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The use of soil quality indicators to assess soil functionality in restored semi-arid ecosystems

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Introduction

Semi-arid and arid environments are highly vulnerable to land degradation and their restoration has commonly showed low rates of success (James et al., 2013). A systematic knowledge of soil functionality is critical to successful restoration of degraded ecosystems since approximately 80% of ecosystem services can be connected to soil functions. The assessment of soil functionality generally involves the evaluation of soil properties and processes as they relate to the ability of soil to function effectively as a component of a healthy ecosystem (Costantini et al., 2015) Using soil quality indicators may be a valuable approach to assess functionality of topsoil and novel substrates used in restoration (Muñoz-Rojas et al., 2014; 2015). A key soil chemical indicator is soil organic C, that has been widely used as an attribute of soil quality because of the many functions that it provides and supports (Willaarts et al., 2015). However, microbial indicators can be more sensitive to disturbances and could be a valuable addition in soil assessment studies in restoration programs. Here, we propose a set of soil quality indicators to assess the soil status in restored soils (topsoil and waste material) of semi-arid environments. The study was conducted during March 2015 in the Pilbara biogeographical region (northwestern Australia) at an iron ore mine site rehabilitated in 2011.

Methods

Soil samples were collected from two sub-areas with different soil materials used as growth media: topsoil retrieved from nearby stockpiles and a lateritic waste material utilised for its erosive stability and physical competence. An undisturbed natural shrub-grassland ecosystem dominated by Triodia spp. and Acacia spp. representative of the restored area was selected as the analogue reference site. Soil physicochemical analysis were undertaken according to standard methods. Soil microbial activity was measured with the 1-day CO_2 test, a cost-effective and rapid method to determine soil microbial respiration rate based on the measurement of the CO_2 burst produced after moistening dry soil (Muñoz-Rojas et al., 2016). Soil microbial abundance of specific groups was measured by phospholipid fatty acid analysis.

Results and discussion

We showed that in addition to organic C and C:N ratio, biological indicators (microbial diversity and activity in particular), are the most sensitive indicators to detect differences among reconstructed soils and analogue undisturbed soils in semi-arid areas. The 1-day CO_2 test is an alternative cost- and time-effective method to measure microbial activity and assess soil functionality of restored soils. Our results also showed a positive effect of vegetation on reconstructed soils and a recovery of soil functionality in waste material to levels similar to topsoil once vegetation is established, although soil quality levels are still far from those in undisturbed native soils four years post-restoration. Soil functionality is critical in the restoration process, particularly in semi-arid areas, and the methods used here could be effectively applied in a broad range of restoration projects in arid and semi-arid environments.

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