Актуальные направления фундаментальных и прикладных исследований

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Nguyen Phuong Dong
Doctor of Philosophy in Geography
Nguyen Phuong
Doctor of Geological and Mineralogical Sciences
Vu Thi Lan Anh, Nguyen Thi Cuc
Postgraduates
Hanoi University of Mining and Geology
No.18 Vien Street - Duc Thang Ward- Bac Tu Liem District - Ha Noi- VietNam
phuongdongmdc@gmail.com

ASSESSMENT OF ENVIRONMENTAL SITUATION AND FORECAST ENVIRONMENTAL FLUCTUATIONS AT AREAS OF COPPER MINING AND APATITE MINING ACTIVITIES IN LAO CAI PROVINCE, VIET NAM

Abstract. Lao Cai province is evaluated as one of the provinces with diversity and high economic mineral resources of our country. In the past time, many Apatite and Copper ore exploitation and processing projects have been implemented and brought a significant source of revenue to the state and local budgets. However, mining activities have also caused many environmental and public health consequences, so the study assesses the environmental situation and predicts environmental changes (water, soil, air), which regarding mineral exploitation activities in general, areas of copper, apatite ore exploitation and Tang Loong industrial zone in particular are essential.

This paper introduces the results of the assessment of the environmental situation and forecast of environmental changes related to copper and apatite ore mining activities on the basis of applying a combination of a number of mathematical methods and the Metis-lis model. Beside that, proposing some solutions to minimize the environmental impact in copper and apatite ore mining and processing in Lao Cai province.

Keywords: Environmental situation, environmental fluctuations, mineral exploitation, Lao Cai Province

1. BACKGROUND

Lao Cai is the province with the greatest potential for copper and apatite ore, being a mineral resource that plays an important role in the development of our country's chemical, fertilizer and copper metallurgical industry. However, mining activities are only really sustainable when they meet the following objectives: mining safe; rational and efficient exploitation and use of natural resources and environment protection. Therefore, the study assesses the status quo and predicts environmental changes in mining activities in general; exploiting and processing copper and apatite ores in particular for the sake of sustainable development are essential and topical. There are many different research methods and perspectives; in particular, mathematical models are considered as an important tool to explain the distribution characteristics and relationships of environmental pollution factors; especially their fluctuations in the environment of soil, water and air caused by natural processes and human activities.

The paper introduces the results of applying a number of mathematical models, combining the Meti-lis model to assess the current status and fluctuations of some natural environmental components (air, soil, water) on the basis of research. Researching in some areas where copper ore, apatite ore and Tang Loong industrial zone are located, Lao Cai province. At the same time, from the research results, the author proposes a number of solutions to minimize negative impacts on the environment in mineral activities in Lao Cai province.

2. OVERVIEW OF RESEARCH AREA AND CURRENT SITUATION OF MINING AND PROCESSING COPPER, APPATIT OF LAO CAI PROVINCE

2.1. Overview of the research area

Lao Cai is a northern border province with relatively complex topographic features, monsoon tropical climate. However, due to being located deep inside the continent, it is influenced by complicated terrain factors, so the weather changes a lot, different over time and space. Temperature spikes often occur in the form of high or low temperatures during the day (in Sa Pa area, the temperature falls below 00C and snowy in many days). Currently, infrastructure is on the rise, industrial production is increasing significantly.

The study area belongs to three structural zones: Song Hong, Phan Xi Pang and Song Lo zones. Participating in geological structure, there are metamorphic formations, terrigenous sediments, eruptive sediments, intrusive magmatic formations and unconsolidated sediments aged from Arkei to Quaternary. Tectonic activities in the area developed quite strongly, typically the deep fault system of the Red River, Song Chay, Bat Xat - Lung Po ... [1]. The result of summarizing existing documents, in Lao Cai province has discovered and identified over 150 mines and mineral deposits distributed in different geological formations. In particular, copper ore is distributed mainly in Bat Xat, Cam Duong and Van Ban; apatite ore is concentrated into 03 partitions: Bat Xat - Lung Po; Bat Xat - Ngoi Bo and Ngoi Bo - Bao Ha formations of quartz-carbonate schist, quartz schist - sericite - apatite, carbonate schist - sericite - apatite contain coal material of the Cam Duong Formation ($€_{cđ}$).

2.2. Situation of exploiting and processing appatite ore and copper in Lao Cai

a. Apatite ore

In our country, apatite ore is mainly exploited in Lao Cai to produce fertilizer for agriculture (Supe Phosphate and Lam Thao chemical factory); poor P2O5 content is used to produce melted phosphate. A small amount of apatite ore in Lao Cai has been used to produce yellow phosphorus in Ta Loong Industrial Park, Lao Cai (Photo 1). Currently there are 5 businesses that are granted apatite mining licenses, namely Apatite Vietnam One Member Limited Liability Company, Van Thang Investment Joint Stock Company, Tam Dinh Lao Cai Apatite Investment Joint Stock Company, Agricultural Materials Joint Stock Company and the Company. Nam Tien Lao Cai Joint Stock Company and 2 enterprises were allowed to collect and salvage apatite ore. Currently, the total output of ore required for annual production is about 2.4 million tons (800,000 tons of grade I, 400,000 tons of grade II ore, 1.2 million tons of sort ore), but the period of 2018 - 2019 is only about 1.2 to 1.3 million tons / year; In general, the exploited output in the period of 2011 - 2019 tends to decrease.

