# ENVIRONMENTAL IMPACTS AT MINING COMPANY: A CASE STUDY IN DAI TU DISTRICT AND ENVIRONMENTAL SOLUTIONS

**Pham Ngoc Huyen**
*TNU - University of Agriculture and Forestry*

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**ABSTRACT**

The information about Nui Phao mining company as well as the perception from local communities who live around Nui Phao company about the operation and effect of the company was investigated in this article. In this case, the company staffs and the local communities are the source of information for environmental impact assessment in Nui Phao mining company. In order to obtain the result, an interview was conducted with a questionnaire consisting of two sections about the waste, noise, and water condition based on the perception of company and local people. The results were compared with the Vietnamese National Standard. The results showed that the status of air and waste was still within the permitted standard although there was a little problem with wastewater of the company. Besides, other related aspects such as residents' health, smell of tap water at home, etc were all good based on the local residents' opinion. It is concluded that residents in the area had hardly experienced any bad impacts of the mining company. However, some measures are also proposed for prevention, and response of environmental problems..

# ĐÁNH GIÁ TÁC ĐỘNG MÔI TRƯỜNG TẠI CÔNG TY KHAI THÁC NÚI PHÁO: NGHIÊN CỨU TẠI HUYỆN ĐẠI TỪ VÀ CÁC GIẢI PHÁP MÔI TRƯỜNG

**Phạm Ngọc Huyền**
*Trường Đại học Nông Lâm – ĐH Thái Nguyên*

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**TỪ KHÓA**

Các tác động môi trường
Công ty khai thác
Ô nhiễm môi trường
Công ty khai thác Núi Pháo
Huyện Đại Từ

**TÓM TẮT**

Bài báo này khảo sát thông tin về Công ty khai thác Núi Pháo cũng như nhận thức của cộng đồng địa phương sống xung quanh về hoạt động và ảnh hưởng của công ty. Nhân viên của công ty và cộng đồng địa phương là nguồn cung cấp thông tin trong việc thực hiện đánh giá các tác động môi trường của Công ty khai thác Núi Pháo. Để có được kết quả, cuộc phỏng vấn được thực hiện với một bảng câu hỏi bao gồm hai phần về tình trạng chất thải, tiếng ồn và nước dựa trên nhận thức của nhân viên trong công ty và người dân địa phương. Kết quả của nghiên cứu này được so sánh với Tiêu chuẩn Quốc gia Việt Nam và cho thấy tình trạng không khí và rác thải nằm trong tiêu chuẩn cho phép tuy vẫn có một vấn đề nhỏ đối với thực trạng nguồn nước thải của công ty. Ngoài ra, các khía cạnh liên quan khác như sức khỏe của người được phỏng vấn, mùi nước máy tại nhà của họ, v.v. đều tốt. Kết luận rằng người dân trong khu vực ít bị ảnh hưởng từ các hoạt động của công ty Núi Pháo. Tuy vậy, bài báo cũng đề xuất một số giải pháp để phòng tránh và giải quyết những vấn đề môi trường có thể gặp phải.

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*Email: huyen221098@gmail.com*

## 1. Introduction

There is a need for economic development in both industrialized and developing countries in order for people to improve their standard of living and reach their full human potential [1]. The mining industry is a fundamental source for building infrastructures and an enabler for a country's growth. Over the last decade, mining has been among the top human activities that have the most disturbing and catastrophic impacts on the environment, extensively affecting the ecological, economic, and social elements in the vicinity [2]. There is an increasing global concern for the decontamination of historically polluted industrial sites that pose significant environmental risks for terrestrial and aquatic ecosystems, as well as for human health. These contaminated sites can also often suffer damage of physical and biological components [3]. In the region of the Apuseni Mountains, part of the Western Carpathians in Romania, metal mining activities have a long-standing tradition. These mining industries created a clearly beneficial economic development in the region. But their activities also caused impairments to the environment, such as acid mine drainage resulting in long-lasting heavy metal pollution of waters and sediments [4].

