BUKTI KORESPONDENSI

Relationships of Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia

Muhammad Arsyad, Vistarani Arini Tiwow, Meytij Jeanne Rampe, Henny Lieke Rampe

Karbala International Journal of Modern Science
Vol. 8, Iss. 3, 2022
https://kijoms.uokerbala.edu.iq/home/vol8/iss3/11/

History for Manuscript Number: KIJOMS-D-22-00203

Correspondence Date	Letter
May 09, 2022	PDF Built and Requires Approval
May 09, 2022	Author Submits New Manuscript Confirmation
May 09, 2022	Author Notice – Technical Check Failure
May 14, 2022	PDF Built and Requires Approval
May 14, 2022	Author Notice of Manuscript Number
May 26, 2022	Editor Decision - Revise
June 09, 2022	PDF Built and Requires Approval
June 09, 2022	Author Submits Revision Confirmation
June 13, 2022	Editor Decision – Revise
June 13, 2022	PDF Built and Requires Approval
June 13, 2022	Author Submits Revision Confirmation
June 17, 2022	Editor Decision - Accept
August 02, 2022	Published Online

SUBMIT ARTICLE

UNM

Muhammad Arsyad <m_arsyad288@unm.ac.id>

Editorial Manager Registration

2 pesan

The Journal <em@editorialmanager.com> 9 Mei 2022 pukul 07.53
Balas Ke: The Journal <trashjo@ariessys.com>
Kepada: Muhammad Arsyad <m_arsyad288@unm.ac.id>

.

Dear Dr Arsyad,

Thank you for registering for the Editorial Manager online submission and peer review tracking system for Karbala International Journal of Modern Science.

Here is your username, which you need to access Editorial Manager at https://www.editorialmanager.com/kijoms/.

Username: m_arsyad288

If you do not know your confidential password, you may reset it by clicking this link: https://www.editorialmanager.com/kijoms/l.asp?i=63699&l=C64M327K

Please save this information in a safe place.

You can change your password and other personal information by logging into the Karbala International Journal of Modern Science website and clicking on the Update My Information link on the menu.

Best regards,

Karbala International Journal of Modern Science

_____
In compliance with data protection regulations, you may request that we remove your personal registration details at any time. (Use the following URL: https://www.editorialmanager.com/kijoms/login.asp?a=r). Please contact the publication office if you have any questions.

Muhammad Arsyad <m_arsyad288@unm.ac.id> 9 Mei 2022 pukul 09.53
Kepada: Vistarani Arini Tiwow <vista.arini@gmail.com>

[Kutipan teks disembunyikan]

UNM

Muhammad Arsyad <m_arsyad288@unm.ac.id>

Submission Confirmation for Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia - [EMID:16f618bd10c55f19]

1 pesan

The Journal <em@editorialmanager.com> 9 Mei 2022 pukul 17.50
Balas Ke: The Journal <trashjo@ariessys.com>
Kepada: Muhammad Arsyad <m_arsyad288@unm.ac.id>

Dear Dr Arsyad,

Your submission entitled "Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia" has been received by journal Karbala International Journal of Modern Science

You will be able to check on the progress of your paper by logging on to Editorial Manager as an author. The URL is https://www.editorialmanager.com/kijoms/.

Your manuscript will be given a reference number once an Editor has been assigned.

Thank you for submitting your work to this journal.

Kind regards,

Karbala International Journal of Modern Science

_____

Karbala International Journal of Modern Science

Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia

--Manuscript Draft--

Manuscript Number:	
Full Title:	Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia
Short Title:	
Article Type:	Original Study
Keywords:	Guano; Magnetic Susceptibility; Heavy Metals; Pearson Correlation
Corresponding Author:	Muhammad Arsyad, M.T. Universitas Negeri Makassar Makassar, Sulawesi Selatan INDONESIA
Corresponding Author Secondary Information:	
Corresponding Author's Institution:	Universitas Negeri Makassar
Corresponding Author's Secondary Institution:	
First Author:	Muhammad Arsyad
First Author Secondary Information:	
Order of Authors:	Muhammad Arsyad
	Vistarani Arini Tiwow
	Meytij Jeanne Rampe
Order of Authors Secondary Information:	
Manuscript Region of Origin:	INDONESIA
Abstract:	This study aims to analyze the magnetic properties and the relationship between magnetic susceptibility and heavy metal content in guano. Guano samples were taken and measured for magnetic susceptibility, XRD, and XRF. The results showed that guano contains superparamagnetic grains and stable single domain measuring <0.05 m with a specific mass of magnetic susceptibility 7.2 to 147.6 x 10-8 m3/kg. Based on Pearson correlation coefficient analysis, magnetic susceptibility is negatively correlated with Fe. Meanwhile, Fe is positively correlated with other heavy metals (Cu, Zr, and Nb). Thus, magnetic susceptibility has the potential as a proxy for detecting heavy metals.
Suggested Reviewers:	Maxwell O Kanu, M.Sc. Taraba State University maxiexpress007@gmail.com
	Mengxiu Zeng Zhejiang Normal University mengxiuzeng@zjnu.edu.cn
	Dragan D Govedarica University of Novi Sad dragang@uns.ac.rs
	Octolia Togibasa Universitas Cenderawasih octolia@gmail.com

UNM

Muhammad Arsyad <m_arsyad288@unm.ac.id>

Your submission entitled Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia - [EMID:5abd69152c83d894]

2 pesan

The Journal <em@editorialmanager.com> 10 Mei 2022 pukul 03.09
Balas Ke: The Journal <trashjo@ariessys.com>
Kepada: Muhammad Arsyad <m_arsyad288@unm.ac.id>

Dear Dr Arsyad,

Your submission entitled "Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia" has been received by the journal, however, it is being returned to you for the following reason(s):

1- The manuscript needs to be revised by a professional English speaker.
2- Please follow the "Publication Ethics" shown in the link below:
https://kijoms.uokerbala.edu.iq/home/publication_ethics.html

3- All references should be edited strictly according to the KIJOMS style as shown on the website below:
https://citationsy.com/styles/karbala-international-journal-of-modern-science
OR as shown on the website below:
https://paperpile.com/s/karbala-international-journal-of-modern-science-citation-style/
4- All authors should be mentioned in all references in the References Paragraph.

Please address the above issue(s) prior to resubmitting your manuscript.

Thank you for submitting your work to this journal.

Kind regards,

Ahmed Mehmood Abdul-Lettif, Ph.D.
Managing Editor
Karbala International Journal of Modern Science

_____
In compliance with data protection regulations, you may request that we remove your personal registration details at any time. (Use the following URL: https://www.editorialmanager.com/kijoms/login.asp?a=r). Please contact the publication office if you have any questions.

Muhammad Arsyad <m_arsyad288@unm.ac.id> 10 Mei 2022 pukul 06.20
Kepada: Vistarani Arini Tiwow <vista.arini@gmail.com>

[Kutipan teks disembunyikan]

UNM

Muhammad Arsyad <m_arsyad288@unm.ac.id>

Your PDF Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia has been built and requires approval

2 pesan

The Journal <em@editorialmanager.com> 14 Mei 2022 pukul 20.28
Balas Ke: The Journal <trashjo@ariessys.com>
Kepada: Muhammad Arsyad <m_arsyad288@unm.ac.id>

Dear Dr Arsyad,

The PDF for your submission, "Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia" is ready for viewing.

This is an automatic email sent when your PDF is built. You may have already viewed and approved your PDF while on-line, in which case you do not need to return to view and approve the submission

Please go to https://www.editorialmanager.com/kijoms/ to approve your submission.

Username: m_arsyad288
If you do not know your confidential password, you may reset it by clicking this link: https://www.editorialmanager.com/kijoms/l.asp?i=64369&l=Y44IDFE2

Your submission must be approved in order to complete the submission process and send the manuscript to the Karbala International Journal of Modern Science editorial office.

Please view the submission before approving it to be certain that your submission remains free of any errors.

Thank you for your time and patience.

Editorial Office Staff
Karbala International Journal of Modern Science
https://www.editorialmanager.com/kijoms/

_____
In compliance with data protection regulations, you may request that we remove your personal registration details at any time. (Use the following URL: https://www.editorialmanager.com/kijoms/login.asp?a=r). Please contact the publication office if you have any questions.

Muhammad Arsyad <m_arsyad288@unm.ac.id> 15 Mei 2022 pukul 05.30
Kepada: Vistarani Arini Tiwow <vista.arini@gmail.com>

[Kutipan teks disembunyikan]

Karbala International Journal of Modern Science

Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia

--Manuscript Draft--

Manuscript Number:	
Full Title:	Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia
Short Title:	
Article Type:	Original Study
Keywords:	Guano; Magnetic Susceptibility; Heavy Metals; Pearson Correlation
Corresponding Author:	Muhammad Arsyad, M.T. Universitas Negeri Makassar Makassar, Sulawesi Selatan INDONESIA
Corresponding Author Secondary Information:	
Corresponding Author's Institution:	Universitas Negeri Makassar
Corresponding Author's Secondary Institution:	
First Author:	Muhammad Arsyad
First Author Secondary Information:	
Order of Authors:	Muhammad Arsyad
	Vistarani Arini Tiwow
	Meytij Jeanne Rampe
	Henny Lieke Rampe
Order of Authors Secondary Information:	
Manuscript Region of Origin:	INDONESIA
Abstract:	This study aims to analyze the magnetic properties and the relationship between magnetic susceptibility and heavy metal content in guano. Guano samples were taken and measured for magnetic susceptibility, XRD, and XRF. The results showed that guano contains superparamagnetic grains and stable single domain measuring <0.05 m with magnetic susceptibility value 7.2 to 147.6 x 10 -8 m 3 /kg. Based on Pearson correlation coefficient analysis, magnetic susceptibility is negatively correlated with Fe. Meanwhile, Fe is positively correlated with other heavy metals (Cu, Zr, Nb). Thus, magnetic susceptibility has the potential as a proxy for detecting heavy metals.
Suggested Reviewers:	Maxwell O Kanu, M.Sc. Taraba State University maxiexpress007@gmail.com
	Mengxiu Zeng Zhejiang Normal University mengxiuzeng@zjnu.edu.cn
	Dragan D Govedarica University of Novi Sad dragang@uns.ac.rs
	Octolia Togibasa Universitas Cenderawasih octolia@gmail.com

DECISION: REVISE 1

UNM

Muhammad Arsyad <m_arsyad288@unm.ac.id>

Your Submission - [EMID:9340876bd44102d2]

2 pesan

The Journal <em@editorialmanager.com> 26 Mei 2022 pukul 14.16
Balas Ke: The Journal <trashjo@ariessys.com>
Kepada: Muhammad Arsyad <m_arsyad288@unm.ac.id>

Ref.: Ms. No. KIJOMS-D-22-00203
Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia
Karbala International Journal of Modern Science

Dear Dr Arsyad,

Reviewers have now commented on your paper. You will see that they are advising that you revise your manuscript. If you are prepared to undertake the work required, I would be pleased to reconsider my decision.

For your guidance, reviewers' comments are appended below.

If you decide to revise the work, please submit a list of changes or a rebuttal against each point which is being raised when you submit the revised manuscript.

Your revision is due by Jun 09, 2022.

To submit a revision, go to https://www.editorialmanager.com/kijoms/ and log in as an Author. You will see a menu item call Submission Needing Revision. You will find your submission record there.

Yours sincerely

Ahmed Mehmood Abdul-Lettif, Ph.D.
Managing Editor
Karbala International Journal of Modern Science

Reviewers' comments:

Reviewer #1: Dear Editor in Chief of Karbala International Journal of Modern Science
As the reviewer of the manuscript entitled as 'Magnetic Properties and Heavy Metals Content of Guano in Bat Cave, South Sulawesi, Indonesia, I went through the manuscript and found that it has merits to publish in an international Journal. It has high implications for empirical applications too. It suffers from major shortcomings that I have highlighted on the attached PDF manuscript file.. In overall, I am recommending for publication after major revision. Moreover, I am strongly suggesting to be improved linguistically and grammatically by a native in English.

Sincerely Yours .

Reviewer #2: 1) Minor information of country missing in Abstract

2) Redefine the research objective clearly in Introduction

3) Figure 1 is unclear as many essential information not visible.

There is additional documentation related to this decision letter. To access the file(s), please click the link below. You may also login to the system and click the 'View Attachments' link in the Action column.
https://www.editorialmanager.com/kijoms/l.asp?i=65914&l=ZU3RHORT

2 lampiran

KIJOMS-D-22-00203_reviewer.pdf
845K

KIJOMS-D-22-00203_reviewer(1).pdf
790K

Muhammad Arsyad <m_arsyad288@unm.ac.id> 26 Mei 2022 pukul 14.23
Kepada: Vistarani Arini Tiwow <vista.arini@gmail.com>

[Kutipan teks disembunyikan]

---

2 lampiran

KIJOMS-D-22-00203_reviewer.pdf
845K

KIJOMS-D-22-00203_reviewer(1).pdf
790K

Karbala International Journal of Modern Science

Attachments for Manuscript Number KIJOMS-D-22-00203 R2
"Relationships of Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia"

Action	Uploaded By	Description	File Name	File Size
Revision 1				
Original Submission				
Download	Reviewer 2	KIJOMS-D-22-00203	KIJOMS-D-22-00203_reviewer.pdf	777 KB
Download	Reviewer 1		KIJOMS-D-22-00203_reviewer.pdf	795 KB

Main Menu

REVIEWER #1

Karbala International Journal of Modern Science

Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia

--Manuscript Draft--

Manuscript Number:	KIJOMS-D-22-00203
Full Title:	Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia
Article Type:	Original Study
Keywords:	Guano; Magnetic Susceptibility; Heavy Metals; Pearson Correlation
Manuscript Region of Origin:	INDONESIA
Abstract:	This study aims to analyze the magnetic properties and the relationship between magnetic susceptibility and heavy metal content in guano. Guano samples were taken and measured for magnetic susceptibility, XRD, and XRF. The results showed that guano contains superparamagnetic grains and stable single domain measuring <0.05 m with magnetic susceptibility value 7.2 to 147.6 x 10 -8 m 3 /kg. Based on Pearson correlation coefficient analysis, magnetic susceptibility is negatively correlated with Fe. Meanwhile, Fe is positively correlated with other heavy metals (Cu, Zr, Nb). Thus, magnetic susceptibility has the potential as a proxy for detecting heavy metals.

Karbala International Journal of Modern Science, 2022, *, **-**

Magnetic Properties and Heavy Metals Content of Guano in Bat Cave, South Sulawesi, Indonesia

Muhammad Arsyad[1], Vistarani Arini Tiwow[1], Meytij Jeanne Rampe[2], and Henny Lieke Rampe[3]

[1]Physics Department, Faculty of Mathematics and Natural Sciences, Makassar State University, Indonesia;
[2]Chemistry Department, Faculty of Mathematics and Natural Sciences, Manado State University, Indonesia;
[3]Biology Department, Faculty of Mathematics and Natural Sciences, Sam Ratulangi University, Indonesia.
Email: m_arsyad288@unm.ac.id

Received Month Day, Year (2022).

ABSTRACT

Bat Cave is one of the caves with guano deposits in the Rammang-Rammang karst area, South Sulawesi, Indonesia. The guano deposits can indicate environmental changes in the cave. This study aims to analyze the magnetic properties and correlation between magnetic susceptibility and heavy metal content in guano. Sampling was carried out in Bat Cave, and magnetic susceptibility, XRD (mineralogy analysis), and XRF (heavy metal content analysis) were measured. The results showed that the guano sample contained superparamagnetic grains and stable single domain (SP-SSD) measuring <0.05 m with a low value of magnetic susceptibility ranging from 7.2 to 147.6 x 10^{-8} m^3/kg. The location of caves in karst areas and climate change affect the magnetic grains. The Pearson correlation coefficient analysis results showed that magnetic susceptibility had a negative correlation with the heavy metal content of Fe. Meanwhile, Fe has a positive correlation with the content of other heavy metals such as Cu, Zr, and Nb. Thus, magnetic susceptibility has the potential as a proxy indicator to detect the presence of heavy metals.

