Comprehensive approach for mine water management in Vietnamese hard coal mines under transition

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Abstract

The R&D project WaterMiner investigates on the example of the mining area Hon Gai (Vietnam) under different spatiotemporal situations how and to what extent the existing water demand in the mines, and parts of the water demand in the surrounding area, can be covered by treated mine water. In the course of harder implementation of environmental legislation as well as transition from open pit to underground mining, there is a need for a comprehensive approach in mine water management. In addition, WaterMiner is developing a planning guidance, how to improve the mine water treatment and surface runoff management.

Keywords: hard coal mining, mine water management, comprehensive approach, Vietnam

Introduction

Hard coal mining in Northern Vietnam takes place in three different mining areas in Quang Ninh Province, one is located on Hon Gai Peninsula. Both open pit and underground mines are working in the region. They all operate under the parent company Vietnam National Coal – Mineral Industries Holding Corporation Limited (VINACOMIN).

The mine water treatment was improved throughout the last fifteen years, the mine water management is still far from a comprehensive approach (DoNRE, 2016). In the course of harder implementation of environmental legislation and the transition from open pit to underground mining further improvement of mine water management in the area is needed.

The R&D project WaterMiner, funded by the Federal German Ministry of Education and Research (BMBF), focuses on a need-based and efficient reuse and recycling concept of mine water management for current and future situations and the improvement of mine water treatment to satisfy environmental requirements.

WaterMiner consists of the following work packages: project coordination and baseline analysis (eE+E environmental Engineering and Ecology, RUB Ruhr University of Bochum); data management (Disy Informationssysteme Ltd., Karlsruhe); monitoring information concept (ribeka Ltd., Bornheim); material flow analysis (eE+E, RUB, Ruhr University of Bochum); technical concepts for surface water, sediment and coal sludge management (DGFZ Dresden Groundwater Research Centre, LUG Engineering Ltd., Cottbus; VINACOMIN, Vietnam National Coal and Mineral Industries Holding Corporation Ltd.); economic concepts (Environmental Economics, University of Koblenz-Landau).

Comprehensive approach for current and future situations

For current and future situations, the project provides suggestions how to improve the operation of the existing mine water treatment and mine water management by the following steps:

- Temporal analysis – understanding the transition of the mining system
- System analysis – understanding the mine water system
- Spatial analysis – definition of drainage units (DUs)
- Material flow analysis (MFA) – calculating the internal water connections and water flows in the Drainage Units
- Recommendations for improvement

