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Biocrust re-establishment trials demonstrate beneficial prospects for mine site rehabilitation in semi-arid landscapes of Australia

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Biocrusts live at the interface between the atmosphere and the soil; powered by photosynthesis they strongly influence a range of soil micro-processes. At Jacinth-Ambrosia mine site, on the edge of the Nullarbor Plain (South Australia), biocrusts are a significant component of the semi-arid soil ecosystem and comprised mainly of cyanobacteria, lichens and mosses. Cyanobacteria directly contribute to soil surface stabilisation, regulation of soil moisture and, provide a biogeochemical pathway for carbon and nitrogen fertilisation. Following disturbance, rehabilitation processes are underpinned by early soil stabilisation that can be facilitated by physical crusts or bio-active crusts in which cyanobacteria are ideal soil surface colonisers.

Biocrust growth trials were carried out in autumn and winter (2012) to test the re-establishment phases of highly disturbed topsoil associated with mine site operations. The substrate material originated from shallow calcareous sandy loam typically found in chenopod shrublands. The biocrust-rich substrates (1–5 cm) were crushed (biocrush) or fine sieved followed by an application of concentrated cyanobacterial inoculum. Each treatment comprised four replicated plots that were natural or moisture assisted (using subsurface mats). After initial saturation equal amounts of water were applied for 30 days at which time half of all of the plots were enclosed with plastic to increase humidity. From 30–60 days water was added as required and from 60–180 days all treatments were uncovered and subjected periodic wet-dry cycles.

At 180 days diverse biocrusts had re-established across the majority of the treatments, incorporating a mix of cyanobacterial functional groups that were adapted to surface and subsurface habitats. There were no clear trends in diversity and abundance. Overall, the moisture assisted biocrush and sieved biocrush appeared to have 80% cyanobacterial diversity in common. Differences were found between the surface and subsurface cyanobacterial genera in the moisture assisted trials across both treatments.

The biocrush and sieved biocrush treatments had all increased in cover between 14–30 days. During 30–60 days the enclosed inoculated biocrush doubled its cover and the sieved inoculated biocrush increased by $\sim$110%. All of the open treatments decreased in cover between 30–60 days. Cyanobacteria biomass (chlorophyll a) trended similarly across all regrowth trial plots for the first 60 days, with a reduction in biomass after the first 30 days followed by increases at 60 days. There was a reduction in biomass (compared to 60 days) across most of the growth plots following the dry phase (120–180 days). Mean photosynthetic yield (YII) at the conclusion of trials were significantly different for the biocrush plots compared to the moisture assisted biocrush. This contrasted to the mean YII for the sieved biocrush that were generally lower. Across all treatments pH was within the normal site range while EC values were marginally lower. At the conclusion of the trials the majority of the treatments had increased in total C and N. The compressive strength of the regrown biocrusts differed significantly between all the open and sieved biocrush treatments compared to their enclosed counterparts. The open sieved biocrush had the lowest strength of all treatments.

Biocrust re-establishment during mining rehabilitation relies on the role of cyanobacteria as a means of early soil stabilisation. Provided there is adequate cyanobacterial inoculum in the topsoil their growth and the subsequent crust formation should take place largely unassisted. Growth trials however, showed on a small scale, that accelerated biocrust recovery could be achieved with inoculation and additional moisture.