Nickel Industry Background in Indonesia – Risks Involved and Solutions Needed

Rainforest and River in Indonesia – Foto: Yosafat Herdian, Unsplash

Introduction – Why Europe has to Reduce its Nickel Demand

As the main consumer of global raw materials such as nickel, Europe's responsibility to reduce its consumption cannot be ignored. The impact of the increasing demand for nickel is not only felt at the local level, but also in the main supplying countries. Indonesia, as one of the biggest contributors of nickel in the world, has experienced the significant impact of the exploitation of this raw material. This article will explore the urgency and importance of reducing nickel consumption and investigate the economic, social, and environmental impacts that could happen if the necessary measures are not immediately taken.

Globally, Indonesia currently sits at the center of the world's attention for its wealth of nickel deposits that are commoditized globally. In 2022, Indonesia's nickel reserves account for 42.3% of the total global nickel reserves estimated at 130 million metric tons. Indonesia's nickel reserves are predicted to still have 55 million metric tons at the end of 2023.[1]

1 https://databoks.katadata.co.id/datapublish/2024/02/13/indonesia-kantongi-cadangan-nikel-terbesar-global-pada-2023#:~:text=Menurut%20laporan%20Badan%

In Indonesia, nickel ore mining and processing as well as the biggest nickel processing industry are located in the Islands of Sulawesi and Halmahera. The history of nickel mining and processing began with the early nickel exploration and exploitation in the 1930s, when it was first discovered in Sulawesi Island.

Foreign Direct Investments

In 1973, the government prepared a new regulation on mining work contracts called the third-generation mining work contracts. The approved foreign investment amounted to 174 projects with a total investment plan of US$ 4,052.9 million. The government's official document, Laporan Repelita II (the Five-year Development Plan II Report) 1969, showed massive exploitation of nickel mines in Indonesia was first done in 1978 by the nickel mining unit of PT Antam in Southeast Sulawesi. In the same year, the government created a policy to mobilize workers through transmigration, so the company gained access to cheap labor in land clearing and mining. This is strengthened by the fact that the community transmigrated from Java Island to Sulawesi Island faced land conflicts, because the land plots given to them were within a company's work contract area.

Up until today, Foreign Direct Investment has become the drive behind the growth acceleration of nickel processing in Indonesia. Based on the results of the Aksi Ekologi dan Emansipasi Rakyat (AEER) assessment in 2023[2], in the past 10 years between 2015 and 2022, FDI realization reached US$ 18.6 billion in Central Sulawesi, US$ 11.9 billion in North Maluku, and US$ 6.6 billion in Southeast Sulawesi. FDI funded the construction of Rotary Kiln Electric Furnace (RKEF) and High-Pressure Acid Leaching (HPAL) production facilities, stainless steel production factories, and supporting infrastructures especially Steam Electric-Power Plant (PLTU) captive power.

Multinational companies became a factor that drives the FDI's massive development in the nickel processing industry and its derivative industry in Indonesia. Corporations such as Tsingshan Holding Group, Delong Nickel Industry Co Ltd, Huayou Cobalt Co Ltd, Green Eco Manufacture (GEM) Co Ltd, Lygend Resources Technology Co Ltd, Contemporary Amperex Technology Co Ltd, CNGR Advanced Material Co Ltd from China had successfully invested capitals in both the nickel-based industrial sites and non-industrial sites in Indonesia. These companies became the main beneficiaries.

The success of the multinational companies as main beneficiaries gains full support from the Indonesian government through its policies. Starting from the regulation for mining work contract permit, ease of licensing for industrial entrepreneurs as stipulated in the decree of the Minister of Industry No. 254/M/SK/6/1980 on Principal Provisions of Industrial Business Licensing, Law on Land Acquisition No. 2 of 2012 intended to facilitate and legalize land acquisition for entrepreneurs on behalf of development. During the office of President Joko Widodo, the government provided support and wide opportunities to the interest of the main beneficiaries. The government issued a series of policies through the establishment of the Presidential Regulation on Acceleration of National Strategic Projects (Percepatan Proyek Strategis Nasional/PSN) in 2016, which have been amended three times, the Mineral and Coal Law of 2009 which was amended in 2020, and the Government Regulation No. 2 of 2022 on Work Creation. These regulations facilitate investment including downplaying the status of environmental impact assessments.

