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Heavy metal pollution from mining activities in soil using geochemical contamination indices at Quy Hop, Nghe An

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Introduction

The mining industry has been increasingly which playing in an important role in Vietnam's economy. However, besides the positive aspects, mining activities also cause adverse impacts on the environment (such as soil, water, air pollution and noise pollution, etc.) [5], especially the risk of heavy metal contamination in soil and water environment, that not only causing the current effects but also could happen for a long time, even after stopping the mining.

In fact, the damage of heavy metal contamination in soil environment and water environment in mining locations is an incredibly serious problem, which has a direct and long-term impact on people's life and health. For mining areas which is being exploited, environmental factors are also regularly examined and evaluated by enterprises and state management agencies. But the mines that have stopped mining, regular assessment and monitoring of environmental conditions are mostly ignored, so the environmental implications of the mining areas have stopped working. Actual action is taking place very worrying [1].

Quy Hop, Nghe An region has variety and diverse mineral resources with 82 mineral processing mines and workshops in operation. In particular, in addition to the mines of construction stone, metal minerals such as tin, iron, lead-zinc, etc. have great potential and are currently being exploited in many places [4]. The process of exploiting metal minerals and recruiting placer ore in the river bed generates waste from the process of mining and ore reclamation, including: Covered soil, layers of no ore discharged from mining pits, soil and stone from the stage of reclaiming ore, sediment from the river bottom is disturbed ... The composition of such waste contains many heavy metal elements including mercury, cadmium, cobalt, lead, antimony, arsenic, iron, zinc, manganese. Besides, the environmental protection work is not completed well, has led to the environment in many mining areas are polluted and degraded quite seriously. Therefore, it is imperative to assess the content of heavy metals in the soil environment in order to promptly provide mitigation measures. There are many ways to determine the content of heavy metals in soil, especially using geochemical indicators to calculate heavy metal content to assess environmental pollution is one of the most reasonable method, which is an effective and highly feasible approach.

Geochemical contamination indies in assessing environmental pollution

These geochemical index below are used to evaluate the heavy metal pollution level in the study area:

Geoaccumulation Index - I_{geo}

The geoaccumulation index (I_{geo}) is used to assess the metal pollution in sediments (Mueller, 1969). It is calculated based on the comparison of total content of metal in the sample and the base value of that metal., therefore, it could be predicted that any increase in the current level is caused by the human act on the nature:

$$I_{geo} = \log \frac{C_n}{1,5.B_n} \qquad (2.1)$$

With: C_n: The content of metal n in the sample (mg/l)

B_n: The content of metal n in the earth crust (mg/l)

1,5: The coefficient value to decrease the impact of the petrography alteration in sediments on the base value.

The base value is only the average of the metals content in the Earth crust. In fact, the metal content of rocks and soils could vary depend on the location.

Contamination Factor - CF

The contamination factor CF is one of the most important index in assessment of metal pollution to indicate the influence of the metal content on sediments. It is calculated based on the the concentration of each metal in the sediments and their base value (Hakanson, 1980):

$$CF = \frac{C_n}{B_n} \qquad (2.2)$$

With: C_n: the concentration n in the sediments (mg/l)

B_n: the concentration n in the Earth crust (mg/l)

Enrichment Factor - E)

The Enrichment Factor – EF is used to evaluate the impact of human activities on the environmental by the inrichment of metal within sediments (Liu et al.,2005):

$$EF = [X/Mn]_{\text{the sample}} \; / \; [X/Mn]_{\text{Earth crust}} \qquad (2.3)$$

With : *X:* The study metal element

$[X/Mn]_{\text{the sample}}$: The ratio between the content of X and Manganese in the sample

$[X/Mn]_{\text{Earth crust}}$: The ratio between the content of X and Manganese in the Earth crust.

The elements ,which are selected for the comparison, are often the common and inflexible such as Alumium (Chatterjee et al., 2007; Sutherland, 2000), Tin and Iron (Zhang et al., 2007) or Manganese (Liu et al., 2005). In this research, the colectted data do not have Alumium, Iron and Tin, thus, the Manganese is used.

