

Vertical Distribution of Silica Content Based on Drill Hole Depth in a Nickel Laterite Deposit, Towara Village, North Morowali, Indonesia

Difri Candra A.N, Muhammad Ihsyam*

Department of Chemical Engineering, Faculty of Industrial Technology, Muslim University of Indonesia, Jl. Urip Sumaharjo No.Km 5 Panaikang, Panakukang, Makassar City, South Sulawesi 90231, Indonesia


*Corresponding author: ihsyammuhammad15@gmail.com (Muhammad Ihsyam)

Received 3 Nov 2025

Revised 18 Dec 2025

Accepted 31 Dec 2025

Citation: Ihsyam, Muhammad, and Difri Candra A.N. 2025. "Vertical Distribution of Silica Content Based on Drill Hole Depth in a Nickel Laterite Deposit, Towara Village, North Morowali, Indonesia". *Journal of Green Chemical and Environmental Engineering* 1 (4): 234-41.

 [10.63288/jgcee.v1i4.19](https://doi.org/10.63288/jgcee.v1i4.19)

Abstract: This study aims to observe the relationship between SiO₂ content and Ni content with variations in the depth of laterite nickel production in the Towara area. The independent variable was nickel extraction at depths of 1, 5, 10, and 15 meters from four drill holes spaced 100 meters apart. The dependent variable was nickel ore samples. Samples were obtained through drilling activities, followed by wet and dry preparation, including size reduction, drying, grinding to 200 mesh, and pelletization, before being analyzed using XRF according to the JIS M-8109-1996 standard. The results of the study showed a negative relationship between SiO₂ content and Ni content. A depth of 10 meters had the highest Ni content of 1.977 % at a medium SiO₂ content of 33.577 %. A depth of 15 meters showed a very high SiO₂ content (>66%) with a low Ni content (<0.3 %). The Limonite and Saprolite zones dominated the interval with high Ni content, while the Bedrock and Below Laterite Deposit zones were dominated by high SiO₂ and low Ni content. An increase in silica content at a certain depth indicates a decrease in nickel enrichment potential, making silica an important parameter in evaluating nickel prospect zones.

Keywords: Nickel, Silica, Laterite, Depth, Lithology, Towara.

1. Introduction

Due to its geological location, Indonesia is rich in natural resources, particularly non-renewable mining materials [1]. One such strategic resource is nickel. Nickel is a metal with numerous uses, including as a base material for the manufacture of anti-corrosion metals, an alloy in stainless steel production, and various other industrial products [2][3]. Due to its versatility, nickel is a highly valued commodity on the global market. Since 1950, demand for nickel has increased by an average of 4% per year and is expected to continue to rise in the coming decade, in line with technological developments and industrial needs, particularly in the electric vehicle and renewable energy sectors [4].

Nickel Laterite Ore (Nickel Ore) is a nickeliferous deposit formed when olivine minerals in peridotite are decomposed by acidic groundwater [5]. Nickel laterite ores are classified as limonite, saprolite, and serpentine [6]. Silica minerals are compounds commonly found in mining or quarrying materials, such as quartz sand, granite, and feldspar, all of which contain silica crystals (SiO₂) [7]. The presence of silica and other elements in laterite nickel ore (Ni) is one factor influencing the nickel content of the ore [8]. Therefore, highly accurate and precise chemical analysis is required to accurately determine the elemental composition [9]. One analytical method capable of producing



results with a high degree of accuracy is X-Ray Fluorescence (XRF), which is effective for quickly and non-destructively detecting and measuring elemental content, including silica [10].

Nickel content is a major concern in the nickel mining industry. According to the Minister of Energy and Mineral Resources Regulation No. 11 of 2019, nickel content below 1.7% is prohibited for export [11]. This presents a major challenge for all nickel mining companies [12]. One of the obstacles in nickel mining is the instability of the nickel content obtained from each ore extraction [13]. This issue has become a major challenge in laterite nickel mining, particularly in determining the appropriate location and understanding the structure of the rocks and soils that make up the ore to meet the desired nickel content standards [14]. The decline in nickel content can be influenced by various factors, one of which is the internal composition of the ore itself, including elements and other compounds that make up the ore [15]. These factors form naturally during the laterization process in the soil and contribute to variations in the nickel content produced from laterite deposits [16].