Keywords: Guano; Magnetic Susceptibility; Heavy Metals; Pearson Correlation

1. Introduction

Guano has been studied in environmental magnetic studies for ancient climate changes [1] and environmental changes in caves [2, 3]. In its development, environmental magnetic studies have been carried out on materials such as urban soils [4-7], iron sands [8-11], river sediments [12-16], lake sediments [17-19], marine sediments [20, 21], leachate [22-25], agricultural land [26-28], peatland [29-33], volcanic soil [34], and guano [35-37]. Environmental magnetics involves the relationship of magnetic properties to the process of environmental change due to sediment transport factors, human activities, industrial activities, and agricultural activities [14].

Guano deposits can record environmental changes in caves. Assessment of environmental changes is accompanied by changes in magnetic mineralogy and can be traced through magnetic minerals as carriers of the magnetic properties of guano. Magnetic properties can be reviewed based on the type of mineral, mineral concentration, domain and grain size, and grain shape [38]. Thus, the source of magnetic minerals can be estimated. Magnetic identification and measurement were chosen because their effectivity, quick results, inexpensive, and do not damage the material. This method is complemented by chemical analysis [38, 39].

Magnetic minerals are influenced by the content of iron (Fe) which is a ferromagnetic element. Fe can be detected, although its presence in magnetic minerals is small. In environmental magnetic studies, it is proven that the magnetic mineral content is associated with heavy metals content [40, 41]. Similarly, magnetic properties can indicate the presence of heavy metals in guano deposits.

Several studies have been conducted on the relationship between magnetic susceptibility and heavy metal content. A study of guano from the Bubau and Mampu Caves in South Sulawesi found a strong correlation between magnetic susceptibility and Fe content [35]. Furthermore, studies on guano from Solek Cave, West Sumatra, found a weak correlation between magnetic susceptibility and Fe content [36]. The study of the relationship between magnetic susceptibility and heavy metal content also found a weak correlation in the guano of Bau-Bau cave, East Kalimantan [42]. These studies

Summary of comments: BUKTI KORESPONDENSI-MUHAMMAD ARSYAD-KIJOMS.pdf

Page:16

Number: 1 Author: Subject: Sticky Note Date: 2022-05-14 23:42:49

Relationships of .....

Number: 2 Author: Subject: Highlight Date: 2022-05-14 23:42:35

Number: 3 Author: Subject: Sticky Note Date: 2022-05-14 23:52:19

see and cite yo:
1- Karimi, R., et al. (2011). Relationships between magnetic susceptibility and heavy metals in urban topsoils in the arid region of Isfahan, central Iran. Journal of Applied Geophysics, 74(1) , 1-7.

2- Dankoub, Z., et al., (2012). Spatial distribution of magnetic properties and selected heavy metals in calcareous soils as affected by land use in the Isfahan region, Central Iran. Pedosphere, 22(1), 33-47.

3- Naimi, S., & Ayoubi, S. (2013). Vertical and horizontal distribution of magnetic susceptibility and metal contents in an industrial district of central Iran. Journal of Applied Geophysics, 96, 55-66.

4- Ayoubi, S., Amiri, S., & Tajik, S. (2014). Lithogenic and anthropogenic impacts on soil surface magnetic susceptibility in an arid region of Central Iran. Archives of Agronomy and Soil Science, 60(10), 1467-1483.

5- Ayoubi, S., Jabbari, M., & Khademi, H. (2018). Multiple linear modeling between soil properties, magnetic susceptibility and heavy metals in various land uses. Modeling Earth Systems and Environment, 4(2), 579-589.
6- Ayoubi, S., Soltani, Z., & Khademi, H. (2018). Particle size distribution of heavy metals and magnetic susceptibility in an industrial site. Bulletin of environmental contamination and toxicology, 100(5), 708-714.
7. Ayoubi, S., Adman, V., & Yousefifard, M. (2019). Use of magnetic susceptibility to assess metals concentration in soils developed on a range of parent materials. Ecotoxicology and environmental safety, 168, 138-145.

8- Ayoubi, S., & Karami, M. (2018). Pedotransfer functions for predicting heavy metals in natural soils using magnetic measures and soil properties. Journal of Geochemical Exploration, 197, 212-219.

9- Ayoubi, S., Adman, V., & Yousefifard, M. (2019). Efficacy of magnetic susceptibility technique to estimate metal concentration in some igneous rocks. Modeling Earth Systems and Environment, 5(4), 1743-1750.

Number: 4 Author: Subject: Highlight Date: 2022-05-14 23:43:10

prove that magnetic susceptibility correlates with heavy metal content [43, 44]. In addition, environmental magnetic studies are associated with magnetic minerals, geochemical parameters, domains, and grain size [39]. Specific magnetic characteristics are influenced by transporting material from the outside environment into the cave through wind or water flow during the rainy season [35]. Furthermore, it is also influenced by the geology of the location studied.

The characterization of magnetic properties and the correlation of magnetic susceptibility with heavy metal content in guano caves in karst environments have not been studied, especially in Indonesia. Therefore, studying the magnetic environment and its relationship with heavy metal content is essential. Magnetic analysis was performed from the magnetic measurements and heavy metal content, X-Ray Fluorescence (XRF), and X-Ray Diffraction (XRD). The test results are used to describe the relationship between magnetic susceptibility and the heavy metal content of guano. This information can improve understanding of magnetic analysis, its relationship with heavy metals and to test the magnetic susceptibility as a proxy for heavy metals in guano in the karst environment, especially in Bat Cave.

2. Method

Bat Cave is located in the Rammang-Rammang Karst Area, particularly Berua Village. Bat Cave has a cave mouth width of about 10 m, a cave width of about 25 m, a cave height of about 50 m, and a length of cave that can be reached about 15 m. Bat Cave is located at an elevation of 54 m 119°40'19.5" east longitude and 4°58'33.0" south latitude.

Guano samples were taken from the Bat Cave in the Rammang-Rammang Karst Area, Maros, South Sulawesi, Indonesia. There are thirty points from the mouth of the cave to the cave's depth that can be reached 30 m due to the oxygen levels in the cave at a depth of more than 30 m getting smaller, so the cave guider does not allow it. The sampling point locations are shown in **Figure 1**. At each sampling point, at a depth of 10 cm the sample was taken and put into polyethylene plastic. The guano samples were prepared in the laboratory by being cleaned of impurities and dried at room temperature. The samples were mashed using pastels and mortar, then sieved using a 100 mesh sieve. At this stage, a sample of guano powder is produced. The guano powder sample was weighed at 15 g using a digital scale and put into a plastic clique.

Magnetic measurements were carried out on samples of guano powder using a Bartington MS2B Susceptibilitymeter (Bartington Instrument Ltd., Oxford, UK), which operated at low (470 Hz) and high (4700 Hz) frequencies [39]. The measurement results were analyzed using Multisus software. Measurements at two frequencies to obtain magnetic susceptibility depend on frequency (χ_{FD}) [45, 46] so that the types of magnetic minerals, magnetic mineral domains, and magnetic mineral sources can be interpreted. Based on the results of magnetic susceptibility testing, ten samples with the highest values were selected. The selected guano samples were tested using a Shimadzu Uniquant'X X-Ray Fluorescence (XRF) device and analyzed using PCx Uniquant software to determine the magnetic mineral content and heavy metals.

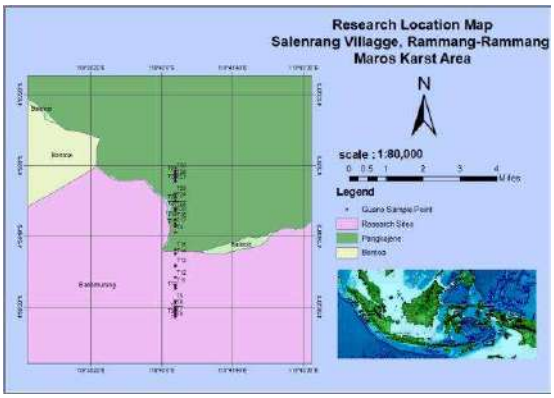


Figure 1. Sampling location in Bat Cave

Two samples were selected for X-Ray Diffraction (XRD) testing from ten samples. The samples were put into a beaker and extracted using a bar magnet to separate the magnetic particles and not the magnetic particles contained in the guano sample. The sample is put in a plastic bag and tested. At this stage, a sample of the extracted guano powder is produced. XRD testing using the Rigaku MiniFlex II type XRD tool to determine the type and concentration of magnetic minerals. It operates at 30 kV voltage, 15 mA current, 0.02° scan width, 4°/min scan rate per time, and 5°-90° scan interval. Qualitative analysis using PDXL2 software with search and match method equipped with ICDD (International Center for Diffraction Data) card 2011. At the same time, the quantitative analysis uses the RIR (Reference Intensity Ratio) method [47, 48].

3. Results and Discussion

The magnetic susceptibility measurements of guano samples on the surface area of guano deposits in Bat Caves are shown in **Table 1**. Meanwhile, the graph plots of the magnetic susceptibility (χ_{LF}) and frequency-dependent magnetic susceptibility (χ_{FD}) at each point

Page:17

Number: 1 Author: Subject: Highlight Date: 2022-05-14 23:52:32

Number: 2 Author: Subject: Sticky Note Date: 2022-05-14 23:53:01

Identify the objectives clearly at the end of introduction section

Number: 3 Author: Subject: Highlight Date: 2022-05-14 23:53:08

Number: 4 Author: Subject: Sticky Note Date: 2022-05-14 23:53:16

Materials and Methods

Number: 5 Author: Subject: Comment on Text Date: 2022-05-14 23:54:24

Figure could not show clearly the location please focus on the figure and show more clearly

are shown in **Figure 1**. The magnetic susceptibility of guano samples (χ_{LF}) ranged from 7.2 to 147.6 x 10^{-8} m^3/kg. The χ_{LF} profile of the Bat Cave guano sample fluctuated along with the cave depth as far as 15 m from the cave mouth. The lowest χ_{LF} values are 7.2 x 10^{-8} m^3/kg, located at point 20. χ_{LF} values more than 100 x 10^{-8} m^3/kg are located at points 8, 13, 27, and 29. Meanwhile, χ_{FD} varies from 2.78 to 8.70 %.

Table 1. Magnetic susceptibility values of Bat Cave guano samples.

Sample	*χ_{LF} (x 10^{-8} m^3/kg)*	*χ_{HF} (x 10^{-8} m^3/kg)*	*χ_{FD} (%)*
T01	79.8	75.5	5.39
T02	58.1	55.6	4.30
T03	81.9	77.0	5.98
T04	59.4	57.3	3.54
T05	67.3	64.4	4.31
T06	86.1	81.1	5.81
T07	72.8	68.8	5.49
T08	125.5	116.4	7.25
T09	92.3	85.2	7.69
T10	64.7	61.3	5.26
T11	63.8	60.9	4.55
T12	73.5	68.8	6.39
T13	147.6	135.5	8.20
T14	42.8	40.8	4.67
T15	80.4	75.9	5.60
T16	62.2	58.5	5.95
T17	47.4	45.6	3.80
T18	73.7	69.1	6.24
T19	65.9	63.0	4.40
T20	7.2	7.0	2.78
T21	53.8	51.3	4.65
T22	52.2	50.1	4.02
T23	94.1	86.8	7.76
T24	79.1	74.2	6.19
T25	53.3	50.7	4.88
T26	67.5	63.6	5.78
T27	106.4	98.2	7.71
T28	81.4	75.6	7.13
T29	117.3	107.1	8.70
T30	60.1	57.2	4.83

The χ_{LF} range of guano samples contains a mixture of (canted) antiferromagnetic and paramagnetic minerals. Meanwhile, χ_{LF} guano Bat Cave mostly has a relatively low value. The low χ_{LF} indicates that the guano sample's iron (Fe) level is also low [49]. Fe content is one of the constituent elements of guano deposits associated with other elements in the Bat Cave. Thus, it is indicated that the Bat Cave is still natural and not influenced by anthropogenic factors. Several studies have reported that the magnetic susceptibility of guano in low-value surface areas is not influenced by anthropogenic but by the location of the cave and climate [35].

Bat Cave guano samples have a higher χ_{LF} than χ_{HF}. The bar graph plot of χ_{LF} and χ_{HF} is shown in **Figure 2**. It can be seen that χ_{LF} and χ_{HF} have significant differences in values. Different values of specific mass measurement of magnetic susceptibility at different frequencies will result in frequency-dependent magnetic susceptibility (χ_{FD}), which indicates the presence and amount of superparamagnetic minerals [49]. Variation of χ_{FD} (2.78 to 8.70 %) indicates that the guano sample belongs to the category of medium χ_{FD} % in which the guano sample contained an admixture of superparamagnetic (SP) and coarser non-SP grains, or SP grains <0.005 μm [39]. SP behavior is a unique property of the simple domain (SD), with a grain size of <0.03 m. The magnetization is solid but unstable. The thermal energy counteracts the induced magnetization quickly after removing the magnetic field. Its magnetic susceptibility is much greater than that of paramagnetic behavior. SP is characterized by its response to susceptibility measured at different frequencies.

The distribution of domains and magnetic mineral sources in the guano sample was interpreted by plotting a scaterring of χ_{FD} and χ_{LF}, as shown in **Figure 3**. The range of χ_{FD} values from 2-10% shows that the domain type is dominated by superparamagnetic (SP) and stable single domain (SSD). SP domain has a finer grain while SSD has a coarser grain [50]. Magnetic mineral sources are indicated to be pedogenic, bacterial magnetosomes, and autogenic or biogenic [39]. These sources can be influenced by climatic factors, namely the transportation

Number: 1 Author: Subject: Sticky Note Date: 2022-05-14 23:56:38

not necessary to present all data. just calculate the descriptive statistics and provide them like: minimum, maximum, median, CV, Skewness, Kurtesis

Number: 2 Author: Subject: Highlight Date: 2022-05-14 23:55:25

of materials through water flowing into the cave and the cave's location in the karst area, namely the minerals that make up the karst, such as $CaCO_3$ and gypsum. In addition, it comes from bat droppings and material transported by wind from outside the cave into the cave [36, 37]. Therefore, following the interpretation of the χ_{LF} distribution of the Bat Cave guano sample, the cave is still natural.

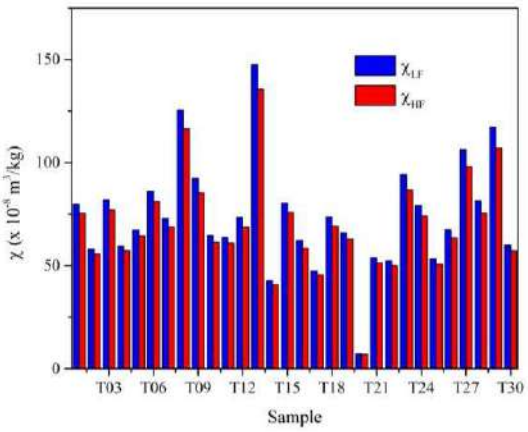


Figure 2. Histogram of magnetic susceptibility at low (χ_{LF}) and high frequency (χ_{HF}) of Bat Cave guano samples.

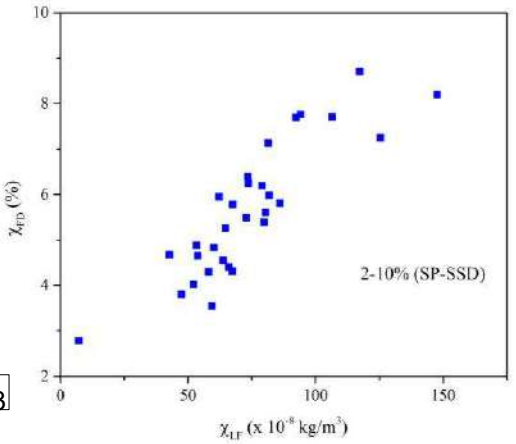


Figure 3. Scattering of frequency-dependent (χ_{FD}) and low-frequency (χ_{LF}) magnetic susceptibility of Bat Cave guano samples.

XRD analysis was done to identify magnetic mineral content in guano samples. As shown in **Figure 4**, the XRD diffractogram of the extracted guano samples. Based on the results of XRD analysis, the guano samples contained magnetite (Fe_3O_4) and hexaferrum (Fe). The calcium indium content was also identified, namely Ca_3In in sample T08 and Ca_8In_3 in sample T29. In addition, the guano sample contains silicon dioxide (SiO_2) and calcium aluminum antimonide ($Ca_{14}AlSb_{11}$).

