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Technical Evaluation of Landslide Risk and Environmental Contamination Due to Manganese Mining Activities at PT Ngali Sumbawa Mining

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ABSTRACT

Manganese mining activities conducted by PT Ngali Sumbawa Mining, a national private company holding a Mining Business License (IUP) since 2011 and located in Lape Village, Lape District, West Nusa Tenggara, have the potential to generate environmental impacts, particularly related to slope stability and surface water quality in the surrounding mining area. Therefore, this study aimed to assess the potential environmental hazards associated with manganese mining activities. The evaluation of landslide susceptibility toward Ngali Hamlet and the potential for water pollution was undertaken as a preliminary effort to ensure that mining operations are implemented in accordance with sustainable mining principles. This study employed a descriptive quantitative approach through literature review, field observations, and laboratory analyses. The findings indicate that the slope conditions within the mining area of PT Ngali Sumbawa Mining are generally stable, suggesting a low potential for landslides. In addition, the water quality in areas affected by mining activities remained within the environmental quality standards established by the government.

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ABSTRAK

Kegiatan penambangan mangan yang dilakukan oleh PT Ngali Sumbawa Mining, sebuah perusahaan swasta nasional yang telah memiliki Izin Usaha Pertambangan (IUP) sejak tahun 2011 dan berlokasi di Desa Lape, Kecamatan Lape, Nusa Tenggara Barat, berpotensi menimbulkan dampak lingkungan, khususnya terkait kestabilan lereng dan kualitas air permukaan di sekitar area tambang. Oleh karena itu, penelitian ini bertujuan untuk mengkaji potensi bahaya lingkungan yang ditimbulkan akibat aktivitas penambangan mangan. Evaluasi kerawanan longsor terhadap Dusun Ngali serta potensi pencemaran air dilakukan sebagai upaya awal untuk memastikan bahwa kegiatan penambangan dilaksanakan sesuai dengan prinsip-prinsip pertambangan berkelanjutan. Penelitian ini menggunakan pendekatan deskriptif kuantitatif melalui studi literatur, observasi lapangan, dan analisis laboratorium. Hasil penelitian menunjukkan bahwa kondisi lereng di wilayah tambang PT

Ngali Sumbawa Mining secara umum berada dalam kondisi stabil sehingga memiliki potensi longsor yang rendah. Selain itu, kualitas air pada area yang terdampak aktivitas penambangan masih berada dalam baku mutu lingkungan yang ditetapkan oleh pemerintah.

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Introduction

Manganese (Mn) is a strategic mineral commodity that plays an important role in both the conventional steel industry and the rapidly growing renewable energy sector. Traditionally, manganese has been utilized as an essential metallurgical additive due to its ability to improve the strength, hardness, and corrosion resistance of steel products. Along with the global transition toward sustainable energy systems, the role of manganese has become increasingly significant in the battery manufacturing industry. Manganese is one of the primary components used in lithium-ion battery cathodes, particularly Nickel–Cobalt–Manganese (NCM) batteries, which are widely applied in electric vehicles and energy storage technologies. Global manganese demand is projected to increase substantially over the coming decades as a consequence of the rapid development of battery industries and clean energy technologies. Indonesia possesses considerable manganese resources distributed across several regions, particularly East Nusa Tenggara, West Nusa Tenggara, and parts of South Sulawesi. National resource assessments indicate that Indonesia has approximately 79.7 million tons of manganese resources, with measured reserves estimated at around 36 million tons (Guberman, 2025; Idrus et al., 2013).

The strategic importance of manganese has been formally recognized through national policy under the Decree of the Minister of Energy and Mineral Resources No. 69.K/MB.01/MEM.B/2024, which classifies manganese as a “Strategic Mineral.” This designation reflects the important role of manganese in supporting downstream industrial development, strengthening national economic resilience, and improving industrial competitiveness. Unlike the category of “Critical Minerals,” which primarily focuses on the availability of raw materials for advanced technologies and future energy systems, the classification of manganese as a strategic mineral emphasizes its broader contribution to national industrial and economic development. Emphasized that the sustainable management of manganese resources must be integrated with long-term energy transition policies. The increasing utilization of manganese in battery technologies indicates that the sustainability and efficiency of strategic mineral supply chains, including manganese, nickel, and lithium, will significantly influence the success of future clean energy transitions (Sun et al., 2021).

