

# **Solution approaches in order to reduce environmental impacts due to coal mining in Quangninh**

K. Broemme <sup>(a)</sup>, H. Stolpe <sup>(b)</sup>

<sup>(a)</sup> RAME-Project, Environmental Technology and Ecology, Bochum University, Germany c/o VINACOMIN, Vietnam,

<sup>(b)</sup> Environmental Technology and Ecology, Bochum University, Germany

**Abstract:** *The RAME project currently is developing environmental concepts for the coal mining industry in Quangninh, Vietnam. The project is working in the fields of waste rock dump stabilization and recultivation, mine water treatment and water management, dust mitigation, environmental management, environmental information systems and environmental planning. The objective of the project is to adapt available technologies to the specific conditions in the coal mining in Vietnam and to test their effectiveness in pilot plants and field experiments which are implemented by the partner Vietnam National Coal and Mineral Industries Group (VINACOMIN). Besides the research activities the project includes capacity building activities for staff members of VINACOMIN.*

*The research activities in the field of mine water treatment and water management take place in Dongtrieu/Uongbi area. Detailed investigations have been carried out on the quality of mine and other waste waters to be expected from the mine facilities of Vangdanh in order to design a waste water treatment plant. A different solution approach with artificial wetlands will be tested for the acid lakes in Dongtrieu area.*

*The projects on stabilization and recultivation of dumps and on dust mitigation are located in Nuibeo, Hongai. Due to the short distance between open pit area and living areas in Nuibeo both tasks require effective solutions. The projects on environmental planning and management have a general approach in order to combine the solutions developed in the other project parts. The paper describes the ongoing research activities of the RAME project.*

## **1. Introduction**

The environmental problems which have to be solved in the hard coal mining areas in Quangninh at the moment in parts are similar with the hard coal and lignite mining industry in Germany. Due to differences in

geology, climate and mining technology the solutions can be based on already known technologies in Germany but they have to be adapted to the local conditions. The RAME project follows this approach in all its activities.

## 2. Projects on waste water treatment

The project on waste water treatment from a mine by using classic treatment technology is implemented at Vangdanh underground coal mine in Dongtrieu/Uongbi area. Altogether mine water from five adits on the premises of Vangdanh Coal Company as well as the waste water from several kitchens, sanitary facilities and a large laundry has to be collected and treated.

For the design of the treatment facilities and the treatment steps to be integrated an exact knowledge of the hydro-chemical composition of the mine and waste waters are required. The following table shows the contents of the monitoring program.

Table 1: Monitoring parameter

Sum parameters	Cations	Anions	Others
TSS	Fe (II)	Sulfate	Total P
TS	Fe total	Chloride	Total N
BOD <sub>5</sub>	Fe dissolved	Ortho-Phosphate	Nitrite-Nitrogen
COD	Al, Mn, Ca, Mg, K, Na,	Nitrate	
DOC	Si, Hg, Cr, Zn, Cd, As,	Nitrite	
	Pb, Cu, NiAmmonium nitrogen	Nitrate-Nitrogen	

An extensive sampling and analyzing program for the determination of the quantities and the qualities of the different waste water streams was developed and implemented together with the Vietnamese partners. To find a decision on combined or separate treatment of mine and sanitary waste waters a decision matrix like shown in table 2 was developed.

According to TCVN 5945-B, the Vietnamese standard for industrial waste water discharge the BOD should be reduced to 50 mg/l, the COD to 100 mg/l and the total suspended solids to 100 mg/l. The monitoring results show very high TSS values for the mine waters with corresponding high BOD and COD values.

Table 2: Decision matrix for selection of treatment steps

Case	Mine water (high volume)	Sanitary water (low volume)	Mixture of mine and sanitary water	Which waters do not meet TCVN requirements?	Combined or separate treatment	Consequences
1	C-org high	C-org high	C-org high	all	combined	One mine water treatment plant with integrated aeration for C-Org treatment
2	C-org low	C-org high	C-org middle	Sanitary Water and mixture	separate	Two separated treatment plants
3	C-org low	C-org high	C-org low	Only sanitary water	combined	One mine water treatment plant without integration of aeration

Based on the results from the monitoring of waste water quality the project team in agreement with the engineers of VINACOMIN decided for the option with two separated treatment plants, one for mine water and one for sanitary waste water from the facilities above ground. The figures 1 and 2 show the general layout of the two treatment plants. The monitoring of waste water quality is continued monthly. It is accompanied by further scientific investigations in Germany using a small-scale experimental waste water treatment plant which was built up in Dresden.

Currently the detailed design for the treatment facilities is worked out in order to prepare all necessary documents for the procedures required before the construction can start.

The project on treatment of mine effluents by using constructed wetlands technology will be located in Dongtrieu area. Dongtrieu is the western-most mining area in Quangninh. There are in total seven lakes,

some of them are natural, some are artificial lakes established for irrigation purposes of agricultural land. The lakes are affected by the surrounding hard coal mining activities carried out in Maokhe and Uongbi. In this area most of the mines are quite small. There are open pit mines as well as underground mines.