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[2] Arianto Sangaji and Pius Ginting, 'Multinational companies and Nickel Downstreaming in Indonesia' (AEER 2023)

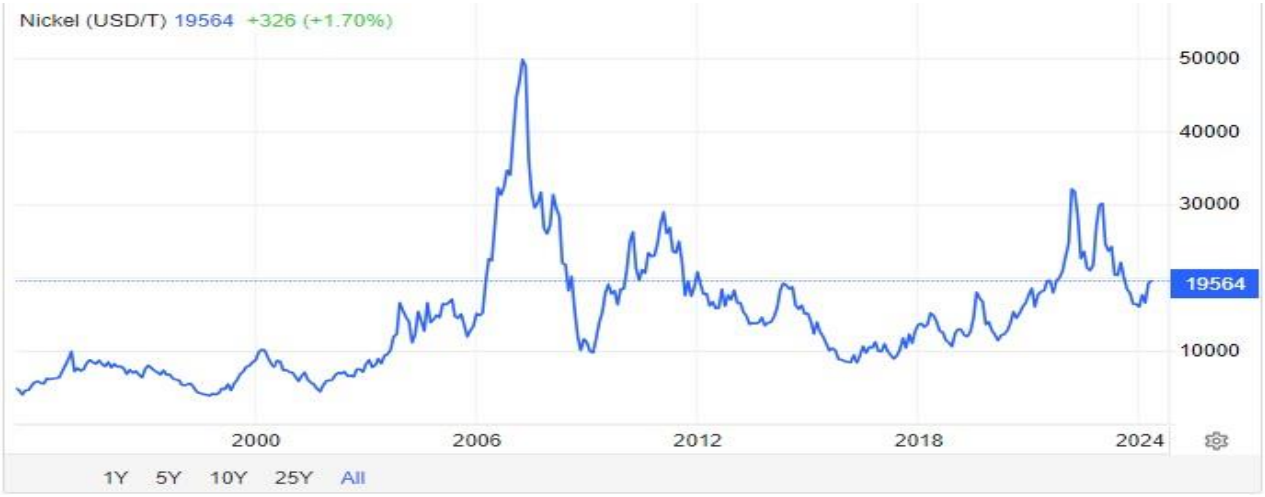

Figure 1. Global nickel price trend

Source: https://tradingeconomics.com/commodity/nickel

Tax Regime

The government also provided special tax incentives for investors who built nickel smelters and its derivative industry. Apart from duty exemptions for imports of goods and capital, one of the most important of which is the provision of tax holiday facilities[3].

Tax reduction is designated to induce investment in the mining and nickel processing industry. However, the tax exemption facility harms the loss of state revenue, economic and social injustice, a massive increase in mining activity, and the risk of economic dependence on one sector which can be dangerous in the event of nickel price fluctuations.

The provision of tax holiday was not well considered. The Indonesian government provided a 100% tax exemption on foreign direct investment in 2020 along with the nickel ore export ban policy that began in the same year.

Downstreaming has become the government's main program that encourages Indonesian nickel production. The production increased immensely to the extent that the price of nickel dropped throughout 2023. Rizkia Darmawan, a Research Analyst of PT Mirae Asset Sekuritafs Indonesia, said that the decline in nickel prices was triggered by abundant supply. Commodity analyst and founder of Traderindo.com, Wahyu Tribowo Laksono, said the global production trend has also not shown a decline, "Particularly in Canada, which continues to make new investments, the lack of signs of slowed production means that the stock surplus will remain and prices will continue to fall."[4] This condition has the potential to prolong the price drop trend throughout 2024 as well.

We can see that the global nickel price is unstable and drastically dropped from the highest price in 2007 all the way to January 2024 (Figure 1). With the significant nickel price drop, ironically, the environmental impacts like deforestation, sedimentation, air and water pollution are increasing along with the production increase and inversely proportional to the increase in economic income. The government needs to slow down nickel production and encourage developed countries to reduce raw material consumption. An article in the Jakarta Globe also mentioned that the

[3] Law no. 25 of 2007 on Capital Investment
[4] https://koran.tempo.co/read/ekonomi-dan-bisnis/486842/apa-dampak-anjloknya-harga-nikelhttps://koran.tempo.co/read/ekonomi-dan-bisnis/486842/apa-dampak-anjloknya-harga-nikel

nickel price dropped amid a global surplus supply of metal, caused by Indonesia's cheap mines production.[5]

Cheap and Dirty Nickel Mining and Processing Industry Practices for Communities

The Indonesian Statistics (Badan Pusat Statistik, BPS) reported that Indonesia's nickel export value in January 2024 was recorded at US$ 496.96 million. This figure shrank by 4.7% compared to the value of nickel exports in December 2023 which reached US$ 521.8 million. Although fluctuations in state income generated from nickel are quite large because they contribute to global nickel production, how does it contribute to poverty alleviation in Indonesia?