The situation of socio-economic development of countries in the world in recent years has had impacts on the environment and has made the living environment of human beings change and become worse day by day. In recent years, the problems of air pollution are climate change - global warming, ozone layer depletion, and acid rain [5]. Most countries in South and Southeast Asia, including Vietnam, have high levels of air pollution, with average annual levels often 3–10 times higher than WHO air quality standards [6]. Typically, the situation of increasing environmental pollution in urban areas and around industrial clusters, industrial production facilities, mine areas, construction sites, etc. is occurring more and more complicatedly.

Vietnam's environmental impact assessment (EIA) system has been amended multiple times since its beginning in 1993, thanks to a series of legislative modifications to the Law on Environmental Protection (LEP) and its accompanying Circulars and Decrees, demonstrating the government's commitment to improve environmental performance [7].

Thousands of large socioeconomic development projects are implemented each year across the country [8]. From 2011 to the present, Vietnam has produced almost 7,000 EIA reports, 250 of which are approved by the Ministry of Natural Resources and Environmenteach year [9]. EIAs are also conducted by the provinces, with an estimated yearly approval rate of 35 EIAs per area. Such rapid expansion puts a strain on Vietnam's natural resources and jeopardizes the country's environmental purity [10]. The LEP's technical and legislative framework for EIA in Vietnam was reviewed and revised in 2005 and again in 2014, altering several circulars, decrees, and technical recommendations. Despite various advancements, there was still a significant gap between the theory and reality of environmental impact assessment in Vietnam.

The LEP was re-evaluated in 2014, with the resultant Law on Environmental Protection 2014 [11] providing significant improvements in identifying the types of projects that require EIA, biodiversity impact assessment processes, human health impact assessment processes, and the inclusion of a certification system for EIA practitioners [12]. Despite this, the greater issues of Vietnamese EIA noted above persist, the most notable of which is that EIA is limited in its requirement for local community involvement and is primarily employed for specific types of projects.

The economic and social situation of Thai Nguyen city in recent years has made encouraging developments. However, due to various reasons during the development process, this has caused serious environmental problems, especially in Nui Phao mining area, Dai Tu district. Nui Phao mine is a polymetallic mine located in three communes of Hung Son, Ha Thuong, and Tan Linh of Dai Tu district, Thai Nguyen province [13]. The mine is operated by Nui Phao Mining Company. The main areas of the project in Nui Phao include an open-pit polymetallic mine, waste rock disposal facilities, a modern mine plant and facilities, including crushing, grinding, thickening, flotation, leaching and gravity recovery facilities [14]. This problem is directly

affecting the lives and health of the people and puts great pressure on the environmental management in the city.

Indeed, the effects of mining at Nui Phao Mining Comany (NPMC) have had an impact on many areas of life, especially natural resources and the surrounding environment. Therefore, the purpose of this paper is to evaluate the impacts of NPMC on the surrounding environment and propose ecological solutions to help the company take measures to effectively treat the environment which contributes to improving the community's quality of life.

## 2. Materials and methods

### *2.1. Study area*

The study area of the Nui Phao Mining Company will be conducted in Dai Tu district, Thai Nguyen province in Vietnam. Our research area includes 3 communes Hung Son, Ha Thuong, and Tan Linh in Dai Tu district, Thai Nguyen province.

### *2.2. Methods*

The operation process of NPMC will generate environmental pollution agents: exhaust gas, wastewater, solid waste (hazardous and non-hazardous) with scale and different ingredients. To evaluate the status of environment in NPMC, a systematic sample was carried out in this area on 6$^{th}$ May 2022.

The collected samples are air, solid waste, soil quality and water quality in NPMC. In order to evaluate the environmental status, we have been using the Vietnamese standards as Decision No. 3733/2002/QD-BYT and QCVN 26:2010/BTNMT on the air; QCVN 08-MT: 2015/BTNMT: National technical regulation on surface water; QCVN 24: 2009/BTNMT: National Technical Regulation on Industrial Wastewater.

