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Potential environmental impacts from mineral water extraction at Mo Da hot spring, Kim Boi, Hoa Binh, Vietnam

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1. Introduction

Hoa Binh province has a massive reserves of mineral water, which brings a great potential to the industrial growth. The mineral water resources mainly concentrate on Kim Boi district, leading to extractions and factories are constantly constructed and developed in whole area, and Mo Da in particular. Furthermore, Mo Da resides at a mineral water zone which is fairly wide and has a large thickness. Mineral water in Pecmi – Triat sediment contains a low mineralized total. This water storey have a huge value because of a low mineralized total and high quality, ensuring people's eating needs. In addition, it also have warm temperature (about 36,5°C), the hydrothermal systems involves the utilization of resting and tourism.

Purpose of researching: Using airborne images to seek water resource locations, using and analysing spectral bands of satellite image, which helps to produce the mineral maps via special Indicator of the spectral bands obtained. Basing on achievement obtained, finding locations and concentrated density of water resources. After that, assessing the status and affected arena to the surroundings caused by extraction of mineral water.

2. Study area

2.1. Introducing about potential of mineral water and hydrothermal at Mo Da hot spring.

At Mo Da area, mineral water in Pecmi – Triat sediment contains a low mineralized total. This water storey have a huge value because of a low mineralized total and high quality, ensuring people's eating needs. In addition, it also have warm temperature (about 36,5°C) which produces hydrothermal, and the hydrothermal systems involves the utilization of resting and tourism.

Mineral water distributes in depth 36 – 124,0 meters, especially in broken zone sharply (about 50 – 100 meters). Hydrogeological systems contains a range of springs and temporary flows. Nowadays, the springs and temporary flows develop significantly, which causes the terrain of extracting areas to be segmented and complex. The notable thing is Chieng spring.

The quality of water taken at Chieng spring shows: water spring has a good quality, insipid water, a low mineralized total (hitting 0,07 – 0,21 g/l). Water has pH =

6,4 – 7,9 depending on season, weak acidity in dry season, weak basic in rainy season. The content of Cl^- tends to gradually drop from rainy season (reaching 14,18 mg/l) to dry season (just 10,64 mg/l). Chemical form of water is bicarbonate calcium magnesium. Spring is also place where receive local waste, so the water quality of spring can not ensure for daily consumption.

In researching area, there are many branches of spring, short and slope temporary flow, providing water for Chieng spring, which make the hydrogeology complex. Overall, surface water system plays an important role in providing water for residents.

2.2. Geological structure and hydrogeology of researching area

According to geological document obtained, mineral water mining at Mo Da, Ha Bi, Kim Boi, Hoa Binh located in depression of Da river and lie neatly in structural zone at Ninh Binh province. There was many researching projects about geology of this area such as report of building Geological map of the Northern Vietnam at 1:500.000 was published in 1964 by A.E. Dovjikov and Geological Vietnam (the North) was published in 1977 by Tran Van Tri...

There are several perforations serving for monitoring and mineral water extraction in the researching arena, which are working well. Geographical coordinates of the area are limited:

105°29'30'' – 105°31'30'' East longitude

20°40'55'' – 20°42'30'' North latitude

LK7 perforation has coordinates according to VN2000 projection zone 6° :

X: 2289413; Y: 552611

Based on collected documents from monitoring projects and additional researching materials, we point out the geological features of the mining monitored:

PALEOZOIC – MESOZOIC

Geologically, upper Permian period – lower Triassic period and Địch Giốc Cun ($P_2 - T_{1gc}$). Địch Giốc Cun distributes in the Southwest of the area, prolonging from Chieng bridge to Song village, Mo Doi village surrounds Kim Boi magma block, limestone mountain is located in Mo Doi village. Moreover, it also reveals around several small limestones, running along the F2 fault. At other locations, stones of this form are covered by Quaternary period sediment (such as along Chieng spring and valley prolonging 12b route) and Địch Mường Hung (in the North and Northeast)

MESOZOIC

Lower triassic period and Địch Mường Hung (T_{1mh}). Địch Mường Hung distributes in the North of the area, Northwest of the mineral water mining (the North of Chieng spring), spreading about 3km². Structure of Địch Mương Hung is continental

sediments mixed carbonat and tuffit which are brown and purple brown. Stones have characteristics and subclasses clearly, winding and tending to lie steeply to the Northwest or Northeast. Because of the impacts caused by faults, stones are cockled, lie tendency is not stable.