Research on the effect of silica on nickel content in laterite ore has previously been conducted by Mahadika [17] [18], who analyzed the correlation between SiO_2 and nickel content in the Ussu laterite deposit, Malili District, East Luwu Regency, South Sulawesi Province. The results showed an average SiO_2 content of 46.87%, while the average nickel content was 0.28%. The study concluded that the presence of silica influences nickel content at that location [19].

This study differs from previous studies, particularly in terms of the location and characteristics of the laterite deposits analyzed. While Mahadika [20] This study was conducted in East Luwu Regency, and it was conducted in North Morowali, which has different geological conditions and laterite deposit characteristics. Furthermore, this study will further explore the extent to which silica content can affect nickel content using an analytical method that focuses more on elemental distribution using Energy Dispersive X-Ray Fluorescence (EDXRF) [21]. Therefore, this study is expected to provide deeper insight into the relationship between silica and nickel content in laterite ore at different research locations [22].

2. Research and Methodology

2.1 Sampling

Nickel samples were taken from several drilling locations at depths of 1 meter, 5 meters, 10 meters, and 15 meters in four different holes spaced 100 meters apart. Preparation was then performed.

2.2 Wet Sample Preparation

Each sample increment from the special check and test pit sampling is reduced in size to -10 mm using a jaw crusher, wet preparation, and a -10 mm sieve, or manually using a hammer on a metal plate. Composite the sample by mixing and quartering the sample to a minimum of 25 mm and 34 mm x 10 mm. Then, take a cross cell for general analysis weighing approximately 1.5 - 2 kg. Oven-dry the sample for general analysis at 150°C for approximately 4-5 hours.

2.3 Dry Sample Preparation

After the sample is confirmed dry, reduce the grain size using a jaw crusher for dry preparation to -10 mm. Reduce the grain size with a double-roll crusher, then composite it by mixing, and then reduce the volume using a 4x5 matrix cross cell method using a 5D scope. Then, split the sample with a 3 mm splitter twice: one portion for general analysis (approximately 500 grams) and the other for backup (3 mm). \pm 500 grams, perform grain size with a mill or disk mill pulverizer, continue the

screening test to ensure all sample particles have reached a size of 200 mesh then composite with mixing and matrix 4x5 samples cross cell method using a 1D scoop for General Analysis ± 250 grams and some for back up 200 mesh weight ± 250 grams. Then the General Analysis sample is weighed and put into an aluminum cup of ± 10 grams to continue the process of making coin-shaped plates using a pellet press which is then continued for the analysis process (JIS M-8109-1996) [23]

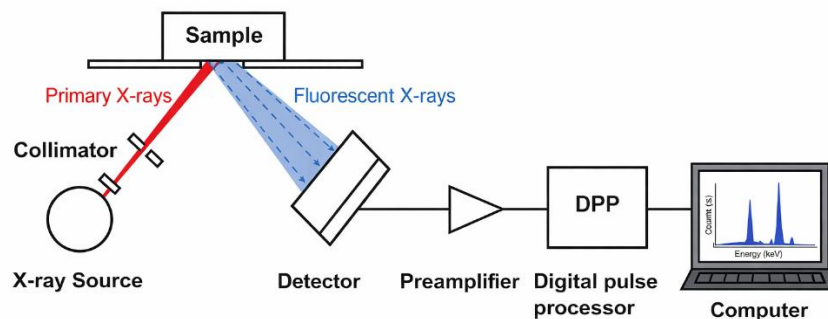


Figure 1. Research process design

3. Results and Discussion

This study aims to observe the relationship between silica (SiO_2) content and nickel (Ni) levels based on analysis data at various points and depths in the Towara area. The data show variations in the concentration of this chemical element at depths of 1, 5, 10, and 15 meters at several drilling points.

3.1 One Meter Drilling Depth

The following is the analysis data at the 1-meter depth.