The synthetic pollution index

- Degree of Contamination - C_d

The degree of contamination is defined by the total degree of contamination of all metal element in the same sample to assess the pollution level of the study area (Hakanson, 1980:

$$C_d = \sum_{i=1}^{m} CF_i \qquad (2.4)$$

With: *m:* the number of elements in the sample

CF: the contaminated index of the elements in the sample

- Average Pollution Index - PI_{Avg}

The Average Pollution Index (PI_{Avg}) is ultilized to evaluate the quality of environmental in post-mining period (Bhattacharya et al., 2006):

$$PI_{Avg} = \frac{1}{m}\sum_{i=1}^{m} CF_i \qquad (2.5)$$

With: *m* the number of elements in the sample

CF: the contaminated index of the elements in the sample

- Pollution Load Index - PLI

The Pollution Load Index (PLI) is used to assess the quality of the sediments generally Evaluate the overall quality of sediment (Tomlinson et al., 1980):

$$PLI = \sqrt[n]{CF_1 * CF_2 * \cdots * CF_n} \qquad (2.6)$$

With: *CF* The contaminted index of the elements in the sample

n The number of elements in the sample

3. Decentralization levels of geochemical environmental pollution according to Geochemical contamination indies

*G*eochemical contamination indies

For Geochemical contamination indies, the threshold level of environmental pollution is carried out as proposed in Gong et's study in 2008 as in the following table::

Table 1. Decentralized level of pollution based on Geochemical contamination indies

Level	I_{geo}	*CF*	*EF*	*pollution*
1	< 0	< 1	< 2	not
2	0-1	1-3	2-5	low
3	1-3	3-6	5-20	Average
4	3-5	6-12	20-40	high
5	> 5	> 12	> 40	Very high

The synthetic pollution index

The level of environmental pollution based on the value of the geochemical indexes of C_d, PI_{Avg} và PLI is classified into levels according to the following tables:

Table 2. Decentralized level of pollution based on index C_d

Level	Value	*pollution level*
1	$C_d < m$	low
2	$m \leq C_d < 2m$	Average
3	$2m \leq C_d < 4m$	high
4	$C_d > 4m$	Very high

With : m is primes are in the sample.

Table 3. Decentralized level of pollution based on indies PI_{Avg} and PLI

Level	PI_{Avg}	*PLI*	*pollution level*
0	$PI_{Avg} \leq 1$	$PLI \leq 1$	*Not pollution*
1	$PI_{Avg} > 1$	$PLI > 1$	*pollution*

4. Results and discussion

The soil environment in the mining areas in general is at risk of contamination, especially the concentration of heavy metals often exceeds the permissible limits many times. The influence of heavy metals on organisms and humans is great, it causes very serious consequences [2]. Content of heavy metals in soil environment in mine area in Quy Hop was determined by ICP-MS analysis method and analysis results are shown in Table 4.

Table 4: Results of analysis of some soil samples in the study area [4]

T	M odel	Coordinate		Analysis results (ppm)							
		X	Y								
	QCVN 03/2015 (mg/kg);										
	Q	2	5								
	Q	2	5								
	Q	2	5								
	Q	2	5								
	Q	2	5								
	Q	2	5								
	Q	2	5								
	Q	2	5								
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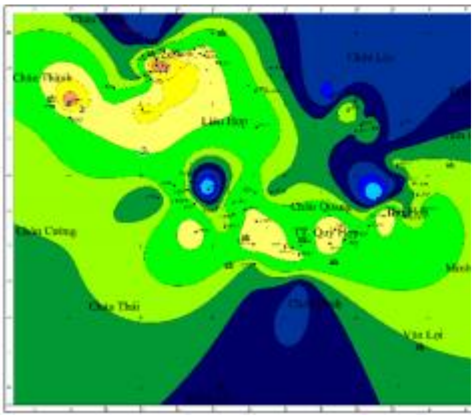
	Q	2	5								
	Q	2	5								
	Q	2	5								