PT Ngali Sumbawa Mining (PT NSM) is a national private mining company engaged in manganese ore extraction and development in accordance with Indonesia’s mineral downstreaming policy. The company is located in Ngali Village, Lape District, Sumbawa

Regency, West Nusa Tenggara Province. PT NSM holds a Production Operation Mining Business License (IUP-OP) No. 45 of 2011, covering a Mining Business License Area (WIUP) of approximately 188 hectares. Initial exploration activities were conducted during the 2010–2011 period, followed by the commencement of production operations in 2012.

Based on the evaluation and revision of the Work Plan and Budget (RKAB) documents for the 2024–2026 operational period, PT NSM obtained approval for annual manganese production of up to 13,000 tons, with processed product output reaching approximately 12,346 tons per year. Mining activities at the site are conducted using a conventional open-pit mining system involving heavy equipment such as excavators, breakers, and dump trucks for ore extraction and transportation. The company was initially financed by domestic private investors and subsequently underwent ownership restructuring in March 2025.

Despite its economic significance, open-pit mining activities have the potential to generate environmental impacts, particularly related to slope stability and water quality degradation in surrounding areas. According to Mukherjee & Singh, (2022), excavation activities, overburden disposal, and intensive heavy equipment operations in open-pit mining systems frequently alter land morphology and increase the susceptibility to slope failure and landslides, especially in areas characterized by steep topography and volcanic geological formations. In addition to geotechnical hazards, deterioration in water quality represents another important environmental concern associated with manganese mining activities. North Maluku Province demonstrated that manganese and nickel mining operations may increase the concentrations of manganese (Mn) and iron (Fe) in nearby surface water bodies. Elevated heavy metal concentrations may reduce water quality and pose risks to surrounding communities if mining waste is not managed properly through effective environmental control systems (Bidul & Widowaty, 2024). Moreover, Rusydi et al., (2021) reported that mining activities in eastern Indonesia contribute to an increased risk of groundwater contamination due to natural leaching processes and mine runoff during periods of high rainfall. Consequently, periodic water quality monitoring is essential to minimize environmental pollution and support sustainable mining practices.

Considering the geological characteristics of Sumbawa Island, which are predominantly composed of volcanic rock formations with relatively steep slopes, as well as the presence of residential settlements surrounding the mining area, studies related to environmental hazard assessment are highly important. Therefore, this study aims to evaluate the potential environmental impacts associated with manganese mining activities at PT Ngali Sumbawa Mining, particularly regarding landslide susceptibility toward Ngali Hamlet and the potential for water pollution. This assessment is expected to provide preliminary scientific information to support environmentally responsible mining management in accordance with the principles of sustainable mining.

Method

This study employed a descriptive quantitative approach to evaluate the potential for landslides and environmental pollution associated with manganese mining activities at PT Ngali Sumbawa Mining, located in Lape Village, Lape District, Sumbawa Regency, West Nusa Tenggara Province. The research was conducted through literature review, field observations, laboratory testing, and data analysis to obtain a comprehensive understanding of the geotechnical and environmental conditions within the mining area.

The literature review involved the examination of scientific journals, technical reports, and government regulations to identify factors influencing slope instability and environmental pollution, particularly water quality degradation in mining areas. Field observations were carried out to collect primary data regarding geological and geomorphological conditions, surrounding environmental characteristics, water sources, vegetation, and the proximity of mining activities to residential areas. In situ water quality measurements were conducted at the processing sump and sedimentation pond to determine pH and Total Dissolved Solids (TDS) values.

Laboratory analyses were performed on two water samples collected from the processing sump and sedimentation pond. The analyzed parameters included pH and Total Suspended Solids (TSS) to evaluate the effectiveness of sedimentation and mine water treatment processes.

Data processing and analysis were conducted using Slide software to assess slope stability and landslide potential. Environmental pollution analysis was performed descriptively by comparing in situ and laboratory water quality results with the applicable government water quality standards. The findings were further supported by relevant theories and previous studies related to environmental impacts and mining geotechnics.