Figure 1 shows air sampling locations (a) and wastewater sampling locations (b) at NPMC (Masan High-tech Materials Corporation, 2022). The locations of air sampling at NPMC was described in table 1.


*(a)* *(b)*

**Figure 1.** *Air sampling locations at NPMC (a) and (b) wastewater sampling locations at NPMC (Masan High-tech Materials Corporation, 2022)*

**Table 1.** *Locations of air sampling at NPMC*

| | Sample | Longitude | Latitude | Describe the monitoring point |
|---|---|---|---|---|
| 1 | LS1 | 105$^o$48’24,6” | 21$^o$36’55,7” | Evaluate the quality of air in factory |
| 2 | LS2 | 105$^o$48’24,7” | 21$^o$36’55,8” | Evaluate the quality of air in factory |
| 3 | LS3 | 105$^o$48’28,7” | 21$^o$36’55,8” | Evaluate the quality of air in factory |
| 4 | LS7 | 105$^o$48’24,2” | 21$^o$36’58,8” | Evaluate the quality of air in factory |
| 5 | LS8 | 105$^o$48’25,8” | 21$^o$36’51,3” | Evaluate the quality of air in resident area |
| 6 | LS9 | 105$^o$48’27,9” | 21$^o$37’01,3” | Evaluate the quality of air in resident area |

In addition, the interviews were also conducted on the list of questions that we prepared. Totally of 26 residents from hamlets 12, 13, and 14 in Tan Linh commune, Dai Tu district, Thai Nguyen province, and some of the employees from NPMC responded interview. The interviews were conducted with individuals to collect information from local residents, and mining company employees/ managers. The interviews took place in person at individuals' homes, mining sites, cafés, and shops. Questionnaires were tailored for the two groups: community members and mining company employees. Interview topics included mining impacts on air and water quality as well as the effect of solid waste.

## 3. Results and discussion

### *3.1. Impact to air quality*

The area near the factory from LS1 – LS7 all have a temperature of ~24$^0$C, within the specified range of Vietnam's working area air temperature regulation QCVN - 24/2016/BYT [15]. For humidity and wind speed, the data are within the permitted level of QCVN - 24/2016/BYT [15]. Since the result shows that the air quality is still within the permitted level by Vietnamese standard, the truth of data above is also supported by the interview result with the local respondents. Based on the survey of 26 respondents who live in the mining site area, seven households agreed that the company activities contribute to air pollution. Meanwhile, nineteen respondents claimed that they did not have any problems with the air quality. Those who agreed with the statement are aged from 35 to 60 and dominated by farmers since the survey took place in Tan Linh commune which has many tea farms. The interview result proves that the air quality does not significantly affect the local community since the percentage of people who are vulnerable does not even reach the half of total respondents. Table 2 presents analysis results of air quality.

**Table 2.** *Analysis results of air quality*

| | Sample | Analytical criteria | | |
|---|---|---|---|---|
| | | Air temperature ($^0$C) | Humidity (%) | Wind speed (m/s) |
| 1 | LS1 | 24.0 | 65.2 | 0.3 |
| 2 | LS2 | 24.2 | 65.1 | 0.2 |
| 3 | LS3 | 24.1 | 65 | 0.3 |
| 4 | LS7 | 24.3 | 64.8 | 0.2 |
| 5 | LS8 | 25.2 | 64.2 | 0.2 |
| 6 | LS9 | 25.2 | 65 | 0.3 |
| **QCVN -24/2016/BYT** | | **18-32** | **40-80** | **0.2-1.5** |

Based on the pollution coefficient established by the World Health Organization (WHO) for mineral mining, it is possible to predict the total amount of dust generated from ore mining in the absence of a pollution control system infected as follows.