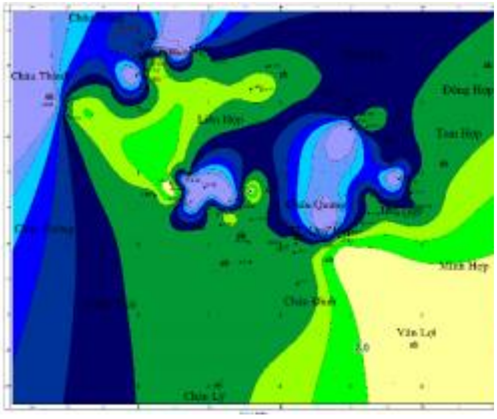
Calculation results of heavy metal content in soil in the study area through the following geochemical indicators:

4.1. Geoaccumulation Index - I_{geo}

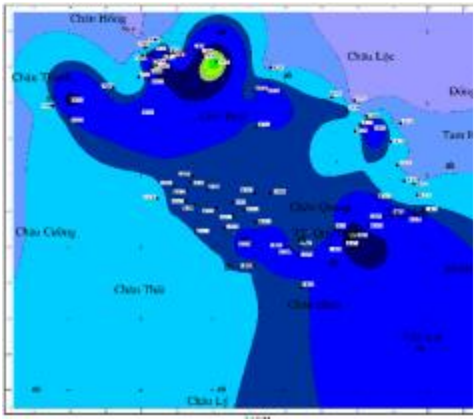
Based on the formula (2.1), the author has calculated the pollutant Geoaccumulation index (Igeo). The results of soil sample analysis for each element and the calculation results are shown in Fig.1.



