Geochemical indicators and characterization of soil water repellency in three dominant ecosystems of Western Australia

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Introduction

Soil water repellency (SWR) has critical implications for restoration of vegetation in degraded areas as it is responsible of poor plant establishment and a high incidence of erosion processes. Different organic substances are capable of inducing SWR. Polar molecules such as certain fatty acids, and waxes (eg, esters and salts of fatty acids) are the main constituents of hydrophobic coatings on soil mineral particles (Doerr et al., 2005). Plant species most commonly associated with SWR are evergreen trees with a considerable amount of resins, waxes or aromatic oils such as eucalypts and pines. Most of these substances are abundant in ecosystems and are released to soil by plants as root exudates or decaying organic debris, and by soil fauna, fungi and other microorganisms, but a thorough knowledge of substances capable of inducing hydrophobicity in soils is still not complete (Jordán et al., 2013).

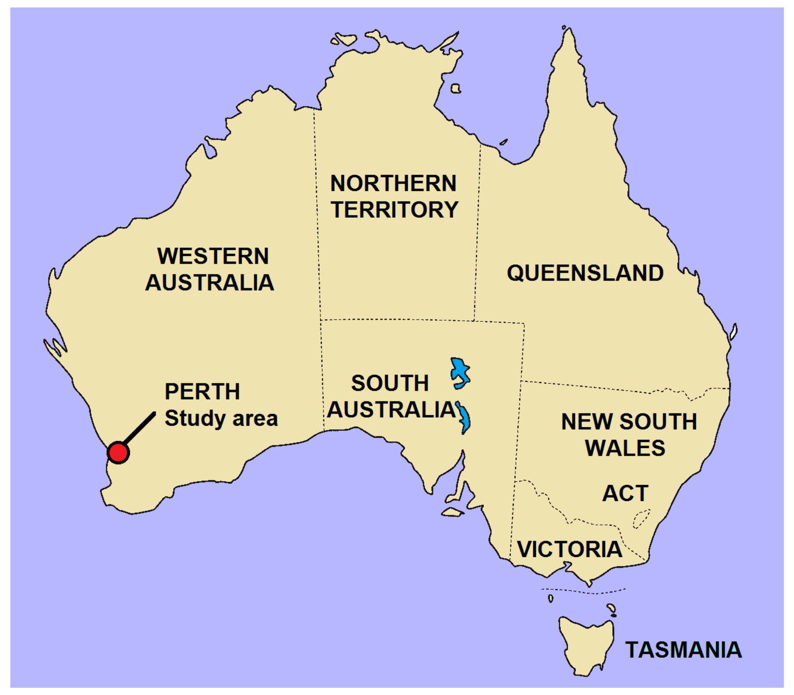

Figure 1. Aproximate distribution of banksia species in Western Australia and study area.

Although SWR has been reported worldwide in different soil types, and under different climate conditions and land uses, there are still many research gaps in this area, particularly in semi-arid areas. The objective of this work is to identify geochemical indicators of SWR in three dominant ecosystems of Western Australia: costal dunes, banksia woodlands, eucalypt woodlands and semi-arid grasslands.

Methods

This research was conducted in three dominant ecosystems of Western Australia (WA), e.g. semi-arid grassland in the Pilbara region (North WA), banksia woodland, and a coastal dune area (both located in South WA) (Figure 1). These environments have different climate characteristics and soil types but similar vegetation communities (Figure 2). Soil samples were collected under the canopy of a broad range of plant species that compose the dominant vegetation communities of these ecosystems, and SWR was measured under lab conditions in oven-dry samples (48 h, 105 ºC). 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 pH and electrical conductivity (EC) were determined in deionised water (1:2.5 and 1:5 w/v, respectively). The structural characterization of soil organic matter (SOM) was analysed by direct analytical pyrolysis (Py-GC/MS) performed at 500 ºC (González-Vila et al., 2009). Only chromatogram peaks with an area higher than 0.2 % were identified and used to obtain the relative abundance of main chemical families in each vegetation cover (Figure 3).

Figure 2. General view of shrubland in one of the study areas (left) and a detail of water-repellent soil aggregates formed by banksia root clusters (right).

Figure 3. Py-GC/MS equipment.