**Table 3.** *Total dust load generated during operation (Masan High-tech Materials Corporation, 2022)*

| Activities | Mining capacity(tons/day) | Pollution coefficient (kg/tons) | Load (kg/day) |
|---|---|---|---|
| Mining activities | 10,000 | 134 | 1,340 |
| Transport | 10,000 | 0.17 | 1,700 |
| | Total | | 3,040 |

Table 3 presents the total dust load generated during operation provided by NPMC; daily amount of dust was 10,000 tons/day from mining activities and other 10,000 tons/day from transportation. In addition, pollution coefficient from mining area was 134 kg/tons with 0.17 kg/tons of transport activities. Thus, the load of 3,040 kg/day arising during ore mining was a lot. Around the open mining area, there are few people living, the nearest household is 300 m to the

north of the company, so this source of dust only affects the environment and objects around the mining area.

Emissions from the transportation of mining ore: During the stable operation, there are about 10,000 tons of mining ore transported out of the mining area daily. The total volume of vehicles entering and leaving the area was about 3000 trucks. With the whole mining area of 921 ha, and dust reduction measures which was applied by the company, the number of 3000 vehicles a day had a small impact on the mining workers and some residents in the immediate vicinity of Nui Phao company.

Dust arising from the explosion of mines: Matters arising from the explosion and destruction of rocks include many different sizes. In fact, the mining field shows that most types of boulders and crushed stones were fired around the center of the explosion within a radius of 100 – 200 m, while the dust was blown up about 10-15 m. Dust of fine-grained raft (0.05-0.1 mm) along with explosive fumes was spread away and windward. However, this dust arises instantaneously and is diluted with high air, which does not have a frequent effect on human health. According to Mr. An, a local resident living near the company, the most explosive intensity is every 2 days and it depends on the mining time. So the impact on the air from this activity was not serious. Table 4 presents analysis results of air quality.

**Table 4.** *Analysis results of air quality*

| | Samples | Name | | | | | |
|---|---|---|---|---|---|---|---|
| | | *** Noise (dBA)** | ***TSP ($mg/m^3$)** | ***$H_2S$ ($mg/m^3$)** | **$N0_2$ ($mg/m^3$)** | **$SO_2$ ($mg/m^3$)** | **CO ($mg/m^3$)** |
| *1* | LS1 | 72.6 | 0.16 | < 0.03 | <0.08 | <0.026 | < 5 |
| *2* | LS2 | 67.7 | 0.62 | < 0.03 | <0.08 | <0.026 | < 5 |
| *3* | LS3 | 63.7 | 0.1 | < 0.03 | <0.08 | <0.026 | < 5 |
| *4* | LS7 | 70.8 | 0.17 | < 0.03 | <0.08 | <0.026 | < 5 |
| *5* | LS8 | 70 | 0.1 | < 0.03 | <0.08 | <0.026 | < 5 |
| *6* | LS9 | 62.6 | 0.11 | < 0.03 | <0.08 | <0.026 | < 5 |
| Decision No. 3733/2002/ QD-BYT | | **8.5** | **0.3** | **10** | **5** | **5** | **20** |
| QCVN 26:2010/BTNMT | | **85** | | | | | |

### *3.2. Impact of solid waste*

#### *3.2.1. Domestic solid wastes*

The domestic solid waste was from food and beverage activities of workers working in the exploitation area and the company. Emission volume was estimated that the amount of domestic solid waste generated was 0.74 kg/person/day [16]. The total number of employees working at Nui Phao mining company was 1,096 people. Therefore, the total amount of domestic waste generated was 811.04 kg/day. This amount of waste was a lot and it was stored in the discharge area for 3-7 days, which would partially affect the quality of the soil and air, as well as the water source if it rained.

#### *3.2.2. Industrial waste*

Industrial waste from mineral exploitation activities with compositions was mainly dust, soil, and sand. According to the interview, the exploitation and emission ratio was 1:2, it means that 1 ton of ore has 2 tons of waste. Therefore, the total volume of solid waste generated in a day was about 20,000 tons.

With the volume of 20,000 tons of solid waste, if there is no appropriate method of collection and management of this land mass, it will cause environmental pollution. Dust and soil will

spread into the surrounding environment, or experience hurricanes and this mass of soil will be washed away and flow to the lower reaches.