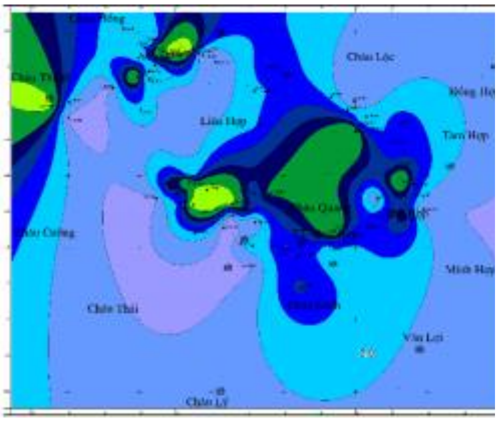
As



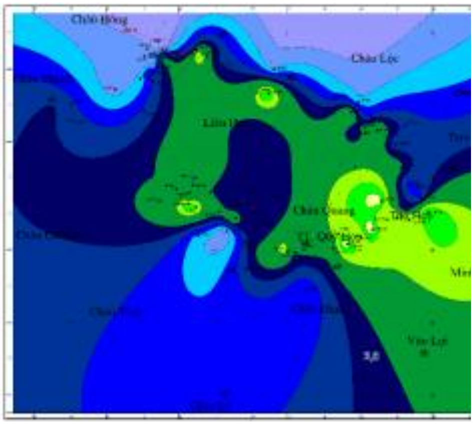
Cr^{6+}



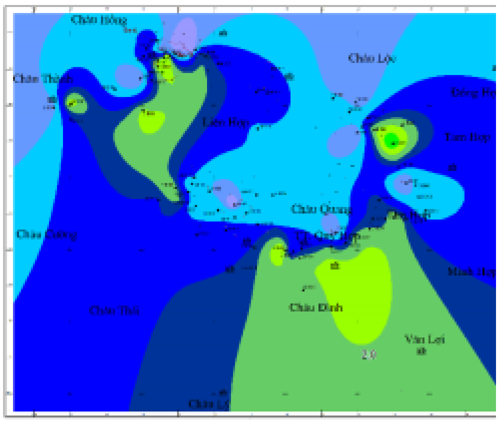
Cu



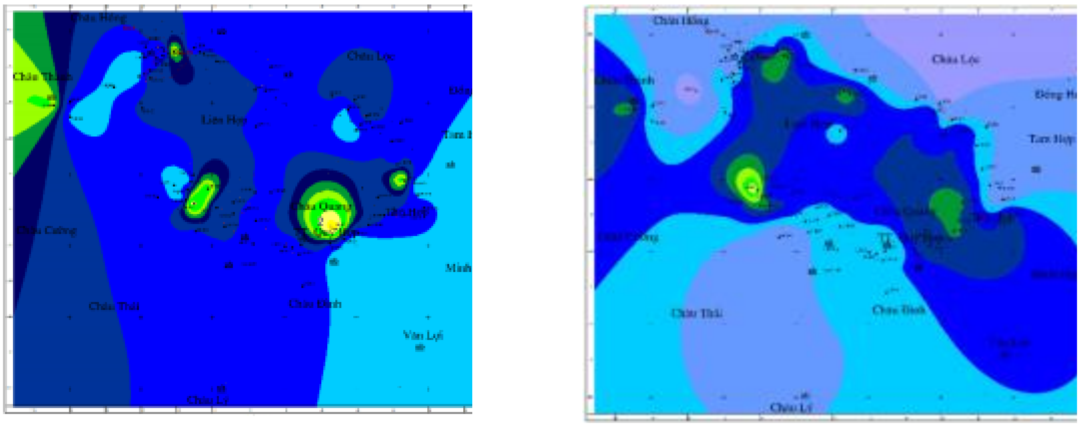
Hg



Mn



Pb



Sb Zn

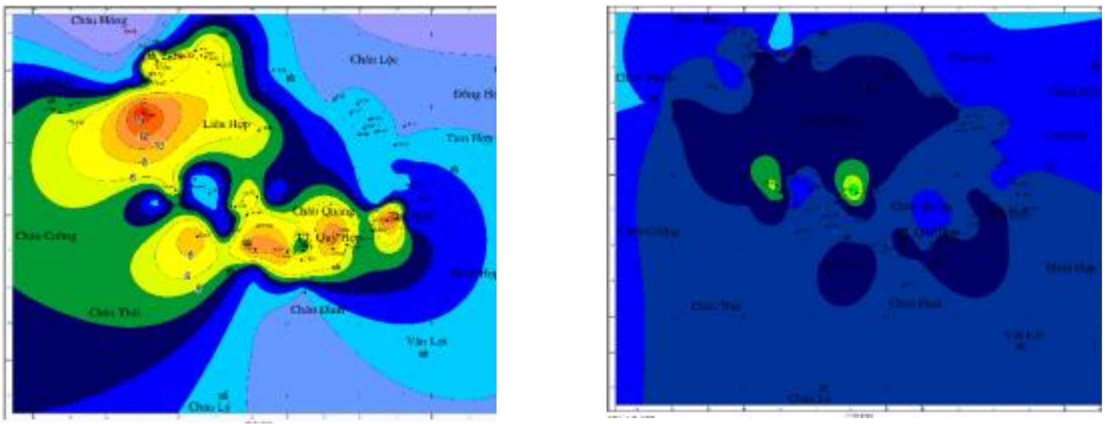
Fig 1. Partitioning of pollution level according to calculation results

Igeo index of elements As, Cr_6^+, Cu, Hg, Mn, Pb, Sb, Zn in soil

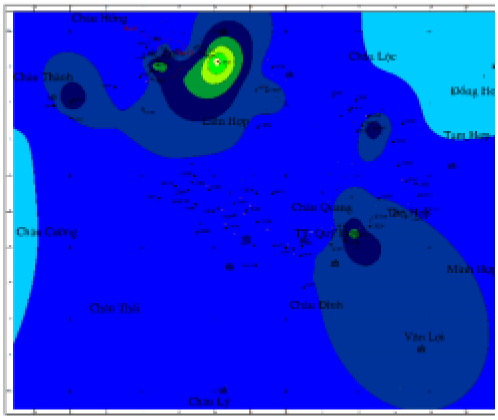
Through the index calculation results Igeo can see that most elements are in the range from zero to less pollution. However, there are many positions within the pollution levels of Sb and As elements. At the same time, based on the calculation of the Igeo index of the elements in the soil, it can be seen that most of the elements are closely related to the mining areas in Quy Hop, the common pollution locations. located at the mine site or ore gathering area and disposal site..