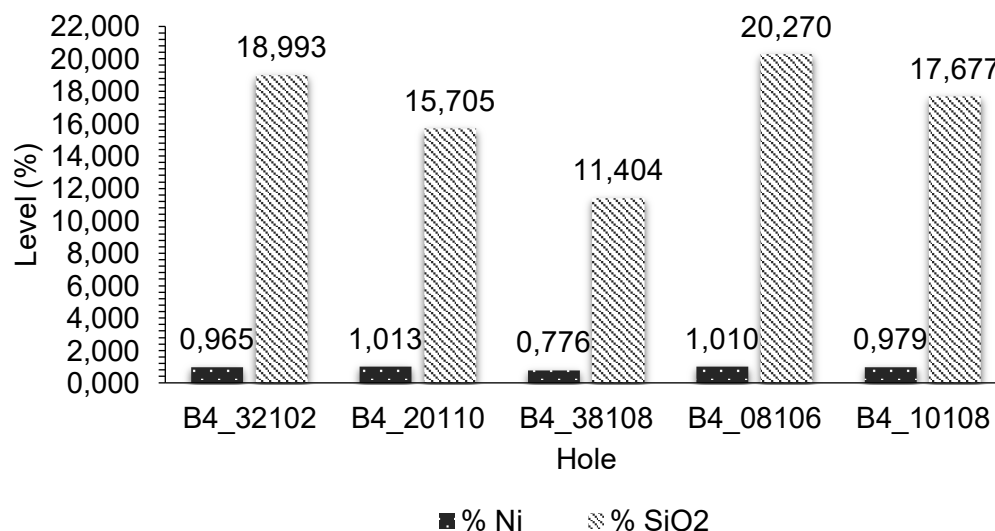


Figure 2. One Meter Depth Analysis Results

Description:

B4_32102: First drill point, B4_20110: Second drill point, B4_38108: Third drill point, B4_08106: Fourth drill point, B4_10108: Fifth drill point

Based on the graph at a depth of 1 meter from five drill points (B4_32102, B4_20110, B4_38108, B4_08106, and B4_10108) in Towara Village, East Petasia, North Morowali, the silica (SiO_2) content varies significantly, ranging from 11.404% to 20.270%. Point B4_08106 shows the highest silica

content at 20.270%, while point B4_38108 has the lowest silica content at 11.404%. Meanwhile, the nickel (Ni) content is relatively low and stable, ranging from 0.776% to 1.013%. The highest nickel content is found at point B4_20110 (1.013%), while the lowest is at point B4_38108 (0.776%).

The striking variation in silica content at this depth indicates that the rocks in the 1-meter layer are dominated by materials with varying degrees of weathering, likely still in the surface zone or upper laterite, which has not yet reached the typically nickel-rich saprolite zone. No direct correlation between silica and nickel is apparent at this depth. For example, although point B4_08106 has the highest silica content, its nickel content is not the highest. Conversely, the point with the highest nickel content (B4_20110) has an intermediate silica content.

Based on these results, it can be concluded that at a depth of 1 meter, silica content tends to remain high, while nickel content is not significant. This indicates that this layer is still part of the upper weathering zone and has not yet reached the optimal depth for economic nickel exploration. Therefore, to fully understand the relationship between silica content and nickel distribution, further analysis at greater depths is necessary [24].

3.2 Five-Meter Drilling Depth

The following is the analysis data from the 5-meter point.

