Research brief – research scoping and stakeholder feedback
February 2022

Topsoil deficits affecting mine rehabilitation in Queensland

Mine rehabilitation and topsoil deficits

Topsoil deficits are an inherent aspect of open cut mining. This is because the post-mining surface area of waste rock dumps and mine void slopes is greater than the comparatively flat area from which topsoil was harvested prior to mining. The situation is further exacerbated at older mine sites where topsoil was often not harvested prior to mining, or where it has been stockpiled for years, resulting in the loss of nutrients (especially available nitrogen) and biological activity (viable seeds, earthworms, microorganisms). As a result of these deficits in quality and/or quantity of topsoil, mine rehabilitation activities may have to rely on a thin layer of stockpiled topsoil, nutritionally deficient subsoil, overburden, or a combination of these, as the surface layer. These materials present physically and chemically challenging conditions for plant establishment and may be prone to erosion leading to poor rehabilitation outcomes. Careful management is needed to ensure that the surface materials that remain after mining can sustain the proposed vegetation, are not prone to erosion and will support final rehabilitation objectives.

Best practice priorities for addressing topsoil deficits

Successful rehabilitation to support ecosystem or agricultural post-mining land uses is underpinned by reconstruction of a healthy soil profile. Regardless of whether the starting material is mine spoil, subsoil, or stockpiled topsoil, rehabilitation outcomes can be improved by soil management activities that focus on modifying the physical, chemical and biological properties of soil.

Soil structure and soil chemical properties can be influenced by a range of practices including:

- deep ripping to reduce compaction,
- addition of chemical ameliorants to reduce dispersion,
- organic matter addition to improve particle aggregation,
- fertilisers to address macro and micronutrient deficiencies, and
- irrigation to stimulate natural soil forming processes.

However, whether these approaches are relevant at each site must be determined on the basis of comprehensive soil characterisation. This critical step in rehabilitation is often overlooked, done incompletely, or inconsistently across sites. Soil improvement approaches must also take into account the proposed post-mining vegetation. For example, native plants often prefer nutrient poor substrates with limited phosphorus. Incorrect or excessive fertiliser addition has been shown to result in poorer rehabilitation outcomes for some native ecosystem rehabilitation (Erskine and Fletcher, 2013; Emmerton, 2019).

Soil biology is also an important component of soil quality that is often overlooked during mine rehabilitation. Natural microbial processes are responsible for carbon sequestration, nutrient cycling and aggregate formation in soils. There is potential to harness or stimulate these natural processes to accelerate soil formation from poor quality substrates and improve mine rehabilitation outcomes. Organic-rich materials (e.g., biosolids, compost, worm castings, manure) can promote natural soil forming processes and improve soil quality (Wijesekara et al., 2016). There is emerging research underway in Australia investigating the potential for microbial inoculants to accelerate the spoil-to-soil transformation during mine rehabilitation (da Silva et al., 2021; Gunathunga et al., 2021; Li et al., 2022).

Stakeholder perspectives on topsoil deficits research

There was a consensus among stakeholders that topsoil deficits are a significant hindrance to successful mine rehabilitation in Queensland. Stakeholders welcomed research to address topsoil deficits and some volunteered case studies that may be useful to investigate further. Others wanted to be able to access case studies showing successful rehabilitation under topsoil deficit situations.

Case studies volunteered from stakeholders included:

- the use of biosolids at West Moreton coal mines (New Hope Group)
- the conservation of topsoil for grazing rehabilitation and use of poorer quality material for woodland rehabilitation at Central Queensland coal mines (BHP Mitsubishi Alliance)
- combining potentially acid forming material with red mud and biosolids for native ecosystem restoration on waste rock at Mt Carrington mine, NSW (Maddocks, Lin and McConchie, 2004)
- eco-engineering of red mud from alumina refineries (Rio Tinto, UQ, Queensland Alumina Limited)

A recurrent theme from several stakeholders was that soil requirements for grazing rehabilitation are different to those for native ecosystem re-establishment. Those stakeholders were generally in favour of conserving better quality soil for rehabilitation to grazing outcome and undertaking native ecosystem restoration on coarse waste and/or employing rock mulch approaches.

Soil organic matter and soil carbon were topics of interest to multiple stakeholders. Academic researchers noted that mine rehabilitation is currently excluded from the national soil carbon accounting framework and identified that as a barrier to practices that promote soil formation. Industry representatives were keen to understand the situations where biosolids and organic matter may be useful in rehabilitation. Access to sufficient quantities of good quality organic material (e.g., compost, biosolids) in the remote and regional areas where mines are generally located was highlighted as a significant barrier in this regard. The Office of the Queensland Mine Rehabilitation Commissioner has been engaging with the Queensland Organics Strategy team in Environmental Policy and Planning to highlight this need and ensure that the mining sector is included as a possible end user of organic waste, during their planning for disposal or redirection of organic waste in Queensland over the next 10 years. For example, backloading of organic waste on road or rail networks to mining regions should be considered, as well as opportunities to establish composting and organics industries locally within mining regions.

Other aspects relating to topsoil deficits raised by stakeholders included: the critical importance of water in the soil formation process, the use of regenerative agriculture and intensive land management approaches, Transport and Main Roads style soil reconstruction techniques, the use of strip emplacement of topsoil rather than thinly spreading it and consideration of soil alternatives such as silt recovered from dams on site.

Most stakeholders acknowledged that research to address topsoil deficits was higher priority than research or guidance on how to prevent it (i.e., by best practice topsoil handling and management) because topsoil deficits are largely a legacy issue. However, one stakeholder noted that there is still ambiguity around topsoil stockpile heights and that could be a low priority research item for consideration in the future.

Research plan

The Office of the Queensland Mine Rehabilitation Commissioner is currently developing guidance relating to best practice soil management approaches that will inform rehabilitation planning. This includes best practice soil sampling regimes (sampling intensity, appropriate indicators, methods) to characterise the physical and chemical characteristics of soil and support rehabilitation planning, as well as best management approaches that can be employed to improve soil physicochemical properties. Future research will focus on reviewing and consolidating soil biology concepts to highlight opportunities for the industry to address topsoil deficits via biological amendments and/or stimulating biological processes *in situ*. Research into opportunities for rehabilitation in the absence of topsoil will also be undertaken.

References

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