4.2. Contamination Factor - CF

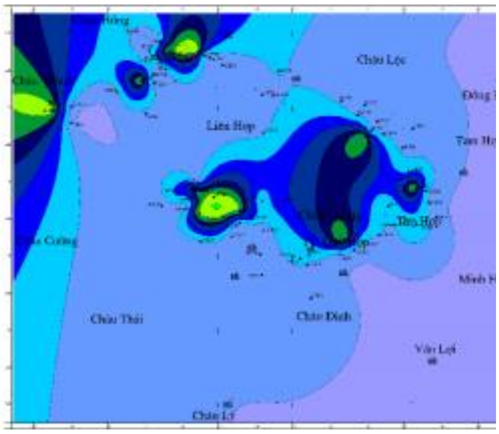
Based on the formula (2.2), the author has calculated the contamination index (CF) for each element according to the results of soil sample analysis and the calculation results are shown in Fig.2 Through on the calculation results The CF index can be found that most elements are in the range from zero to less polluted. However, many positions are in the pollution level of Sb and As elements.



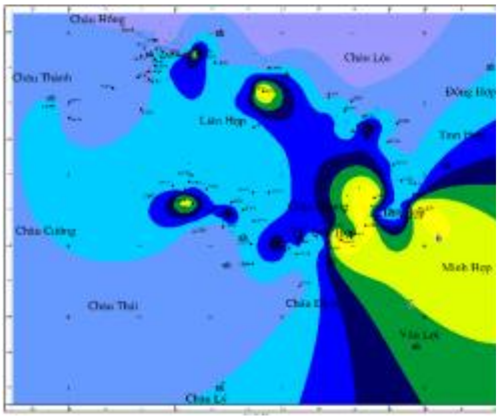
As Cr^{6+}



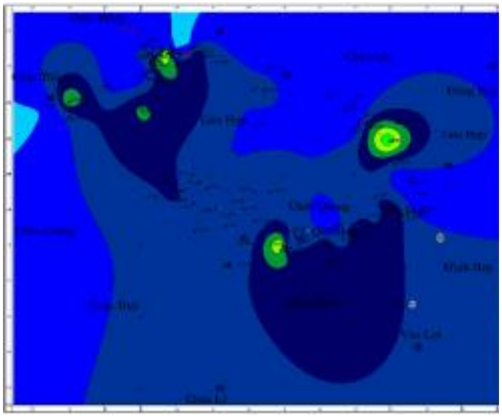
Cu



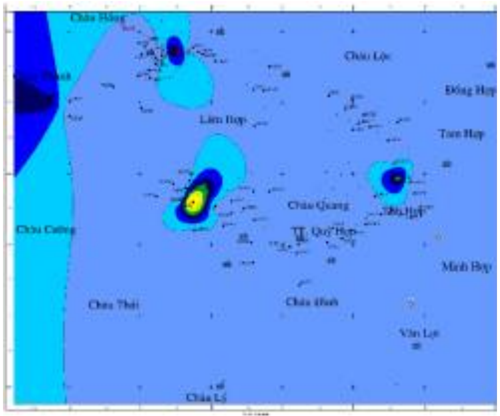
Hg



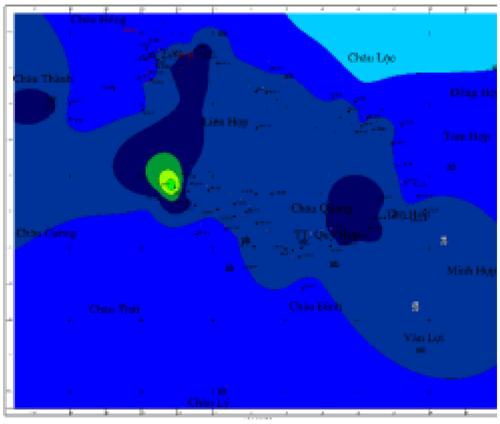
Mn



Pb



Sb



Zn

Fig 2. Partitioning of pollution level according to calculation results

CF index of elements As, Cr_6^+, Cu, Hg, Mn, Pb, Sb, Zn in soil

4.3. Enrichment Factor - EF

Based on the formula (2.3) mentioned in part 2, the author has calculated the contamination index (EF) for each element according to the results of soil sample analysis and the calculation results are shown in Table 5. Based on the results of calculating the index EF, it can be seen that most elements are in the range from zero to less pollution. However, many positions are in the pollution level such as Sb and As elements.

