

Disruptive Technologies in Mine Water Management – The Future

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Abstract

This paper outlines the development of a mine water management system using “smart” technology. It will provide the mining industry with many advantages in mine water treatment and management, as it integrates the fourth industrial revolution in its system, such as nano-electric sensors being installed almost everywhere in the mine to monitor real time data and quantum computing for faster data processing that is being administered in the blockchain. This will enable a collection of all possible mine water treatment parameters and eventually the development of a “smart” mine water treatment plant.

Keywords: Nano-electric Sensors, Quantum Computing, Blockchain, Mine Water Management

Introduction

Current mine water management usually consists of “blindly” end-of-the-pipe treatment. This treatment does not take into consideration water chemistry or volume changes prior to arriving at the plant. Neither does it take into consideration the effects of the weather or operational procedures. Yet, all these parameters can be monitored and processes regularly and potential changes in volume or the water chemistry can be identified hours or weeks in advance, allowing the mine water management (e.g. pumping rates) and treatment adjust to the predictable, future changes. In addition, this allows optimizing the work flow at the mine water management site and ordering consumables or scheduling electricity needs before they are necessary.

As the world is adjusting to the fourth industrial revolution, usage of disruptive technologies in mine water management is advantageous. This will help to treat and manage polluted mine water more effectively by improving the currently existing mine water management technologies. This will be achieved without disturbing the industry, by: improving (e.g. technological age of the mine), implementing existing (e.g. electrocoagulation, integrated membrane technologies) and researching new

technologies (e.g. new sensors, valorisation of mine water).

This paper describes a step by step approach in developing a system that uses disruptive technologies to treat and manage mine water. The system uses industry 4.0 technology such as nanotechnology in electronics by e.g. developing RFID-based mine water sampling (Cheng et al. 2008; Yu and Meyyappan 2006). The use of GoldSim (Nalecki and Gowan 2008; Usher et al. 2010; Wolkersdorfer 2008) together with quantum computing (Tabakin 2017) will help to visualise and dynamically simulate the large amount of data to be collected during the study. Mine water treatment in almost all current mine water treatment plants is not effective enough as it does not take advantage of all the potential residing in modern technology. Current mine water treatment plants normally react instantly when the volumes or chemistry changes (Wolkersdorfer 2008), therefore, there is usually no interaction between precipitation, water inflow into the mine, technological changes within the mine, water analysis of the plant and the outflow or storage of the treated water.

This proposed, new technology will help with accurate continuous data collection and monitoring as opposed to scheduled, discontinuous monitoring. In consequence,

this will lead to better decision making. It will also help in detecting any changes in the mine water quality trend before it occurs, i.e. early detection of changes in the mine water chemistry and volumes. Inflow and outflow monitoring will allow for an accurate water balance and therefore take precautions if there is a risk of overflow in the plant. More advantages include reduced uncertainty in determining the potential risks posed by the mine on the environment, e.g. flooding will be detected before it occurs. Costs of treating mine water will be reduced as there might be no necessity for regular chemical monitoring, and all necessary steps can be done using the system discussed in this context. The technology will also help in improvement of mine water models, i.e. chemical and water balance models.

Parameters to be measured and processed include online monitoring of flow and physio-chemical parameters, results of sampling campaigns, RFID controlled sample management, results of chemical analyses of the mine water and data processing, e.g. statistics of various scales. Due to the large volumes of data that will be collected, techniques used in the process will include blockchain technology for data tracing (e.g. Ikeda 2018), quantum computing (e.g. Tabakin 2017), expert systems, fuzzy based decision mechanisms (e.g. Golestanifar and Ahangari 2012) or neural networks (e.g. Diamantopoulou 2005; Singh et al. 2009) and an overall control of the quantity and quality of mine water using the above techniques in artificial intelligence.

Methods

In most cases, an underground mine is likely to have polluted mine water; therefore, this proposed technology will be best implemented and tested in a mine with mine water problems. The mine water management in this mine will be converted stepwise and disruptive technologies will be integrated accordingly. This will include setting up quantum computing (in the long run), installing RFID tagged devices (e.g. pumps, sensors), setting up a digital object management scheme based on existing name conventions and teaching the employees how to use this technology to provide them with

the best available option to manage the water in the mine. A project plan will be set up in conjunction with the mine and all the relevant water pathways and users that are pertinent for the water treatment and technologically advanced water treatment process. In this concept, all water pathways into, through and out of the mine will be monitored and used to feed the developed system with relevant data (fig. 1). The system will give a clearer picture of the mine water management in the mine, i.e. how much water flows into, leaves and flows through the mine ("mine water make").

To avoid unauthorised access, a digital rights management is imperative, which includes managing different access levels of various users. Because of the problems related to wireless devices in a real situation environment (e.g. Chen et al. 2015), not all sensors might become wireless sensors. Yet, current technology development might be able to provide innovative sensor technology which is able to overcome those problems and other problems encountered in water related sensor technology (e.g. Zhuiykov 2012). However, new sensors or technologies will not be developed; rather existing sensors and technologies will be adapted into the developed system. Yet, there will be development of a concept and software application to include all necessary concepts into a working system at a real mine with the need of more sophisticated water management.