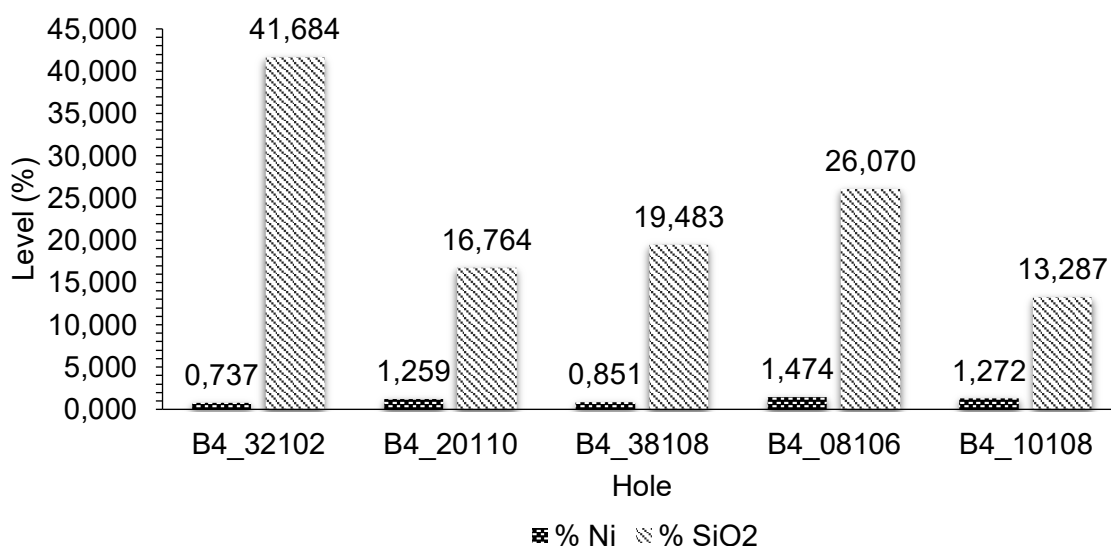


Figure 3. Five Meter Depth Analysis Results

Based on the element content graph at a depth of 5 meters at five drill points (B4_32102, B4_20110, B4_38108, B4_08106, and B4_10108) in Towara Village, East Petasia, North Morowali, significant variations in silica (SiO₂) and nickel (Ni) content are evident. The highest silica content was recorded at point B4_32102 at 41.684%, while the lowest was at point B4_10108 at 13.287%. Meanwhile, the nickel content at this depth showed a higher range than at a depth of 1 meter, with values ranging from 0.737% to 1.474%. The highest nickel content was recorded at point B4_08106 at 1.474%, while the point with the lowest nickel content was B4_32102 at 0.737%. Compared with data at a depth of 1 meter, nickel content increased at most points, particularly at points B4_08106 and B4_20110. Conversely, silica content showed a variable pattern, with point B4_32102 experiencing a very significant increase (from 18.993% to 41.684%), while other points decreased or

experienced only a small increase. In general, there is a tendency for nickel content to increase with depth, particularly at points with relatively lower silica content [25].

This indicates that at a depth of 5 meters, some points are approaching or have entered the saprolite zone, a deeper weathering layer that is generally rich in nickel and poorer in silica. This is consistent with the geological characteristics of laterite, where silica tends to be concentrated in the upper layer (limonite), while metals such as nickel accumulate more heavily at the bottom due to leaching processes. Therefore, observations at this depth reinforce the hypothesis that nickel distribution is negatively correlated with silica content, especially when compared between points, which show a striking contrast in both parameters [26].

2.3 Ten Meter Drilling Depth

The following is the analysis data from the 10-meter point.