AEER team's field research in March 2024 (unpublished) concluded from the accounts of several local residents that the accumulated economic, social, and environmental impacts show increasingly obvious inequalities in the lives of the surrounding communities. One of the community members shared:

"Ever since the company's coal dust and PLTU smoke disturbed my family's health, I feel hosa (shortness of breath). With six children I have difficulties finding a job, and my husband had stopped working, because he had to go farther to open sea and we have no capital in terms of boat and no money. For day-to-day food, I have to take on debts, and currently, it has accumulated beyond our capability to repay. I could not get a loan anywhere. I foraged for tubers in the neighbor's land to eat. Also, water supply is now limited because water springs in the mountain have been controlled by local water businesses to be distributed to the companies."

Figure 2. Skin disease on an adult woman in Tanauge village, North Morowali Regency, suspected caused by coal dust

Foto: Yayasan Tanah Merdeka

The Context of Morowali Regency and North Morowali Regency

Morowali Regency and North Morowali Regency are located in Central Sulawesi Province. These two regencies are one of the main locations of the nickel mining and smelter industry in Indonesia. PT Vale Indonesia, PT Gunbuster Nickel Industry, and PT Indonesia Morowali Industrial Park (IMIP) which integrates several tenant companies are major companies participating in Indonesian nickel production located in the area.

[5] https://jakartaglobe.id/business/indonesian-nickel-miners-face-plummeting-prices-and-oversupply-concerns

1. Economic Impacts on the Communities in Morowali Regency and North Morowali Regency

Mining activities and the nickel processing industry have caused structural impoverishment. The degree of economic exploitation is extreme in Morowali and North Morowali, the two regencies that are the main nickel producer in Indonesia. Poverty in these two regencies is categorically high, in 2022 Morowali Regency was at 12.58% and North Morowali Regency at 12.97%. These numbers are above the average poverty line at the province level (Central Sulawesi Province) only reaching 12.33%.

Based on AEER findings in 2023, the lives of fishermen are increasingly concerning from time to time, especially fishermen who live around the nickel industry area that have adverse impacts on the sea ecosystem. One of the examples affecting the community's economy is the PT IMIP Steam Electric-Power Plant (PLTU) hot wastewater. Sea water temperature at the coastline of Kurisa Hamlet, Morowali Regency, reached 31.4˚C and there is a degradation of seawater quality that threatens the entire marine ecosystem and livelihoods of island communities.

In one sample case ("A fisherman family in Kurisa Hamlet, Morowali, Central Sulawesi"), a local resident changed profession and became a garbage collector after the nickel processing company began operation near their residence. Twenty years ago, Mr. Ahmad (an alias) was relocated to the Kurisa Hamlet to maintain his activity as a fisherman with a small boat as his main capital. He said that he was able to fulfill the daily needs of his family only with the fish he caught, which was still easy to do. However, since the establishment of nickel mining and processing in Morowali, Mr. Ahmad's condition has been increasingly concerning. His boat can no longer be used to sail far to the sea. Currently, Mr. Ahmad does simple gardening and utilizes the forest for its resources. Mrs. Hafifa, Mr. Ahmad's wife, as the family's breadwinner had switched to scavenging for bottle scraps around the company area. This is not an easy job; she was often accused of being a thief to being threatened by company security.

Figure 3. The sea near the operating smelting nickel industry in Morowali Regency

Foto: AEER

2. Social Impacts on the Communities in Morowali Regency and North Morowali Regency

Nickel management activities and their supporting infrastructure have led to the destruction of local communities' living spaces. The social impacts are agrarian conflicts, horizontal conflicts, loss of livelihoods, deteriorating health, loss of local food, exploitation of women's labor through reproductive work, shifting professions from fishermen/farmers to laborers, scavengers, sea taxis, and prostitutes.