Results

Our results show that soil water repellency is poorly correlated with microbial activity and moderately correlated with pH and electrical conductivity. After Py-GC/MS analysis, soil organic matter in the Banksia woodland and the coastal dune showed a high heterogeneity (Fig. 4). In the Banksia woodland two different patterns were observed. Samples under Banksia spp. showed a SOM with clear signs of alteration (humified) that included a high contribution of stable families like unspecific aromatic compounds and alkane/alkene pairs whereas under Eucalyptus spp. showed a less altered SOM with a high relative contribution from lignocellulose (lignin and carbohydrates), together with a low relative content of recalcitrant families. However in the soil samples from coastal dunes a very similar SOM chemical composition was found in all cases. The dominant family was unspecific aromatic compounds (>30%), followed by alkane/alkene pairs and a high relative contribution from N bearing peptide compounds. This, together with a low relative amount of carbohydrate and lignin derived (methoxyphenols) compounds points to a SOM that undergoes great alteration processes, possible because of high turn-over rates. Very low contents of SOM were found in the Pilbara system, under Py-GC/MS detection levels, and therefore it was not possible to establish its chemical composition. A principal components analysis (PCA) axes based on the relative abundances of chemical families of compounds released after SOM pyrolysis (70.9 % of total variation explained in the two first axes Fig. 5) indicate that water repellence is closely related with fatty acids and the presence of short chain hydrocarbons.

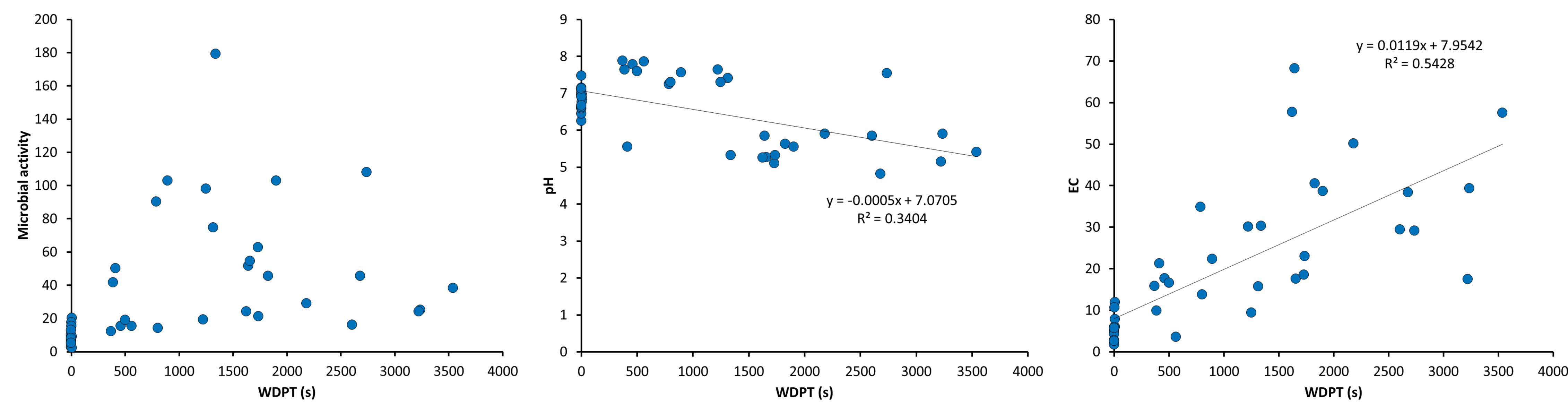

Figure 4. Linear relation between microbial activity (qCO_2), pH and EC (dS/m) and soil water repellency (WDPT, s).