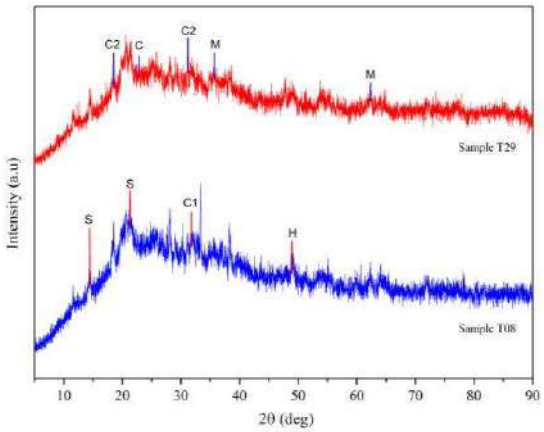


Figure 4. XRD diffractogram of extracted Bat Cave guano sample where S=silicon dioxide (SiO_2), C1=calcium indium (Ca_3In), H=hexaferrum (Fe), C2=calcium indium (Ca_8In_3), M=magnetite (Fe_3O_4), C=calcium aluminum antimonide ($Ca_{14}AlSb_{11}$).

Minerals Ca_3In, Ca_8In_3, $Ca_{14}AlSb_{11}$, and SiO_2 are thought to originate from the external environment and enter the cave through water media that drip on the walls of the cave during the rainy season. Meanwhile, magnetite and hexaferrum are thought to have come from the external environment through the wind entering the cave. Elemental calcium in the minerals calcium indium and calcium aluminum antimonide originates from carbonate rocks. Carbonate rocks contain karst constituent minerals such as calcite ($CaCO_3$), aragonite ($CaCO_3$), and dolomite ($CaMg(CO_3)_2$). However, it can also occur in other rocks formed from these minerals and other water-soluble minerals such as gypsum ($Ca_2SO_4.2H_2O$) [51-53]. This result is by the χ_{FD} interpretation regarding the magnetic mineral source of the guano sample.

Fe_3O_4 is a mineral with solid magnetic properties or high magnetic susceptibility, while CaIn has weak or low magnetic susceptibility. Thus, the guano sample contains a mixture of minerals with strong and weak magnetic properties. Because the concentration of CaIn is greater than Fe_3O_4, it indicates that the value of magnetic susceptibility in the guano sample is low. It measures the magnetic susceptibility of the Bat Cave guano sample, which was obtained low.

The results of the XRF analysis regarding the heavy metals content in the Bat Cave guano samples with varying concentrations are shown in **Table 2**. The heavy metals identified were iron (Fe), zinc (Zn), copper (Cu), zircon (Zr), and neodymium (Nb). The heavy metal in guano is indicated as material carrying magnetic proper-

Page:19

Number: 1 Author: Subject: Sticky Note Date: 2022-05-14 23:59:08

How wad the effects of Calcite and gypsum on magnetic susceptibility?

Number: 2 Author: Subject: Highlight Date: 2022-05-14 23:58:29

Number: 3 Author: Subject: Sticky Note Date: 2022-05-15 00:00:06

plot the line that regress the points, and provide the equation and R2 values on the figure

Number: 4 Author: Subject: Highlight Date: 2022-05-14 23:59:13

ties in the cave. Fe dominated the heavy metal content of the guano sample. The concentration of Fe in all samples showed low concentrations, thus causing low magnetic susceptibility. The concentration of Fe becomes the controller of the magnitude of the magnetic susceptibility in a sample [36, 46, 54].

Table 2. Heavy metal content in Bat Cave guano samples.

Sample	Fe (%)	Zn (ppm)	Cu (ppm)	Zr (ppm)	Nb (ppm)
T03	17.70	7160	1660	2160	389
T06	17.31	7590	1160	2020	362
T08	20.56	6270	0	4160	651
T09	21.29	6410	1260	3760	708
T13	15.52	7270	1800	2700	400
T15	18.01	5860	1300	3440	423
T23	26.25	5690	2890	4420	532
T27	23.82	6180	2160	6320	618
T28	23.56	8190	4800	3580	540
T29	20.74	4880	1040	3510	544

The high concentration of heavy metals indicates the high value of magnetic susceptibility and vice versa. This paper reports that the source influences the magnitude of guano's magnetic and heavy metal susceptibility. Mixed sources are pedogenesis, bacterial magnetosomes, autogenic, and biogenic [55, 56]. Magnetic mineral content can occur naturally due to climatic factors and the location where this source acts as a contaminant [35]. Thus, the magnetic susceptibility parameter can be used as a proxy indicator to detect the presence of heavy metals [43, 44].

The Pearson correlation coefficient between susceptibility magnetic and heavy metal content of the guano samples is shown in **Table 3.** The Pearson correlation coefficient shows how strong the relationship between heavy metals as well as between susceptibility magnetic and heavy metals. The Pearson correlation coefficient between χ_{FD} and Fe (R=0.38) has a positive correlation (**Figure 5a**). Pearson correlation coefficient between χ_{LF} and Fe (R=-0.24) (**Figure 5b**), Zn (R=-0.20), and Cu (R=-0.36) has a negative correlation. The same is true between χ_{FD} and Zn (R=-0.39).

Table 3. Pearson correlation coefficient between magnetic susceptibility and heavy metal content of guano samples.

	Fe	Zn	Cu	Zr	Nb
Fe	1.00				
Zn	-0.28	1.00			
Cu	0.50	0.46	1.00		
Zr	0.73	-0.44	0.14	1.00	
Nb	0.64	-0.36	-0.06	0.70	1.00
χ_{LF}	-0.24	-0.20	-0.36	0.13	0.14
χ_{FD}	0.38	-0.39	0.08	0.43	0.53

Meanwhile, the Pearson correlation coefficient χ_{LF} with Zr (R=0.13) and χ_{LF} with Nb (R=0.14) have a positive correlation. Likewise, the Pearson correlation coefficient χ_{FD} with heavy metal content (Zr R=0.43 and Nb R=0.53) has a positive correlation. Pearson correlation coefficient χ_{FD} with Cu (R=0.08) almost does not correlate. The negative correlation of χ_{LF} with Fe indicates that the low concentration of Fe causes a low magnetic susceptibility value of the guano sample. Fe is a ferromagnetic element affecting the magnetic susceptibility value of guano samples [14, 36].

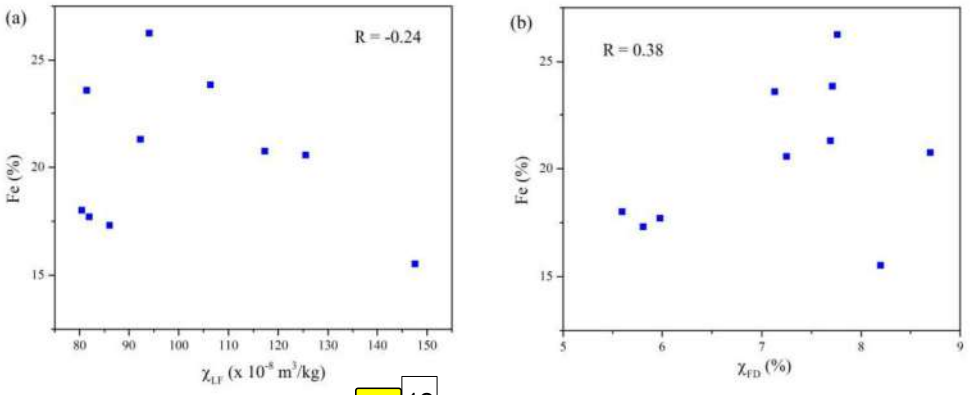


Figure 5. Plot of (a) χ_{LF} with Fe and (b) χ_{FD} with Fe

Page:20

Number: 1 Author: Subject: Highlight Date: 2022-05-15 00:04:35

Number: 2 Author: Subject: Highlight Date: 2022-05-15 00:02:47

Number: 3 Author: Subject: Sticky Note Date: 2022-05-15 00:04:25
change "R" to "r"

Number: 4 Author: Subject: Sticky Note Date: 2022-05-15 00:02:56
reword

Number: 5 Author: Subject: Highlight Date: 2022-05-15 00:04:09

Number: 6 Author: Subject: Highlight Date: 2022-05-15 00:04:10

Number: 7 Author: Subject: Highlight Date: 2022-05-15 00:04:12

Number: 8 Author: Subject: Highlight Date: 2022-05-15 00:04:14

Number: 9 Author: Subject: Highlight Date: 2022-05-15 00:04:15

Number: 10 Author: Subject: Sticky Note Date: 2022-05-15 00:04:01
Did you evaluate the normality of data that is mandatory for this correlation?

Number: 11 Author: Subject: Highlight Date: 2022-05-15 00:03:09

Number: 12 Author: Subject: Sticky Note Date: 2022-05-15 00:04:45
plot the line that regress the points, and provide the equation and R2 values on the figure

Number: 13 Author: Subject: Highlight Date: 2022-05-15 00:04:36

Number: 14 Author: Subject: Highlight Date: 2022-05-15 00:04:37

Number: 15 Author: Subject: Highlight Date: 2022-05-15 00:04:38

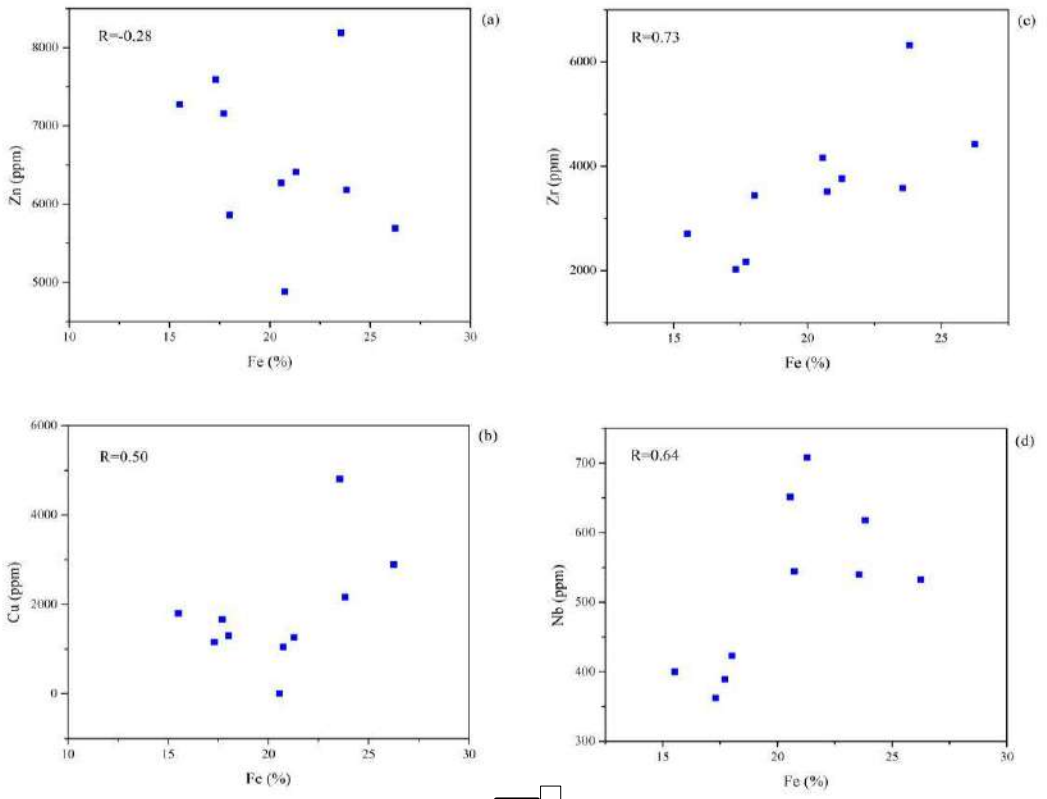


Figure 6. Plot of heavy metal content (a) Fe with Zn, (b) Fe with Cu, (c) Fe with Zr, and (d) Fe with Nb.

Elements of Fe with other heavy metals such as Cu, Zr, and Nb have a positive Pearson correlation coefficient. Meanwhile, Fe has a negative correlation with Zn (R=-0.28). **Figure 6** shows a plot of Fe with other heavy metals (Zn, Cu, Zr, and Nb). Based on these results, magnetic susceptibility is known as a proxy indicator to detect the presence of heavy metals, where heavy metals are associated with Fe [43, 44]. Sources of magnetic susceptibility and heavy metals can be affected by the location of the guano sampling. The guano sample came from the Bat Cave in a karst environment. Location and climate factors affect the Fe content in magnetic minerals [35]. This evidence confirms that the Bat Cave is still natural due to the low magnetic particles of the guano sample. Magnetic particles come from pedogenic components, bacterial magnetosomes, and autogenic or biogenic components. In addition, the presence of heavy metals in the guano samples affects the magnetic particles.

4. Conclusions

Bat Cave guano's magnetic susceptibility is relatively low and varies from 7.2 to 147.6 x 10^{-8} m^3/kg. The guano sample contains fine and coarse superparamagnetic (SP) and stable single domain (SSD) grains with a grain size of <0.05 m. The guano samples contained a mixture of antiferromagnetic and paramagnetic minerals. The value of magnetic susceptibility is influenced by Fe content. Fe element is associated with several other heavy metals such as Zn, Cu, Zr, and Nb. The correlation obtained is dominantly positive. The location and climate factors of Bat Cave in a karst environment affect Fe content in magnetic minerals. The fine grains of magnetic minerals are distributed into the cave through the wind. Meanwhile, coarse magnetic mineral grains are distributed during the rainy season in the cave.

5. Acknowledgements

The author would like to thank students (Ardianto, Siti Halijah, and Nurul Fadillah) who have assisted in sampling. The author also thanks Misdayanti, S.Si., who has assisted in collecting XRD data. Moreover, we also thank Arise Sambolangi, S.Si., who has assisted in collecting magnetic susceptibility data.