Most apatite mines in the province are exploited mainly by open-cast method. However, due to the complex geological structure, the technology of exploitation and processing is still limited, leading to a large loss of ore and a high consumption of fuel. The rate of concentrate recovery in refining factories is not high (the loss rate is up to 32.06%).

Photo 1. Producing yellow phosphor at the industrial park

Photo 2. Overview of mining pits (2017)

b. Copper ore

Currently, Lao Cai copper joint venture enterprise is the only unit in Vietnam that organizes the mining and processing of copper ore on an industrial scale. Production started from the end of 1994, until the end of 2003. The company organized exploitation according to the open-cast method (Photo 2). In the period of 2011 - 2017, output from 1,097 - 1,469 million tons of raw ore / year; In 2019 alone, the production will reach over 2.2 million tons of raw ore.

Screening by flotation method to recover copper ore and wet magnetic field in weak magnetic field to recover magnetite ore. The refining factory went into production between southern 2006 and the copper smelting factory in Tang Loong industrial zone was completed in the first quarter of 2007.

The copper smelter factory is located in Tang Loong, equipped with copper smelting equipment according to the latest Chinese technology. The annual output of the metallurgical plant is expected to be copper (99.95%) is 10,571 tons / year, sulfuric acid (98%) is 39,943 tons/year, gold bullion (99.95% Au) is 367 kg/ year and silver ingots (99.95% Ag) is 206 kg.

3. RESEARCH METHODS

3.1. Collect and inherit documents

Documents related to the study area were collected including:

- Geological - mineral documents, environmental geology, documents on the current status of mining, ore sorting and related environmental issues, results of environmental sample analysis, ... in the previous reports [2] [1] [3] .

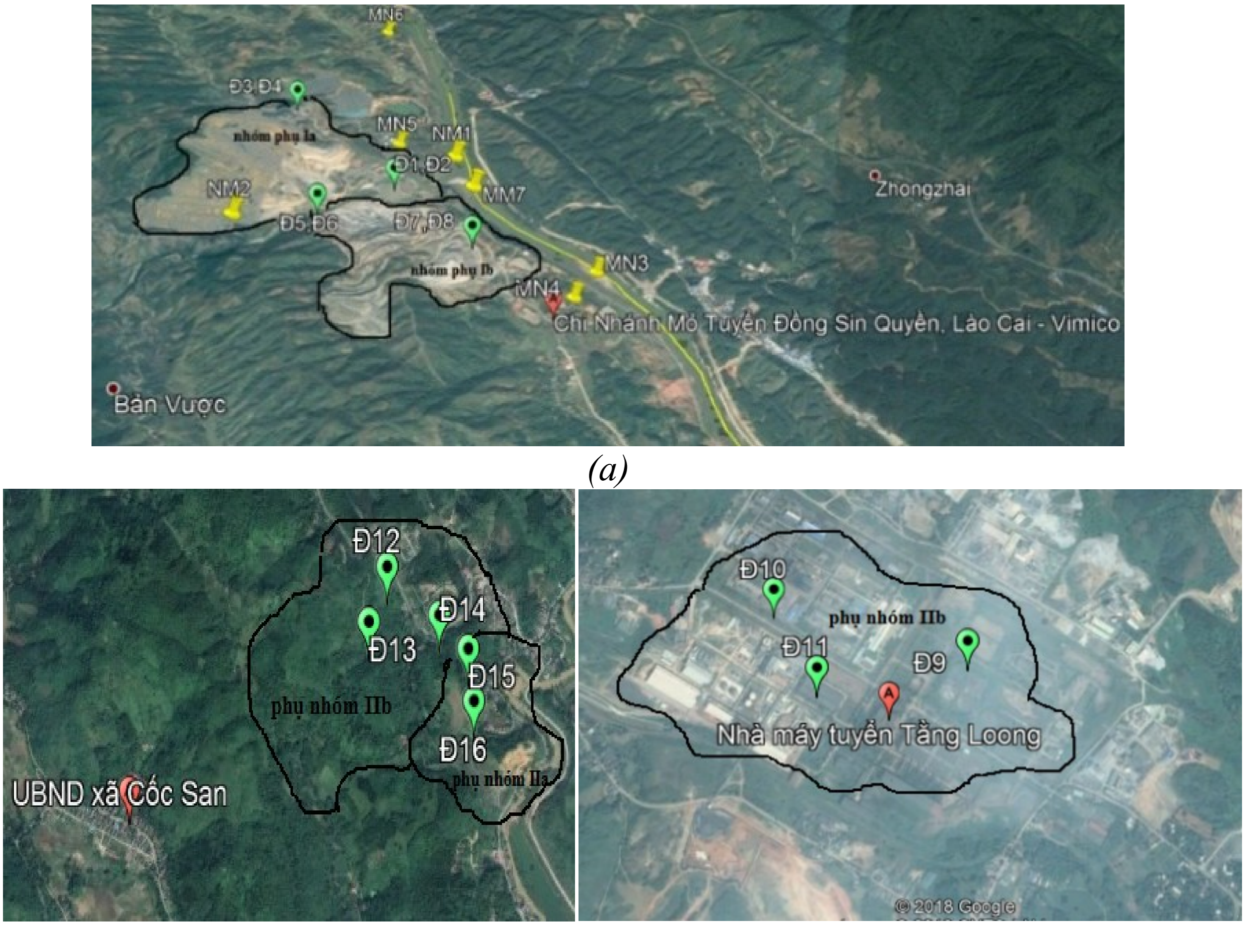
- Collecting information related to the environment, information on hydro-meteorology, air monitoring documents for chimneys of factories in Tang Loong industrial park (IZ) in 2012 – 2019 [4].