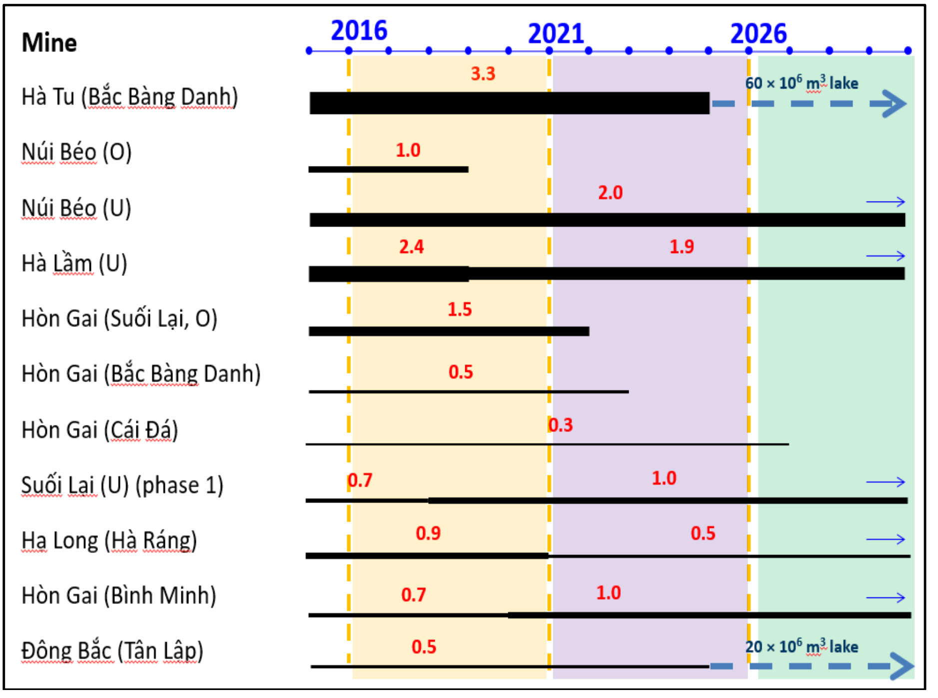


Figure 1 Planned coal production in Hon Gai area, in million tonnes (according to GoV, 2016)

a) Temporal Analysis: Understanding the transition of the mining system

In 2016 (existing situation), 11 mines (open pit (O), underground mining (U), see Figure 1) are extracting coal in Hon Gai. A large number of open pits are scheduled to be closed within the next 10 years (see Figure 1). On the other hand, coal extraction from deep seams by underground mining will increase.

As a result, the amount of mine drainage water changes according to location, quality and quantity. This transition has consequences for the whole mining system.

The relevant temporal situations of transition are defined as follows:

Existing situation (year 2016-2021), intermediate situation (year 2021-2026) and final situation (after year 2026) (see Figure 2).

The existing situation is divided into phase 1 and phase 2, the other situations have one phase each (phase 3 and phase 4). For all phases a short analysis of the situation is given according to mine water drainage amount, mine water treatment, mine water reuse (internal use and external use) (see Figure 2).

In phase 4 one of the former open pits will be transformed to a pit lake with reservoir and sedimentation function (rainwater, surface runoff).

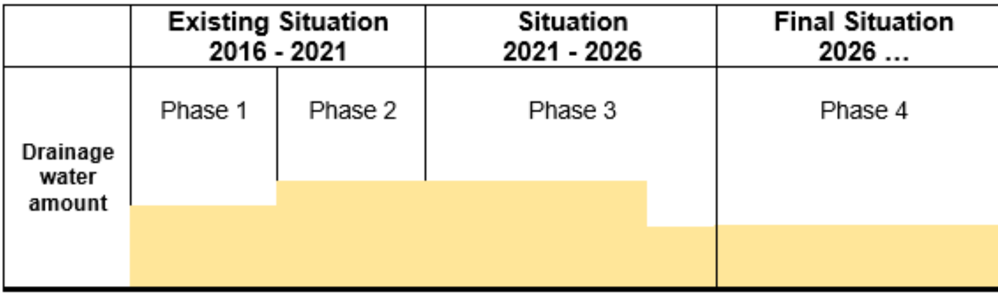
b) System Analysis: Understanding the mine water system of Hon Gai

The mine water flows consist of groundwater, surface runoff, imported (QUAWACO public water supply) and exported flows (discharge Mine Water Treatment Plant (MWTP)), as well as in-situ rainfall and evaporation. There is no capture of mine waters in the surrounding of the mines (see Figure 3).

Each mine operates at least one mine water treatment plant (MWTP) (see Figure 3). The mine water flows via regulating basins to the MWTPs. In the rainy season and especially during heavy rainfall events mine water is only partially treated (Ulbricht, 2018).

The treated mine water is partially reused inside the mines (internal uses). Additionally, there is a large water demand in the surrounding urban area of Ha Long City, especially during dry season (external uses).