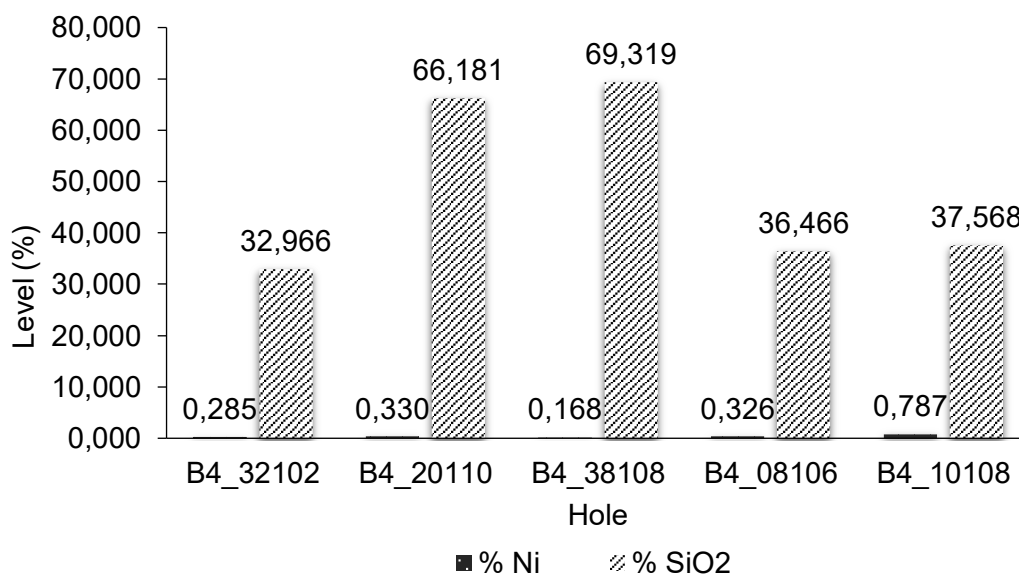


Figure 4. Ten Meter Depth Analysis Results

Based on the analysis results at a depth of 15 meters from five drill points (B4_32102, B4_20110, B4_38108, B4_08106, and B4_10108) in Towara Village, East Petasia, North Morowali, a significant decrease in nickel (Ni) content was observed compared to the previous 10-meter depth. The highest nickel content was recorded at point B4_10108 with a value of 0.787%, while the lowest point was at B4_38108 with a content of only 0.168%. Overall, nickel content at this depth was well below the average content at depths of 5 and 10 meters, indicating a reduction in Ni metal accumulation in this layer.

Conversely, silica (SiO₂) content showed a sharp increase at several points, particularly at points B4_38108 and B4_20110, reaching 69.319% and 66.181%, respectively. Other points, such as B4_32102, B4_08106, and B4_10108, recorded silica levels in the 32–38% range, which is still considered high. This drastic increase in silica indicates that the 15-meter depth has likely re-entered the nickel-poor, silica-rich limonite zone, or a transition zone where most heavy metals have been leached downward due to prolonged leaching [27].

This phenomenon indicates that after reaching the optimal depth for nickel accumulation at 5–10 meters, the zone below again shows a nickel-poor, silica-rich trend. Geologically, this could occur due to a stratigraphic shift or a vertical non-uniformity in the soil layer structure. Silica accumulation

<https://ejournal.candela.id/index.php/jgcee>

at this depth could potentially originate from advanced weathering of silicate minerals or a higher concentration of silica-bearing material at certain depths.

Thus, at a depth of 15 meters, observations indicate that silica content dominates, while nickel content decreases significantly. This indicates that the optimum point for economic nickel exploration is not in this layer, but rather at an earlier depth, specifically in the 5 to 10 meter layer, which exhibits the highest nickel content and relatively lower silica content. This finding is important as a basis for technical decisions regarding nickel exploration and mining in the Towara Village area [28].

4. Conclusion

Observations show that silica (SiO_2) content tends to increase with depth, particularly at 15 meters, indicating higher silica accumulation in the lower layers due to leaching. Silica content in the North Morowali nickel mining area ranges from 11.404% to 69.319%, with the highest value recorded at the 15-meter drill point.

Conflict of Interest: The authors declare no conflicts of interest.