Methods to be included are data processing, statistical methods, simulation (e.g. GoldSim; Nalecki and Gowan 2008; Usher et al. 2010) into an expert system or artificial intelligence-based decision process, depending on the complexity of the data. Due to blockchain technology that will be applied in this system, data will be accessed anywhere, anytime, and users shall be able to trace the source of data.

After a clearer approach to introducing disruptive technologies and developing the system (fig. 2), the following will then be achieved:

- Concept and software to run the developed system on an existing mine,
- Use smart technology to manage mine water underground, during transportation and in the process,
- Investigate sensor technology for mine water,

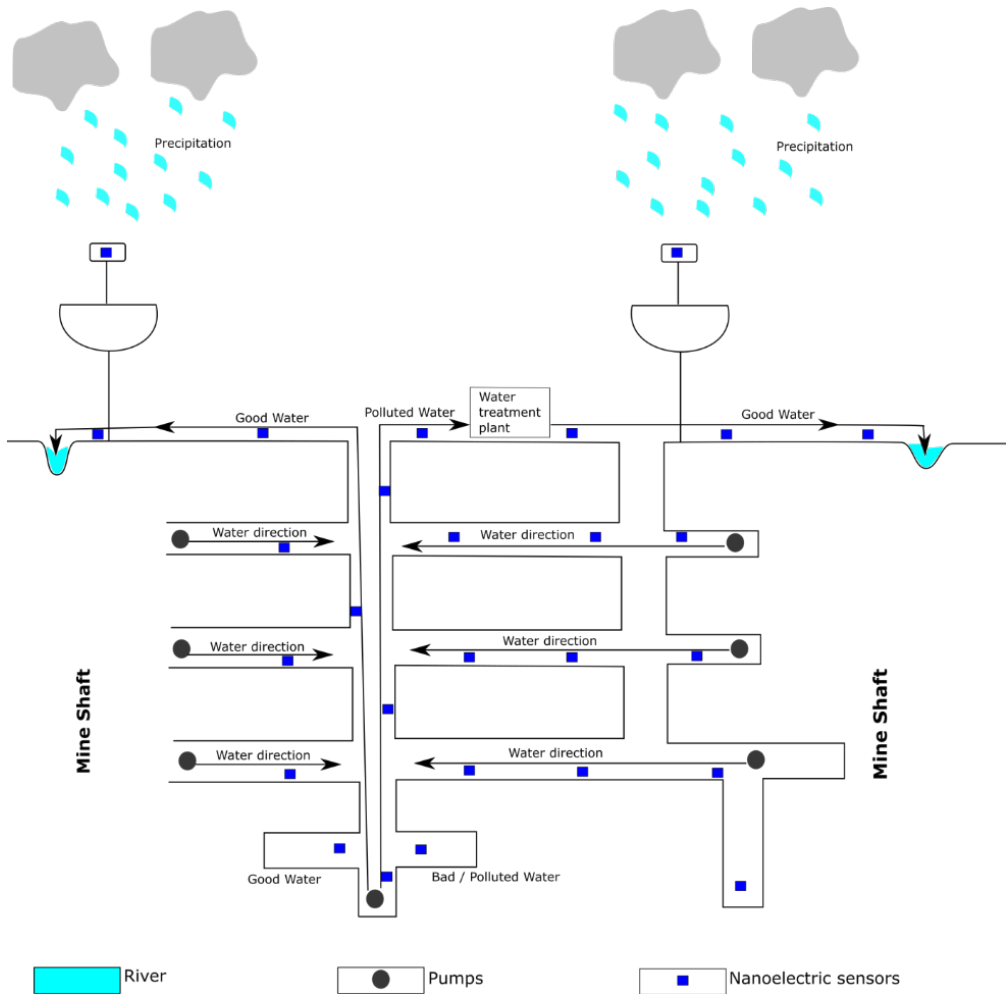


Figure 1 Water treatment operation in a mine with new technology

- Describe the geothermal energy in the mine water within the process, and
- Provide a technological concept for managing mine water in the view of "smart" technology.

This will then lead to a fully functioning system, which includes all aspects of mine water management from sampling to data processing to process control (fig. 3). In addition, there will be a need to identify and describe methods of separating the water streams in a mine so that the amount of polluted water that needs treatment can be minimised. Techniques to separate different water streams in surface or underground mines are known (e.g. Birk et al. 1964) but usually not used because practical and cost reasons might interfere with the management

of various water streams. This study will identify methods that are currently used and how they could be implemented in the mine of the future.