Table 5: Calculation results Enrichment Factor (EF) in soil

	S	X	Y						F	A
	Q	2	5						0	3
	Q	2	5						0	8
	Q	2	5						0	2
	Q	2	5						0	4
	Q	2	5						3	9
	Q	2	5						0	3
	Q	2	5						1	6
	Q	2	5						0	9
	Q	2	5						0	3
	Q	2	5						0	
	Q	2	5						0	6
	Q	2	5						0	3
	Q	2	5						0	1
	Q	2	5						0	3
	Q	2	5						0	2
	Q	2	5						0	3
	Q	2	5						0	8
	Q	2	5						0	2
	Q	2	5						0	3
	Q	2	5						0	4

4.4. The synthetic pollution index

Based on the formula for calculating The synthetic pollution index include Degree of Contamination - C_d, Average Pollution Index - PI_{Avg} *and* Pollution Load Index - *PLI* As mentioned in Section 2.2.4, the author used the results of calculating the the contamination index (CF) to calculate and obtain the following results:

Table 6: Calculation results The synthetic pollution index in soil

	SH	X	Y (m)	Cd	P	PLI
	QH.	214	512778	7,42	0,	0,19
	QH.	214	513090	17,2	2,	0,99
	QH.	214	513325	18,5	2,	0,75
	QH.	214	514031	12,9	1,	0,54
	QH.	214	511090	6,01	0,	0,15
	QH.	214	511380	58,8	7,	1,06
	QH.	214	511662	11,5	1,	0,22
	QH.	214	511015	13,3	1,	0,94
	QH.	214	510677	16,3	2,	0,44
	QH.	214	510682	66,7	8,	0,61
	QH.	214	510330	11,2	1,	0,42
	QH.	214	510342	6,90	0,	0,36
	QH.	214	509879	20,6	2,	0,56
	QH.	214	505882	57,6	7,	0,75
	QH.	214	504936	10,0	1,	0,25
	QH.	214	505852	8,34	1,	0,36
	QH.	214	516175	8,17	1,	0,51
	QH.	214	516766	10,2	1,	0,72
	QH.	214	517060	4,46	0,	0,25
	QH.	214	516237	9,09	1,	0,38

5. Conclusions

Mineral exploitation and processing industry is important and significant to the national economy of every country. However, mining operation and mineral processing have always been one of the industries causing worst impacts on the ecological environment. In particular, the influence of the content of heavy metals arising from the mining process has left very serious consequences.. The calculation and evaluation of heavy metal content in the soil is extremely urgent for early measures to prevent their impact on the environment..

The calculation of heavy metal content by Geochemical contamination indies is one of the most reasonable method, which is an effective and highly feasible approach. Based on the calculation of geochemical indices and distribution diagrams of elements, the cause of soil pollution in the study area is the elements As (Arsenic) and Sb (Antimony). With the general geochemical indicators of pollution level of the pollution level index (Cd), and the average pollution index (PI_{Avg})) are quite similar, showing that the soil environment in one area The study area in some places is highly contaminated to very high levels