Page:21

Number: 1 Author: Subject: Sticky Note Date: 2022-05-15 00:04:55

plot the line that regress the points, and provide the equation and R2 values on the figure

Number: 2 Author: Subject: Highlight Date: 2022-05-15 00:04:55

REFERENCES

[1] L. Nejman, L. Lisá, N. Doláková, I. Horáček, A. Bajer, J. Novák, D. Wright, M. Sullivan, R. Wood, R.H. Gargett, M. Pacher, S. Sázelová, M. Nývltová Fišáková, J. Rohovec, M. Králík, Cave deposits as a sedimentary trap for the marine isotope stage 3 environmental record: The case study of Pod Hradem, Czech Republic, Palaeogeography, Palaeoclimatology, Palaeoecology. 497 (2018) 201-217. https://doi.org/10.1016/j.palaeo.2018.02.020

[2] M. I. Bird, E. M. Boobyer, C. Bryant, H. A. Lewis, V. Paz, W. E. Stephens, A long record of environmental change from bat guano deposits in Makangit Cave, Palawan, Philippines, Earth and Environmental Science Transactions of the Royal Society of Edinburgh, 98 (2007) 59–69. https://doi.org/10.1017/S1755691007000059

[3] E. Aidona, S. Pechlivanidou, C. Pennos, Environmental magnetism: application to cave sediments, Bulletin of the Geological Society of Greece. 47(2) (2013) 892-900. https://doi.org/10.12681/bgsg.11128

[4] N. K. Meena, S. Maiti, A. Shrivastava, Discrimination between anthropogenic (pollution) and lithogenic magnetic fraction in urban soils (Delhi, India) using environmental magnetism, Journal of Applied Geophysics. 73 (2011) 121–129. https://doi.org/10.1016/j.jappgeo.2010.12.003

[5] M. O. Kanu, O. C. Meludu, S. A. Oniku, Comparative study of top soil magnetic susceptibility variation based on some human activities, Geofisica Internacional. 53 (4) (2014) 411-423. https://doi.org/10.1016/S0016-7169(14)70075-3

[6] M. O. Kanu, N. Basavaiah, O. C. Meludu, A. S. Oniku, Investigating the potential of using environmental magnetism techniques as pollution proxy in urban road deposited sediment, Int. J. Environ. Sci. Technol. 14 (2017) 2745–2758. https://doi.org/10.1007/s13762-017-1356-5

[7] D. C. Mello, J. A. M. Dematte, N. E. Q. Silvero, L. A. D. L. Raimo, R. R. Poppiel, F. A. O. Mello, A. B. Souza, J. L. Safanelli, M. E. B. Resende, R. Rizzo, Soil magnetic susceptibility and its relationship with naturally occurring processes and soil attributes in pedosphere, in a tropical environment, Geoderma. 372 (2020) 114364. https://doi.org/10.1016/j.geoderma.2020.114364

[8] V. A. Tiwow, M. Arsyad, Sulistiawaty, M. J. Rampe, W. I. B. Tiro, Analysis of magnetic mineral types of iron sand at Sampulungan Beach, Takalar Regency based on magnetic susceptibility values, Materials Science Forum. 967 (2019) 292-298. https://doi.org/10.4028/www.scientific.net/MSF.967. 292

[9] O. Togibasa, S. Bijaksana, G. C. Novala, Magnetic properties of iron sand from the tor River Estuary, Sarmi, Papua, Geosciences. 8 (2018) 113. https://doi.org/10.3390/geosciences8040113

[10] O. Togibasa, M. Akbar, A. Pratama, S. Bijaksana, Distribution of magnetic susceptibility of natural iron sand in the Sarmi Coast Area, J. Phys.: Conf. Ser. 1204 (2019) 012074. https://doi.org/10.1088/1742-6596/1204/1/012074

[11] Fadhilah, H. Prabowo, T. Saldi, The feasibility test of physical and chemical peoperties of Muaro Binguang Pasaman Barat iron sand for Semen Padang, J. Phys.: Conf. Ser. 1594 (2020) 012037. https://doi.org/10.1088/1742-6596/1594/1/012037

[12] S. Sudarningsih, S. Bijaksana, R. Ramdani, A. Hafidz, A. Pratama, W. Widodo, I. Iskandar, D. Dahrin, S. J. Fajar, N. A. Santoso, Variations in the concentration of magnetic minerals and heavy metals in suspended sediments from Citarum River and its tributaries, West Java, Indonesia, Geosciences. 7 (2017) 66. https://doi.org/10.3390/geosciences7030066

[13] S. Bijaksana, R. Yunginger, A. Hafidz, M. Mariyanto, Magnetic mineral characteristics, trace metals, and REE geochemistry of river sediments that serve as inlets to Lake Limboto, Sulawesi, Indonesia, Data in Brief. 26 (2019) 104348. https://doi.org/10.1016/j.dib.2019.104348

[14] M. Mariyanto, M. F. Amir, W. Utama, A. Hamdan, S. Bijaksana, A. Pratama, S. Sudarningsih, Heavy metal contents and magnetic properties of surface sediments in volcanic and tropical environment from Brantas River, Jawa Timur Province, Indonesia, Science of the Total Environment. 675 (2019) 632–641. https://doi.org/10.1016/j.scitotenv.2019.04.244

[15] M. Mariyanto, M. F. Amir, W. Utama, A. M. Hamdan, S. Bijaksana, A. Pratama, R. Yunginer, S. Sudarningsih, Environmental magnetism data of Brantas River bulk surface sediments, Jawa Timur, Indonesia, Data in Brief. 25 (2019) 104092. https://doi.org/10.1016/j.dib.2019.104092

[16] V. A. Tiwow, Subaer, Sulistiawaty, J. D. Malago, M. J. Rampe, M. Lapa, Magnetic susceptibility of surface sediment in the Tallo tributary of Makassar City, J. Phys.: Conf. Ser. 1899 (2021) 012124. https://doi.org/10.1088/1742-6596/1899/1/012124

[17] H. Guan, C. Zhu, T. Zhu, L. Wu, Y. Li, Grain size, Magnetic susceptibility and geochemical characteristics of the loess in the Chaohu Lake Basin: implications for the origin, palaeoclimatic change and provenance, Journal of Asian Earth Sciences. 117 (2016) 170–183. http://dx.doi.org/10.1016/ j.jseaes.2015.12.013

[18] M. Lone, H. Achyuthan, R. A. Shah, S. J. Sangode, Environmental magnetism and heavy metal assemblages in lake bottom sediments, Anchar Lake, Srinagar, NW Himalaya, India, International Journal of Environmental Research. 12(5) (2018) 489-502. https://doi.org/10.1007/s41742-018-0108-9

[19] R. Yunginger, S. Bijaksana, D. Dahrin, S. Zulaikah, A. Hafidz, K. H. Kirana, S. Sudarningsih, M. Mariyanto, S. J. Fajar, Lithogenic and anthropogenic components in surface sediments from Lake Limboto as shown by magnetic mineral characteristics, trace metals, and REE geochemistry, Geosciences. 8 (2018) 116. https://doi.org/10.3390/geosciences8040116

[20] K. Avinash, P. J. Kurian, A. K. Warrier, R. Shankar, T.C. Vineesh, R. Ravindra, Sedimentary sources and processes in the Eastern Arabian Sea: Insights from environmental magnetism, geochemistry and clay mineralogy, Geoscience Frontiers. 7 (2016) 253e264. http://dx.doi.org/10.1016/j.gsf.2015.05.001

[21] J. Nizou, F. Demory, C. D. Brunaud, Monitoring of dredged-dumped sediment dispersal off the bay of the seine (Northern France) using environmental magnetism, C. R. Geoscience. 348 (2016) 451–461. http://dx.doi.org/10.1016/j.crte.2015.02.005
[22] S. Bijaksana, E. K. Huliselan, Magnetic properties and heavy metal content of sanitary leachate sludge in two landfill sites near Bandung, Indonesia, Environmental Earth Sciences. 60(2) (2010) 409–419. https://doi.org/10.1007/s12665-009-0184-4
[23] E. K. Huliselan, S. Bijaksana, W. Srigutomo, E. Kardena, Scanning electron microscopy and magnetic characterization of iron oxides in solid waste landfill leachate, Journal of Hazardous Materials. 179 (2010) 701–708. https://doi.org/10.1016/j.jhazmat.2010.03.058
[24] K. Kirana, N. Aufa, E. K. Huliselan, S. Bijaksana, Magnetic and electrical properties of leachate, ITB J. Sci. 43A(3) (2011) 165-178. https://doi.org/10.5614/itbj.sci.2011.43.3.2
[25] G. C. Novala, D. Fitriani, K. Susanto, K. H. Kirana, Magnetic properties of soils from Sarimukti landfill as proxy indicators of pollution (Case study: Desa Sarimukti, Kabupaten Bandung Barat), IOP Conf. Ser.: Earth Environ. Sci. 29 (2016) 012015. https://doi.org/10.1088/1755-1315/29/1/012015
[26] Y. Bian, T. Ouyanga, Z. Zhu, N. Huang, H. Wan, M. Li, Magnetic properties of agricultural soil in the Pearl River Delta, South China – Spatial distribution and influencing factor analysis, Journal of Applied Geophysics. 107 (2014) 36–44. http://dx.doi.org/10.1016/j.jappgeo.2014.05.003
[27] N. Y. Daryanti, S. Zulaikah, N. Mufti, D. S. Haryati, Characteristics of magnetic susceptibility and geochemistry of paddy soils in Malang City, East Java, IOP Conf. Ser.: Earth Environ. Sci. 311 (2019) 012032. https://doi.org/10.1088/1755-1315/311/1/012032
[28] D. S. Haryati, S. Zulaikah, Sunaryono, N. Y. Daryanti, Magnetic properties and magnetic minerals morphology of orchards soils Batu Malang, IOP Conf. Ser.: Earth Environ. Sci. 311 (2019) 012040. https://doi.org/10.1088/1755-1315/311/1/012040
[29] Anisah, F. Marpaung, A. Purwandani, D. Nugroho, L. Sumargana, Early study of magnetic permeability and magnetic susceptibility of peat in Ogan Komering Ilir, South Sumatera, Indonesia, IOP Conf. Series: Earth and Environmental Science. 500 (2020) 012025. https://doi.org/10.1088/1755-1315/500/1/012025
[30] E. D. Ningsih, R. Putra, C. D. L. Maisonneuve, M. Phua, S. Eisele, F. Forni, J. Oalmann, H. Rifai, Identification of magnetic mineral forming elements in peatland Alahan Panjang West Sumatra Indonesia, section DD REP B 693 using x-ray fluorescence, J. Phys.: Conf. Ser. 1481 (2020) 012018. https://doi.org/10.1088/1742-6596/1481/1/012018
[31] P. Afriyeni, H. Rifai, C. B. Maisonneuve, F. Forni, S. Eisele, M. Phua, R. Putra, Identification of magnetic minerals in peatland at the section of DD REP B 693 Lake Diatas using XRD (x-ray diffraction), J. Phys.: Conf. Ser. 1481 (2020) 012027. https://doi.org/10.1088/1742-6596/1481/1/012027
[32] N. Aisyah, H. Rifai, C. B. Maisonneuve, J. Oalmann, F. Forni, S. Eisele, M. Phua, R. Putra, Scanning electron microscope (SEM) imaging and analysis of magnetic minerals of Lake Diatas peatland section DD REP B 693, J. Phys.: Conf. Ser. 1481 (2020) 012025. https://doi.org/10.1088/1742-6596/1481/1/012025
[33] A. Sasmita, H. Rifai, R. Putra, N. Aisyah, M. Phua, S. Eisele, F. Forni, C. B. Maisonneuve, Identification of magnetic minerals in the peatlands cores from Lake Diatas West Sumatra, Indonesia, J. Phys.: Conf. Ser. 1481 (2020) 012019. https://doi.org/10.1088/1742-6596/1481/1/012019
[34] E. Agustine, D. Fitriani, L. O. Safiuddin, G. Tamuntuan, S. Bijaksana, Magnetic susceptibility properties of pesticide contaminated volcanic soil, AIP Conf. Proc. 1554 (2013) 230. https://doi.org/10.1063/1.4820327
[35] H. Rifai, R. Putra, M. R. Fadila, C. M. Wuster, Magnetic susceptibility and heavy metals in guano from South Sulawesi caves, IOP Conf. Ser.: Mater. Sci. Eng. 335 (2018) 012001. https://doi.org/10.1088/1757-899X/335/1/012001
[36] R. Putra, H. Rifai, C. M. Wurster, Relationship between magnetic susceptibility and elemental composition of guano from Solek Cave, West Sumatera, J. Phys.: Conf. Ser. 1185 (2019) 012011. https://doi.org/10.1088/1742-6596/1185/1/012011
[37] I. A. Sandi, M. F. A. Fauzan, Fitriani, M. J. Rampe, V. A. Tiwow, A review of the magnetic susceptibility of guano deposits in caves, J. Phys.: Conf. Ser. 1899 (2020) 012125. https://doi.org/10.1088/1742-6596/1899/1/012125
[38] S. Bijaksana, E. K. Huliselan, L. O. Safiuddin, D. Fitriani, G. Tamuntuan, E. Agustine, Rock magnetic methods in soil and environmental studies: fundamentals and case studies, Procedia Earth and Planetary Sci. 6 (2013) 8-13. https://doi.org/10.1016/j.proeps.2013.01.001
[39] J. Dearing, Environmental Magnetic Susceptibility: Using the Bartington MS2 System. British Library Cataloguing in Publication Data, 1999.
[40] E. A. Cowan, E. E. Epperson, K. C. Seramur, S. A. Brachfeld, S. J. Hageman, Magnetic susceptibility as a proxy for coal ash pollution within riverbed sediments in a watershed with complex geology (Southeastern USA), Environ. Earth Sci. 76 (2017) 657. https://doi.org/10.1007/s12665-017-6996-8
[41] I. S. Wnuk, B. G. Kostrubiec, S. Dytłow, P. Szwarczewski, P. Kwapuliński, J. Karasiński, Assessment of heavy metal pollution in Vistula River (Poland) sediments by using magnetic methods, Environmental Science and Pollution Research. 27 (2020) 24129–24144. https://doi.org/10.1007/s11356-020-08608-4
[42] N. G. D. Rusli, Hamdi, F. Mufit, Relationship between basic composition of magnetic mineral and magnetic suseptibility value of guano from Bau Bau Cave East Kalimantan, Pillar of Physics. 4 (2014) 49-56. http://dx.doi.org/10.24036/1843171074
[43] M. Zeng, Y. Song, Y. Li, C. Fu, X. Qiang, H. Chang, L. Zhu, Z. Zhang, L. Cheng, The relationship between environmental factors and magnetic susceptibility in the Ili Loess, Tianshan Mountains, Central Asia, Geological

Journal. 2018 (2018) 1–13. https://doi.org/10.1002/gj.3182

[44] D. D. Govedarica, M. B. Gavrilov, T. M. Zeremski, O. M. Govedarica, U. Hambach, N. A. Tomi, I. Senti, S. B. Markovi, Relationships between heavy metal content and magnetic susceptibility in road side loess profiles: a possible way to detect pollution, Quaternary International. 502(A) (2019) 148-159. https://doi.org/10.1016/j.quaint.2018.01.020

[45] S. Zulaikah, R. Azzahro, S. B. Pranita, E. S. Mu'alimah, N. Munfarikha, Dewiningsih, W. L. Fitria, H. A. Niarta, Magnetic susceptibility and morphology of natural magnetic mineral deposit in vicinity of human's living, IOP Conf. Ser.: Mater. Sci. Eng. 202 (2017) 012023. https://doi.org/10.1088/1757-899X/202/1/012023

[46] B H Iswanto, S Zulaikah, Selection method to identify the dominant elements that contribute to magnetic susceptibility in sediment, J. Phys.: Conf. Ser. 1402 (2019) 044087. https://doi.org/10.1088/1742-6596/1402/4/044087

[47] V. A. Tiwow, M. Arsyad, P. Palloan, P., M. J. Rampe, Analysis of mineral content of iron sand deposit in Bontokanang Village and Tanjung Bayang Beach, South Sulawesi, Indonesia, J. Phys.: Conf. Ser. 997 (2018) 012010. https://doi.org/10.1088/1742-6596/997/1/012010

[48] M. Arsyad, V. A. Tiwow, M. J. Rampe, Analysis of magnetic minerals of iron sand deposit in Sampulungan Beach, Takalar Regency, South Sulawesi using the x-ray diffraction method, J. Phys.: Conf. Ser. 1120 (2018) 012059. https://doi.org/10.1088/1742-6596/1120/1/012059

[49] V. A. Tiwow, M. J. Rampe, M. Arsyad, Study of frequency-dependent magnetic susceptibility to the iron sand in Takalar Regency, Sainsmat. VII (2) (2018) 136-146. https://doi.org/10.35580/sainsmat7273662018

[50] M. O. Kanu, O. C. Meludu, S. A. Oniku, A preliminary assessment of soil pollution in some parts of Jalingo Metropolis, Nigeria using magnetic susceptibility method, Jordan Journal of Earth and Environmental Sciences. 5(2) (2013) 53-61.

[51] D. A. McFarlane, J. Lundberg, New records of guano-associated minerals from caves in Northwestern Borneo, International Journal of Speleology. 47 (2) (2018) 119-126. https://doi.org/10.5038/1827-806X.47.2.2169

[52] M. Arsyad, N. Ihsan, V. A. Tiwow, Analysis of mineral sediment characteristics of Bantimurung Bulusaraung National Park in the Karst Maros Region, J. Phys.: Conf. Ser. 1572 (2020) 012007. https://doi.org/10.1088/1742-6596/1572/1/012007

[53] M. Arsyad, V. A. Tiwow, Sulistiawaty, I. A. Sahdian. Analysis of physical properties and mechanics of rocks in the karst region of Pangkep Regency, J. Phys.: Conf. Ser. 1572 (2020) 012008. https://doi.org/10.1088/1742-6596/1572/1/012008

[54] S. Samanta, K. Amrutha, T. K. Dalai, S. Kumar, Heavy metals in the Ganga (Hooghly) river estuary sediment column: evaluation of association, geochemical cycling and anthropogenic enrichment, Environ. Earth Sci. 76 (2017) 140. https://doi.org/10.1007/s12665-017-6451-x

[55] C. M. Munteanu, A. Giurginca, M. Giurginca, C. G. Panaiotu, G. Niculescu, Potentially toxic metals concentrations in soils and cave sediments from karst areas of Mehedinţi and Gorj counties (Romania), Carpathian Journal of Earth and Environmental Sciences. 7(1) (2012) 193-204.