Based on the collected data and additional research documents during the field geological survey of the field, the author synthesized to draw general information about the current state of the natural environment in the declared areas. mining and sorting of copper ores and apatite or adjacent areas.

3.2. Geological and environmental survey method

Conducting a number of environmental geological survey routes in mining areas, waste disposal areas, ore enrichment sorting factories, along streams and along intra-mine transport routes (Figure 1).

Figure 1: Location of sampling and zoning for forecasting soil pollution in the study area: a) Sin Quyen copper mine; b) Lang Mon apatite mine; c) apatite mine disposal area near Tang Loong sorting plant [5] [6] .



(a)

(b) (c)

Figure 1. Location of sampling and zoning for forecasting soil pollution in the study area: a) Sin Quyen copper mine; b) Lang Mon apatite mine; c) apatite mine disposal area near Tang Loong sorting plant [5].

Note: Location of surface water sampling (rivers, streams) Location of soil sampling

3.3. Modeling method and application news

To solve the research objectives of the thesis, students apply the following modeling methods:

a. Modeling method

**** One-way statistical math method:***

Using statistical math to determine the distribution characteristics of environmental parameters and the relationship between environmental parameters in the study area, the thesis uses statistical statistical methods (one-dimensional statistical model).

The content summarized as follows:

- *Normal distribution model:* If the parameters of the study follows the standard statistical distribution, the characteristic statistical quantities determined by the formula after:

+ Average value:

$$\overline{X}=\frac{1}{N}\sum_{i=1}^{N}X_i \text{ or } \overline{X}=\frac{1}{N}\sum_{j=1}^{K}N_j\overline{X_j}=\sum_{j=1}^{N}f_j.\overline{X_j}\ \left(f_j=\frac{N_j}{N}\right) \quad (1)$$

+ Variance:

$$\sigma^2 = \frac{1}{N-1}\sum_{i=1}^{N}(X_i - \bar{X})^2 \text{ or } \sigma^2 = \frac{1}{N-1}\sum_{j=1}^{N}(X_j - \bar{X})^2 = \sum_{j=1}^{K} fi\,(X_i - \bar{X})^2 \quad (2)$$

Inside: σ^2 - Variance; X_i - Value reference dose rate at the position i (form i); $\overline{X_J}$ - The average projection dose rate is about j; N - Number of measurement points (number of samples) studied; N_j - Number of samples in the range j.

+ Coefficient of variation: $V = \sigma / \bar{X}$ .100% (3)

- *Standard logistic distribution model:* When the parameters are distributed according to standard logarithms, it is necessary to improve X_i in the form of $\ln X_i$, the statistical characteristics are determined by the following formula:

+ Average value: $m = e^{\overline{lnx} + \frac{1}{2}\sigma^2 ln}$ (4)

+ Variance: $D = e^{2m + \sigma_{ln}^2} \cdot (e^{\sigma_{ln}^2} - 1)$ (5)

+ Coefficient of variation: $V = \sqrt{e^{\sigma_{ln}^2} - 1}$ .100% (6)

In the above formulas: $\overline{lnx}$ - Average value of ln (X_i); σ_{lnx} - Standard deviation (variance of the military) of ln (x_i).

**** Two-dimensional statistical math method***

The method used to determine the correlation depends between different parameters. For example, the concentration of pollutant with distance from the monitoring point to the source of pollution, or determining the correlation between the criteria to be considered in the soil and water environment in a certain area. The statistical model can be very convenient to forecast river water pollution; However, all models also have the disadvantage of not allowing forecasts in the case when the amount of pollutant emissions increases dramatically[7].

Use two-dimensional statistical methods to solve the following tasks:

- Quantitative analysis of the nature of the relationship and its trend.
- Assessing the degree of strictness of the correlation relationship through the determination of correlation coefficients or correlation ratio.
- Develop regression equations expressing the dependence between two certain research indicators.