Large storage water entities are not available to reserve surplus water in rainy season, resulting in water deficits in dry season. The surface water runoff is not managed properly due to the lack of a



Characterization

Background	**Phase 1:** Existing situation with open pit and underground mining **Phase 2:** strict implementation of effluent standards for the whole drainage water amount	**Phase 3:** Open pit mining will be finished step by step, underground mining is continued and extended	**Phase 4:** Open pit mines closed, residual pit lake in Ha Tu, underground mining continues
Treatment	**Phase 1:** Existing treatment capacity = drainage water amount (open pit & underground) **Phase 2:** Increasing drainage water amount, treatment capacity not sufficient	**Phase 3:** decreasing treatment of open pit drainage, continued treatment of underground mine drainage	**Phase 4:** Pit lake in former Ha Tu mine, no treatment of open pit drainage needed, continued treatment of underground mine drainage
Internal uses	**Phase 1:** full internal reuse, no surplus for external uses **Phase 2:** full internal reuse, surplus for external uses	**Phase 3:** decreasing internal water demand, due to closure of open pit mines	**Phase 4:** Internal water demand reduced (underground mining, irrigation for revegetation, dust prevention etc.)
External uses	**Phase 1:** no reuse for external uses **Phase 2:** Surplus for external uses	**Phase 3:** surplus for external uses	**Phase 4:** Pit lake in former Ha Tu mine as a reservoir for external water supply

Figure 2 *Phases in mining transition in Hon Gai area (eE+E)*

comprehensive approach, hydrologic monitoring stations and technology.

c) Spatial Analysis: Mine water Drainage Units

To facilitate an improved mine water management, drainage units (see Figure 4) were defined. They are distinguished by their different topography, hydrology features, mine operation and ownership.

d) Material flow analysis (MFA): Calculating the internal water connections and water flows within the Drainage Units

The Umberto NXT Efficiency software is applied to identify, quantify and assess the potential for the reuse of mine water and to improve the mine water management regarding the different situations of spatial and temporal development of the mining area.

According to the particular situation of the mine water system, the MFA considers the following elements:

a) Mine water sources (pumped water from open pits and underground mines, surface runoff, etc.)