Observing the social change, those affected by the negative impacts are entities with various layers of identity (race, ethnicity, religion, gender, profession, citizenship, or political choice). For instance, the women laborers, fisherwomen, women farmers, and women small traders, both who are migrants and local people, have the breadwinner status, low economy, low education, and no influence in their community.

2.1. Productive versus Reproductive

Nickel processing companies gain an advantage of different layers of people's identities because of the patriarchal system that is deeply rooted in Indonesian society, which leads to a gender productivity gap. In Indonesia's mining and nickel processing industry, as in many other heavy sectors, gender roles are often observed in a highly polarized context. Men tend to dominate field and technical work and are considered productive, while women, whose involvement is often never taken into account and recognized, contribute a lot to domestic work and services. Women hold the key role in supporting physical labor through domestic work. They prepare food, manage the household, and care for family members, which indirectly supports the continuity of mining and industrial operations. Women's involvement is often unrecognized or unpaid, despite being vital to economic operations.

Many women workers at PT IMIP experience severe work pressures. They work between 16 and 18 hours per day and must divide their time between domestic duties and productive work at the company. This situation is exacerbated by non-inclusive road infrastructure and work facilities that are prone to sexual harassment and disruption of reproductive health. In addition, due to being required to meet the standards of job performance set by the company, many women workers experience miscarriages and reproductive health problems, which ultimately make them decide to stop working.

Another example case is also experienced by female small-scale traders who allocate roughly the same time amount between 16 and 18 hours per day. In addition to domestic work, women in the industrial areas of Morowali and North Morowali are also involved in the informal economy related to industry and mining. They are engaged in the sale of food, clothing, and other goods to the workers. However, these activities are considered less important than formal mining jobs. As a result, activities that are considered unimportant to their families and communities result in female small-scale traders becoming isolated and their condition is exacerbated by the lack of information obtained about construction developments around them.

2.2 Conditions of workers in the Nickel Processing Industry

The Occupational Health and Safety (OHS) standard issue is still a priority for discussion and advocacy. Particularly in Central Sulawesi, where throughout 2023 10 cases killed 36 workers and injured 47 workers. High-risk vulnerability points for workers include: laborers operating dump trucks, dozers, excavators, and cranes, facing the furnace heat (between 1,400 and 1,600 ˚C), exposure to hot metal, fires and explosions, and collapsing mine walls.[6] Specifically, women workers in the nickel processing industry also experience sexual harassment and inadequate facilities, such as toilets, lactation rooms, breast milk storage refrigerators, nutrition for pregnant women, and road / bus stop infrastructure.

The feminization of workers in the nickel processing industry also occurs. The company builds a public image that they have emancipated women, but the factual condition is the exploitation of women laborers. The feminization of labor in the nickel industry is masculine, which means that it is synonymous with destructiveness, by displacing farmers, evicting residents, and depriving them of living space. In the nickel industry, women are seen as unpaid servants. The higher the nickel production, the more women's roles are exacerbated by feminization. Women take on

[6] Data Yayasan Tanah Merdeka, Annual Report 2023

roles that are juxtaposed with high technology and high risk, even in the nickel industry, the labels ranger pink or crane purple are born for female workers. Feminization by these nickel companies is only a slogan without regard to the actual needs of women workers.

As the backbone of the massive growth of the nickel processing industry, the workers are the ones who are most disadvantaged. The bad standards of work health and safety had turned Morowali and North Morowali no less than a killing field. Work-related deaths and suicide cases among Chinese immigrant workers show the darkest side of nickel mainstreaming in Indonesia.[7]

Figure 4. A "warung" or small shop managed by a housewife in Tanauge Village, North Morowali Regency

Foto: AEER

3. Environmental Impacts

3. 1 Indonesian Nickel Production Still Utilizes Dirty Energy Sources

The nickel industry in Morowali produces stainless steel and nickel sulfide as battery components. The process of nickel extraction and processing consumes a large quantity of energy. Most of the energy is supplied by coal which produces the high emission carbon. Based on the data from the Global Energy Monitor (2024), PT IMIP nickel processing industry located in Morowali uses its power generation infrastructure to supply the area's energy needs. The power plant uses 100% coal energy. For instance, PT Gunbuster Nickel Indonesia (PT GNI) has a production capacity of 2,000,000 metric tons of nickel pig iron (NPI), operates a 945 MW Steam Electric-Power Plant (PLTU), and plans to operate an additional 1350 MW PLTU which is currently under construction. Other companies still use PLTU in their nickel production. PT Wan Xiang Steel Indonesia with a power of 130 MW; PT Virtue Dragon Nickel Indonesia with a power of 530 MW; PT Aneka Tambang operating in Pomalaa with a power of 60 MW.