The correlation coefficient reflects the correlation between the two parameters (parameters) x, y, denoted by R_{xy}, determined by the formula:

$$R_{xy} = \frac{\sum_{i=1}^{n} x_i y_i - \frac{1}{n}\sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{\sqrt{\left[\sum_{i=1}^{n} x_i^2 - \frac{1}{n}\left(\sum_{i=1}^{n} x_i\right)^2\right]\left[\sum_{i=1}^{n} y_i^2 - n\left(\sum_{i=1}^{n} y_i\right)^2\right]}} \quad (7)$$

In which: x_i; y_i is the value of the parameters x and y, respectively, at the ith (monitoring point) sample; n is the number of samples (points) studied.

Linear correlation is a correlation form having a correlation field oriented in the form of straight lines of the form: y = a + bx (8); or $y = \bar{y} + R_{xy}\frac{\sigma_y}{\sigma_x}(x - \bar{x}); x = \bar{x} + R_{xy}\frac{\sigma_x}{\sigma_y}(y - \bar{y})$ (9)

Or in the form of non-linear equations [3].

In which: Formula (8) - a, b is the constant of the regression equation to find. To find a, b, one usually uses the least squares method and takes the partial derivative according to a and b [2]. Formula (9) - $\bar{y}$; $\bar{x}$ α is the average value of the parameters x, y; Other symbols indicated in formula (7).

Based on the established equation, the values of the random quantities (environment parameters) to be predicted can be determined according to the values of the random quantities (environmental parameters).

**** Dendrogram analysis***

The objects (parameters) are branched in the Dendrogram based on the principle of similarity in the observed properties. This method is also used in computational biology to illustrate gene clustering or patterns [8]. In geology, it is used a lot in grafting elements according to geochemical documents or grafting on geological geological objects, etc. In environmental research investigations, Dendrogram can be used to support method of classification, or grouping of objects (environmental parameters) to clarify the relationship between environmental geological objects [9]. If the parameters are discontinuous random values, the similarity between them is usually based on a pair correlation coefficient (R_{xy}). In addition, the grouping of objects to observation (or sampling points), often using standardized distance d_{ij} and defined by the formula:

$$d_{ij} = \sqrt{\sum_{k=1}^{m} \frac{(x_{ik} - x_{jk})^2}{m}} \quad (10)$$

In which: x_{ik} - Value of property k belongs to object i; x_{jk} - Value of property k belongs to object j; m: research properties (targets).

The smaller the value of d_{ij}, the greater the similarity between objects (sampling point).

b. Model of Meti - Lis

To evaluate the scenarios of emission emissions from the chimneys of factories in the IZ, the author uses the model of Meti-lis version 2.03. This model is built on the principle of dispersion for point sources according to the Gausse equation [8].

In this paper, the author uses METI-LIS software to simulate and calculate the spread of air pollution due to emissions from the chimneys of Tang Loong industrial park, in order to determine the scope and level of impact with summer, winter and for adverse weather cases to the surroundings. Software developed by the Ministry of Economy, Trade and Industry.

4. RESULTS AND DISCUSSION

4.1. Environmental status of mining activities

a. Air environment

The results of air monitoring in the study area are summarized in Table 1.

Table 1. Summary of air environment monitoring results (period 2012 - 2019) [4]

Parameter	Research subjects			National Technical Regulation on Ambient Air Quality QCVN 05:2013/BTNMT
	Sin Quyen copper mine mining area	Apatit mine mining area	Tang Loong industrial area	
Noise level (dBA)	$\frac{46-83}{64.5}$	$\frac{42-79}{64.5}$	$\frac{56-89}{72.5}$	70 (QCVN26:2010/ BTNMT)
Dust (mg/m^3)	0.08 – 0.39	0.1-2.92	0.13 – 3.62	0.30
CO (mg/m^3)	0.4-1.12	0.4-8.60	1.21 - 58	30
SO_2 (mg/m^3)	0.02-0.26	0.0025-0.77	0.0025-0.55	0.35
CO_2 (%)	0.025-0.033	0.0-8.60	1.21-58.0	-
NO_2 (mg/m^3)	0.03-0.17	0.006-2.29	0.003-0.43	0.2

From table 1, notice:

- The air environment around apatite mining area, Sin Quyen copper mine and Tang Loong Industrial Park polluted. The reason is that in the mining and recruiting area, there are large-capacity equipment, or there are often means of transport operating, drilling and blasting activities, loading and unloading, transportation of soil and rock, causing noise. High noise and dust amount. Therefore, the content of dust, noise and toxic gases in ore mining and sorting areas is higher than in surrounding areas.

b. Water Environment

- *Surface water:* In order to assess the current state of the surface water environment, the author has collected and synthesized the results of analysis of water samples, including 70 samples in 02 mining sites and 45 samples in Tang Loong industrial park. The results of document processing have drawn the following comments:

Most of the average physical and chemical indicators, COD, BOD, heavy metal content (Fe, As, Hg, Cd) in the surrounding area are still at low level, within the permitted range according and distributed according to standard statistical distribution function model; There are some samples exceeding the permissible criteria, the distribution is very uneven (V = 114.6%) and the standard log distribution has 2 vertices.