Results

Landslides are geological phenomena characterized by the movement of soil, rock, debris, or a combination of these materials downslope due to slope instability. According to the Badan Nasional Penanggulangan Bencana (BNPB), landslides occur when the stability of slope-forming materials is disturbed, resulting in mass movement along the slope surface. Slope instability is generally influenced by several factors, including slope morphology, physical and mechanical properties of soil and rock materials, hydrological conditions, vegetation cover, and rainfall intensity. High soil moisture content caused by rainfall may reduce the shear strength of slope materials and decrease the slope safety factor, thereby increasing the likelihood of landslides. In addition, limited vegetation cover and unconsolidated materials may accelerate erosion processes and further contribute to slope failure (Candra & Septiani, 2024; Ekawati et al., 2024).

The Mining Business License Area (WIUP) of PT Ngali Sumbawa Mining is located in Lape District and is situated between two nearby settlements, namely Lape Village and Ngali Village, with distances of approximately 1,945 m and 2,030 m from the mining area, respectively. Slope gradient is considered one of the primary controlling factors affecting landslide susceptibility. Gentle slopes generally possess higher resisting forces capable of maintaining slope stability, whereas steep slopes are more vulnerable to failure. Spatial analysis conducted within the WIUP area indicated that slope gradients vary from flat to steep categories. However, most mining areas are characterized by relatively gentle slopes, which contribute to lower landslide susceptibility .

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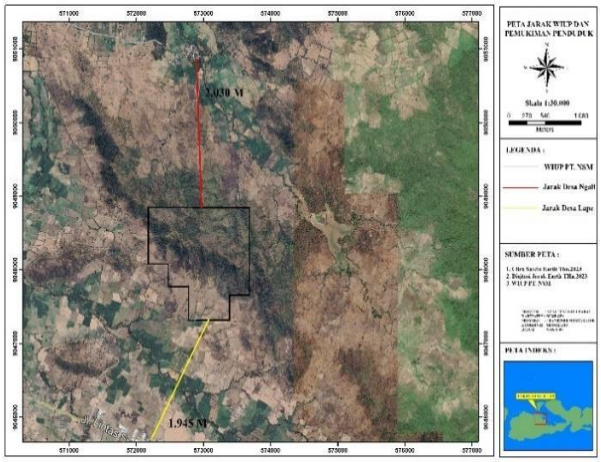

Figure 1 Map of the Distance Between the PT Ngali Sumbawa Mining Mining Business License Area (WIUP) and Lape Village and Ngali Village

Field observations showed that areas potentially affected by landslides are still dominated by natural in-situ materials that have not undergone intensive mining disturbance. Furthermore, vegetation cover surrounding the mining area remains relatively dense. Vegetation functions as a natural stabilizing factor by reinforcing soil structure and reducing erosion rates, thereby minimizing the potential for slope failure.

Slope stability analysis was performed using two-dimensional (2D) slope modeling with Slide software. The analysis utilized secondary lithological data with characteristics comparable to the geological conditions at the study area. The results indicated that potential slope failure was identified only within the soil layer, particularly at Ramp 2. This area exhibited the lowest safety factor (SF) value of 0.428, with an estimated failure zone extending approximately 2 m from the ramp surface. The low safety factor in this section is primarily associated with heavy equipment loading, particularly excavator operations with an estimated operational load of 235.20 kN/m². Nevertheless, instability was identified only locally at Ramp 2, while the majority of analyzed slopes exhibited safety factor values greater than 1.3, indicating generally stable slope conditions throughout the northern section of the mining area.

Table 1 Slope Gradient Classification of PT Ngali Sumbawa Mining and Surrounding Areas

Color	Class	Slope Gradient (%)	Classification
	1	0–3	Flat
	2	3–8	Gently Sloping
	3	8–15	Moderately Sloping
	4	15–30	Moderately Steep
	5	30–45	Steep
	6	45–60	Very Steep
	7	60–100	Extremely Steep

