Challenges of defining what 'success' looks like for closure of pit lakes as aquatic ecosystems

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Extended Abstract

Defining end uses for pit lakes is considered a crucial step towards their successful closure. Possible end uses for pit lakes include their use, as aquatic ecosystems, and for various forms of power generation, recreational activities and agricultural/aquacultural purposes. There is a strong regulatory and community interest in ensuring that pit lakes are used productively post closure, particularly since opportunities for income generation and employment in the local area are likely to decrease once mining ceases. In our review of future (end) uses, Lund and Blanchette (2023) we concluded that closure of pit lakes as an aquatic ecosystem was, in most cases the lowest risk option for all stakeholders. Currently, successful closure of pit lakes is based on the notions of safety, stability, non-pollution, and sustainability. The challenge lies in defining what successful rehabilitation means for pit lakes, primarily because there are typically no meaningful reference sites (Blanchette and Lund 2016). Reference sites being typically natural waterbodies that can be used for comparison with the pit lake. This study aims to explore and begin to define characteristics that indicate successful rehabilitation.

The authors reviewed their data on biodiversity and water quality collected since the early 1990s at former coal mine pit lakes in Queensland, New South Wales, and Western Australia. The pit lakes that we have studied have a range of water qualities, from highly acidic (typical AMD, for example Kumar et al. 2011), to low pH and poorly buffered (for example Lund et al. 2012), to neutral pH, with low metal concentrations and variable salinity (for example Lund and Blanchette 2021). These data, both published and unpublished, were analysed to draw conclusions about the expected trajectories for biodiversity and water quality over the course of years to decades, depending on whether pit lakes are not rehabilitated, partially rehabilitated, or fully rehabilitated.

Unrehabilitated pit lakes were still on mine leases and usually used as water storages, no rehabilitation in the catchment or of the lake had occurred. Partial rehabilitation involves contouring and shaping banks, burying potentially acid forming material, and revegetating catchments with upland vegetation. However, it does not include direct treatment of pit lake water or attempts to stimulate aquatic organisms, such as fringing or riparian zones. Lake Kepwari in Collie, Western Australia, has been fully rehabilitated and successfully returned to the State Government. It is now a major tourist attraction. One of the key differences between the fully rehabilitated Lake Kepwari and partially rehabilitated co-occurring Collie lakes is the permanent connection of the lake to a seasonal river system, which has dramatically improved water quality (Lund et al. 2018; McCullough and Schultze 2015). HL2 is a small, shallow pit lake located in the Hunter Valley, NSW, which has been fully rehabilitated and planted with fringing vegetation (Blanchette and Lund 2021).

The data analysis indicates that rehabilitation had only a marginal effect on the richness and abundance of the studied taxa when compared to nearby reference natural lakes or to other non-rehabilitated pit lakes over the studied time frames. Without rehabilitation, water quality (excluding salinity) and biodiversity in the pit lakes remained largely unchanged over decades. The majority of collected taxa were common and pollution-tolerant across all sampled pit lakes, whether rehabilitated or

not. Species richness of multiple taxonomic groups was lower in pit lakes than would be anticipated by ecologists given the relatively good water quality. This reduced richness is suspected to be due to the lack of developed organic sediments, habitat, and fringing and riparian vegetation. The lakes that have been partially rehabilitated tend to have poor water quality due to acid mine drainage in the area. The study found that there was no relevant difference in biodiversity between the partially rehabilitated lakes and the unrehabilitated ones. This suggests that catchment revegetation and shallow littoral gradients alone may not be enough to increase species richness. Although the fully rehabilitated pit lakes had ecologically advantageous features such as river flow or small size and depth, their biodiversity was only marginally greater than that of the partially or unrehabilitated lakes.

Zamora-Marin et al. (2021) conducted a study on small artificial ponds in Europe and found that these ponds typically contained less than 55% of the alpha (local or point) taxa richness of co-occurring natural ponds. The study revealed that some of the low diversity was associated with poor habitat. However, in terms of beta (between communities) diversity, the ponds potentially contributed strongly to overall regional diversity. Therefore, it is important to consider the importance of pit lakes to regional biodiversity in a landscape context, rather than in isolation. A study by Petruželová et al. (2023) noted a distinct lag in biodiversity development for small glacial lakes in Czechia recovering from acidification, indicating that decades may be required before biodiversity responds to rehabilitation efforts.

Currently, it is perceived that pit lake rehabilitation is largely based on the build it and they will come approach. However, it is argued that current (Australian) approaches are overly simplistic in terms of creating adequate habitats, with too much focus on safety and engineering considerations and insufficient identification of biodiversity needs. Pit lakes can be colonised by a range of common tolerant species. However, an increase in biodiversity is likely to be slow and successional, making it a poor indicator of rehabilitation success, except over a long timeframe. Focusing closure criteria on the establishment of suitable habitat would enable shorter timeframes and set trajectories for likely ecosystem development. Research is needed to determine the key habitat features and the required quantity (area or extent) for each lake within the landscape context.

Keywords: Biodiversity, water quality, coal mining, rehabilitation, pit lakes

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