It should also be noted that some stream water (Trat stream, Khe Chom stream) after receiving wastewater, the content of some pollutants increased significantly.

- *Groundwater:* Summary of analysis results of underground water samples in the exploitation area and surrounding areas (taken in the period 2010-2018) shows that the metal content in the water (pH = 5.94-7.68); As (0.001 to <0.005mg/l); Pb (<0.001 to <0.005mg/l), Hg (0.0001 - 0.001mg/l) is low, except Mn (<0.01 - 95.8 mg/l), Cd (<0.001 - 0.051mg/l) in the Tang Loong industrial zone, exceeding the permissible targets no seasonal changes. This is an issue that needs attention when using underground water in Tang Loong industrial zone for living.

- *Waste water:*

+ *Wastewater from Sin Quyen copper ore mining pits*: pH = 6.5 - 8.5; As (0.0008 - 0.02mg/l); Pb (0.009 -0.02mg/l); Hg (0.001 - 0.008); Cd (K. detected up to 0.002mg/l). After treatment, mine wastewater meets the permissible standards according to QCVN 10:2011 (column B).

+ *Waste water from apatite ore mining pits*: pH = 6.1 - 6.3, suspended solids (21-35mg/l), and COD (19.01-22-22.99mg/l), BOD (12.22 -21.45 mg/l) are within the allowed limits. Content of some heavy metals (mg/l) such as Fe (2.75 – 6.74l), Cd (0.017 – 0.026), Pb (1.160 -1.574), Mn (3.21 – 6.38), As (0.070 - 0.081), PO_4^{3-} (5.75 - 7.91) exceeded the permitted norms according to QCVN 08:2015. In general, apatite ore mining waste water in the dry and rainy seasons caused pollution.

+ *Tang Loong Industrial Park:* The most typical pollution parameters in the wastewater of the sorting plant: suspended solids range from 790 - 840 mg/l higher than the permitted standard 7-9 times; COD, BOD are higher than permitted standards; phosphate ranges from 25 – 31.5 mg/l and heavy metals Pb, Cd, Fe, Zn, As are all higher than permitted standards; Flour in waste water ranges from 73 - 88.2 mg/l, many times higher than the permitted standard.

c. Earth environment

From the results of sample analysis, use formulas 1, 2, 3 (sample set following the distribution function according to the standard model) to determine the statistical characteristics of the content of elements in the area. The summary results are in Table 2.

Table 2. Statistical characteristics of the concentration of heavy metal elements in the soil [3]

Element	Content (mg/kg)			Variance (σ^2)	Coefficient of variation (V%)	Statistical distribution function	QCVN 03-MT:2015 (industrial land)
	min	max	Average				
Pb	0.77	61.51	29.86	509.48	75.6	Standard distribution	300
Zn	13.04	165	75.6	3191.55	74.7	Standard distribution	300
Hg	0	10^{-3}	7.10^{-4}	5.10^{-4}	3194.4	Standard distribution	-
Cd	0.08	0.84	0.3	0.1	105.4	Standard distribution	10
Cu	9.34	82.5	54.8	709	48.6	Standard distribution	300
Cr	0	3.89	0.75	1.89	183.3	Standard distribution	250
As	0	3.1	1.26	1.64	101.6	Standard distribution	25

From table 2 found:

- The content of heavy metal elements in the soil of copper and apatite ore exploitation areas is within the permitted limits compared with QCVN03-MT:2015/BTNMT (for industrial land). Most elements in the soil environment are distributed according to the standard distribution model.

- Cu element is relatively evenly distributed, Pb, Zn elements are unevenly distributed; Cd, As very unevenly distributed; Cr, Hg are particularly unevenly distributed; This proves that Hg, Cr elements have local distribution position with high content. In particular, element Hg has a large degree of variation in the soil environment in the study area, but the content is very low (content <0.001 mg/kg of soil).

From the analysis results [2] [3], using formula 7 to calculate the correlation coefficient between the heavy metal elements in the soil. Calculation results show that Pb is very closely related to Zn (R = 0.98), Hg is very closely related to Cu (R = 0.94) and these elements are quite closely related to Pb, Zn (R = 0.69 - 0.78); As has almost no relation or close relationship with other elements (R = -0.03 to 0.43); Cr also has a very close relationship with Cd (R = 0.94).

4.2. Group the soil sampling locations according to the analysis

To support the method of classification, or grouping of research subjects, the author uses Dengram method. The grouping starts from the determination for each pair of objects according to the typical values for the degree of similarity calculated by the results of the concentration of heavy metal elements in the soil. Use formula (13) to calculate d_{ij}. Based on the result of calculation (d_{ij}), conduct sampling groups [9] [5]. Result of grouping as follows:

- Group I: consisting of sampling points for mining sites and Sin Quyen copper ore mining and disposal sites.
- Group II: includes apatite soil sampling sites and dump sites.