CENOZOIC

Quaternary period (Q). Unconsolidated sediments of Quaternary period distribute throughout such as depression, valley, stream bed of Chieng spring, Dam Thi, along 12b route. The thickness of Quaternary period is largest about 26 meters.

MAGMA

Based on documents obtained and factual researching on the site, in the South and Southwest of Mo Da mineral water mining, it reveals a magma block which is pervaded by acid. This magma block is called Kim Boi (aT₃nb). Surface area is about 60 -70 km² (Geological map of Hanoi and Ninh Binh at 1:200.000) and can be seen when go on the route. The main components of the magma block is biotit, granit, mica granular form and pocfia. It also one of the causes which producing hydrothermal resources in Mo Da area.

FAULT

With observation on surface (topographic, geomorphology, revealed locations) and researching results of geophysics, deep drilling...these are two faults determined at mining area. Firstly, F₁ is a deep fault, prolonging from West to East and acrossing the mineral water mining. This is a vital fault, which plays an important role in producing, circulating, storing local mineral water. It lasts about hundreds kilome^trs, including about 4km acrossing the mineral water mining, tilted angle of fault-surface is about 75 – 80° (according to 47 Geological Group's document). Secondly, F₂ is a branch of fault, from fault F₁ at Mo Da to the North, prolonging valley where has mineral water resources.

The developments of two faults F₁, F₂ was discovered and determined based on factual document, mesuring geophysics, drilling... It proves the impacts of two faults to mineral water mining area is crucial. Faults also play a vital role in producing, circulating, storing and revealing local mineral water in Mo Da mining in particular and other areas in general. Moreover, there are defenitely many other faults which people have not had sufficiently materials to determine and confirm their survival.

HYDROGEOLOGY

Based on researching results of geology, hydrogeology of Mo Da area, compacting with document obtained from many authors, observing the hydrogeological characteristics of area is fairly complicate. In the region, having formation containing water, other formation lie alternately, leading to need more materials when investigate mineral water such as demonstrative documents and fundamentalist science. The main feature of this region is the presence of entities containing water with various contents from wealth to

needy, component of petrography, absorbing of rock which depends on area and depth, being complex because of elements of tectonics.

2.3. Actual state of mineral water extraction

Water resources in researching area are utilized for various different purposes in daily life such as agriculture, industry, civil, entertainment and environment. Normally, per capita consumption is about 60 – 100 (l/a day) for daily activities, not to mention that manufacturing activities of agriculture and industry. Moreover, mineral water is also extracted and produced. Bottle water, for instance, are supplied for local residents in particular and whole nation in general. There are several locations where have hydrothermal resources are also invested for tourism, entertainment attraction,... This contributes partly to the economic growth in region.

3. Methodology

Remote sensing technology for geology has advanced tremendously over the last few years, particularly as regards the use of imaging spectrometers (hyperspectral sensors) for operational use. The Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) (Porter and Enmark, 1987) has reached a level of excellence where it can be used for quantitative mineral mapping for a variety of geology subdisciplines (Kruse 1993). This research was developed by a group of lectures and student in Hanoi University of Mining and Geology, we utilized remote sensing image acquisition to determine the main structural bands on the image which is used remote sensing to create. Moreover, combining with data of fault systems from geological document, we can point out the detrimental impacts of mineral water extraction to the environment and ecology.

Extracting mineral water causes various detrimental impacts on the environment and the local ecology. Firstly, destroying the structure of geology in the region which is created by drilling perforation to extract. Subsidence is also born because of the shortage of groundwater suddenly. Secondly, hazardous waste, solid waste and waste water are constantly increasing by workers' daily activities. That massive trash can have serious effect to the soil environment and water environment of the mining region. Furthermore, machines and vehicles used for extraction on the site produce a large amount of dust and noise, which affects to the air environment and local residents' life.

