Mining and Environment in Vietnam, Research Work of the Research Association Mining and Environment (RAME), Status Report 2011

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Abstract

The RAME research project started its first activities in Vietnam at the end of 2005. The aim of the BMBF (German Federal Ministry of Education and Research) funded research and development project is to develop methods to reduce the environmental impacts due to hardcoal mining in Quang Ninh province by selected technical measures and enhancement of the environmental management. Based on a preliminary survey the fields dump stabilization and recultivation, mine water treatment, dust mitigation and after mining landuse were identified as main research fields. Currently, six partprojects are ongoing and one partproject is submitted for approval. Each partproject is divided into four working phases: investigation; conceptual design, discussion and approval; implementation and post-processing. The paper gives an overview on the status quo of the ongoing research works in the partprojects and their first results.

Keywords: coal mining; environmental management; mine water treatment; waste rock dump; dust mitigation, after mining landuse

1 Introduction

In 2005 the Research Association Mining and Environment (RAME) and the Vietnam National Coal – Mineral Industries Group (VINACOMIN, former VINACOAL Vietnam National Coal Corporation) agreed on a collaboration in order to develop environmental concepts and measures for Quang Ninh hardcoal mining areas as VINACOMIN did not have much experience in environmental protection work at that time [2]. After a pre-feasibility study performed from 2005 to 2006 both sides decided to go on with the collaboration and started several joint research projects whose results are implemented in Quang Ninh. RAME is funded by BMBF (German Federal Ministry of Education and Research).

The pre-feasibility study found that the main environmental problems in Quang Ninh are related to the three main subjects water, dumps and dust. There were two projects on the issue of water treatment installed. One is developing a mine water treatment plant for an underground mine site using modern technology. The second project tests the applicability of constructed wetlands for the mine water treatment. Another two projects on the issue of dumps were installed. One project develops concepts for the stabilization of dump bodies and slopes in the dumps. The second project develops concepts on the recultivation of dump surfaces

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which is not only improving the landscape but also reducing the emissions caused by the dump. There is one more technical project on dust mitigation installed in order to develop solutions to reduce the dust immission especially in residential areas. All above mentioned projects develop technical concepts. In order to also improve the overall environmental management in VINACOMIN a core project was installed which develops management concepts, links the other project with each other and combines the results from all projects into one final handbook.

Each of the partprojects starts with an investigation phase where all necessary information are collected. Then the conceptual design follows which has to be discussed with all partners and VINACOMIN. For investments by VINACOMIN also the Vietnamese project documents have to be prepared in order to get the final approval. After that the concept is implemented. Each partproject also includes a post-processing phase in order to accompany the start of operation and evaluate the project results.

2 Environmental Management

Decisions about environmental measures require knowledge about the emission sources, the transmission paths and the immission areas for the current state and for the future as prognosis. Furthermore, knowledge about environmental technologies, environmental hazards, environmental legislation, the available budget and the costs of measures is required. Managing all this information for one mine site only is not possible without any tool for information management. But in the case of VINACOMIN there are various sites with a lot of information varying in space and time. Therefore, the organization of the environmental information will be done by an environmental information system which is developed in collaboration with RAME [11].

As the second main component for an improved environmental management a new environmental report structure is developed. Additional to quarterly monitoring results the report analyses data on pollution sources and implemented environmental measures in order to determine the environmental impact in a certain area. Larger regions are divided into smaller management units like catchment areas or mine sites. In order to prioritize management units for environmental measures on the other hand the environmental sensitivity based on landuse information is determined. Combining environmental impact and environmental sensitivity for each management unit results into different priorities. For management units with a high priority the report then also contains recommendations for environmental measures and monitoring. In this way the report is a valuable instrument for decision making in the field of environmental measures.

The partproject is carried out by the Institute for Environmental Technology and Ecology at Ruhr University of Bochum. Currently, the partproject is completing the detailed works for the environmental information system and the environmental report. There is an ongoing discussion with VINACOMIN in order to be able to fulfill all requirements of the future users.

3 Mine Water Treatment

As project site for mine water treatment the underground mine Vang Danh was chosen as underground mining activities will increase significantly in Quang Ninh in the next years when deeper coal seams have to be mined. The mine waters running from the adits are characterized by high concentrations of Fe(II) and Mn(II). They show high BOD_5- and COD-values as well as high amounts of suspended solids, which mainly consist out of coal dust and already precipitated hydroxides [7]. Both water fluxes and water qualities show high fluctuations due to seasonal changes and the production processes.