Drawing of technological process layout sanitary waste water system

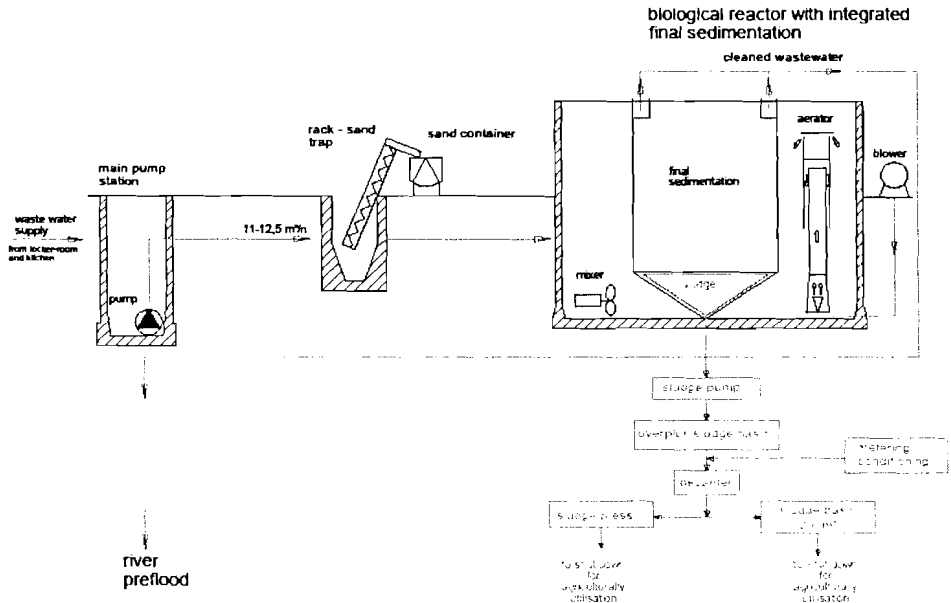


Figure 1: General layout of the mine water treatment plant

The lakes are located downstream of the mining areas. They receive direct discharges but also diffuse effluents like seepage waters from adjacent dump sites. Furthermore, some lakes developed in former open pit voids and some lakes are partially filled with waste rock materials. All this resulted in a rapid decrease of water quality in the lakes. Analyses have shown high Iron and Manganese contents corresponding with low pH values which often range between 3 and 4. Some heavy metals like Cadmium also show high concentrations.

Within the project currently the various inflows into the lake are further investigated and regular water samples are taken. In order to develop an overall concept for the recovery of the lakes the actual status of the lake and the lake sediments as well as quantity and quality of all inflows have to be described in detail.



stringently structured and homogeneous steep slopes. The design objective here is to maximize the available waste rock volume on a limited area and guaranteeing the stability at the same time. Figure 3 shows a typical table mountain shaped waste rock dump.

Based on available topographical data and first estimations on geotechnical parameters provided by the geologists of VINACOMIN a first digital model was built up. The stability of exemplary slopes was calculated. Different options of stabilization methods were evaluated. These studies led to a detailed investigation program on site and in geotechnical labs because the available data on the characteristics of the waste rock and the internal structure of the dump are not sufficient.

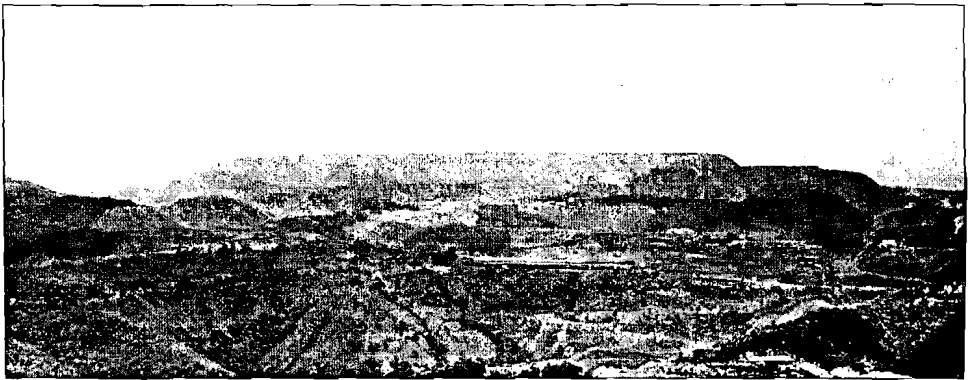


Figure 3: Waste rock dump with the typical table mountain shape

The investigation program includes the determination of geotechnical parameters of the waste rock. Furthermore, homogeneous sections in the dump have to be identified. The waste rock is dumped from the top. This leads to significant sections with different characteristics in the dump. As the waste rock material originates from blasting the sizes of rock and particles are highly variable. The first studies have shown that a natural size distribution in the vertical direction of the dump was formed. Big rocks are found at the foot of the dump, the small sized particles remain in the upper parts of the dump. The rock sizes are estimated at 10 % sized from 0 to 50 mm, about 80 % sized from 50 to 800 mm and about 10 % sized bigger than 800 mm. This leads to the conclusion that the dumps have to be considered as screen dumps.