The Company introduced a number of measures to reuse waste rock and soil in 2020, the Company reused 987,051-ton waste land mines for the construction of internal mine works such as: damming tailings reservoirs, leveling, filling embankments of waste dumps, making roads and some other works [17].

*3.2.3. Hazardous waste*

Hazardous waste is arising from maintenance and repair activities of vehicles transport and construction machinery and equipment. During the operation period, other types of waste of the company were mainly identified as grease-contaminated wastes (mops, oil residue) and waste grease arising from repair and maintenance of machinery, mechanical construction equipment, and transportation.

The waste will be dumped into the solid waste storage area and takes 3 to 7 days of storage. Therefore, it can have an impact on the environment if it rains, toxic substances will follow the water to seep into the ground and flow into the environment. In hot weather, it will cause a stench and affect the working environment.

### *3.3. Impact to water quality*

**Table 5.** *Analysis results of treated wastewater at wastewater treatment station (NM1 and NM2) in NPMC 2022*

| | **Analytical criteria** | **Unit** | **Result TNN44** | | **QCVN 08-MT:2015 /BTNMT** | |
|---|---|---|---|---|---|---|
| | | | **NM1** | **NM2** | **A1** | **A2** |
| 1 | pH | - | 6.78 | 6.98 | 6-8,5 | 6-8,5 |
| 2 | Floating solids (TSS) | mg/l | 11.7 | 13.5 | **20** | **30** |
| 3 | $NH_4^+$ | mg/l | 0.14 | 0.18 | **0.3** | **0.3** |
| 4 | Total Phosphorus | mg/l | 0.08 | 0.11 | **0.1** | **0.2** |
| 5 | Sulphur ($H_2S$ parameter) | mg/l | <0.14 | <0.14 | **0.2** | **0.5** |
| 6 | Total Nitrogen | mg/l | 1.25 | 1.67 | **2** | **5** |
| 7 | Chemical oxygen demand (COD) | mg/l | 9.6 | 12.0 | **10** | **15** |
| 8 | Biochemical oxygen demand ($BOD_5$) | mg/l | 5.2 | 5.7 | **4** | **6** |
| 9 | Iron (Fe) | mg/l | 0.065 | 0.098 | **0.5** | **1** |
| 10 | Zing (Zn) | mg/l | 0.078 | 0.071 | **0.5** | **1** |
| 11 | Asen (As) | mg/l | <0.0005 | <0.0005 | **0.01** | **0.02** |
| 12 | Lead (Pb) | mg/l | <0.009 | <0.009 | **0.02** | **0.02** |
| 13 | Coliform | MPN/100ml | 869 | 995 | **2500** | **5000** |

During the mining process, water used to recruit ore by the screw toroid system will be discharged into the environment. According to the actual norms, to recruit 1 $m^3$ of coarse ore sand, the amount of water used is 2 $m^3$. The water after the selection will seep through the sand layer. The ore sand layer itself is a layer of yellow sand containing water, so it does not cause dirt and pollution. About 80% of the water from the waste sands is recovered for treatment and reuse. The remaining 20% will be treated before being released into the environment.

Additionally, the water problem is the main issue of local communities. There were around fifteen respondents who stated that they have water problems. This number is quite bigger than the air quality problem. The problems are varied starting from the odor, color, and taste. The quality of water in this context means the water from the source of communities' daily use. People in this area still rely on the source of water from the mountain and the well. They stated that the water they consume from mountain flow is stinky, cloudy, dirty, and turbid, and the taste

is not truly plain. Table 5 present analysis results of treated wastewater at wastewater treatment station (NM1 and NM2) in NPMC 2022.

### *3.4. Perspectives of the local community and company staffs on the impacts of NPMC*

From the process of observing, surveying and interviewing workers of the company as well as people residing nearby, the analysis results show that the impact of Nui Phao Company on the environment is not significant. Based on the interview with the company staffs, they stated that they have followed the guidelines by the local government since they also have the monitoring system by sending their observed water sample (wastewater) to the person in charge in governmental level to ensure that the company does not excess the maximum limit of the treated wastewater. The author also observed from the start to the end of the mining operation, from digging the materials until treating the waste. However, opinions from people living near the mining area are also mentioned in this article. They gave varied responses regarding the given questions since the questions were asking about their contribution in environmental impact assessment involvement, the impacts they experience during the mining operation, and their opinion related the existence of the company. However, the author do not find any significant or harsh effect to the locals regarding the mining operation based on the statement by the local residents.