[56] J. Johnson, M. Vincent, Tracing heavy metals in urban ecosystems through the study of bat guano-a preliminary study from Kerala, India, Journal of Threatened Taxa. 12(10) (2020) 16377–16379. https://doi.org/10.11609/jott.6225.12.10.16377-16379

REVIEWER #2

Karbala International Journal of Modern Science

Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia

--Manuscript Draft--

Manuscript Number:	KIJOMS-D-22-00203
Full Title:	Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia
Article Type:	Original Study
Keywords:	Guano; Magnetic Susceptibility; Heavy Metals; Pearson Correlation
Manuscript Region of Origin:	INDONESIA
Abstract:	This study aims to analyze the magnetic properties and the relationship between magnetic susceptibility and heavy metal content in guano. Guano samples were taken and measured for magnetic susceptibility, XRD, and XRF. The results showed that guano contains superparamagnetic grains and stable single domain measuring <0.05 m with magnetic susceptibility value 7.2 to 147.6 x 10 -8 m 3 /kg. Based on Pearson correlation coefficient analysis, magnetic susceptibility is negatively correlated with Fe. Meanwhile, Fe is positively correlated with other heavy metals (Cu, Zr, Nb). Thus, magnetic susceptibility has the potential as a proxy for detecting heavy metals.

Karbala International Journal of Modern Science, 2022, *, **-**

Magnetic Properties and Heavy Metals Content of Guano in Bat Cave, South Sulawesi, Indonesia

Muhammad Arsyad[1], Vistarani Arini Tiwow[1], Meytij Jeanne Rampe[2], and Henny Lieke Rampe[3]

[1]Physics Department, Faculty of Mathematics and Natural Sciences, Makassar State University, Indonesia;
[2]Chemistry Department, Faculty of Mathematics and Natural Sciences, Manado State University, Indonesia;
[3]Biology Department, Faculty of Mathematics and Natural Sciences, Sam Ratulangi University, Indonesia.
Email: m_arsyad288@unm.ac.id

Received Month Day, Year (2022).

ABSTRACT

Bat Cave is one of the caves with guano deposits in the Rammang-Rammang karst area, South Sulawesi, Indonesia. The guano deposits can indicate environmental changes in the cave. This study aims to analyze the magnetic properties and correlation between magnetic susceptibility and heavy metal content in guano. Sampling was carried out in Bat Cave, and magnetic susceptibility, XRD (mineralogy analysis), and XRF (heavy metal content analysis) were measured. The results showed that the guano sample contained superparamagnetic grains and stable single domain (SP-SSD) measuring <0.05 m with a low value of magnetic susceptibility ranging from 7.2 to 147.6 x 10^{-8} m^3/kg. The location of caves in karst areas and climate change affect the magnetic grains. The Pearson correlation coefficient analysis results showed that magnetic susceptibility had a negative correlation with the heavy metal content of Fe. Meanwhile, Fe has a positive correlation with the content of other heavy metals such as Cu, Zr, and Nb. Thus, magnetic susceptibility has the potential as a proxy indicator to detect the presence of heavy metals.

Keywords: Guano; Magnetic Susceptibility; Heavy Metals; Pearson Correlation

1. Introduction

Guano has been studied in environmental magnetic studies for ancient climate changes [1] and environmental changes in caves [2, 3]. In its development, environmental magnetic studies have been carried out on materials such as urban soils [4-7], iron sands [8-11], river sediments [12-16], lake sediments [17-19], marine sediments [20, 21], leachate [22-25], agricultural land [26-28], peatland [29-33], volcanic soil [34], and guano [35-37]. Environmental magnetics involves the relationship of magnetic properties to the process of environmental change due to sediment transport factors, human activities, industrial activities, and agricultural activities [14].

Guano deposits can record environmental changes in caves. Assessment of environmental changes is accompanied by changes in magnetic mineralogy and can be traced through magnetic minerals as carriers of the magnetic properties of guano. Magnetic properties can be reviewed based on the type of mineral, mineral concentration, domain and grain size, and grain shape [38]. Thus, the source of magnetic minerals can be estimated. Magnetic identification and measurement were chosen because their effectivity, quick results, inexpensive, and do not damage the material. This method is complemented by chemical analysis [38, 39].

Magnetic minerals are influenced by the content of iron (Fe) which is a ferromagnetic element. Fe can be detected, although its presence in magnetic minerals is small. In environmental magnetic studies, it is proven that the magnetic mineral content is associated with heavy metals content [40, 41]. Similarly, magnetic properties can indicate the presence of heavy metals in guano deposits.

Several studies have been conducted on the relationship between magnetic susceptibility and heavy metal content. A study of guano from the Bubau and Mampu Caves in South Sulawesi found a strong correlation between magnetic susceptibility and Fe content [35]. Furthermore, studies on guano from Solek Cave, West Sumatra, found a weak correlation between magnetic susceptibility and Fe content [36]. The study of the relationship between magnetic susceptibility and heavy metal content also found a weak correlation in the guano of Bau-Bau cave, East Kalimantan [42]. These studies

Page:27

Number: 1 Author: Subject: Highlight Date: 2022-05-18 23:33:59

add South Sulawesi, Indonesia

prove that magnetic susceptibility correlates with heavy metal content [43, 44]. In addition, environmental magnetic studies are associated with magnetic minerals, geochemical parameters, domains, and grain size [39]. Specific magnetic characteristics are influenced by transporting material from the outside environment into the cave through wind or water flow during the rainy season [35]. Furthermore, it is also influenced by the geology of the location studied.

The characterization of magnetic properties and the correlation of magnetic susceptibility with heavy metal content in guano caves in karst environments have not been studied, especially in Indonesia. Therefore, studying the magnetic environment and its relationship with heavy metal content is essential. Magnetic analysis was performed from the magnetic measurements and heavy metal content, X-Ray Fluorescence (XRF), and X-Ray Diffraction (XRD). The test results are used to describe the relationship between magnetic susceptibility and the heavy metal content of guano. This information can improve understanding of magnetic analysis, its relationship with heavy metals and to test the magnetic susceptibility as a proxy for heavy metals in guano in the karst environment, especially in Bat Cave.

2. Method

Bat Cave is located in the Rammang-Rammang Karst Area, particularly Berua Village. Bat Cave has a cave mouth width of about 10 m, a cave width of about 25 m, a cave height of about 50 m, and a length of cave that can be reached about 15 m. Bat Cave is located at an elevation of 54 m 119°40'19.5" east longitude and 4°58'33.0" south latitude.

Guano samples were taken from the Bat Cave in the Rammang-Rammang Karst Area, Maros, South Sulawesi, Indonesia. There are thirty points from the mouth of the cave to the cave's depth that can be reached 30 m due to the oxygen levels in the cave at a depth of more than 30 m getting smaller, so the cave guider does not allow it. The sampling point locations are shown in **Figure 1**. At each sampling point, at a depth of 10 cm the sample was taken and put into polyethylene plastic. The guano samples were prepared in the laboratory by being cleaned of impurities and dried at room temperature. The samples were mashed using pastels and mortar, then sieved using a 100 mesh sieve. At this stage, a sample of guano powder is produced. The guano powder sample was weighed at 15 g using a digital scale and put into a plastic clique.

Magnetic measurements were carried out on samples of guano powder using a Bartington MS2B Susceptibilitymeter (Bartington Instrument Ltd., Oxford, UK), which operated at low (470 Hz) and high (4700 Hz) frequencies [39]. The measurement results were analyzed using Multisus software. Measurements at two frequencies to obtain magnetic susceptibility depend on frequency (χ_{FD}) [45, 46] so that the types of magnetic minerals, magnetic mineral domains, and magnetic mineral sources can be interpreted. Based on the results of magnetic susceptibility testing, ten samples with the highest values were selected. The selected guano samples were tested using a Shimadzu Uniquant'X X-Ray Fluorescence (XRF) device and analyzed using PCx Uniquant software to determine the magnetic mineral content and heavy metals.

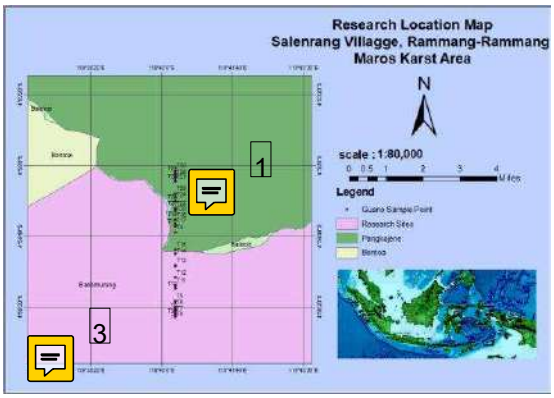


Figure 1 Sampling location in Bat Cave.

Two samples were selected for X-Ray Diffraction (XRD) testing from ten samples. The samples were put into a beaker and extracted using a bar magnet to separate the magnetic particles and not the magnetic particles contained in the guano sample. The sample is put in a plastic bag and tested. At this stage, a sample of the extracted guano powder is produced. XRD testing using the Rigaku MiniFlex II type XRD tool to determine the type and concentration of magnetic minerals. It operates at 30 kV voltage, 15 mA current, 0.02° scan width, 4°/min scan rate per time, and 5°-90° scan interval. Qualitative analysis using PDXL2 software with search and match method equipped with ICDD (International Center for Diffraction Data) card 2011. At the same time, the quantitative analysis uses the RIR (Reference Intensity Ratio) method [47, 48].

3. Results and Discussion

The magnetic susceptibility measurements of guano samples on the surface area of guano deposits in Bat Caves are shown in **Table 1**. Meanwhile, the graph plots of the magnetic susceptibility (χ_{LF}) and frequency-dependent magnetic susceptibility (χ_{FD}) at each point

Page:28

Number: 1 Author: Subject: Sticky Note Date: 2022-05-19 09:08:56

sample location not visible as too small

Number: 2 Author: Subject: Highlight Date: 2022-05-19 09:05:58

improve and be clear with the research objective here

Number: 3 Author: Subject: Sticky Note Date: 2022-05-19 09:08:04

Not visible if to compress in such a small space.

Number: 4 Author: Subject: Highlight Date: 2022-05-19 09:07:47

are shown in **Figure 1**. The magnetic susceptibility of guano samples (χ_{LF}) ranged from 7.2 to 147.6 x 10^{-8} m^3/kg. The χ_{LF} profile of the Bat Cave guano sample fluctuated along with the cave depth as far as 15 m from the cave mouth. The lowest χ_{LF} values are 7.2 x 10^{-8} m^3/kg, located at point 20. χ_{LF} values more than 100 x 10^{-8} m^3/kg are located at points 8, 13, 27, and 29. Meanwhile, χ_{FD} varies from 2.78 to 8.70 %.

Table 1. Magnetic susceptibility values of Bat Cave guano samples.

Sample	*χ_{LF} (x 10^{-8} m^3/kg)*	*χ_{HF} (x 10^{-8} m^3/kg)*	*χ_{FD} (%)*
T01	79.8	75.5	5.39
T02	58.1	55.6	4.30
T03	81.9	77.0	5.98
T04	59.4	57.3	3.54
T05	67.3	64.4	4.31
T06	86.1	81.1	5.81
T07	72.8	68.8	5.49
T08	125.5	116.4	7.25
T09	92.3	85.2	7.69
T10	64.7	61.3	5.26
T11	63.8	60.9	4.55
T12	73.5	68.8	6.39
T13	147.6	135.5	8.20
T14	42.8	40.8	4.67
T15	80.4	75.9	5.60
T16	62.2	58.5	5.95
T17	47.4	45.6	3.80
T18	73.7	69.1	6.24
T19	65.9	63.0	4.40
T20	7.2	7.0	2.78
T21	53.8	51.3	4.65
T22	52.2	50.1	4.02
T23	94.1	86.8	7.76
T24	79.1	74.2	6.19
T25	53.3	50.7	4.88
T26	67.5	63.6	5.78
T27	106.4	98.2	7.71
T28	81.4	75.6	7.13
T29	117.3	107.1	8.70
T30	60.1	57.2	4.83

The χ_{LF} range of guano samples contains a mixture of (canted) antiferromagnetic and paramagnetic minerals. Meanwhile, χ_{LF} guano Bat Cave mostly has a relatively low value. The low χ_{LF} indicates that the guano sample's iron (Fe) level is also low [49]. Fe content is one of the constituent elements of guano deposits associated with other elements in the Bat Cave. Thus, it is indicated that the Bat Cave is still natural and not influenced by anthropogenic factors. Several studies have reported that the magnetic susceptibility of guano in low-value surface areas is not influenced by anthropogenic but by the location of the cave and climate [35].

Bat Cave guano samples have a higher χ_{LF} than χ_{HF}. The bar graph plot of χ_{LF} and χ_{HF} is shown in **Figure 2**. It can be seen that χ_{LF} and χ_{HF} have significant differences in values. Different values of specific mass measurement of magnetic susceptibility at different frequencies will result in frequency-dependent magnetic susceptibility (χ_{FD}), which indicates the presence and amount of superparamagnetic minerals [49]. Variation of χ_{FD} (2.78 to 8.70 %) indicates that the guano sample belongs to the category of medium χ_{FD} % in which the guano sample contained an admixture of superparamagnetic (SP) and coarser non-SP grains, or SP grains <0.005 μm [39]. SP behavior is a unique property of the simple domain (SD), with a grain size of <0.03 m. The magnetization is solid but unstable. The thermal energy counteracts the induced magnetization quickly after removing the magnetic field. Its magnetic susceptibility is much greater than that of paramagnetic behavior. SP is characterized by its response to susceptibility measured at different frequencies.

The distribution of domains and magnetic mineral sources in the guano sample was interpreted by plotting a scaterring of χ_{FD} and χ_{LF}, as shown in **Figure 3**. The range of χ_{FD} values from 2-10% shows that the domain type is dominated by superparamagnetic (SP) and stable single domain (SSD). SP domain has a finer grain while SSD has a coarser grain [50]. Magnetic mineral sources are indicated to be pedogenic, bacterial magnetosomes, and autogenic or biogenic [39]. These sources can be influenced by climatic factors, namely the transportation

of materials through water flowing into the cave and the cave's location in the karst area, namely the minerals that make up the karst, such as $CaCO_3$ and gypsum. In addition, it comes from bat droppings and material transported by wind from outside the cave into the cave [36, 37]. Therefore, following the interpretation of the χ_{LF} distribution of the Bat Cave guano sample, the cave is still natural.

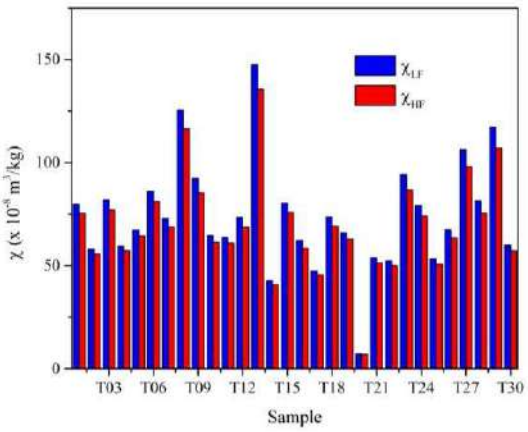


Figure 2. Histogram of magnetic susceptibility at low (χ_{LF}) and high frequency (χ_{HF}) of Bat Cave guano samples.

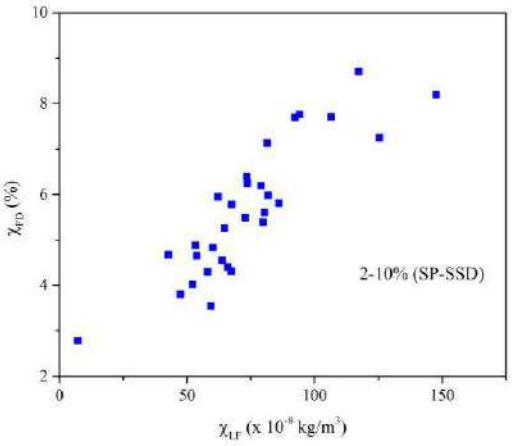


Figure 3. Scattering of frequency-dependent (χ_{FD}) and low-frequency (χ_{LF}) magnetic susceptibility of Bat Cave guano samples.