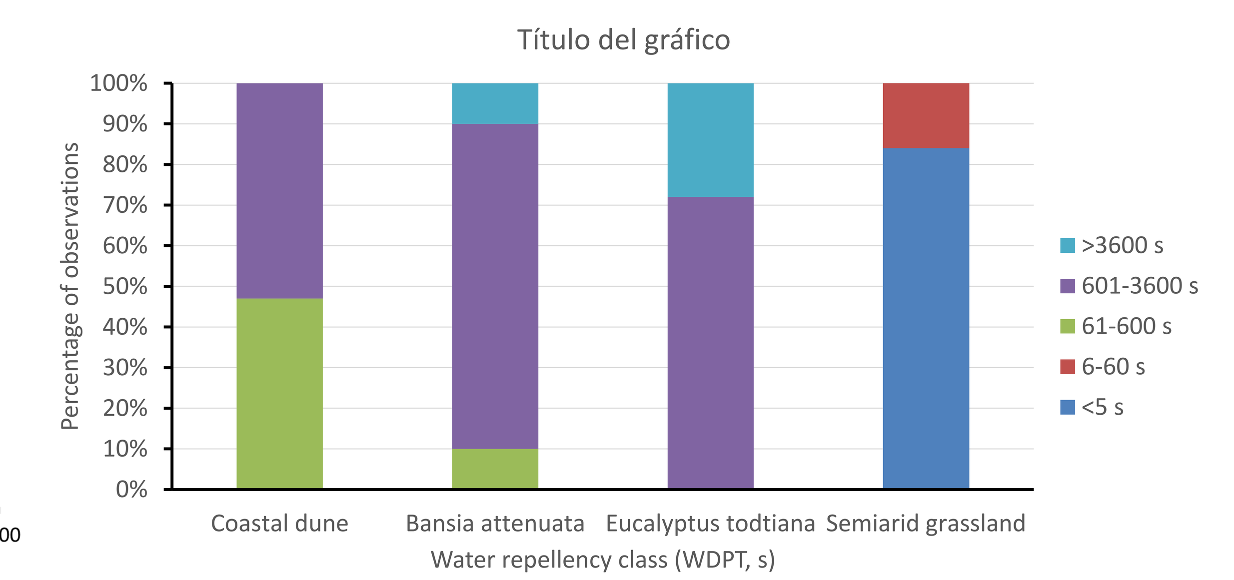

Figure 5. Soil water repellency below different plant species and communities.

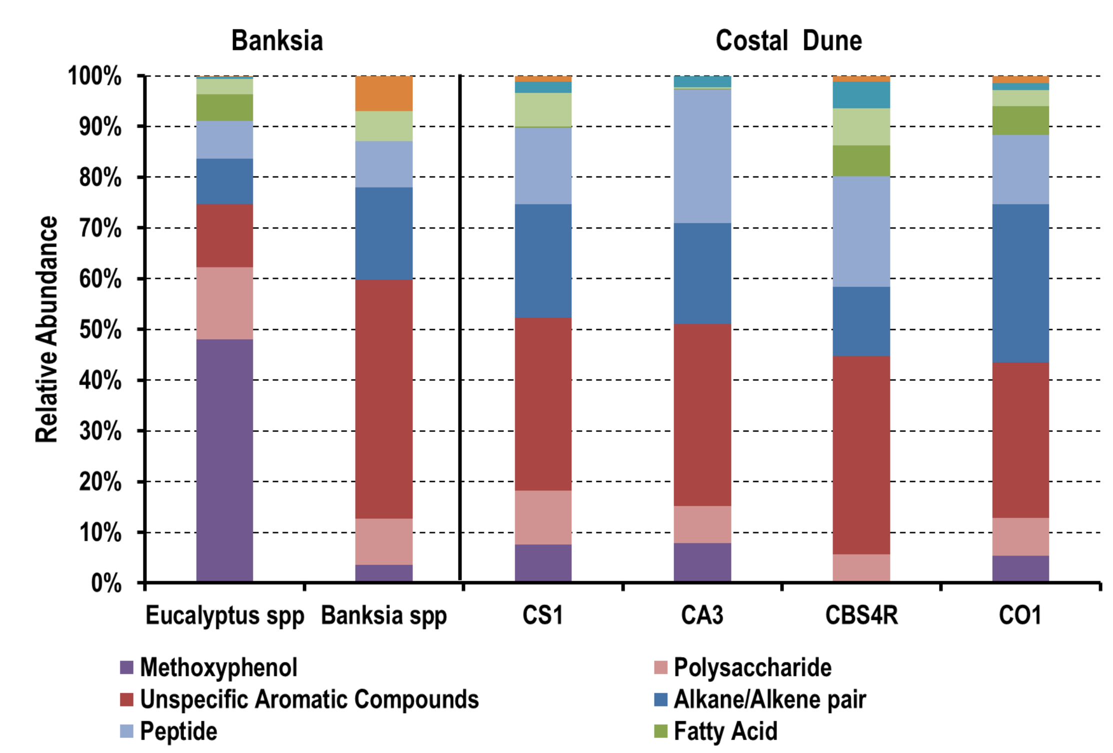

Figure 6. Relative percentage of the main chemical families identified by Py/GC/MS from Banksia and Costal Dune.