With the extreme effects mentioned above, determining influenced area and proposing precautionary measures are completely necessary. Since Mo Da is a mountainous zone, monitoring or taking water samples throughout the area to create a map is absolutely impossible. Utilizing Remote Sensing helps to shorten time and to enhance accuracy when build geological map.

4. Results and discussion

4.1. Discussion of water quality

The assessment of water quality and water reserves are the most vital things in monitoring, researching any mineral water resources. Mineral water quality is evaluated by analysis results of the chemical components of water sample. The analysis results are compared to current regulations and standards to point out the ability and level of meeting the purposes of water, and mineral water at LK& perforation in particular, we follow the standard of water used for drinking.

Mineral water reserves is evaluated by document of water suction for experiment and specialized calculated measures.

Analysis results of the mineral water samples in the process of water suction for experiment: including 3 times lower, water suction for experiment and monitoring results in May and October show that components gradually, proving the stability. Some examples are followed:

The content of TDS varies from 255 mg/l to 395 mg/l

The content of CO₂ varies from 19mg/l to 21 mg/l

The content of As always stays below 0,00 mg/l

The content of Flo varies from <0,10 mg/l to <0,5 mg/l

The content of Iot varies from 0,007 mg/l to <0,04mg/l

The temperature stay unchanged at 36,5°C, which is appropriate to use for bathing, healthy recovery, soaking,...

Level of total mineralization in water is lightly low, just 0,35 g/l, which ensure the need of drinking compared to current standard.

The analysis results also show that the mineral water quality does not (a little bit) change over time (stay stable many years in extracting time). This is insurance of unchanged quality of mineral water.

With the assessment metioned above, allowing to assess mineral water in LK7 perforation to be a valuable and rare water resource that needs to extract and utilized efficiently to develop the economy, society and civil.

4.2. Discussion of the impacts on the environment in the future

Water is a precious natural resource and the important condition for creatures' life on the Earth. Nowadays, the economical and social development, the growth of agriculture and industry are accompanied by the need of using water more and more. Because of water supply systems have not met the need of using water for human daily activities or manufactures, drilling wells for mineral water extraction are increasingly popular without strict management of the officials, leading to the risk of quality and reserves of mineral water.

Those are several basic impacts of extraction and using mineral water:

- Causing the level of mineral water lower: exploitation of mineral water without zoning causes the amount of mineral water to be exhausted, resulting to the lower level of mineral water.

- Affecting to construction of groundwater extraction: When construction of groundwater extraction run, it's effects spread quickly to others areas nearby and neighboring extracting systems, leading to increasing extracting fee and decreasing extracting performance. Distances between extracting construction as near as level of water lower.