On the plateau of the dumps several cracks up to 30 m long could be observed. Until now they are not monitored regularly. The project will include them into the investigation program. One of the tasks for

stabilization is to find the critical cracks in the dump which could fail first. In this context also the water infiltrating into and running through the dump has to be investigated in detail. Water is especially in the rainy season a crucial factor for the stability of the dumps and the slopes.

After the first investigations some technologies for the stabilization of dumps and dump slopes were selected. In the ongoing project they will be tested on their suitability for the dumps in Quangninh area. Furthermore, concepts for long-term monitoring of the dumps are developed.

The project team is currently collecting data on the geology in Nuibeo open pit mine and its surrounding areas, on the history of the waste rock dump, on climatic conditions including rainfall and wind. Furthermore, drillings through the dump are prepared which will be accompanied by geotechnical and geochemical / mineralogical analyses. The analyses will yield information on the composition of the dump and its material properties and will enable for an assessment of the overall geotechnical stability and the water balance as well as of the potential impact of the dumped material on ground and surface water. The drillings will be extended into permanent seepage water monitoring wells. The monitoring will also include a monitoring of the stability of the dump body and of the stability in the slopes.

The latest slopes at the dump are constructed using the traditional hillside dumping method. The project will examine their stability depending on the climatic conditions, the slope inclination and the plant growth.

In the result of the ongoing data collection a proposal for the borehole locations and sites for trench sampling on the dump will be drafted. The drill core and trench samples will yield information on the composition of the dump and its material properties and will enable for an assessment of the overall geotechnical stability and the water balance as well as of the potential impact of the dumped material on ground and surface water. One of the boreholes will be constructed as observation well in order to allow for continuous groundwater/seepage water monitoring.

Parallel to the geotechnical works also re-soiling and recultivation techniques are developed and tested on one of the dumps in Quangninh (see also: Stefan Klotz & Ursula Nigmann: Reclamation of mining land – spontaneous re-vegetation and possibilities of restoration).

#### **4. Environmental management and planning**

The method of Environmental Impact Assessment (EIA) was introduced in Vietnam by the Law of Environmental Protection in 1993. After the approval of the new Law from 2005 and the implementation

guidelines 80-2006-ND-CP and 08-2006-TT-BTNMT, the use of EIA in Vietnam was even more clarified and all new investment projects have to perform an EIA. As all the mining activities in Quangninh were already running at the time of introducing the new regulations the mines were obliged to perform an EIA for the running operations. The EIA then is resulting in environmental measures which have to be implemented by the mines. Furthermore, an EIA has to be performed in case a mine wants to extend its operation area or increase the coal production.

Nevertheless, the EIA for the mines still not considers the time after the mine closure. So there is currently no planning for the closure itself, the rehabilitation and the land uses which follow-up the mining activities. Another reason that this kind of planning is still missing is that all mines in Quangninh planned to continue the mining for a long time. Due to severe environmental problems especially by open pit mining near the living areas of Hongai VINACOMIN now intends to stop open pit mining in these areas until 2012-2015. That makes a detailed planning for the closing, rehabilitation and the land use after necessary in the near future. The RAME project can contribute to this task by transferring experiences from the former lignite mining areas in Germany to Vietnam and adapting the concepts to the local conditions.

An integrated planning approach first needs to identify all the stakeholders involved in the planning process or effected by its outcome. In case of the mining areas in Quangninh there are many stakeholders:

- mining company (VINACOMIN, daughter companies)
- local residents
- tourism companies, tourists
- provincial authorities:
  - DONRE Department of Natural Resources and Environment
  - DARD Department of Agriculture and Rural Development
  - DPI Department of Planning and Investment
  - DOIT Department of Industry and Trade
  - DOH Department of Health
- small-sized coal trading companies (coal extraction on dumps, in rivers; production of household coal briquettes, coal for brick making industry)
  - Halong Bay Management
  - local water supply and waste water treatment companies
  - construction companies, construction material companies
  - urban and district authorities.

Planning processes should contribute to ease the conflicts especially between the main stakeholders like provincial government, mining



companies, local residents and the tourism industry. This makes it necessary to develop transparent planning and evaluation methods which could be understood by everybody involved. The decision makers as well as the affected stakeholders should be able to understand about the background of the decisions made in the planning process. One possible solution is an improved visualization of different planning options.

## **5. Conclusion**

The Vietnamese coal mining industry is currently investing a lot of efforts into the improvement of the environmental conditions in Quangninh. The current task is to find the best technical and also economical feasible solutions for the mines. Two different approaches are used simultaneously. One approach is to test various measures directly on the site and to improve these measures by observing the outcome. Another approach is to invest more time in the study of the current status and monitoring before designing suitable measures. Anyway in a long-term perspective both approaches will have considerable effects on the environmental conditions in Quangninh. As the knowledge and the experience of the environmental staff also will improve gradually with each project which has been implemented successfully the impacts due to mining in Quangninh will be reduced in the future.