The average content of elements in each group is summarized in Table 3.

Table 3. Average content of soil elements

Group	Sub group	Location	Average content of elements (mg/kg)						
			Pb	Zn	Hg	CD	Cu	Cr	As
I	Ia	Mining site east of Sin Quyen mine and disposal area No. 30 of Sin Quyen mine	40.2	98.4	0.001	0.12	69.36	0	1.39
	Ib	Near the mining site east of Sin Quyen mine and the northeastern dump of Sin Quyen mine							
II	IIa	Apatite disposal area near Tang Loong sorting factory.	1.10	7.07	0	0.34	6.88	1.03	0.41
	IIb	Mining and exploiting Lang Mon.							

From the table 4 draw some following comments:

- The supply of provides heavy metal elements in the soil of copper ore exploitation and disposal sites with complex and different fluctuations compared to the land of mining, dumping sites and the Tang Loong apatite ore sorting factory.
- The average content of heavy metal elements in the soil in the study areas is within the allowed limits (QCVN 03: 2015/BTNMT - Industrial land). However, the average content of Cu, Pb and Zn elements in soil in Sin Quyen copper mine (group I) is 10-40 times higher. Conversely, in the soil and waste rock of apaptite ore mining area, the Cr and Cd content are higher than in Sin Quyen copper ore mining area; Hg is only present in waste rock and soil in Sin Quyen copper mine but its content is very low, smaller than the allowed level.

4.3. Forecast of environmental changes in copper and apatite mining activities

a. Predict the change of factor Pb in surface water

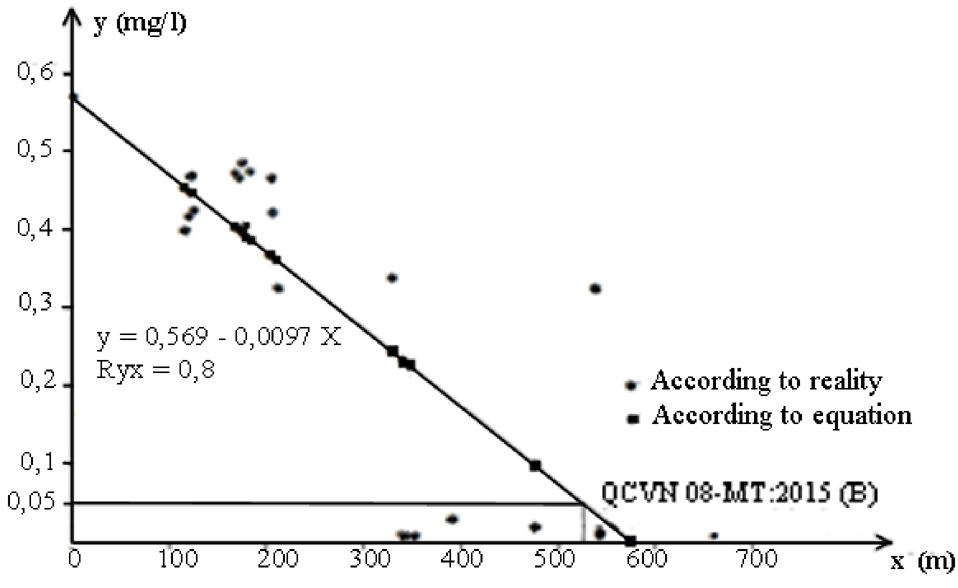
To calculate the distribution of contaminants along rivers and streams, it is common to use typical hydraulic quantities such as: average flow velocity, hydraulic radius and inclined angle of river bed. The basis for calculating the concentration of contaminants in water objects is semi-empirical diffusion theory and empirical formulas for calculating the distribution of substances in turbulent flows. In fact, when solving the dispersion problem along the river, it is necessary to establish the initial and boundary conditions [9]. Due to limited data and within the scope of the paper, the author only mentioned the results of forecasting the fluctuations of Pb in the river and stream water in the study area according to the results of developing the empirical regression equation. From the collected data [2] [3], apply Equation (7), calculate the correlation coefficient between the content of Pb and the distance of the source of pollution (area of copper mining activities): R_{yx} = - 0.80. This result shows that the concentration of Pb in surface water is inversely related to the distance from the observation point to the position of the source of pollution, that is, the farther the distance, the lower the concentration of Pb in the water of rivers and streams. .

That variation, can be inductive to the form of linear regression equations. From the analyzed data, omitting the intermediate calculation steps, establishing the system of equations as the following matrix:

$$\begin{bmatrix} 23 & 6846.31 \\ 6846.31 & 2621408.70 \end{bmatrix} \begin{bmatrix} a \\ b \end{bmatrix} = \begin{bmatrix} 6.42 \\ 1342.96 \end{bmatrix}$$

Solving the side equation system, we have: a = 0.569; b = - 0.0097 Replacing a, b in equation (6), we have: Y_{Pb} = 0.569 - 0.0097X_{kc}; with the regression correlation coefficient Ryx = 0.8.