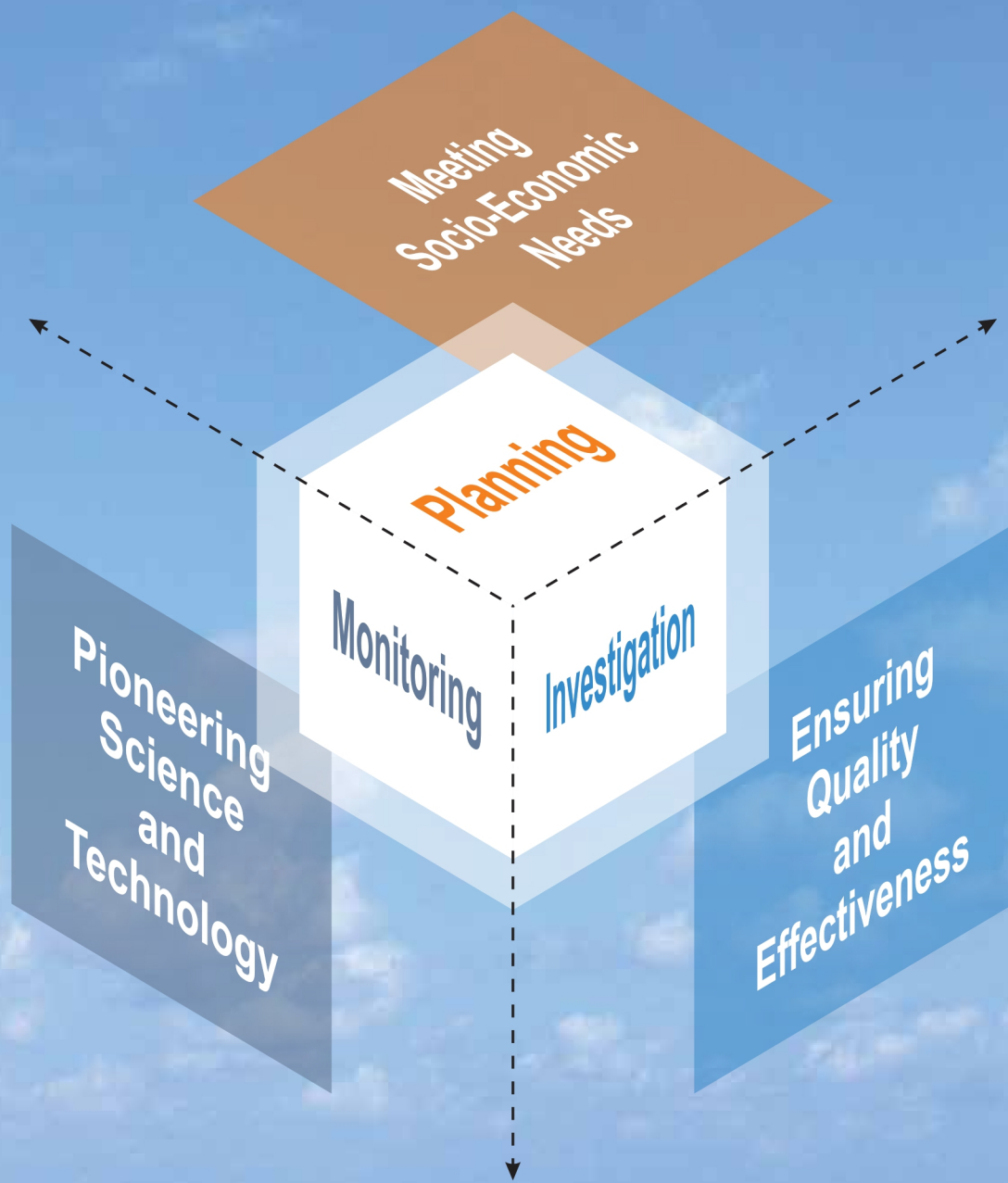
- Causing the subsidence of surrounding constructions: lower level of mineral water underground leads to the subsidence of soil layers in water storeys. At water storey, there is a Ascimet propulsive force for raising soil blocks and stones. When mineral water is taken out, making the lower water level,losing ascimet propulsive force and creating a big gap, leading to subsidence of local constructions and taking a toll on economy as well as human life.

- Intrusion of dirty water and variation of water quality: To compare with watersurface, groundwater are less likely to be polluted. At the perforations, dirty water can follow the edge of perforation to make the water polluted. Moreover, extracting process makes the hydraulic slope higher, which also causes the water contamination... When the mineral water is polluted, it is extremely difficult and complicated to handle, not only need a massive money but also take a long time for dealing with.

- Furthermore, extracting process also has serious effects to the air environment because of the dust and noise produced by working machines on the site. A big amount of waste also is created by workers, which can make the soil environment polluted if they are not recycled by appropriate way.

5. Conclusion

This research is using the hyperspectral remote sensing to determine locations of mineral water resources and hydrothermal at Mo Da hot spring, Ha Bi, Kim Boi, Hoa Binh. There are not only LK7 perforation but also many potential locations, which are being mapped and characterized using these technologies, and methods for integrated study are under development between image acquisition and environmental impacts and risk assessment. We expect that the results will reaffirm the link between the mineral water extraction and environmental influences, lead to a better understanding of the hyperspectral remote sensing.



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