After performing a detailed monitoring program the design parameters for the treatment plant were fixed and the conceptual design started. The designing process was accompanied by laboratory and bench-scale testing where each step of the treatment process was modelled: reaction basin with neutralization by hydrated lime suspension and oxidation by aeration, addition of flocculation aid, sedimentation basin with separation of the precipitated hydroxides and the coal dust, demanganisation unit [10].

It was found that separation of the coal dust together with the freshly forming hydroxides in the sedimentation basin works well. The formation of the hydroxides supports the sedimentation process of the solids and forms a coal-hydroxide-sludge by creating discrete coal particle-hydroxide flocs. The density and solids content of the resulting coal-hydroxide-sludge is dependant on the initial iron concentration, the pH value in the reaction basin and on the addition of flocculation aid [8]. Tests showed, that an increase of the pH-value up to 9 in the reaction basin leads to a Mn-removal of more than 50 % with a comparatively small amount of additional hydrated lime. The surplus manganese has to be removed in a final demanganisation step based on catalytic oxidation of manganese using Mn-oxide coated sands in backwashable continuous up-flow volume filters.

The partproject is carried out by the three companies LMBV international GmbH, GFI Groundwater Research Institute Dresden and eta engineering AG. Currently, the designed mine water treatment plant is under construction while comparative experiments on different kinds of Mn-oxide coated sands are still going on.

4 Constructed Wetlands

As project site for mine water treatment by constructed wetlands Noi Hoang lake in Dong Trieu area was chosen as the acid water in the lake strongly affects the agricultural production downstream. Beside other mine influenced waters there is seepage water through a waste rock dump draining into the lake. The seepage water has an average pH value of 4, high sulfate concentrations up to 4 g/l and high metal contents (Mn, Ni, Al, Fe). The partproject has the task to test whether this kind of water can be treated successfully in a constructed wetland.

The constructed wetland was designed as a passive biological treatment facility with two treatment steps in two basins one after another. The first basin contains a limestone drainage passage covered by mixed manure. The second basin contains a planted gravel filterbed where the water passes through horizontally before it is drained to the lake [5].

Figure 1: Pilot scale constructed wetland at Noi Hoang lake in Dong Trieu

The pilot scale constructed wetland (Figure 1) has a designed capacity of 4.4 m³/h. The seepage water is guided into the wetland by a small ditch. No pumping equipment is necessary. The exact amount of the water flow through the constructed wetland is controlled by weirs and flap valves in the intake pipes. Due to this simple structure the constructed wetland requires low investment and can be operated with low costs. This makes it very interesting as water treatment facility at sites with a small waste water amount but long operation periods.

The partproject is carried out by the company BioPlanta GmbH in Leipzig and the Helmholtz Centre for Environmental Research – UFZ in Leipzig. Currently, the pilot scale constructed wetland is operated by VINACOMIN and monitored regularly in order to make sure that it is working properly for the long term. The first monitoring results show that the constructed wetland treats the metal contents successfully.

5 Dump Stabilization

As project site for dump stabilization the dump Chinh Bac at the open pit mine Nui Beo was chosen. The dump is with a height of 256 m above mean sea level on a total area of 107 ha one of the big waste rock dumps in Quang Ninh [1]. The dump is filled with very heterogeneous waste rock materials using the sidehill fill dumping method [3]. By this a segregation of waste dump particles occurs where fine particles stay at the upper part and coarse material move towards the foot of the dump. The coarse material layers at the foot of the dump enable water movement and can lead to a weak foundation of the dump. Further stability risks are caused by weak material layers inside the dump and subsidence processes due to uncompressed materials. The task of the partproject is to investigate the dump in order to quantify the stability risks and to develop solutions to improve the stability [9].

The research of the partproject is divided into two main components. One is the investigation of the dump stability by monitoring of dump movements, other signs for failures, seepage water flows and geomechanical investigations by drillings and trial pits. The second component is a large scale test of a different dumping method in layers including compression by trucks under controlled conditions in order to develop technical guidelines for the dumping process in the future. The experiment also included the comparative test of different dumping layer thicknesses of 2 m, 4 m and 8 m and will be compared with the sidehill fill dumping.