XRD analysis was done to identify magnetic mineral content in guano samples. As shown in **Figure 4**, the XRD diffractogram of the extracted guano samples. Based on the results of XRD analysis, the guano samples contained magnetite (Fe_3O_4) and hexaferrum (Fe). The calcium indium content was also identified, namely Ca_3In in sample T08 and Ca_8In_3 in sample T29. In addition, the guano sample contains silicon dioxide (SiO_2) and calcium aluminum antimonide ($Ca_{14}AlSb_{11}$).

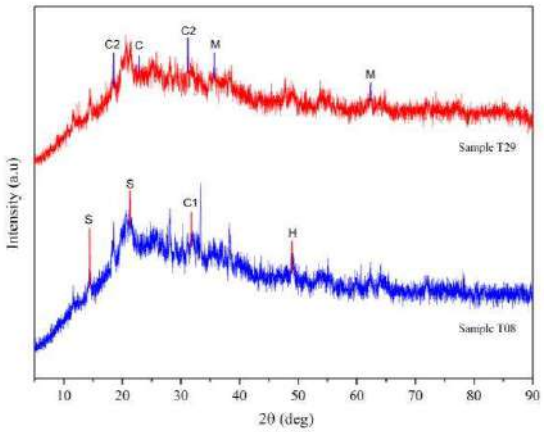


Figure 4. XRD diffractogram of extracted Bat Cave guano sample where S=silicon dioxide (SiO_2), C1=calcium indium (Ca_3In), H=hexaferrum (Fe), C2=calcium indium (Ca_8In_3), M=magnetite (Fe_3O_4), C=calcium aluminum antimonide ($Ca_{14}AlSb_{11}$).

Minerals Ca_3In, Ca_8In_3, $Ca_{14}AlSb_{11}$, and SiO_2 are thought to originate from the external environment and enter the cave through water media that drip on the walls of the cave during the rainy season. Meanwhile, magnetite and hexaferrum are thought to have come from the external environment through the wind entering the cave. Elemental calcium in the minerals calcium indium and calcium aluminum antimonide originates from carbonate rocks. Carbonate rocks contain karst constituent minerals such as calcite ($CaCO_3$), aragonite ($CaCO_3$), and dolomite ($CaMg(CO_3)_2$). However, it can also occur in other rocks formed from these minerals and other water-soluble minerals such as gypsum ($Ca_2SO_4.2H_2O$) [51-53]. This result is by the χ_{FD} interpretation regarding the magnetic mineral source of the guano sample.

Fe_3O_4 is a mineral with solid magnetic properties or high magnetic susceptibility, while CaIn has weak or low magnetic susceptibility. Thus, the guano sample contains a mixture of minerals with strong and weak magnetic properties. Because the concentration of CaIn is greater than Fe_3O_4, it indicates that the value of magnetic susceptibility in the guano sample is low. It measures the magnetic susceptibility of the Bat Cave guano sample, which was obtained low.

The results of the XRF analysis regarding the heavy metals content in the Bat Cave guano samples with varying concentrations are shown in **Table 2**. The heavy metals identified were iron (Fe), zinc (Zn), copper (Cu), zircon (Zr), and neodymium (Nb). The heavy metal in guano is indicated as material carrying magnetic proper-

ties in the cave. Fe dominated the heavy metal content of the guano sample. The concentration of Fe in all samples showed low concentrations, thus causing low magnetic susceptibility. The concentration of Fe becomes the controller of the magnitude of the magnetic susceptibility in a sample [36, 46, 54].

Table 2. Heavy metal content in Bat Cave guano samples.

Sample	Fe (%)	Zn (ppm)	Cu (ppm)	Zr (ppm)	Nb (ppm)
T03	17.70	7160	1660	2160	389
T06	17.31	7590	1160	2020	362
T08	20.56	6270	0	4160	651
T09	21.29	6410	1260	3760	708
T13	15.52	7270	1800	2700	400
T15	18.01	5860	1300	3440	423
T23	26.25	5690	2890	4420	532
T27	23.82	6180	2160	6320	618
T28	23.56	8190	4800	3580	540
T29	20.74	4880	1040	3510	544

The high concentration of heavy metals indicates the high value of magnetic susceptibility and vice versa. This paper reports that the source influences the magnitude of guano's magnetic and heavy metal susceptibility. Mixed sources are pedogenesis, bacterial magnetosomes, autogenic, and biogenic [55, 56]. Magnetic mineral content can occur naturally due to climatic factors and the location where this source acts as a contaminant [35]. Thus, the magnetic susceptibility parameter can be used as a proxy indicator to detect the presence of heavy metals [43, 44].

The Pearson correlation coefficient between susceptibility magnetic and heavy metal content of the guano samples is shown in **Table 3.** The Pearson correlation coefficient shows how strong the relationship between heavy metals as well as between susceptibility magnetic and heavy metals. The Pearson correlation coefficient between χ_{FD} and Fe (R=0.38) has a positive correlation (**Figure 5a**). Pearson correlation coefficient between χ_{LF} and Fe (R=-0.24) (**Figure 5b**), Zn (R=-0.20), and Cu (R=-0.36) has a negative correlation. The same is true between χ_{FD} and Zn (R=-0.39).

Table 3. Pearson correlation coefficient between magnetic susceptibility and heavy metal content of guano samples.

	Fe	Zn	Cu	Zr	Nb
Fe	1.00				
Zn	-0.28	1.00			
Cu	0.50	0.46	1.00		
Zr	0.73	-0.44	0.14	1.00	
Nb	0.64	-0.36	-0.06	0.70	1.00
χ_{LF}	-0.24	-0.20	-0.36	0.13	0.14
χ_{FD}	0.38	-0.39	0.08	0.43	0.53

Meanwhile, the Pearson correlation coefficient χ_{LF} with Zr (R=0.13) and χ_{LF} with Nb (R=0.14) have a positive correlation. Likewise, the Pearson correlation coefficient χ_{FD} with heavy metal content (Zr R=0.43 and Nb R=0.53) has a positive correlation. Pearson correlation coefficient χ_{FD} with Cu (R=0.08) almost does not correlate. The negative correlation of χ_{LF} with Fe indicates that the low concentration of Fe causes a low magnetic susceptibility value of the guano sample. Fe is a ferromagnetic element affecting the magnetic susceptibility value of guano samples [14, 36].

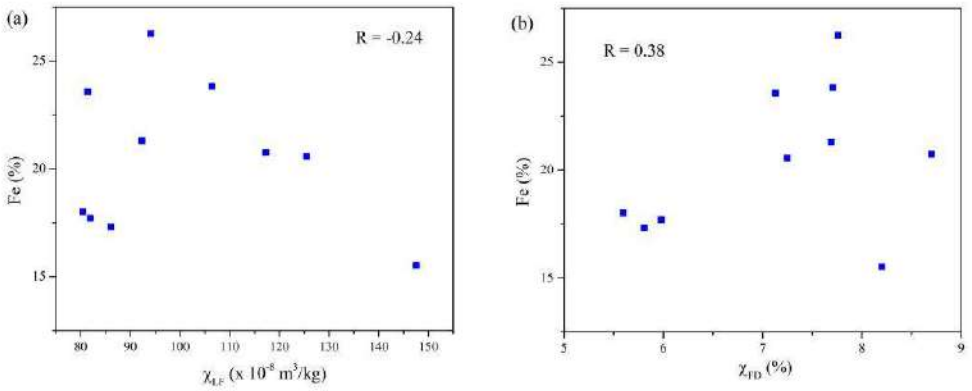


Figure 5. Plot of (a) χ_{LF} with Fe and (b) χ_{FD} with Fe.

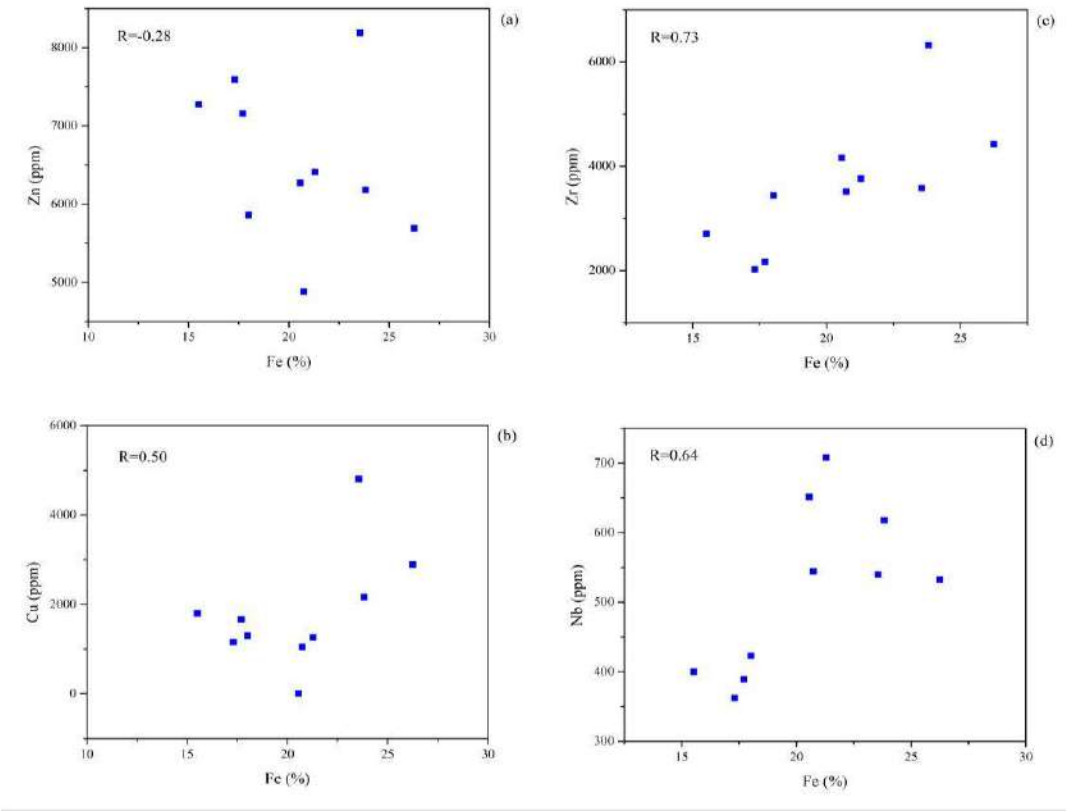


Figure 6. Plot of heavy metal content (a) Fe with Cu, (b) Fe with Cu, (c) Fe with Zr, and (d) Fe with Nb.

Elements of Fe with other heavy metals such as Cu, Zr, and Nb have a positive Pearson correlation coefficient. Meanwhile, Fe has a negative correlation with Zn (R=-0.28). **Figure 6** shows a plot of Fe with other heavy metals (Zn, Cu, Zr, and Nb). Based on these results, magnetic susceptibility is known as a proxy indicator to detect the presence of heavy metals, where heavy metals are associated with Fe [43, 44]. Sources of magnetic susceptibility and heavy metals can be affected by the location of the guano sampling. The guano sample came from the Bat Cave in a karst environment. Location and climate factors affect the Fe content in magnetic minerals [35]. This evidence confirms that the Bat Cave is still natural due to the low magnetic particles of the guano sample. Magnetic particles come from pedogenic components, bacterial magnetosomes, and autogenic or biogenic components. In addition, the presence of heavy metals in the guano samples affects the magnetic particles.

4. Conclusions

Bat Cave guano's magnetic susceptibility is relatively low and varies from 7.2 to 147.6 x 10^{-8} m^3/kg. The guano sample contains fine and coarse superparamagnetic (SP) and stable single domain (SSD) grains with a grain size of <0.05 m. The guano samples contained a mixture of antiferromagnetic and paramagnetic minerals. The value of magnetic susceptibility is influenced by Fe content. Fe element is associated with several other heavy metals such as Zn, Cu, Zr, and Nb. The correlation obtained is dominantly positive. The location and climate factors of Bat Cave in a karst environment affect Fe content in magnetic minerals. The fine grains of magnetic minerals are distributed into the cave through the wind. Meanwhile, coarse magnetic mineral grains are distributed during the rainy season in the cave.

5. Acknowledgements

The author would like to thank students (Ardianto, Siti Halijah, and Nurul Fadillah) who have assisted in sampling. The author also thanks Misdayanti, S.Si., who has assisted in collecting XRD data. Moreover, we also thank Arise Sambolangi, S.Si., who has assisted in collecting magnetic susceptibility data.

REFERENCES

[1] L. Nejman, L. Lisá, N. Doláková, I. Horáček, A. Bajer, J. Novák, D. Wright, M. Sullivan, R. Wood, R.H. Gargett, M. Pacher, S. Sázelová, M. Nývltová Fišáková, J. Rohovec, M. Králík, Cave deposits as a sedimentary trap for the marine isotope stage 3 environmental record: The case study of Pod Hradem, Czech Republic, Palaeogeography, Palaeoclimatology, Palaeoecology. 497 (2018) 201-217. https://doi.org/10.1016/j.palaeo.2018.02.020

[2] M. I. Bird, E. M. Boobyer, C. Bryant, H. A. Lewis, V. Paz, W. E. Stephens, A long record of environmental change from bat guano deposits in Makangit Cave, Palawan, Philippines, Earth and Environmental Science Transactions of the Royal Society of Edinburgh, 98 (2007) 59–69. https://doi.org/10.1017/S1755691007000059

[3] E. Aidona, S. Pechlivanidou, C. Pennos, Environmental magnetism: application to cave sediments, Bulletin of the Geological Society of Greece. 47(2) (2013) 892-900. https://doi.org/10.12681/bgsg.11128

[4] N. K. Meena, S. Maiti, A. Shrivastava, Discrimination between anthropogenic (pollution) and lithogenic magnetic fraction in urban soils (Delhi, India) using environmental magnetism, Journal of Applied Geophysics. 73 (2011) 121–129. https://doi.org/10.1016/j.jappgeo.2010.12.003

[5] M. O. Kanu, O. C. Meludu, S. A. Oniku, Comparative study of top soil magnetic susceptibility variation based on some human activities, Geofisica Internacional. 53 (4) (2014) 411-423. https://doi.org/10.1016/S0016-7169(14)70075-3

[6] M. O. Kanu, N. Basavaiah, O. C. Meludu, A. S. Oniku, Investigating the potential of using environmental magnetism techniques as pollution proxy in urban road deposited sediment, Int. J. Environ. Sci. Technol. 14 (2017) 2745–2758. https://doi.org/10.1007/s13762-017-1356-5

[7] D. C. Mello, J. A. M. Dematte, N. E. Q. Silvero, L. A. D. L. Raimo, R. R. Poppiel, F. A. O. Mello, A. B. Souza, J. L. Safanelli, M. E. B. Resende, R. Rizzo, Soil magnetic susceptibility and its relationship with naturally occurring processes and soil attributes in pedosphere, in a tropical environment, Geoderma. 372 (2020) 114364. https://doi.org/10.1016/j.geoderma.2020.114364

[8] V. A. Tiwow, M. Arsyad, Sulistiawaty, M. J. Rampe, W. I. B. Tiro, Analysis of magnetic mineral types of iron sand at Sampulungan Beach, Takalar Regency based on magnetic susceptibility values, Materials Science Forum. 967 (2019) 292-298. https://doi.org/10.4028/www.scientific.net/MSF.967. 292

[9] O. Togibasa, S. Bijaksana, G. C. Novala, Magnetic properties of iron sand from the tor River Estuary, Sarmi, Papua, Geosciences. 8 (2018) 113. https://doi.org/10.3390/geosciences8040113

[10] O. Togibasa, M. Akbar, A. Pratama, S. Bijaksana, Distribution of magnetic susceptibility of natural iron sand in the Sarmi Coast Area, J. Phys.: Conf. Ser. 1204 (2019) 012074. https://doi.org/10.1088/1742-6596/1204/1/012074

[11] Fadhilah, H. Prabowo, T. Saldi, The feasibility test of physical and chemical peoperties of Muaro Binguang Pasaman Barat iron sand for Semen Padang, J. Phys.: Conf. Ser. 1594 (2020) 012037. https://doi.org/10.1088/1742-6596/1594/1/012037