Conclusions

Integrated control of all relevant water related processes within the mine and the plant to optimise mine water management and treatment is an important part in future mining operations. This will enhance the technology age of mining, bringing mine water management to the next stage and possibly be relevant in the fourth industrial revolution concept. The study will provide the mining industry with many advantages, e.g. instead of purifying a waste during the mine water management process, a resource can

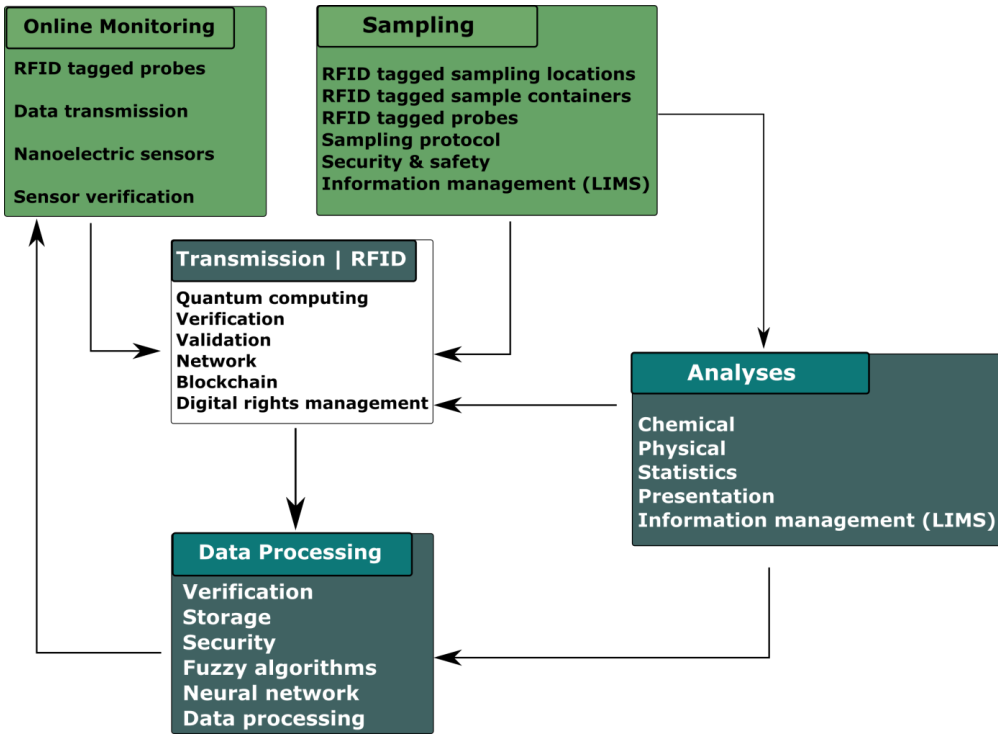


Figure 2 Relevant steps and their connection in the system to be developed with introduction of disruptive technologies

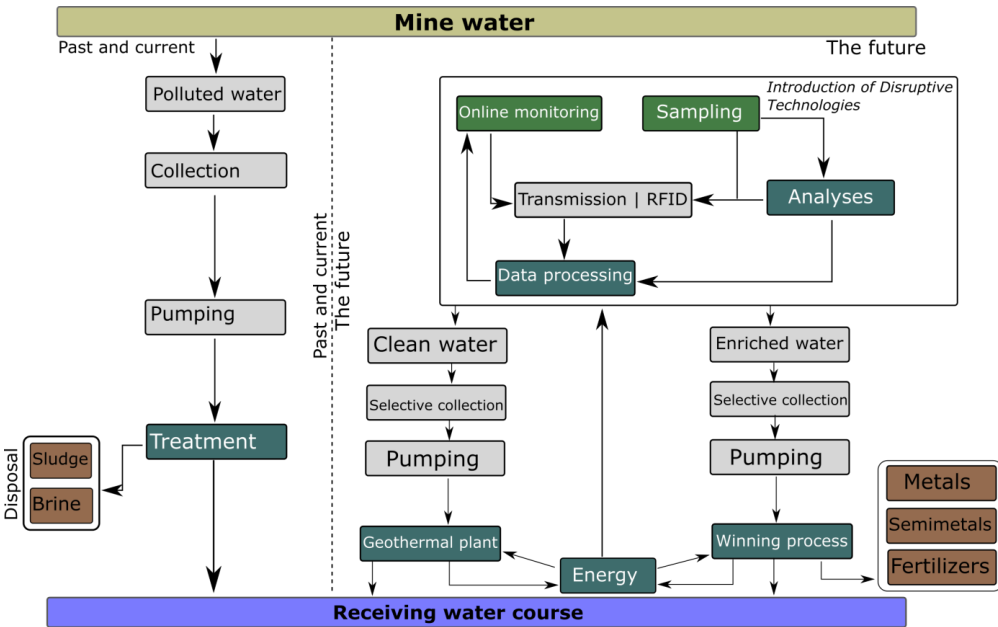


Figure 3 Comparison of past and current mine water treatment plant (left) with the future mine water treatment plant (right)

then be produced, it also helps us to get rid of old habits such as intensive liming and enables the mining industry to produce at lower costs and more environmentally friendly.

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