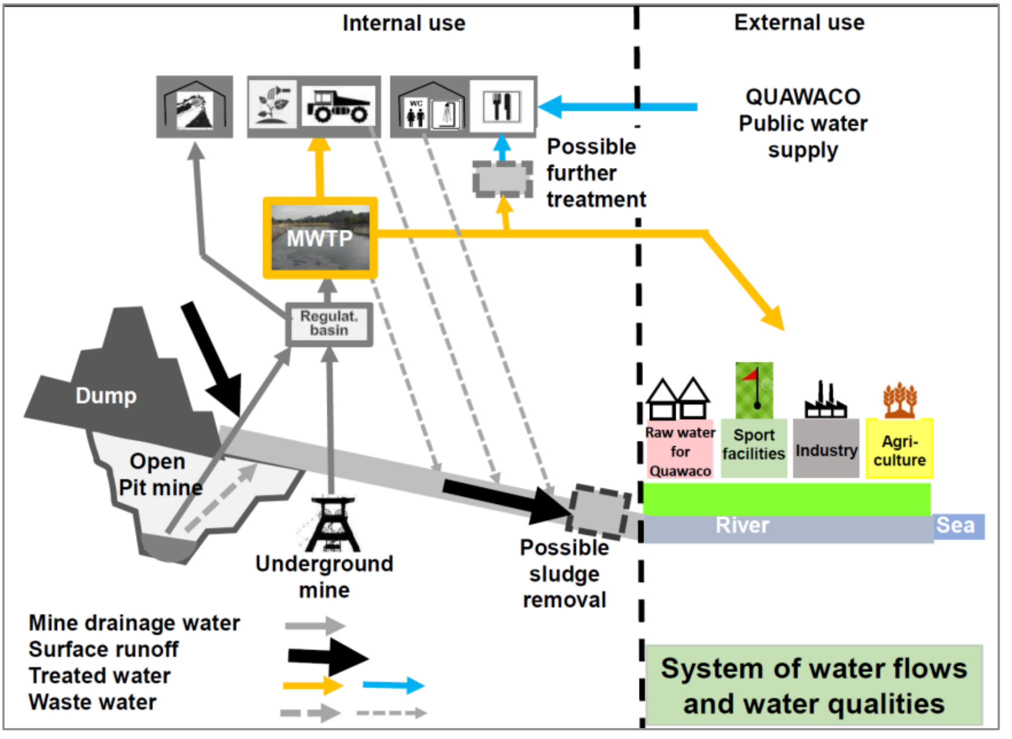


Figure 3 *Elements of the mine water system in Hon Gai (eE+E)*

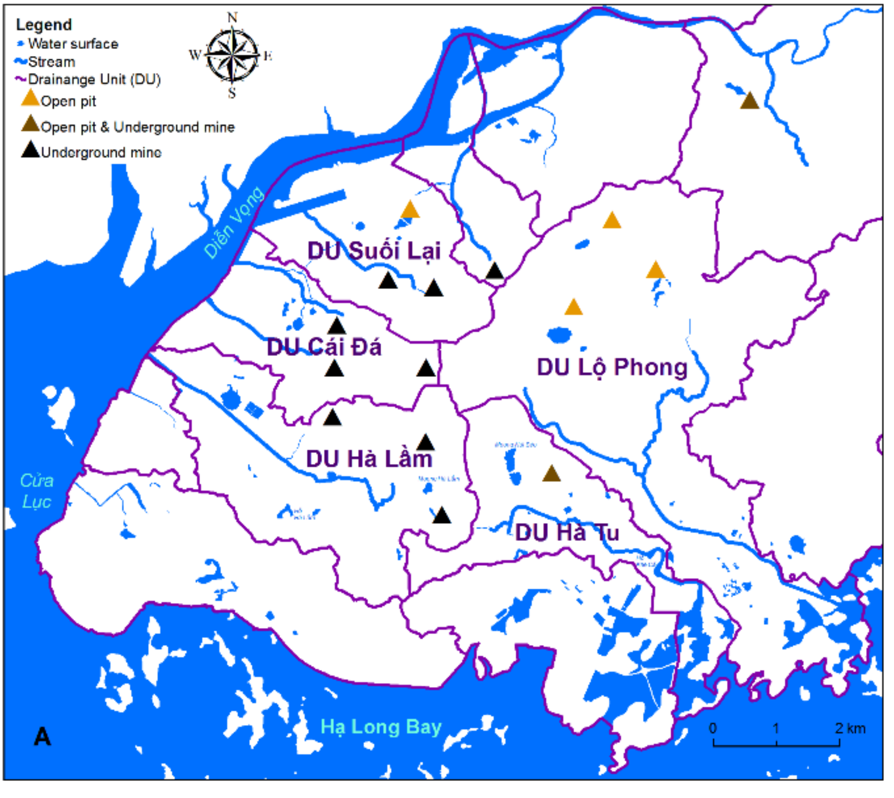


Figure 4 *Drainage Units in Hon Gai (eE+E)*

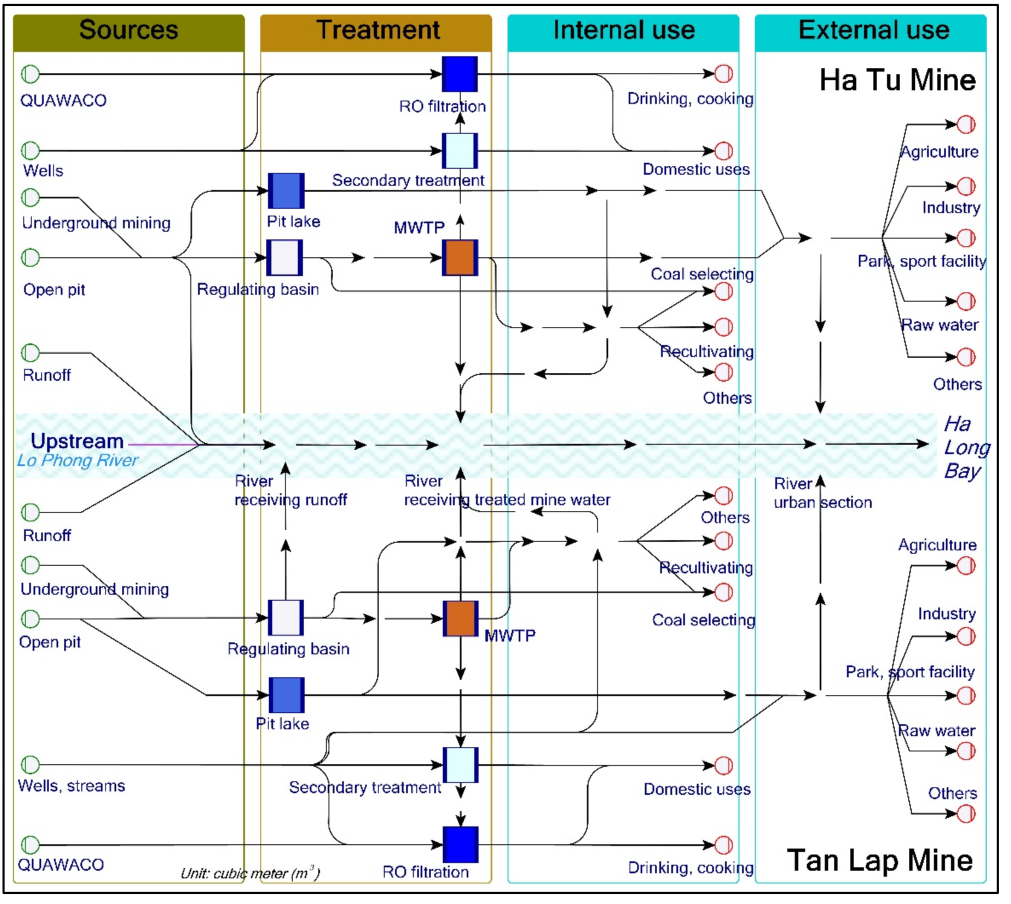


Figure 6 *Material flow analysis of existing situation (Lo Phong Drainage Unit)*

b) Mine water treatment (regulating basins, MWTP, etc.)
c) Internal use (water for drinking, canteen kitchens, wet coal screening, irrigation of recultivated areas, dust control, industrial cleaning, truck washing)
d) External use (irrigation of public parks, urban greens and golf courses, agricultural areas, industrial users, etc.)

Discussion

Mining operations and their water management underlie spatial and temporal changes. Changes in mine water sources, water treatment facilities, internal uses and external uses are substantial factors controlling mine water management.

As mining sites are closed, mine drainage water will decrease, mine water treatment plants will reduce or stop their operation and the water consumption for mining purposes will be reduced or decline. At the same time, along with the expansion of industry, urban areas and tourism, water extraction will increase to provide adequate water and satisfy higher water demands.

Therefore, a material flow analysis is a very suitable instrument to combine the results from the temporal, the spatial and the system analysis and the management of mine impacted water flows. The MFA is focusing on the water flows, but also includes other relevant material flows like energy, supplies and sludge.

Furthermore, it also supports economic analyses, which are usually the most important factors for decision makers.

The lack in dynamic modelling can be solved through the use of several models for small time periods in succession.

Conclusions

There is high demand for mine water reuse and recirculation in the Hon Gai coal mining area.

Therefore, a comprehensive view at all mines, which are operating in Hon Gai peninsula, is necessary to analyse and compare different temporal situations and develop recommendations for both current and future situation.

A MFA, as the central tool of the developed comprehensive approach, is a suitable instrument for the mine water management. Through variations of the water allocation, worst case analyses etc., improved spatiotemporal situations are generated, which are the basis for management and investment decisions.

Both quality and quantity features of mine water are equally considered for proposing measures for reuse and recirculation.

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