram

Description automatically generated

Figure 7 Co-authorship with the strongest collaboration based on nationality and continent

Diagram

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Figure 8 Research themes mapping based on keyword analysis

# Conflict of Interest

*The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest*.

# Author Contributions

Dasapta Erwin Irawan: conceive the ideas, data collecting, drafting the manuscript

Yunuarti Ulfa: data collecting, drafting the manuscript

Rusmawan Suwarman: drafting the manuscript

Edy Riawan; drafting the manuscript

Irwan Iskandar: drafting the manuscript

Thomas Triadi Putranto: drafting the manuscript

Hari Siswoyo: drafting the manuscript

Vinca Pascalia: data cleaning, drafting the manuscript

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# Data Availability Statement

The datasets GENERATED AND ANALYZED for this study can be found in the FIGSHARE REPOSITORY. DOI: <https://doi.org/10.6084/m9.figshare.14864895.v3>.