Comparing approaches to treat coal mine affected water in Queensland

1. Background

Residual voids are often left in place after open cut mining operations cease. Voids left in place often fill with water and in some cases can pose a threat to local fauna, flora, and the community. Ongoing inputs of surface and groundwater combined with evaporative processes can lead to poor water quality. A review of available data describing void water quality showed that coal mine affected water in the Fitzroy basin is typically associated with elevated salinity and sulfate and a range of metals (e.g., aluminium, selenium, copper and zinc) may also be present. In some cases, coal mine affected water can be acidic and metal-rich but such water types are not common for coal mines in Queensland and are not the focus of this brief. Coal mine affected water is generally not suited for beneficial use without treatment. The available modelling studies into mine void water quality in Queensland coal mines predict ongoing increases in salinity with most expected to become unsuitable for beneficial use in the long-term.

Proactive management to treat water both during and after mining can increase beneficial use of mine affected water, limit the waste of a valuable resource and minimise closure risks. Water treatment during the operational phase of mining is able to reduce the volume of coal mine affected water, limit mine closure risks and facilitate post-mining use of coal mine affected water. However, water treatment is not commonly applied in coal mining in Queensland at present. Some constraints and barriers to adopting water treatment can include costs, energy, waste, training and expertise needed.

2. Water treatment technologies

There are well established water treatment techniques capable of addressing high salinity (e.g. Pinto et al., 2016; Zhao et al., 2020; Ahmed et al., 2021; Corral et al., 2021; Sahu, 2021) and other contaminants associated with coal mine affected water. Examples include adsorption, bioremediation, capacitive deionization, desalination, distillation, electrochemical ion exchange, electrocoagulation, electrodialysis, ion exchange, membrane filtration, precipitation, and reverse osmosis (Pinto et al., 2016).

Membrane techniques including reverse osmosis (RO) and electrodialysis (ED) are perhaps the most commonly used technique to desalinate water and remove contaminants. Forward osmosis (FO) or reverse electrodialysis (RED) can be coupled with RO and ED to help overcome some of the constraints and barriers to implementation. For example, recent studies on FO have shown it can reduce energy consumption and provide effective treatment of coal mine affected water (Thiruvenkatachari et al., 2020). In addition, RED can assist with membrane cleaning and generate electricity in some instances (Sahu, 2021; Zoungrana and Çakmakci, 2021). Biological methods including constructed wetlands and microbial biotechnologies are also able to remove contaminants and have been used for the treatment of acidic, metal-rich waters (Fernando et al., 2018; Kumar Patel et al., 2021). However, these approaches have not yet been investigated at large scales for their ability to desalinate water and their application to treat coal mine affected water in Queensland remains unknown. There are also a range of other innovative methods such as ion exchange (Mei and Tang, 2018) and chemical precipitation, nanofiltration (van Hooijdonk, 2019), membrane distillation and solvent extraction (Kesieme, 2015), temperature swing solvent extraction (Reilly, 2019), eutectic freeze crystallisation and thermal crystallisation (Mazli et al., 2020). Although emerging techniques have potential for use in treating coal mine affected water further research including pilot testing may be required. The use of renewable energy sources such as solar and wind can help to make these approaches more economically attractive and sustainable in the long term. Further review and information on water treatment of coal mine affected water are discussed in Fonseca-Teodoro et al., (2022).

3. Comparing water treatment approaches

Water treatment options can be evaluated and compared by considering their suitability for the application and feasibility for implementing them. Suitability refers to a treatment technique's appropriateness of treating the affected water, and feasibility refers to its potential to be implemented at a given mine site. The considerations to be made in evaluating and comparing water treatment options are presented in Table 1. Although it is not possible to identify a single, preferred approach to water treatment that is best suited across the metallurgical and thermal coal mine industry in Queensland, the approach presented here can be applied on a site level to identify and compare water treatment options.

4. Leading practice

Where water quality of Queensland coal mine residual voids is expected to be unsuitable for beneficial use in the short or longer term (i.e. between the present and up to 100 years or longer timeframes predicted to reach an equilibrium), best practice in progressive rehabilitation and closure planning supports a full comparison of the suitability and feasibility of utilising water treatment for managing poor water quality in mine pits with the aim of maximising beneficial use of the water. Water treatment may also provide an appropriate means to manage excess water to minimise or prevent environmental harm. Criteria and the associated variables to consider when evaluating the suitability and feasibility of water treatment options are described in Table 1. Further background and information on how to apply this approach is described in Fonseca-Teodoro et al., (2022).

Table 1. Factors affecting the suitability and feasibility of water treatment options for typical saline, coal mine voids in Queensland (summarised from Fonseca-Teodoro et al., 2022).

Requirement	Criteria	Variable
Suitability	Operational requirements	Treatment rate
		Water recovery
		Salt removal
		Input/Maintenance
		Training and technical skill
Feasibility	Costs	Pre-treatment
		Energy
		Infrastructure
	Waste Management	Final waste disposal
		Treated water reuse potential
		Treated waste reuse potential

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