The above situation is unfortunate, considering the high potential for Sulawesi's renewable energy sources. The potential renewable energy in Sulawesi includes wind energy sources of 11 Gigawatts (GW), solar energy of 27 GW, hydroelectric energy of 5 GW, and geothermal energy of 3 GW. The total renewable energy capacity is 45 GW. This capacity means the ability to produce a large amount of electrical energy of 119 TWh or, if we refer to the draft RUKN of the Ministry of Energy and Mineral Resources 2023, reaching 78% of Sulawesi's energy needs of 153 TWh in 2060. This means that there is a 22% difference in estimated energy needs that is not supplied by renewable energy. This indicates that the level of mineral

[7] Arianto Sangaji and Pius Ginting, 'Multinational companies and Nickel Downstreaming in Indonesia' (AEER 2023)

production in the Sulawesi region should be limited to the carrying capacity of its renewable energy.

3.2 Sea and River Water Conditions Around Nickel Processing Industry Areas

In 2023, nickel mining entities in Indonesia will have 319 permits with an area of almost 900,000 hectares, second only to gold. According to the mapping done by Auriga Nusantara, deforestation caused by nickel mining has cleared out nearly 25,000 hectares in various regions in Indonesia. The increasing needs of the processing industry – due to government policies – have increased the life of nickel mines as they provide raw materials for processing and production.

In the field study done by AEER in September 2023 at PT IMIP, the existence of nickel smelters supported by mineral mining has given an adverse impact on the surrounding river water. La Kumpi River is located on the north side of PT IMIP, and Labota River is located on the southeast side of PT IMIP. Although there is yet no data that PT IMIP's waste is directly discharged to the two rivers, AEER suspected there is an indirect environmental impact on freshwater ecosystems around the nickel industry.

The quality measurement results of both rivers can be seen in Appendix Table 1. From the measurement results, it could be concluded that organic and heavy metal pollution is present in the La Kumpi River and Labota River, which receive pollutant loads from the surrounding area, including from the IMIP industrial area. The presence of heavy metal contaminants in the river water will cause toxic effects both for the aquatic life in it and for the surrounding community if consumed.

In the research, AEER also conducted seawater quality measurements for the area around IMIP. The quality measurement results of both rivers can be seen in Appendix Table 2. The high concentration of metals in coastal waters poses a health threat to both aquatic organisms and local residents. Due to the toxicity and its difficult-to-degrade nature, heavy metals are deposited in fish that ingest them. Without realizing it, these metals will also accumulate in the bodies of people who consume the pollute fish. At certain concentrations, metals are often suspected of causing cancer or other diseases, such as hemochromatosis and metal fume fever[8].

Environmental impact studies were also conducted by AEER at the Indonesia Weda Bay Industrial Park (IWIP) located in Central Halmahera Regency, North Maluku Province in June 2023 by measuring the same parameters. This was done to enrich the data analysis of environmental pollution by nickel processing companies. Appendix Table 3 summarizes the seawater quality around the IWIP.

The wastewater discharge point, Cape Ulie waters, and the mouth of Ake Doma River are located in the marine waters bordering the IWIP industrial area. The seawater at these points contains hexavalent chromium, with concentrations reaching up to 0.024 mg/L. This level exceeds the quality standard set by Initiative for Responsible Mining Assurance (IRMA) criteria (0.0044) and Government Regulation No. 22/2021 for marine tourism and marine biota.

The wastewater discharge channel carries coal plant wastewater from the coal-fired power plant operations. In addition to carrying hexavalent chromium from activities like steel welding and painting, the coal plant wastewater also has a high temperature. This threatens coral reef ecosystems, ultimately

[8] Akpor, O. & Munchie, M. (2010). Remediation of heavy metals in drinking water and wastewater treatment systems: Processes and applications. International Journal of the Physical Sciences, 5(12), 1807-1817. http://www.academicjournals.org/IJPS

leading to a decline in fish populations along the coast. Fishermen now have to venture farther out to sea for their catch.