The partproject is carried out by the Institute of Mining Engineering I at RWTH Aachen University and the company Brenk Systemplanung. The works on the investigation of the dump stability are currently still ongoing. The test dumping experiment was carried out already and its results are currently analysed and evaluated.

6 Dump Recultivation

The partproject on dump recultivation also takes place at Chinh Bac dump at the open pit mine Nui Beo as the top of the dump has reached its maximum height and thus the dumping there was stopped some years ago. The task is to develop and test concepts for a recultivation of the dump site on horizontal areas but also on the slopes which are longterm stable and sustainable.

The partproject followed a natural based approach where the recultivation measures aim to assist nature by utilizing the power of natural succession. Local adapted plant species that occur already in the original natural vegetation are planted in distinct islands with the aim to serve as colonization initials [4]. The process can be further facilitated by providing supplementary soil amendments such as fine material, organic matter or fertilizer [6]. The chosen methodology aims to develop a fully functioning, self-sustaining system that involves besides plants also natural processes of soil development and nutrient cycling. Using this methodol-

ogy successful would reduce the costs for the recultivation of large areas but still keep the time periods for recultivation reasonable short.

In order to develop the method in detail the partproject designed recultivation experiments on horizontal areas and on slope areas. The experiments compare the two tree species (*Mallotus paniculatus, Melia azedarach*) and two grass species (*Thysanolaena maxima, Saccharum spontaneum*) as well as three different ways of soil improvement with topsoil, charred rice-straw and power station ash. Furthermore, the recultivation results are compared with already established plantations of VINACOMIN using traditional recultivation trees like acacia and pine.

Figure 2: **Recultivation experiments at Chinh Bac dump in Nui Beo**

According to the first monitoring results the charred rice-straw has proved to be the most suitable soil amendment. The two grass species developed well and much faster than the tree species. Important criteria for the final selection of species for recultivation have been identified. They are the availability of seeds or seedlings, the tolerance to the poor soil and water conditions, good adaptation to climate and pests, fast litter decomposition and low risk for fires.

The partproject is carried out by the Helmholtz Centre for Environmental Research – UFZ in Leipzig and the company BioPlanta GmbH in Leipzig. The recultivation test site for horizontal areas has been established since two years and is regularly monitored with regards to soil development and plant growth. The results are currently evaluated. The recultivation test site for slope areas has been newly re-established and will be monitored in the same way.

7 Dust Mitigation

As project site for the dust mitigation partproject again Nui Beo was chosen as the area includes open pit mines, large waste rock dumps, coal and waste rock transport routes, coal screening areas and a coal processing plant as well as a coal harbour. Furthermore, the area is located very close to residential areas of Ha Long City which are especially sensitive to dust emissions. The task for the partproject is to perform an extended dust monitoring in the area following the production chains of the coal. As a result the most relevant dust sources are

identified. For these dust sources then dust mitigation measures will be developed.

The dust monitoring started in 2010 with both fixed and mobile equipments. The aim of the dust monitoring program is to assess the dust concentrations at the receiving environment on a real-time basis in order to effectively locate areas where dust liberation is elevated. The fixed dust monitoring devices have a wide measuring range with particle sizing from 0.25 µm to 32 µm and particle mass from 1 to 1,500 µg/m³. The devices also have attached wind sensors and climate sensors for temperature and humidity. They can provide wind speed and direction data. For the mobile dust monitoring and the evaluation of the exposure of workers to dust particles personal air sampling pumps are used.

The partproject is carried out by the Institute of Mining Engineering I at RWTH Aachen University and the companies Brenk Systemplanung and CBM. The monitoring works in Nui Beo area are currently still ongoing and the first dust mitigation measures are developed.

8 Conclusion and Outlook

The collaboration between German scientists and engineers of RAME and Vietnamese engineers of VINACOMIN is successfully implemented in the joint research project. All partprojects have achieved first results and entered the implementation phase. The results are accepted by VINACOMIN. They prove that scientific research done in close collaboration with practice produces concepts which can be applied in practice. The partprojects also show that environmental measures require detailed investigations and even laboratory, bench-scale or pilot scale experiments in advance in order to find out about their effectiveness. Only based on this the necessary investments for environmental measures will be cost-effective.

The joint research project RAME will continue implementing the developed concepts in order to perform a detailed post-processing of all results and to be able to summarize clear recommendations for best practices in environmental planning and management for VINACOMIN.

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