Figure 2 is a graph of the distribution of Pb according to the distance to the source of regional pollution when copper ore is extracted, including the landfill).



From Figure 2 shows: Pb content in rivers and streams within a distance of about 530 m from the source of waste exceeds the permitted standard according to QCVN08-MT:2015 (Column B - water for irrigation and drainage); outside this range, Pb content is significantly reduced and meets the permitted level.

The regression equation has been established as a basis for forecasting the level of Pb pollution in surface water (rivers and streams) related to the waste water from Sin Quyen copper ore mining activities.

The disadvantage of this model, however, is that it does not allow forecasts in the event of a sudden increase in the amount of pollutants emitted by other sources in the study area.

b. Predict the spread of dust and polluted gases from the chimneys of Tang Loong Industrial Zone

The METI-LIS model was established with a series of meteorological data collected from Lao Cai station for 8 years (2012-2019). Calculation model with the exhaust sources from the chimneys of industrial zones, not including the emissions from transportation, construction, etc…; On the other hand, the exact parameters of the chimney are not exactly as: flow rate, operating time, currently assuming the chimneys operate 100%.

**** The input parameters of the model include:***

- Typical pollutants in factories' exhaust fumes: Selection of NO_x and CO_2;
- Simulation mode: Emission factor is simulated by the short-term regime by hour;
- Meteorological data Data on wind direction, wind speed, air temperature in the study area from 2012-2019;
- Map: Area map with dimensions of 10 km x 6 km;
- Point source: Coordinates of the location of the exhaust chimney of selected factories, altitude of exhaust pipes, emission load, exhaust velocity, chimney diameter and flue gas temperature monitored at the chimney .

**** Calculation options:***

- Calculate the average day of the year;
- Calculation of data collected from monitoring documents of 19 chimneys, with over 100 monitoring samples.
- Calculating pollutant distribution with the Southeast wind direction (SE) is the direction with the highest frequency of occurrence (> 36%), the wind speed of 1.8 m/s.
- Assessing in 2 scenarios:

+ Scenario 1: The generated pollutants are not treated

+ Scenario 2: The pollutants are not treated and in adverse weather conditions.

Result

From the meteorological data collected at Lao Cai meteorological stations (2012-2019) [2] [3], the prevailing wind direction of the study area was the Southeast wind direction (SE) with the frequency. 38.73% (Figure 3).

- *Scenario 1* : Generated pollutants are not treated, the model simulates the concentration of SO_2 and NO_x average hour with wind SE direction, the maximum observed wind speed is 1.8 m/s, at the calculated height of 1.5 m (average breathing range), the results obtained are shown in Figures 4, 6.