[12] S. Sudarningsih, S. Bijaksana, R. Ramdani, A. Hafidz, A. Pratama, W. Widodo, I. Iskandar, D. Dahrin, S. J. Fajar, N. A. Santoso, Variations in the concentration of magnetic minerals and heavy metals in suspended sediments from Citarum River and its tributaries, West Java, Indonesia, Geosciences. 7 (2017) 66. https://doi.org/10.3390/geosciences7030066

[13] S. Bijaksana, R. Yunginger, A. Hafidz, M. Mariyanto, Magnetic mineral characteristics, trace metals, and REE geochemistry of river sediments that serve as inlets to Lake Limboto, Sulawesi, Indonesia, Data in Brief. 26 (2019) 104348. https://doi.org/10.1016/j.dib.2019.104348

[14] M. Mariyanto, M. F. Amir, W. Utama, A. Hamdan, S. Bijaksana, A. Pratama, S. Sudarningsih, Heavy metal contents and magnetic properties of surface sediments in volcanic and tropical environment from Brantas River, Jawa Timur Province, Indonesia, Science of the Total Environment. 675 (2019) 632–641. https://doi.org/10.1016/j.scitotenv.2019.04.244

[15] M. Mariyanto, M. F. Amir, W. Utama, A. M. Hamdan, S. Bijaksana, A. Pratama, R. Yunginer, S. Sudarningsih, Environmental magnetism data of Brantas River bulk surface sediments, Jawa Timur, Indonesia, Data in Brief. 25 (2019) 104092. https://doi.org/10.1016/j.dib.2019.104092

[16] V. A. Tiwow, Subaer, Sulistiawaty, J. D. Malago, M. J. Rampe, M. Lapa, Magnetic susceptibility of surface sediment in the Tallo tributary of Makassar City, J. Phys.: Conf. Ser. 1899 (2021) 012124. https://doi.org/10.1088/1742-6596/1899/1/012124

[17] H. Guan, C. Zhu, T. Zhu, L. Wu, Y. Li, Grain size, Magnetic susceptibility and geochemical characteristics of the loess in the Chaohu Lake Basin: implications for the origin, palaeoclimatic change and provenance, Journal of Asian Earth Sciences. 117 (2016) 170–183. http://dx.doi.org/10.1016/ j.jseaes.2015.12.013

[18] M. Lone, H. Achyuthan, R. A. Shah, S. J. Sangode, Environmental magnetism and heavy metal assemblages in lake bottom sediments, Anchar Lake, Srinagar, NW Himalaya, India, International Journal of Environmental Research. 12(5) (2018) 489-502. https://doi.org/10.1007/s41742-018-0108-9

[19] R. Yunginger, S. Bijaksana, D. Dahrin, S. Zulaikah, A. Hafidz, K. H. Kirana, S. Sudarningsih, M. Mariyanto, S. J. Fajar, Lithogenic and anthropogenic components in surface sediments from Lake Limboto as shown by magnetic mineral characteristics, trace metals, and REE geochemistry, Geosciences. 8 (2018) 116. https://doi.org/10.3390/geosciences8040116

[20] K. Avinash, P. J. Kurian, A. K. Warrier, R. Shankar, T.C. Vineesh, R. Ravindra, Sedimentary sources and processes in the Eastern Arabian Sea: Insights from environmental magnetism, geochemistry and clay mineralogy, Geoscience Frontiers. 7 (2016) 253e264. http://dx.doi.org/10.1016/j.gsf.2015.05.001

[21] J. Nizou, F. Demory, C. D. Brunaud, Monitoring of dredged-dumped sediment dispersal off the bay of the seine (Northern France) using environmental magnetism, C. R. Geoscience. 348 (2016) 451–461. http://dx.doi.org/10.1016/j.crte.2015.02.005
[22] S. Bijaksana, E. K. Huliselan, Magnetic properties and heavy metal content of sanitary leachate sludge in two landfill sites near Bandung, Indonesia, Environmental Earth Sciences. 60(2) (2010) 409–419. https://doi.org/10.1007/s12665-009-0184-4
[23] E. K. Huliselan, S. Bijaksana, W. Srigutomo, E. Kardena, Scanning electron microscopy and magnetic characterization of iron oxides in solid waste landfill leachate, Journal of Hazardous Materials. 179 (2010) 701–708. https://doi.org/10.1016/j.jhazmat.2010.03.058
[24] K. Kirana, N. Aufa, E. K. Huliselan, S. Bijaksana, Magnetic and electrical properties of leachate, ITB J. Sci. 43A(3) (2011) 165-178. https://doi.org/10.5614/itbj.sci.2011.43.3.2
[25] G. C. Novala, D. Fitriani, K. Susanto, K. H. Kirana, Magnetic properties of soils from Sarimukti landfill as proxy indicators of pollution (Case study: Desa Sarimukti, Kabupaten Bandung Barat), IOP Conf. Ser.: Earth Environ. Sci. 29 (2016) 012015. https://doi.org/10.1088/1755-1315/29/1/012015
[26] Y. Bian, T. Ouyanga, Z. Zhu, N. Huang, H. Wan, M. Li, Magnetic properties of agricultural soil in the Pearl River Delta, South China – Spatial distribution and influencing factor analysis, Journal of Applied Geophysics. 107 (2014) 36–44. http://dx.doi.org/10.1016/j.jappgeo.2014.05.003
[27] N. Y. Daryanti, S. Zulaikah, N. Mufti, D. S. Haryati, Characteristics of magnetic susceptibility and geochemistry of paddy soils in Malang City, East Java, IOP Conf. Ser.: Earth Environ. Sci. 311 (2019) 012032. https://doi.org/10.1088/1755-1315/311/1/012032
[28] D. S. Haryati, S. Zulaikah, Sunaryono, N. Y. Daryanti, Magnetic properties and magnetic minerals morphology of orchards soils Batu Malang, IOP Conf. Ser.: Earth Environ. Sci. 311 (2019) 012040. https://doi.org/10.1088/1755-1315/311/1/012040
[29] Anisah, F. Marpaung, A. Purwandani, D. Nugroho, L. Sumargana, Early study of magnetic permeability and magnetic susceptibility of peat in Ogan Komering Ilir, South Sumatera, Indonesia, IOP Conf. Series: Earth and Environmental Science. 500 (2020) 012025. https://doi.org/10.1088/1755-1315/500/1/012025
[30] E. D. Ningsih, R. Putra, C. D. L. Maisonneuve, M. Phua, S. Eisele, F. Forni, J. Oalmann, H. Rifai, Identification of magnetic mineral forming elements in peatland Alahan Panjang West Sumatra Indonesia, section DD REP B 693 using x-ray fluorescence, J. Phys.: Conf. Ser. 1481 (2020) 012018. https://doi.org/10.1088/1742-6596/1481/1/012018
[31] P. Afriyeni, H. Rifai, C. B. Maisonneuve, F. Forni, S. Eisele, M. Phua, R. Putra, Identification of magnetic minerals in peatland at the section of DD REP B 693 Lake Diatas using XRD (x-ray diffraction), J. Phys.: Conf. Ser. 1481 (2020) 012027. https://doi.org/10.1088/1742-6596/1481/1/012027
[32] N. Aisyah, H. Rifai, C. B. Maisonneuve, J. Oalmann, F. Forni, S. Eisele, M. Phua, R. Putra, Scanning electron microscope (SEM) imaging and analysis of magnetic minerals of Lake Diatas peatland section DD REP B 693, J. Phys.: Conf. Ser. 1481 (2020) 012025. https://doi.org/10.1088/1742-6596/1481/1/012025
[33] A. Sasmita, H. Rifai, R. Putra, N. Aisyah, M. Phua, S. Eisele, F. Forni, C. B. Maisonneuve, Identification of magnetic minerals in the peatlands cores from Lake Diatas West Sumatra, Indonesia, J. Phys.: Conf. Ser. 1481 (2020) 012019. https://doi.org/10.1088/1742-6596/1481/1/012019
[34] E. Agustine, D. Fitriani, L. O. Safiuddin, G. Tamuntuan, S. Bijaksana, Magnetic susceptibility properties of pesticide contaminated volcanic soil, AIP Conf. Proc. 1554 (2013) 230. https://doi.org/10.1063/1.4820327
[35] H. Rifai, R. Putra, M. R. Fadila, C. M. Wuster, Magnetic susceptibility and heavy metals in guano from South Sulawesi caves, IOP Conf. Ser.: Mater. Sci. Eng. 335 (2018) 012001. https://doi.org/10.1088/1757-899X/335/1/012001
[36] R. Putra, H. Rifai, C. M. Wurster, Relationship between magnetic susceptibility and elemental composition of guano from Solek Cave, West Sumatera, J. Phys.: Conf. Ser. 1185 (2019) 012011. https://doi.org/10.1088/1742-6596/1185/1/012011
[37] I. A. Sandi, M. F. A. Fauzan, Fitriani, M. J. Rampe, V. A. Tiwow, A review of the magnetic susceptibility of guano deposits in caves, J. Phys.: Conf. Ser. 1899 (2020) 012125. https://doi.org/10.1088/1742-6596/1899/1/012125
[38] S. Bijaksana, E. K. Huliselan, L. O. Safiuddin, D. Fitriani, G. Tamuntuan, E. Agustine, Rock magnetic methods in soil and environmental studies: fundamentals and case studies, Procedia Earth and Planetary Sci. 6 (2013) 8-13. https://doi.org/10.1016/j.proeps.2013.01.001
[39] J. Dearing, Environmental Magnetic Susceptibility: Using the Bartington MS2 System. British Library Cataloguing in Publication Data, 1999.
[40] E. A. Cowan, E. E. Epperson, K. C. Seramur, S. A. Brachfeld, S. J. Hageman, Magnetic susceptibility as a proxy for coal ash pollution within riverbed sediments in a watershed with complex geology (Southeastern USA), Environ. Earth Sci. 76 (2017) 657. https://doi.org/10.1007/s12665-017-6996-8
[41] I. S. Wnuk, B. G. Kostrubiec, S. Dytłow, P. Szwarczewski, P. Kwapuliński, J. Karasiński, Assessment of heavy metal pollution in Vistula River (Poland) sediments by using magnetic methods, Environmental Science and Pollution Research. 27 (2020) 24129–24144. https://doi.org/10.1007/s11356-020-08608-4
[42] N. G. D. Rusli, Hamdi, F. Mufit, Relationship between basic composition of magnetic mineral and magnetic suseptibility value of guano from Bau Bau Cave East Kalimantan, Pillar of Physics. 4 (2014) 49-56. http://dx.doi.org/10.24036/1843171074
[43] M. Zeng, Y. Song, Y. Li, C. Fu, X. Qiang, H. Chang, L. Zhu, Z. Zhang, L. Cheng, The relationship between environmental factors and magnetic susceptibility in the Ili Loess, Tianshan Mountains, Central Asia, Geological

Journal. 2018 (2018) 1–13. https://doi.org/10.1002/gj.3182

[44] D. D. Govedarica, M. B. Gavrilov, T. M. Zeremski, O. M. Govedarica, U. Hambach, N. A. Tomi, I. Senti, S. B. Markovi, Relationships between heavy metal content and magnetic susceptibility in road side loess profiles: a possible way to detect pollution, Quaternary International. 502(A) (2019) 148-159. https://doi.org/10.1016/j.quaint.2018.01.020

[45] S. Zulaikah, R. Azzahro, S. B. Pranita, E. S. Mu'alimah, N. Munfarikha, Dewiningsih, W. L. Fitria, H. A. Niarta, Magnetic susceptibility and morphology of natural magnetic mineral deposit in vicinity of human's living, IOP Conf. Ser.: Mater. Sci. Eng. 202 (2017) 012023. https://doi.org/10.1088/1757-899X/202/1/012023

[46] B H Iswanto, S Zulaikah, Selection method to identify the dominant elements that contribute to magnetic susceptibility in sediment, J. Phys.: Conf. Ser. 1402 (2019) 044087. https://doi.org/10.1088/1742-6596/1402/4/044087

[47] V. A. Tiwow, M. Arsyad, P. Palloan, P., M. J. Rampe, Analysis of mineral content of iron sand deposit in Bontokanang Village and Tanjung Bayang Beach, South Sulawesi, Indonesia, J. Phys.: Conf. Ser. 997 (2018) 012010. https://doi.org/10.1088/1742-6596/997/1/012010

[48] M. Arsyad, V. A. Tiwow, M. J. Rampe, Analysis of magnetic minerals of iron sand deposit in Sampulungan Beach, Takalar Regency, South Sulawesi using the x-ray diffraction method, J. Phys.: Conf. Ser. 1120 (2018) 012059. https://doi.org/10.1088/1742-6596/1120/1/012059

[49] V. A. Tiwow, M. J. Rampe, M. Arsyad, Study of frequency-dependent magnetic susceptibility to the iron sand in Takalar Regency, Sainsmat. VII (2) (2018) 136-146. https://doi.org/10.35580/sainsmat7273662018

[50] M. O. Kanu, O. C. Meludu, S. A. Oniku, A preliminary assessment of soil pollution in some parts of Jalingo Metropolis, Nigeria using magnetic susceptibility method, Jordan Journal of Earth and Environmental Sciences. 5(2) (2013) 53-61.

[51] D. A. McFarlane, J. Lundberg, New records of guano-associated minerals from caves in Northwestern Borneo, International Journal of Speleology. 47 (2) (2018) 119-126. https://doi.org/10.5038/1827-806X.47.2.2169

[52] M. Arsyad, N. Ihsan, V. A. Tiwow, Analysis of mineral sediment characteristics of Bantimurung Bulusaraung National Park in the Karst Maros Region, J. Phys.: Conf. Ser. 1572 (2020) 012007. https://doi.org/10.1088/1742-6596/1572/1/012007

[53] M. Arsyad, V. A. Tiwow, Sulistiawaty, I. A. Sahdian. Analysis of physical properties and mechanics of rocks in the karst region of Pangkep Regency, J. Phys.: Conf. Ser. 1572 (2020) 012008. https://doi.org/10.1088/1742-6596/1572/1/012008

[54] S. Samanta, K. Amrutha, T. K. Dalai, S. Kumar, Heavy metals in the Ganga (Hooghly) river estuary sediment column: evaluation of association, geochemical cycling and anthropogenic enrichment, Environ. Earth Sci. 76 (2017) 140. https://doi.org/10.1007/s12665-017-6451-x

[55] C. M. Munteanu, A. Giurginca, M. Giurginca, C. G. Panaiotu, G. Niculescu, Potentially toxic metals concentrations in soils and cave sediments from karst areas of Mehedinţi and Gorj counties (Romania), Carpathian Journal of Earth and Environmental Sciences. 7(1) (2012) 193-204.

[56] J. Johnson, M. Vincent, Tracing heavy metals in urban ecosystems through the study of bat guano-a preliminary study from Kerala, India, Journal of Threatened Taxa. 12(10) (2020) 16377–16379. https://doi.org/10.11609/jott.6225.12.10.16377-16379

REVISION - 1

UNM

Muhammad Arsyad <m_arsyad288@unm.ac.id>

Your Submission - [EMID:a17cb4bd5767a5ba]

2 pesan

The Journal <em@editorialmanager.com> 13 Juni 2022 pukul 23.54
Balas Ke: The Journal <trashjo@ariessys.com>
Kepada: Muhammad Arsyad <m_arsyad288@unm.ac.id>

Ref.: Ms. No. KIJOMS-D-22-00203R1
Relationships of Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia
Karbala International Journal of Modern Science

Dear Dr Arsyad,

Editor has now commented on your paper. You will see that he is advising that you revise your manuscript. If you are prepared to undertake the work required, I would be pleased to reconsider my decision.

For your guidance, editor's comments are appended below.

If you decide to revise the work, please submit a list of changes or a rebuttal against each point which is being raised when you submit the revised manuscript.

Your revision is due by Jun 27, 2022.

To submit a revision, go to https://www.editorialmanager.com/kijoms/ and log in as an Author. You will see a menu item call Submission Needing Revision. You will find your submission record there.

Yours sincerely

Ahmed Mehmood Abdul-Lettif, Ph.D.
Managing Editor
Karbala International Journal of Modern Science

_ Editor's comments:

1- The manuscript needs minor English corrections.
2- Please check the typos of your manuscript.
3- All references should be edited strictly according to the KIJOMS style as shown on the website below:
https://citationsy.com/styles/karbala-international-journal-of-modern-science
OR as shown on the website below:
https://paperpile.com/s/karbala-international-journal-of-modern-science-citation-style/

Reviewers' comments:

Reviewer #1: Dear Editor in Chief of Karbala International Journal of Modern Science

As the original reviewer of the manuscript entitled as ' Relationships of Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia, I went through the manuscript and found that it has merits to publish in an international Journal and it is in line with scopes of your Journal. The authors have improved the manuscript properly that is ready for publication at the present form.