### *3.5. Measures proposed to minimize impact, prevention, and response of environmental problems*

#### *3.5.1. Measures to control and reduce air pollution*

To control dust pollution from mining and transportation activities by limiting dust in the mining stage are to spray water on the surface of the mine to create suitable humidity in the mining plots to limit dust generated during the mining process. The frequency of spraying will ensure that the mining surface always has the necessary moisture. This is a simple method to perform at the mining site. The water source that will be used is spring water flowing into the water tanks in the mining area.

In order to limit dust generated on the transportation route, it is recommended to apply the method of covering the entire vehicle body, avoiding the sand dust of raw ore flying or being scattered on the transportation road. At the same time, all vehicles used to transport raw ore products to the factory for processing should also be sprayed with water before leaving the mining area in order to minimize the amount of dust entering the environment from the above vehicles during transportation product.

To control pollution caused by exhaust fumes from ore processing machines and transportation vehicles as all machinery and equipment must be inspected and maintained according to a plan to ensure that they are always working in good condition. Using the correct engine design such as not overloading, and using the correct fuel as designed should be followed. This helps to limit air and noise pollution and possible occupational accidents.

#### *3.5.2. Controlling pollution caused by wastewater in the mining process*

To treat wastewater containing metals, methods such as chemical precipitation can be used. This method is based on the chemical reaction between the substance added to the wastewater and the metal to be separated. At the appropriate pH, a precipitate is formed and separated by sedimentation. The ion exchange method can also be mentioned as based on the principle of ion exchange method used in ions from synthetic organic resins, hydrocarbon-based polymers and groups of ion exchangers. The ion exchange process is carried out in cationite and anionnite columns.

Next is an electrochemical method based on the redox process to separate metals on electrodes immersed in wastewater containing heavy metals when a direct current flows through. By this method, it is possible to separate metal ions from water without adding chemicals, but it is

suitable for wastewater with high metal concentration (> 1 g/l). In addition, biological methods can also be applied on the principle that some plants and microorganisms in water use metals as trace elements in the mass development process such as water hyacinth, water hyacinth, and algae, etc. With this method, wastewater must have a heavy metal concentration of less than 60 mg/l and must have enough nutrients (nitrogen, phosphorus, etc.) and other trace elements necessary for the growth of plants such as algae.

*3.5.3. Measures to minimize impact on ecosystems*

The mining of ores will affect the ecosystem in the area because the formation of mining sites will disrupt the ecosystem, especially the vegetation. Therefore, in the planning and design process mining site, the company needs to pay attention to the ecology of the mining site. Comparison and assessment of the benefits of sites should be made to select the optimal location so that the impact on the ecosystem is minimal.

Nui Phao Mining Company should control harmful effects on natural ecological conditions by rational use of natural resources. This is a very important factor that needs special attention to limit damage to ecosystems, while effectively using resources and reducing costs in the process of organizing ore mining. Besides, other solutions will also be implemented such as limiting the depth of mining, creating suitable mining locations, protecting existing trees, not digging in areas without ore, and the road system should be designed to avoid areas with lots of greenery. After exploitation, it is necessary to return to the soil and greening bare land in the areas of natural resources that have been affected.

## 4. Conclusion

In conclusion, the research results show from the process of observing, surveying and interviewing of workers of the company as well as people residing nearby. The analysis results show that the impact of Nui Phao Company on the environment was not significant. However, the recommendations given by the author should be considered by the company. A reasonable implementation plan of the above measures may contribute to overcoming environmental pollution during the mining process andimproving the living environment for workers currently working at the factory as well as the life of the local community in Dai Tu district, Thai Nguyen province.

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