5. References

- [1] M. O. Bello, N. Abdus-Salam, and F. A. Adekola, "Utilization of Guinea corn (*Sorghum vulgare*) Husk for Preparation of Bio-based Silica and its Characterization Studies," *Int. J. Environ. Agric. Biotechnol.*, vol. 3, no. 2, 2018.
- [2] Y. Yuliusman, "Recovery Logam Nikel Dari Spent Katalis $\text{NiO}/\text{Al}_2\text{O}_3$ Dengan Teknologi Leaching Menggunakan Amonia-amonium Karbonat," *J. MIPA Unnes*, vol. 39, no. 2, pp. 143–149, 2016.
- [3] N. Rykusova, O. Shestopalov, V. Lebedev, T. Tykhomyrova, and G. Bakharieva, "Identification of Properties of Recycled High-density Polyethylene Composites When Filled with Waste Mud Solids," *Eastern-European J. Enterp. Technol.*, vol. 2, no. 10, pp. 55–60, 2019, doi: <https://doi.org/10.15587/1729-4061.2019.163656>
- [4] S. Allobunga, R. H. K. Putri, M. A. Siamashari, I. J. Julita, A. U. Fathoni, and H. Dwiriawan, "The Mined Volume Calculation in the Traditional Mining Area by Using the Unmanned Aerial Vehicle (UAV) Approach in the Observation Area of CV. Sinergi Karya Solutif, Patikraja District, Banyumas Regency, East Java Province, Indonesia," *J. Earth Mar. Technol.*, vol. 2, no. 2, 2022, doi: <https://doi.org/10.31284/j.jemt.2022.v2i2.2869>
- [5] A. L. M. Haris, "Environmental Governance PT. Surya Saga Utama Post Mining in North Kabaena, Mapila Village, Bombana Regency in Towards Sustainable Development," *J. La Soc.*, vol. 2, no. 2, pp. 6–11, 2021, doi: <https://doi.org/10.37899/journal-la-sociale.v2i2.340>
- [6] O. Siafu, S. S. Rawung, and A. F. Kawulur, "Analysis of Village Fund Budget Management in Bololo Village, North Wasile District, East Halmahera Regency," *Int. J. Appl. Bus. Int. Manag.*, pp. 53–64, 2020, doi: <https://doi.org/10.32535/ijabim.v0i0.876>
- [7] B. Adman, A. W. Nugroho, and I. Yassir, "The Growth of Local Tree Species on Post-coal Mining Areas in East Kalimantan," *J. Penelit. Sos. dan Ekon. Kehutan.*, vol. 7, no. 2, pp. 83–97, 2020, doi: <https://doi.org/10.20886/ijfr.2020.7.2.83-97>
- [8] A. B. Rondonuwu, R. D. Moningkey, and J. L. Tombokan, "The Coral Fish in the Coastal Areas, Likupang Kampung Ambong Village, East Likupang District, North Minahasa Regency," *J. Ilm. Platax*, vol. 7, no. 1, pp. 90–97, 2019, doi: <https://doi.org/10.35800/jip.7.1.2019.21885>
- [9] S. R. Ma'mun, "Impact of Gold Mining on Farmers' Livelihood in Bombana," *Sodality*, vol. 4, no.

<https://ejournal.candela.id/index.php/jgcee>

3, 2016.