Yours .

Reviewer #2: No further editing needed.

---

any time. (Use the following URL: https://www.editorialmanager.com/kijoms/login.asp?a=r). Please contact the publication office if you have any questions.

Muhammad Arsyad <m_arsyad288@unm.ac.id> 14 Juni 2022 pukul 06.39
Kepada: Vistarani Arini Tiwow <vista.arini@gmail.com>

[Kutipan teks disembunyikan]

UNM

Muhammad Arsyad <m_arsyad288@unm.ac.id>

Submission Confirmation for KIJOMS-D-22-00203R2 - [EMID:b365ac46daf76a7e]

2 pesan

The Journal <em@editorialmanager.com> 14 Juni 2022 pukul 10.28
Balas Ke: The Journal <trashjo@ariessys.com>
Kepada: Muhammad Arsyad <m_arsyad288@unm.ac.id>

Ref.: Ms. No. KIJOMS-D-22-00203R2
Relationships of Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia

Dear Dr Arsyad,

Karbala International Journal of Modern Science has received your revised submission.

You may check the status of your manuscript by logging onto Editorial Manager at (https://www.editorialmanager.com/kijoms/).

Kind regards,

_____

In compliance with data protection regulations, you may request that we remove your personal registration details at any time. (Use the following URL: https://www.editorialmanager.com/kijoms/login.asp?a=r). Please contact the publication office if you have any questions.

Muhammad Arsyad <m_arsyad288@unm.ac.id> 14 Juni 2022 pukul 10.34
Kepada: Vistarani Arini Tiwow <vista.arini@gmail.com>

[Kutipan teks disembunyikan]

Karbala International Journal of Modern Science

Relationships of Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia

--Manuscript Draft--

Manuscript Number:	KIJOMS-D-22-00203R1
Full Title:	Relationships of Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia
Short Title:	
Article Type:	Original Study
Keywords:	Guano; Magnetic Susceptibility; Heavy Metals; Pearson Correlation
Corresponding Author:	Muhammad Arsyad, M.T. Universitas Negeri Makassar Makassar, Sulawesi Selatan INDONESIA
Corresponding Author Secondary Information:	
Corresponding Author's Institution:	Universitas Negeri Makassar
Corresponding Author's Secondary Institution:	
First Author:	Muhammad Arsyad
First Author Secondary Information:	
Order of Authors:	Muhammad Arsyad
	Vistarani Arini Tiwow
	Meytij Jeanne Rampe
	Henny Lieke Rampe
Order of Authors Secondary Information:	
Manuscript Region of Origin:	INDONESIA
Abstract:	This study aims to analyze the magnetic properties and the relationship between magnetic susceptibility and heavy metal content in guano. Guano samples were taken and measured for magnetic susceptibility, XRD, and XRF. The results showed that guano contains superparamagnetic grains and stable single domain measuring <0.05 m with magnetic susceptibility value 7.2 to 147.6 x 10 -8 m 3 /kg. Based on Pearson correlation coefficient analysis, magnetic susceptibility is negatively correlated with Fe. Meanwhile, Fe is positively correlated with other heavy metals (Cu, Zr, Nb). Thus, magnetic susceptibility has the potential as a proxy for detecting heavy metals.
Suggested Reviewers:	Maxwell O Kanu, M.Sc. Taraba State University maxiexpress007@gmail.com
	Mengxiu Zeng Zhejiang Normal University mengxiuzeng@zjnu.edu.cn
	Dragan D Govedarica University of Novi Sad dragang@uns.ac.rs
	Octolia Togibasa Universitas Cenderawasih octolia@gmail.com
Response to Reviewers:	Reviewer #1 1. Thank you for the suggestion. We have fixed the article title.

	2. Thank you for the suggestion. We have added some suggested previous research results that are in accordance with our research in the introduction section to the fourth paragraph. 3. Thank you for the comment. We have clearly presented the object of our study in the introduction section of the last paragraph. 4. Thank you for the suggestion. We've fixed the title of the second section "Materials and Methods" 5. Thank you for the comment. We have fixed Figure 1 sampling locations. 6. Thank you for the suggestion. We have improved Table 1 which presents descriptive statistics. 7. Thank you for the question. We have described the effect of calcite and gypsum on magnetic susceptibility in the results and discussion sections of the fourth paragraph. 8. Thank you for the comment. We've fixed Figures 3, 5, and 6. 9. Thank you for the question. We have evaluated the normality of the data using SPSS software with the Kolmogorov-Smirnov (K-S) test. 10. Thank you for the suggestion. We've fixed the word repetition and also changed the "R" to "r" to represent the Pearson coefficient. Reviewer #2 1. Thank you for the suggestion. We have added "South Sulawesi, Indonesia" in the abstract section. 2. Thank you for the comment. We have clearly presented the object of our study in the introduction section of the last paragraph. 3. Thank you for the comment. We have fixed Figure 1 sampling locations.

EDITOR DECISION:

REVISE 2

UNM

Muhammad Arsyad <m_arsyad288@unm.ac.id>

Your Submission - [EMID:a17cb4bd5767a5ba]

2 pesan

The Journal <em@editorialmanager.com> 13 Juni 2022 pukul 23.54
Balas Ke: The Journal <trashjo@ariessys.com>
Kepada: Muhammad Arsyad <m_arsyad288@unm.ac.id>

Ref.: Ms. No. KIJOMS-D-22-00203R1
Relationships of Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia
Karbala International Journal of Modern Science

Dear Dr Arsyad,

Editor has now commented on your paper. You will see that he is advising that you revise your manuscript. If you are prepared to undertake the work required, I would be pleased to reconsider my decision.

For your guidance, editor's comments are appended below.

If you decide to revise the work, please submit a list of changes or a rebuttal against each point which is being raised when you submit the revised manuscript.

Your revision is due by Jun 27, 2022.

To submit a revision, go to https://www.editorialmanager.com/kijoms/ and log in as an Author. You will see a menu item call Submission Needing Revision. You will find your submission record there.

Yours sincerely

Ahmed Mehmood Abdul-Lettif, Ph.D.
Managing Editor
Karbala International Journal of Modern Science

_ Editor's comments:

1- The manuscript needs minor English corrections.
2- Please check the typos of your manuscript.
3- All references should be edited strictly according to the KIJOMS style as shown on the website below:
https://citationsy.com/styles/karbala-international-journal-of-modern-science
OR as shown on the website below:
https://paperpile.com/s/karbala-international-journal-of-modern-science-citation-style/

Reviewers' comments:

Reviewer #1: Dear Editor in Chief of Karbala International Journal of Modern Science

As the original reviewer of the manuscript entitled as ' Relationships of Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia, I went through the manuscript and found that it has merits to publish in an international Journal and it is in line with scopes of your Journal. The authors have improved the manuscript properly that is ready for publication at the present form.

Yours .

Reviewer #2: No further editing needed.

---

any time. (Use the following URL: https://www.editorialmanager.com/kijoms/login.asp?a=r). Please contact the publication office if you have any questions.

Muhammad Arsyad <m_arsyad288@unm.ac.id> 14 Juni 2022 pukul 06.39
Kepada: Vistarani Arini Tiwow <vista.arini@gmail.com>

[Kutipan teks disembunyikan]

REVISION 2

UNM

Muhammad Arsyad <m_arsyad288@unm.ac.id>

Submission Confirmation for KIJOMS-D-22-00203R2 - [EMID:b365ac46daf76a7e]

2 pesan

The Journal <em@editorialmanager.com> 14 Juni 2022 pukul 10.28
Balas Ke: The Journal <trashjo@ariessys.com>
Kepada: Muhammad Arsyad <m_arsyad288@unm.ac.id>

Ref.: Ms. No. KIJOMS-D-22-00203R2
Relationships of Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia

Dear Dr Arsyad,

Karbala International Journal of Modern Science has received your revised submission.

You may check the status of your manuscript by logging onto Editorial Manager at (https://www.editorialmanager.com/kijoms/).

Kind regards,

_____

In compliance with data protection regulations, you may request that we remove your personal registration details at any time. (Use the following URL: https://www.editorialmanager.com/kijoms/login.asp?a=r). Please contact the publication office if you have any questions.

Muhammad Arsyad <m_arsyad288@unm.ac.id> 14 Juni 2022 pukul 10.34
Kepada: Vistarani Arini Tiwow <vista.arini@gmail.com>

[Kutipan teks disembunyikan]

Karbala International Journal of Modern Science

Relationships of Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia

--Manuscript Draft--

Manuscript Number:	KIJOMS-D-22-00203R2
Full Title:	Relationships of Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia
Short Title:	
Article Type:	Original Study
Keywords:	Guano; Magnetic Susceptibility; Heavy Metals; Pearson Correlation
Corresponding Author:	Muhammad Arsyad, M.T. Universitas Negeri Makassar Makassar, Sulawesi Selatan INDONESIA
Corresponding Author Secondary Information:	
Corresponding Author's Institution:	Universitas Negeri Makassar
Corresponding Author's Secondary Institution:	
First Author:	Muhammad Arsyad
First Author Secondary Information:	
Order of Authors:	Muhammad Arsyad
	Vistarani Arini Tiwow
	Meytij Jeanne Rampe
	Henny Lieke Rampe
Order of Authors Secondary Information:	
Manuscript Region of Origin:	INDONESIA
Abstract:	This study aims to analyze the magnetic properties and the relationship between magnetic susceptibility and heavy metal content in guano. Guano samples were taken and measured for magnetic susceptibility, XRD, and XRF. The results showed that guano contains superparamagnetic grains and stable single domain measuring <0.05 m with magnetic susceptibility value 7.2 to 147.6 x 10 -8 m 3 /kg. Based on Pearson correlation coefficient analysis, magnetic susceptibility is negatively correlated with Fe. Meanwhile, Fe is positively correlated with other heavy metals (Cu, Zr, Nb). Thus, magnetic susceptibility has the potential as a proxy for detecting heavy metals.
Suggested Reviewers:	Maxwell O Kanu, M.Sc. Taraba State University maxiexpress007@gmail.com
	Mengxiu Zeng Zhejiang Normal University mengxiuzeng@zjnu.edu.cn
	Dragan D Govedarica University of Novi Sad dragang@uns.ac.rs
	Octolia Togibasa Universitas Cenderawasih octolia@gmail.com
Response to Reviewers:	#Editor: Thank you for the comment. We have corrected the English language and typos of the

	manuscript, as well as edited the references according to the KIJOMS style. Reviewer #1: Thank you for the comment. Reviewer #2: Thank you for the comment.

EDITOR DECISION:

ACCEPTED

UNM

Muhammad Arsyad <m_arsyad288@unm.ac.id>

Your Submission - [EMID:e775351966899358]

2 pesan

The Journal <em@editorialmanager.com> 18 Juni 2022 pukul 00.05
Balas Ke: The Journal <trashjo@ariessys.com>
Kepada: Muhammad Arsyad <m_arsyad288@unm.ac.id>

Ref.: Ms. No. KIJOMS-D-22-00203R2
Relationships of Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia
Karbala International Journal of Modern Science

Dear Dr Arsyad,

I am pleased to tell you that your work has now been accepted for publication in Karbala International Journal of Modern Science.

It was accepted on Jun 17, 2022

Thank you for submitting your work to this journal.

With kind regards

Ahmed Mehmood Abdul-Lettif, Ph.D.
Managing Editor
Karbala International Journal of Modern Scienc

_____

In compliance with data protection regulations, you may request that we remove your personal registration details at any time. (Use the following URL: https://www.editorialmanager.com/kijoms/login.asp?a=r). Please contact the publication office if you have any questions.

Muhammad Arsyad <m_arsyad288@unm.ac.id> 18 Juni 2022 pukul 07.27
Kepada: Vistarani Arini Tiwow <vista.arini@gmail.com>

[Kutipan teks disembunyikan]

Karbala International Journal of Modern Science

Author Main Menu

Alternate Contact Information

Unavailable Dates

Important:

Prior to submitting, please review the Author Guidelines and KIJOMS Publications Ethics..

For additional assistance with Editorial Manager, please click here for the EM Author Tutorial.

New Submissions

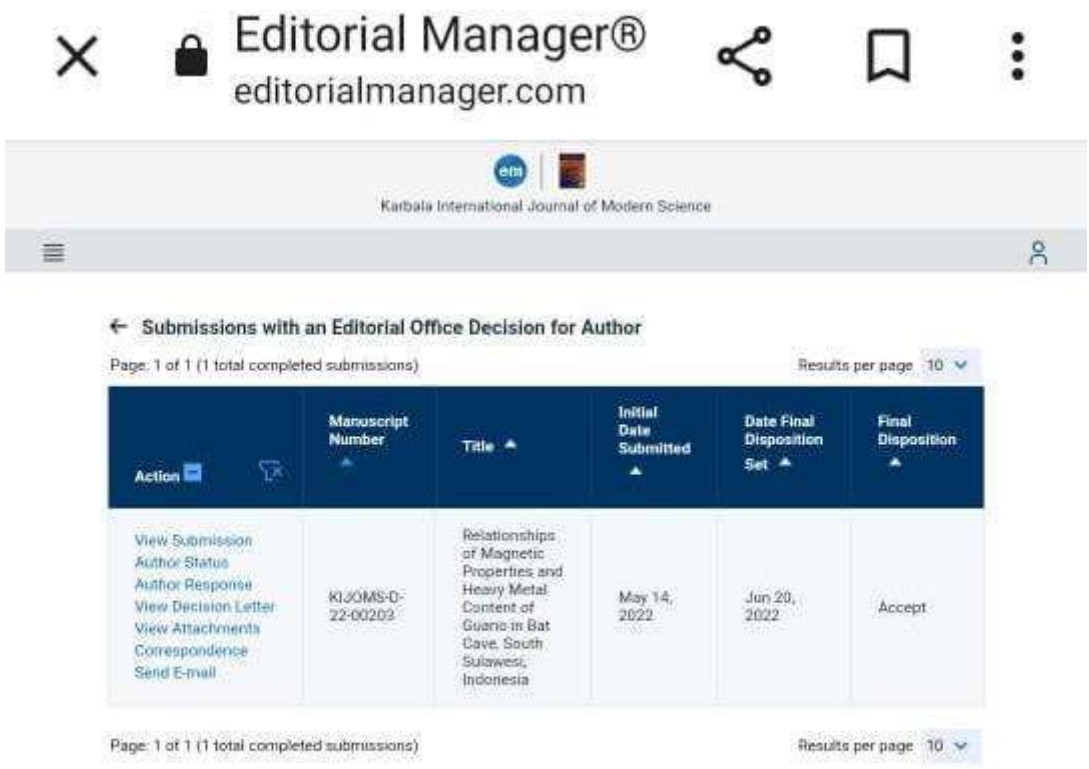
- Submit New Manuscript
- Submissions Sent Back to Author (0)
- Incomplete Submissions (0)
- Submissions Waiting for Author's Approval (0)
- Submissions Being Processed (0)

Revisions

- Submissions Needing Revision (0)
- Revisions Sent Back to Author (0)
- Incomplete Submissions Being Revised (0)
- Revisions Waiting for Author's Approval (0)
- Revisions Being Processed (0)
- Declined Revisions (0)

Completed

- Submissions with a Decision (1)


Editorial Manager®
editorialmanager.com
Karbala International Journal of Modern Science
Submissions with an Editorial Office Decision for Author
Page: 1 of 1 (1 total completed submissions)
Results per page 10
Action
Manuscript Number
Title
Initial Date Submitted
Date Final Disposition Set
Final Disposition
View Submission
Author Status
Author Response
View Decision Letter
View Attachments
Correspondence
Send E-mail
KIJOMS-D-22-00203
Relationships of Magnetic Properties and Heavy Metal Content of Guano in Bat Cave, South Sulawesi, Indonesia
May 14, 2022
Jun 20, 2022
Accept
Page: 1 of 1 (1 total completed submissions)
Results per page 10