The high concentration of hexavalent chromium can pose health risks to humans. This metal can accumulate in fish bodies and later be consumed by the human population. Besides causing skin rashes, its toxic nature can increase the risk of stomach cancer and disrupt reproductive health.

Conclusion

The findings above highlight the exclusionary practices of corporations as well as blatantly show that social and environmental inclusion and sustainability are not yet put as top priorities in Indonesia's economic development.

Sustainable investment should be an absolute requirement, especially when the negative impacts are felt by the community. In this context, the main controllers of the industry, which are the Chinese multinational companies and a handful of Indonesian businessmen or officials, boast the success of downstreaming by producing stainless steel, using NPI as the main raw material. This is clear evidence of a systemic failure that sacrifices the public interest for the benefit of an elite group.

Given the dynamics of who benefits and who loses, as well as the volatile price, it is imperative for the Indonesian government to re-regulate the nickel processing industry by placing restrictions on the construction of new smelters and limits on mining licenses. In addition, it is important to encourage a campaign to limit mineral consumption in countries that import nickel from Indonesia, as the accumulated impacts have seriously affected the ecological sustainability and future generations.

European countries, as one of the end consumers of these produced minerals, need to reduce their consumption of primary minerals and improve the standards of the minerals they receive. If this is done, Indonesia as a producer will inevitably have to rethink the over-exploitation of minerals that has been practiced at the expense of social and ecological sustainability to meet the market demand for minerals.

Figure 5. The operating captive coal-fired power plant of PT GNI in North Morowali Regency

Foto: AEER

Imprint

Publisher:

AEER (Aksi Ekologi & Emansipasi Rakyat)

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Jakarta / Berlin August 2024

This project is supported by the Open Society Foundations. Responsibility for the information and views contained in this publication lies with the authors. The Open Society Foundation cannot be held responsible for any use that may be made of the information contained or expressed therein.

Appendix

Table 1. Results of River Water Quality Measurements at PT IMIP (AEER, 2023)

No.	Parameter	Unit	Quality Standard*	Standard IRMA 2021	La Kumpi River	Labota River
1.	Temperature	^{0}C	Dev 3	<3 diff	26.6	26
2.	Total dissolved solids (TDS)	mg/L	1000	-	1103	1406
3.	Total suspended solids (TSS)	mg/L	40	40	150	14
4.	Acidity level (pH)		6-9	6.5-9.0	8.84	8.84
5.	Chloride (Cl^-)	mg/L	300	230	71	76
6.	Nitrate (as N)	mg/L	10	13	1.2	1.3
7.	Ammonia (as N)	mg/L	0.1	measured	0.17	0.2
8.	Sulfur as H_2S	mg/L	0.002	measured	0.04	0.01
9.	Soluble Hg	mg/L	0.001	0.0001	0.0004	0.0005
10.	Soluble As	mg/L	0.05	0.024	0.007	0.011
11.	Soluble Fe	mg/L	0.3	1	0.18	0.07
12.	Cd	mg/L	0.01	measured	0.023	0.009
13.	Soluble Co	mg/L	0.2	measured	0.031	0.028
14.	Soluble Mn	mg/L	0.10	0.37	0.05	0.09
15.	Soluble Ni	mg/L	0.05	measured	0.02	0.04
16.	Soluble Zn	mg/L	0.05	measured	0.03	0.03
17.	Soluble Cu	mg/L	0.02	measured	0.2	0.15
18.	Soluble Pb	mg/L	0.03	measured	0.018	0.15
19.	Cr^{6+}	mg/L	0.05	0.011	0.018	0.015

Description: Text colored red: quality exceeds the quality standard

*: Class 1 River Water Quality Standard Govt Reg No. 1. 22 of 2021.