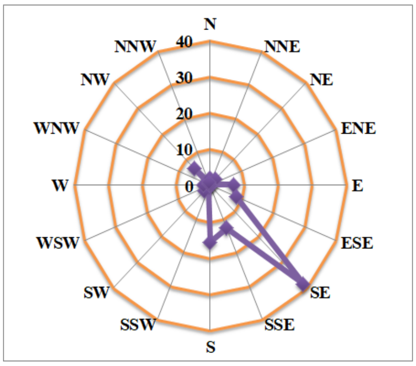


Figure 3. A wind rose diagram for LaoCai

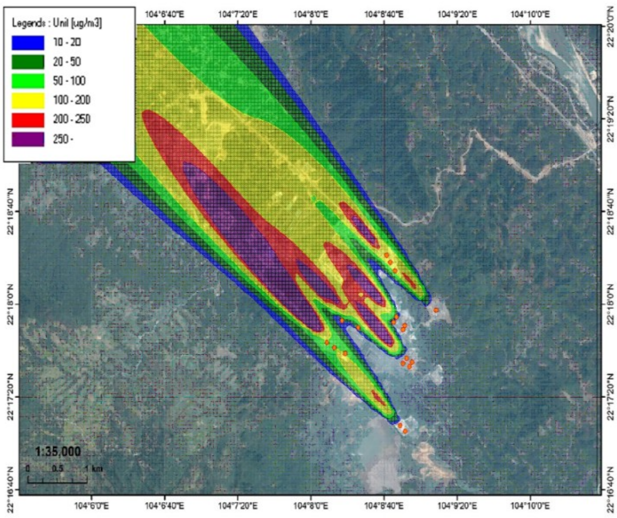


Figure 4. Diagram of the average NO_2 pollutant discharge hour with the wind SE

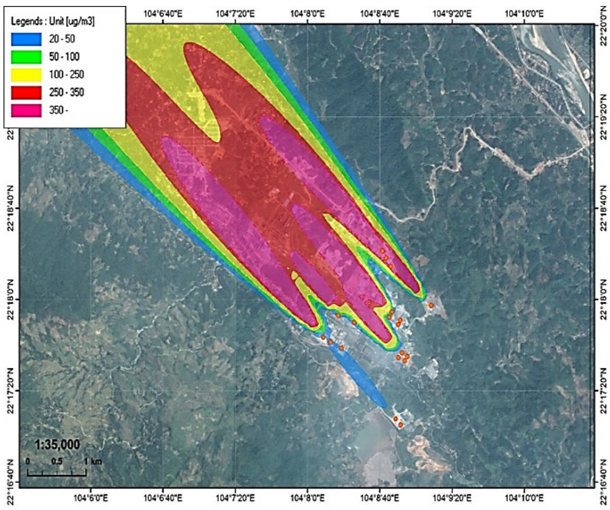


Figure 5. Diagram of hourly average SO_2 dispersion with the wind SE

From Figures 4 and 5, it is found that the distance about 150 m to 3000 m away from the chimneys of the factories in Tang Loong Industrial Park, the average hour NO_X concentration exceeds the permissible QCVN (200 $\mu g/m^3$). The average hour concentration of SO_2 in the range of 350 - 400$\mu g/m^3$ at the junction of industrial park exceeds QCVN.

- *Scenario 2*: The pollutants are not treated and in adverse weather conditions (Figure 7, 8)

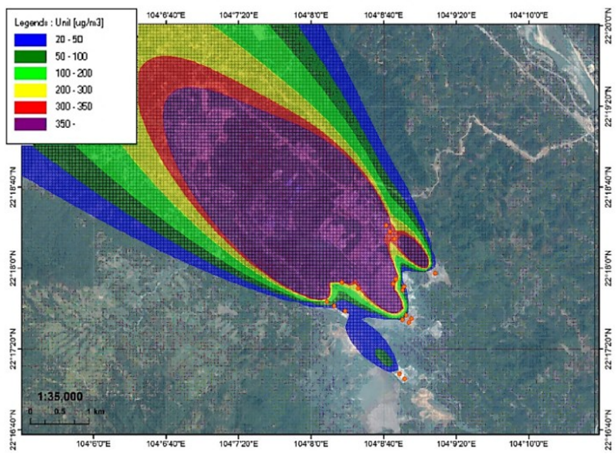


Figure 6. Diagram of SO_2 emissions in adverse weather conditions

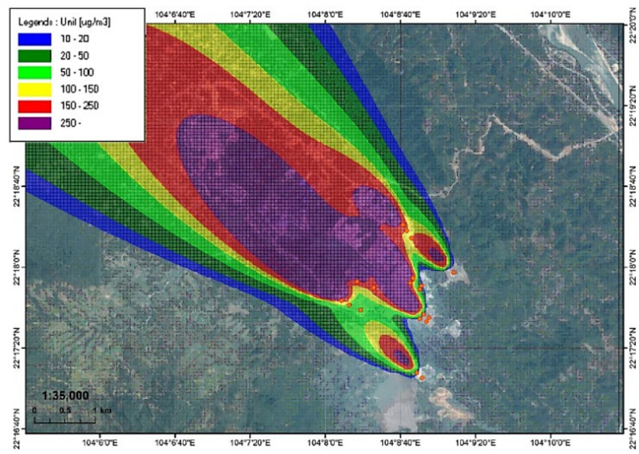


Figure 7. Diagram of NO_2 emissions in adverse weather conditions

From Figures 6 and 7, it can be seen that, under adverse atmospheric conditions, if the exhaust gas from the factory's chimneys is not treated, then within the distance about 100 m to 4000 m there is concentration value SO_2 and NO_x gases exceeded permissible standards. This phenomenon, which can be explained by the stable atmospheric conditions E and F (according to the Passquill-Gifford scale), is mainly at nighttime weather, when the puppet movement is very weak. Therefore, pollutants can be spread very far.

5. CONCLUSION

1) Most of the elements in the soil and water environment in the study area range from very unequal to exceptionally uneven. That, reflected the relatively large fluctuations, is local. Therefore, there are positions of Fe, Pb content in surface water; or elements Pb, Zn, Hg, Cu, As in the soil environment may exceed the permissible level.

2) The results of research on the correlation between elements in the soil environment show that the average content of the elements Cu, Pb, Zn, As in Sin Quyen copper mine is much higher than apatite mine; on the contrary, in apaptite disposal areas, the Cr and Cd content is higher than the Sin Quyen copper mine; Hg appears only in soil in copper mines. This shows that the source of heavy metal elements in the land of Sin Quyen copper mine is different from apatite mining and Tang Loong industrial zones. This is a matter of concern when assessing the level of pollution and identifying sources of heavy metal pollution in the soil in areas of mineral exploitation activities in Lao Cai province.

3) The content of Pb in the water of rivers and streams in Sin Quyen copper mineral activity area is quite variable and depends on the distance of the source of pollution; Such fluctuations are inductive to the form of linear regression equations. The regression equation has been established to allow forecasting of Pb content in river and stream water at any location related to the wastewater from mineral activities in the area.

4) If the exhaust gas from the chimneys is not treated, within a radius of 100 to 4000 m (from Tang Loong Industrial Park) will be polluted by NO_X, SO_2.

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