References

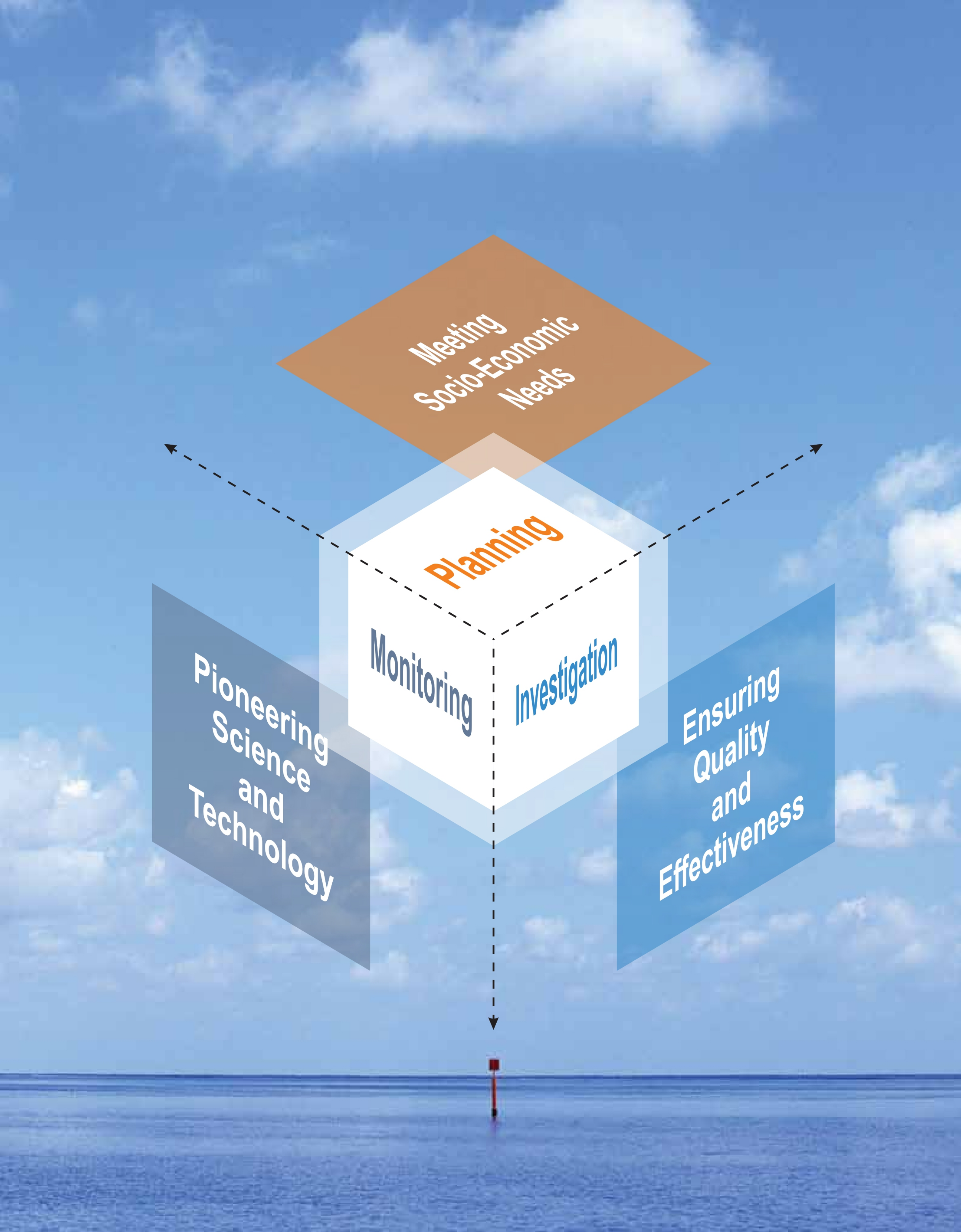
Application of a number of mathematic methods in distribution of environmental pollution areas of mineral mining at Quy Hop, Nghe An.

Ministry of Natural Resources and Environment, Vietnam Remote Sensing Center. Proposal of project using remote sensing and GIS to construct database and evolution maps of areas polluted by industrial and domestic wastewater to provide warning of areas with pollution risk inkey economic zone of Central region, Hanoi

Nguyen Tien Phu, 2014. Evaluation of environmental hazards related to mining activities of Quy Hop area, Nghe An province. Master Thesis, Hanoi University of Mining - Geology, Hanoi.

Ho Van Tu (main author), 2012. Evaluation of environmental status at mining areas in Nghe An and Ha Tinh provinces. North Central Geological Division - General Department of Geology and Minerals of Vietnam.

Nguyen Quoc Phi, Nguyen Phuong, Nguyen Thi Hoa, Nguyen Tien Phu, 2014. GIS and remote sensing for geohazard assessment and environmental impact evaluation of mining activities at Quy Hop, Nghe An, Viet Nam. GIS – IDEAS, p.203-208.



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