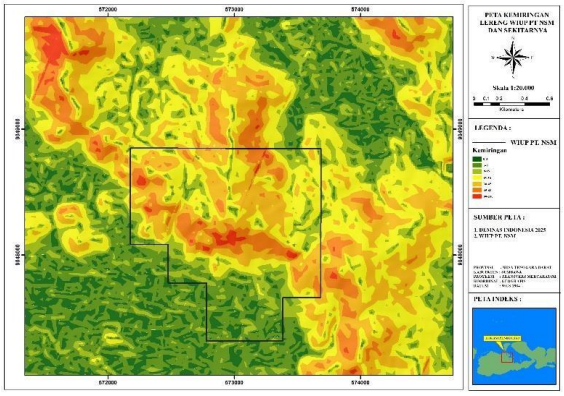

Figure 2 Slope Gradient Map of the Mining Business License Area (WIUP) of PT Ngali Sumbawa Mining and Surrounding Areas

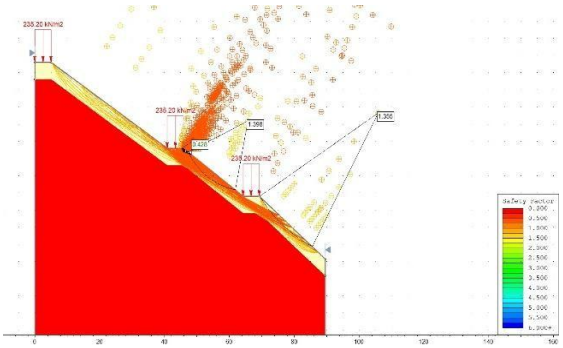

Figure 3 Two-Dimensional Slope Model Using Slide Software

In terms of environmental quality, manganese deposits in eastern Indonesia, particularly within the Nusa Tenggara region, are commonly associated with manganite minerals containing manganese oxide compounds. Field observations at PT Ngali Sumbawa Mining revealed that the dominant lithology consists of pinkish volcanic tuff accompanied by limestone, quartz, and secondary manganese nodules. The presence of limestone and calcite minerals indicates relatively alkaline geological conditions, which play an important role in controlling the geochemical characteristics of mine water.

In situ water quality measurements conducted at the sedimentation pond and processing sump demonstrated that all measured parameters remained within the applicable government water quality standards under Government Regulation No. 22 of 2021. The sedimentation pond exhibited a pH value of 8.12 and a Total Dissolved Solids (TDS) concentration of 401 mg/L, while the processing sump showed a pH value of 8.00 and a TDS concentration of 454 mg/L. These results indicate weakly alkaline water conditions and relatively low concentrations of dissolved solids.

Table 2 In Situ Water Quality Measurements from Mining Activities

Parameter	Unit	Sedimentation Pond	Processing Sump
Total Dissolved Solids (TDS)	mg/L	401	454
pH	–	8.12	8.00

Laboratory analyses further confirmed these findings. Water samples collected from the processing sump showed a pH value of 7.09 and Total Suspended Solids (TSS) concentration below 2.5 mg/L, which is substantially lower than the permitted quality standard. Meanwhile, samples from the sedimentation pond exhibited a pH value of 8.03 and a TSS concentration of

262.5 mg/L. Although the TSS concentration in the sedimentation pond exceeded the Class II water quality standard, this condition is considered reasonable because the sedimentation pond functions specifically as a treatment facility for suspended solids generated during mining and ore processing activities. The effectiveness of the sedimentation process can only be fully evaluated after treated water is discharged from the pond. Since the water remained contained within the sedimentation system during sampling, it had not yet affected surrounding surface water bodies.

Table 3 Laboratory Water Quality Testing from Mining Activities

Parameter	Unit	Sedimentation Pond	Processing Sump
Total Suspended Solids (TSS)	mg/L	262.5	< 2.5
pH	–	8.03	7.09

The neutral to slightly alkaline pH conditions observed in all samples also indicate a relatively low potential for heavy metal dissolution in the mining area. Under neutral and alkaline conditions, dissolved metals tend to precipitate more readily, thereby reducing the risk of heavy metal contamination. This interpretation is supported by the relatively low TDS concentrations measured in both the processing sump and sedimentation pond. The occurrence of limestone and calcite minerals within the study area likely contributes to the buffering capacity of surrounding rocks, preventing acidic conditions from developing and maintaining stable water chemistry.