Table 2. Results of Sea Water Quality Measurements at PT IMIP (AEER, 2023)

No.	Parameter	Unit	Quality Standard*			Standard IRMA 2021	Results			
			Port	Marine tourism	Marine Biota		a	b	c	d
1.	Turbidity	NTU	-	5	5	not regulated	92	10	9	5
2.	TSS	mg/L	80	20	coral: 20 mangrove: 80 seagrass: 20	-	152	20	52	78
3.	Temperature	ºC	natural	natural	natural coral: 28-30 mangrove: 28-32 seagrass: 28-30	-	28.5	31.4	29.1	26
4.	pH		6.5-8.5	7-8.5	7-8.5	6.5-8.7	8.28	8.44	8.13	8.19
5.	Ammonia total (NH_3-N)	mg/L	0.3	0.02	0.3	measured	0.30	0.17	0.29	0.11
6.	Nitrate (NO_3-N)	mg/L	-	0.06	0.06	13	0.0016	0.01	0.05	0.03
7.	Sulfides (H_2S)	mg/L	0.03	0.02	0.01	measured	0.06	0.04	0.07	0.01
8.	Hg	mg/L	0.003	0.002	0.001	0.0004	0.0001	0.0002	0.0002	0.0002
9.	Cr^{6+}	mg/L	-	0.002	0.005	0.0044	0.002	0.004	0.004	0.004
10.	As	mg/L	-	0.025	0.012	0.0125	0.0012	0.0009	0.0018	0.0014
11.	Cd	mg/L	0.01	0.002	0.001	0.004	0.0007	0.0007	0.0005	0.0017
12.	Cu	mg/L	0.05	0.05	0.008	0.0031	0.03	0.06	0.04	0.01
13.	Pb	mg/L	0.05	0.005	0.008	0.0081	0.05	0.05	0.05	0.05
14.	Zn	mg/L	0.1	0.095	0.05	0.015	0.045	0.038	0.012	0.034
15.	Ni	mg/L	-	0.075	0.05	0.07	0.0016	0.0002	0.0022	0.0021

Description: Text colored red: quality exceeds the quality standard

a: Fatufia Village Coastline; b: Inlet of hot water discharge; c: Kurisa Hamlet; d: Langala Island

*: Appendix VIII PP 22 of 2021

Table 3. Results of Sea Water Quality Measurements at PT IWIP (AEER, 2023)

Point	Temperature (°C)	pH	Cr^{6+} (mg/L)	Description
1	31.5	8.62	0.005	Botapo, Gemaf The pH level exceeds the permissible range outlined in Government Regulation 22/2021, (indicating an alkaline tendency in the water); Cr6+ concentration exceeds Government Regulation 22/2021 quality standards for marine tourism and IRMA standards.
2	29.1	8.28	0	Lolaro, Gemaf
3	32.2	8.39	0.001	The mouth of the Ake Sake River The temperature is high for coral reefs and seagrasses.
4	32.3	8.6	0.024	Near the outlet of the coal power plant wastewater discharge Temperature is high for coral reefs and seagrasses; The pH level exceeds the permissible range outlined in Government Regulation 22/2021, (indicating an alkaline tendency in the water); Cr6+ concentration exceeds Government Regulation 22/2021 and IRMA quality standards.
5	35	8.6	0.009	Near the outlet of the coal power plant wastewater discharge. The temperature is high for coral reefs, mangroves, and seagrasses; The pH level exceeds the permissible range outlined in Government Regulation 22/2021, (indicating an alkaline tendency in the water); Cr6+ concentration exceeds Government Regulation 22/2021 and IRMA quality standards.

Point	Temperature (°C)	pH	Cr^{6+} (mg/L)	Description
6	32.4	8.71	0.001	Harbor Area Temperatures are high for coral reefs and seagrasses; The pH level exceeds the permissible range outlined in Government Regulation 22/2021, (indicating an alkaline tendency in the water).
7	32.6	8.64	0.003	Cape Ulie Temperatures are high for coral reefs and seagrasses; The pH level exceeds the permissible range outlined in Government Regulation 22/2021, (indicating an alkaline tendency in the water); Cr6+ concentration exceeds Government Regulation 22/2021 quality standards for marine tourism.
8	33.2	8.69	0	The mouth of the Wosea River Temperatures are high for coral reefs and seagrasses; The pH level exceeds the permissible range outlined in Government Regulation 22/2021, (indicating an alkaline tendency in the water).
9	33.9	8.62	0.015	The mouth of the Ake Doma River Temperatures are high for coral reefs and seagrasses; The pH level exceeds the permissible range outlined in Government Regulation 22/2021, (indicating an alkaline tendency in the water); Cr6+ concentration exceeds Government Regulation 22/2021 and IRMA quality standards.