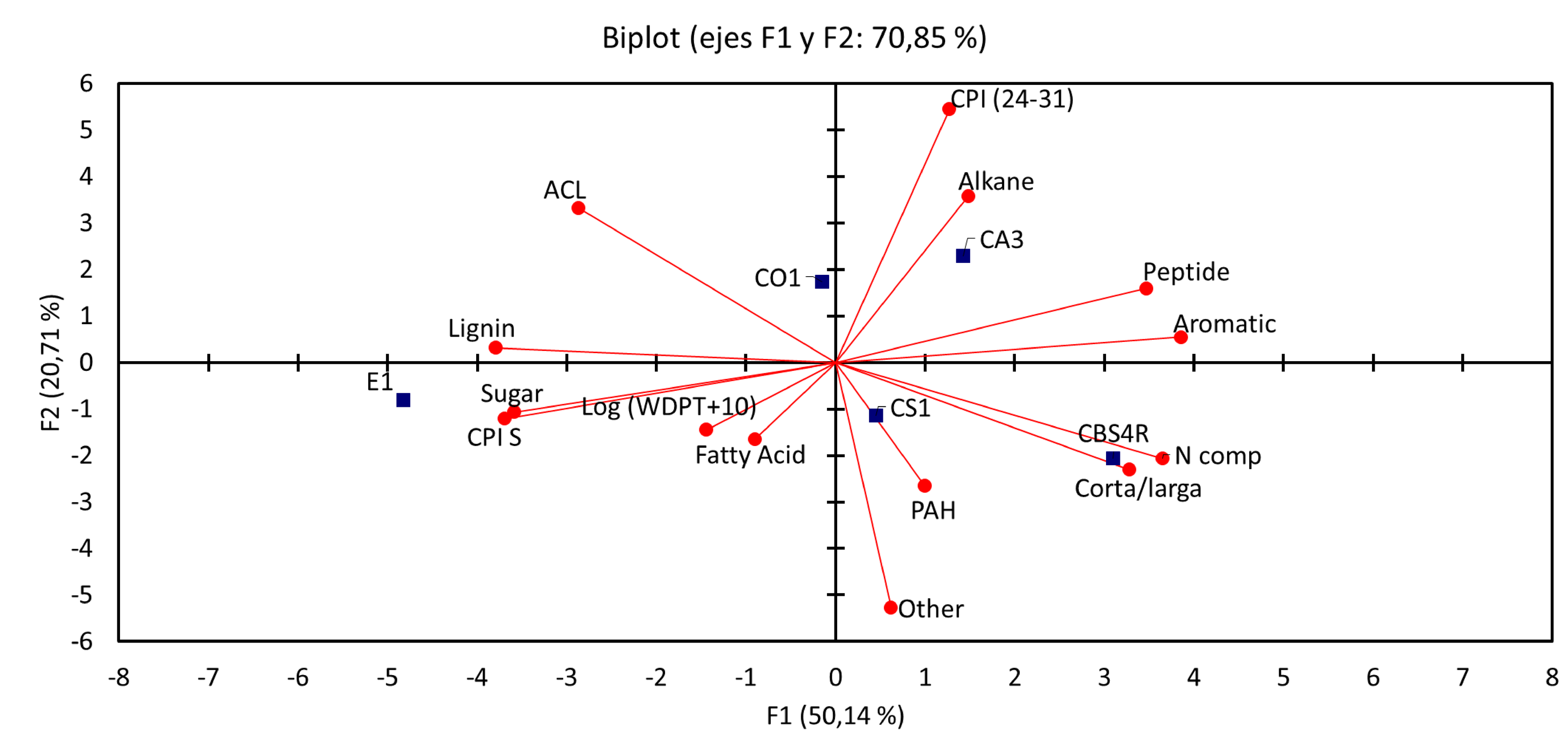

Figure 7. Results of the PCA.

References. All cited references are included in Muñoz-Rojas et al. 2016. Vegetation-induced soil water repellency as a strategy in arid ecosystems. A geochemical approach in Banksia woodlands (SW Australia). Geophysical Research Abstracts, Vol. 18, EGU2016-11368.

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