Table 4 National Water Quality Standards for River Categories

No.	Parameter	Unit	Class 1	Class 2	Class 3	Class 4	Remarks
1	Total Dissolved Solids (TDS)	mg/L	1	1	1	2	Not applicable for estuaries
2	Total Suspended Solids (TSS)	mg/L	40	50	100	400	–
3	pH	mg/L	6–9	6–9	6–9	6–9	Not applicable for peat water (based on natural conditions)

Overall, the comparison between in situ measurements and laboratory analyses indicates that water quality within the mining area generally complies with applicable environmental standards. However, the construction of a dedicated compliance monitoring pond prior to final water discharge is recommended to improve environmental monitoring and ensure that mine water released into surrounding surface water systems consistently meets regulatory requirements.

Conclusion

Based on the results of this study, the landslide potential within the Mining Business License Area (WIUP) of PT Ngali Sumbawa Mining is generally low and localized. Most slopes in the mining area are stable due to relatively gentle slope conditions and adequate vegetation cover. Slope stability analysis using Slide software identified potential instability only at the ramp area, with a Safety Factor (SF) value of 0.428 caused by heavy equipment activities, while other areas showed stable conditions with SF values above 1.3. Water quality analysis from both in situ measurements and laboratory testing indicated that the parameters of pH, Total Dissolved Solids (TDS), and Total Suspended Solids (TSS) generally complied with national water quality standards. Although high TSS values were detected in the sedimentation pond, this condition is related to its function as a settling facility for suspended solids. Overall, the mining activities at PT Ngali Sumbawa Mining have not caused significant environmental pollution beyond the mining area.

References

Akte Perubahan PT. Ngali Maret 2025.

Bidul, S., & Widowaty, Y. (2024). Analisis Yuridis Dampak Pencemaran Lingkungan Pertambangan Mangan dan Nikel di Provinsi Maluku Utara. *JUSTISI*, *9*(3), 412–426. https://doi.org/10.33506/js.v9i3.2768

Candra, A., & Septiani, D. (2024). Analisis penyebab dan upaya mitigasi bencana tanah longsor di Desa Semen Kecamatan Gandusari Kabupaten Blitar, Jawa Timur. In *Maliki Interdisciplinary Journal (MIJ) eISSN* (Vol. 2). http://urj.uin-malang.ac.id/index.php/mij/index

Ekawati, R., Khusna Wahda, S., & Prasetya Adi, N. (2024). Mekanisme Terjadinya Tanah Longsor Desa Tieng Kejajar Analisis Interaksi Gaya Gravitasi dan Kestabilan Lereng. *Lambda: Jurnal Ilmiah Pendidikan MIPA Dan Aplikasinya*, *4*(3), 202–210. https://doi.org/10.58218/lambda.v4i3.952

Guberman, D. (2025). *International Trade Commission Executive Briefings on Trade*.

Idrus, A., Ati, E. M., Harijoko, A., & Meyer, F. M. (2013). Characteristics and Origin of Sedimentary-Related Manganese Layers in Timor Island, Indonesia Karakteristik dan Asal-mula Lapisan Mangan yang berkaitan dengan Sedimen di Pulau Timor, Indonesia. In *Indonesian Journal of Geology* (Vol. 8, Number 4).

IUP Operasi Produksi No. 45 TH. 2011.

Izin IUP OP No.45 Th.2011.

Mukherjee, I., & Singh, U. K. (2022). Environmental fate and health exposures of the geogenic and anthropogenic contaminants in potable groundwater of Lower Ganga Basin, India. *Geoscience Frontiers*, *13*(3), 101365. https://doi.org/10.1016/j.gsf.2022.101365

Peraturan Pemerintah. (n.d.). *PP No. 22 Tahun 2021 Peraturan Pemerintah Tentang Penyelenggaraan Perlindungan Dan Pengelolaan Lingkungan Hidup*.

Rusydi, A. F., Onodera, S.-I., Saito, M., Ioka, S., Maria, R., Ridwansyah, I., & Delinom, R. M. (2021). Vulnerability of groundwater to iron and manganese contamination in the coastal alluvial plain of a developing Indonesian city. *SN Applied Sciences*, *3*(4), 399. https://doi.org/10.1007/s42452-021-04385-y

Sun, H., Wang, J., Ren, J., Zhang, W., Tang, W., Wu, X., & Gu, A. (2021). Current situation of global manganese resources and suggestions for sustainable development in China. *Natural Resources Conservation and Research*, *4*(1). https://doi.org/10.24294/nrcr.v4i1.1554