- [10] F. A. Prasetya, N. Faria, T. E. Susanto, R. N. Firdaus, and Y. A. Zamzami, "Influence of Sand Casting Waste as Substitutor of Quartz Sand in Mortar," *Rekayasa*, vol. 14, no. 3, pp. 416–420, 2021, doi: <https://doi.org/10.21107/rekayasa.v14i3.12451>
- [11] G. Mahadika, "Conditional Harmony: the Relations Between Mining Company and Local People," *J. CIC Lemb. Ris. dan Konsult. Sos.*, vol. 3, no. 1, pp. 1–16, 2021, doi: <https://doi.org/10.51486/jbo.v3i1.24>
- [12] C. Waha, "Protection of Community Economic Rights in Mining Areas in North Sulawesi," *J. Int. Conf. Proc.*, vol. 1, no. 2, 2018, doi: <https://doi.org/10.32535/jicp.v1i2.237>
- [13] A. Arman and A. Saefuddin, "The Local Economy and Rural Development in Berambai Hamlet, East Kalimantan," *Society*, vol. 8, no. 2, pp. 506–516, 2020, doi: <https://doi.org/10.33019/society.v8i2.202>
- [14] V. Sokoltsov, V. Tokarchuk, and V. Sviderskyi, "Influence of Silicons of Different Structures on the Hydration of Compositional Cements," *Technol. Audit Prod. Reserv.*, vol. 6, no. 3, pp. 4–8, 2018, doi: <https://doi.org/10.15587/2312-8372.2018.148312>
- [15] B. Ю. Соколыцов, B. B. Токарчук, and B. A. Свідерський, "Hardening Peculiarities of Blended Cements with Silicate Admixtures of Different Origin," *Eastern-European J. Enterp. Technol.*, vol. 3, no. 11, pp. 9–14, 2015, doi: <https://doi.org/10.15587/1729-4061.2015.43460>
- [16] G. W. Wardhana, "Positioning Evaluation With Gns Using Realtime Precise Point Positioning Method For Mining Mapping Survey," *J. Mar. Sci. Technol.*, vol. 3, no. 1, pp. 18–21, 2022, doi: <https://doi.org/10.12962/j27745449.v3i1.485>
- [17] R. Gandi and S. Sunito, "Mining Industrialization and Deagrarianization in Rural Community (a Case Study of Community Embalut and Bangunrejo, Tenggara Seberang District, Kutai Kartanegara Regency, East Kalimantan)," *Sodality*, vol. 3, no. 1, 2015.
- [18] Mukhaimin, *Analisis Korelasi MgO dan SiO₂ Terhadap Nikel Pada Endapan Nikel Laterit Daerah Ussu, Kecamatan Malili, Kabupaten Luwu Timur, Provinsi Sulawesi Selatan*. Makassar: Universitas Hasanuddin, 2021.
- [19] P. Raharjo, M. D. Saputra, D. Illahude, and P. H. Wijaya, "Identification of Quaternary Sediments and the Existence of Biogenic Gas Sources in the Topang Delta, Meranti, Riau," *Bull. Mar. Geol.*, vol. 34, no. 2, 2019, doi: <https://doi.org/10.32693/bomg.34.2.2019.595>
- [20] M. Mubarak, "Coastline Changes in North Bengkalis Island, Indonesia: Satellite Imagery Analysis and Observation," *J. Degrad. Min. Lands Manag.*, vol. 5, no. 2, pp. 1127–1132, 2018, doi: <https://doi.org/10.15243/jdmlm.2018.052.1127>
- [21] B. B. Токарчук, B. Ю. Соколыцов, and B. A. Свідерський, "Influence of Composition Mineral Additives on Cement Properties," *Technol. Audit Prod. Reserv.*, vol. 3, no. 5, pp. 19–22, 2014, doi: <https://doi.org/10.15587/2312-8372.2014.25355>
- [22] M. Christita, I. Iwanuddin, Y. Kafiari, S. Tabba, and H. S. Mokodompit, "Identification of Water Bacteria From Nickel Post Mining in East Halmahera," *J. Penelit. Sos. dan Ekon. Kehutan.*, vol. 5, no. 1, 2018, doi: <https://doi.org/10.20886/jwas.v5i1.4265>
- [23] W. Witno, N. Puspaningsih, and B. Kuncahyo, "Biomass Estimation Model in Revegetation Area of Nickel Post-Mining," *Media Konserv.*, vol. 23, no. 3, pp. 293–302, 2018, doi: <https://doi.org/10.29243/medkon.23.3.293-302>

- [24] A. Wisanggono, P. Abajjah, K. Akiro, D. Pertiwi, and R. A. Sauzy, "Supergene Enriched, Intrusion Related Low Sulfidation Deposit, Binebase-Bawone, North Sulawesi, Indonesia," *Indones. J. Geosci.*, vol. 7, no. 4, pp. 241–253, 2012, doi: <https://doi.org/10.17014/ijog.7.4.241-253>
- [25] D. Idamayanti, A. Siswanto, R. Widodo, and A. B. Iskandar, "Wet Reclamation for Improving Properties of Waste Silica Sand from Foundry," *Int. J. Eng. Appl. Sci.*, vol. 5, no. 5, 2018.
- [26] A. Masyrroh, F. Dwirani, and F. S. Pujipangesti, "Analysis of iron content in the leaching process of nickel slag as raw material for manufacturing ferro sulfate," *Int. J. Chem. Mater. Sci.*, vol. 5, no. 1, pp. 14–19, Oct. 2022, doi: <https://doi.org/10.21744/ijcms.v5n1.1985>
- [27] H. C. Widiatmoko, E. Mirnanda, and H. Kurnio, "Nickel in Buli Coastal Area, East Halmahera," *Bull. Mar. Geol.*, vol. 35, no. 1, Jun. 2020, doi: <https://doi.org/10.32693/bomg.35.1.2020.598>
- [28] M. N. Pangestu, "Analisis Sistem Pendinginan Absorpsi pada Intake Udara PLTGU," *J. Tek. ITS*, vol. 10, no. 2, 2021, doi: <https://doi.org/10.12962/j23373539.v10i2.71832>