Arid Soils Microbial Enzymatic Activity Profile As Affected By Geographical Location And Soil Degradation Status

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Abstract

Assessment of changes in soil health status is critical for quantifying the impact of any land remediation effort. Minimal carbon, low water content, and limited nutrient availability, common stresses in arid lands, lead to restricted and seasonal microbial activity. This challenges soil health and vegetation restoration efforts. In the present study, we evaluated the total-soil catabolic activity profiles for two distinct arid zone locations, one in the Northern Chihuahuan (NC) desert and a second one on tablelands in the Arizona/New Mexico Plateau (ANMP). At the latter site we targeted undisturbed areas as well as heavy metal contaminated lands remediated after surface coal mining. Carbon use activity profiles were estimated via substrate induced respiration for total soil samples using the MicroResp® system. Results indicate that in general the NC samples exhibited more complex catabolic activity profiles than the non-disturbed ANMP samples. Comparison of rhizosphere and non-rhizosphere soils indicated divergence in catabolic activity profiles was more obvious for the remediated areas than for the native non-disturbed areas. Findings suggest gradients in catabolic activity profiles from rhizosphere to non-rhizosphere locations may possibly be used to assess the rate and status of remediation of such lands. Thus, for arid lands, microbial catabolic activity profiling may be used to evaluate 1) the significance of local climatic and edaphic conditions on metabolic range of the soil microbial activity and 2) the health status of degraded or remediated arid region soils.

Hypothesis

Microbial catabolic profiles in arid soils are sensitive to relatively minor climatic variations and also to changes in soils' physico-chemical parameters induced by human activities.

Objective

The project compared microbial activity profiles in two arid locations in New Mexico: the Northern Chihuahuan desert (Jornada Experimental Range) and the tablelands in the Arizona/New Mexico Plateau (Farmington, NM area). The MicroResp® system was used to evaluate soil enzymatic activity of rhizosphere and non-rhizosphere soils, as influenced by disturbance, soil depth and distance from plants.

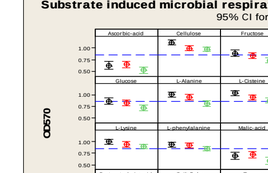
Methods

Sampling

Soil sampling was conducted at the end of November 2009 from three undisturbed sites at the Jornada Experimental Range (32° 29′ N 106° 42′ W) and from the Farmington, NM area (36° 45′ N 108° 11′ W) where we targeted undisturbed areas and lands remediated following surface coal mining. All soils were sandy-loams. Each sampling site was centered around a four-wing saltbush (*Atriplex* spp) plant and the immediately surrounding area. At each site, two types of soil samples were collected, rhizosphere (root) and non-rhizosphere soil. Non-rhizosphere soils were sampled, along three transects per site, at 30 cm and at 60cm from the central *Atriplex* plant. The topsoil crust (0.5cm), the 0.5cm to 5cm, and the 5cm to 25cm layers were collected at each sampling point on the transects. Rhizosphere soil (soil loosely adhering to roots) was collected for each plant species within the 60cm radius of the central *Atriplex* shrub. All soils were stored at 4º C until used. Soils' moisture content at sampling was very low, under the wilting point, and thus little to no microbial activity was expected during storage.

Catabolic activity profiles

For each soil sample the respiration due to microbial activity was measured using the microtitre-plate based respiration system, MicroResp® (Figure 1). Each microtitre well received an equal amount of soil (about 0.3g) supplemented with sole carbon sources (sugars, amino acids, carboxylic acids or fatty acids) and water to the soil's field capacity equivalent. Each well was covered by a perforated seal that only allowed transfer between the well and the respective indicator well above it. Each indicator well contained a calibrated volume of cresol red and bicarbonate in an inert agar base. The soil mix was incubated for up to six hours at 25º C. Respired CO_2 was evaluated by measuring the changes in the color of an indicator dye (cresol red) as pH changed following CO_2 reaction with the bicarbonate.

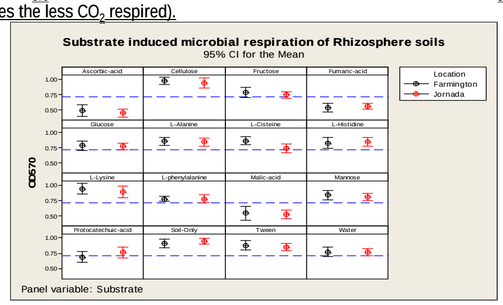


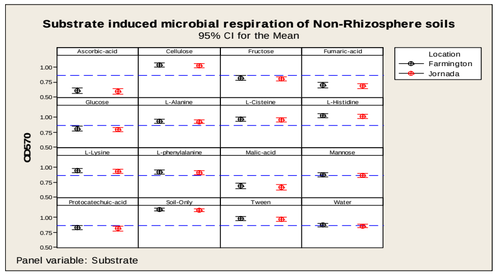
The MicroResp™ system consists of a 96-well "Deepwell" plate in which soil samples amended with various substrates are placed. The plate is separated from a 96 well microtiter plate containing a colorimetric CO2 detection gel by a PTFE lined porus rubber seal. The Secured system is incubated at 25° C for 6 hours before reading at 570nm.

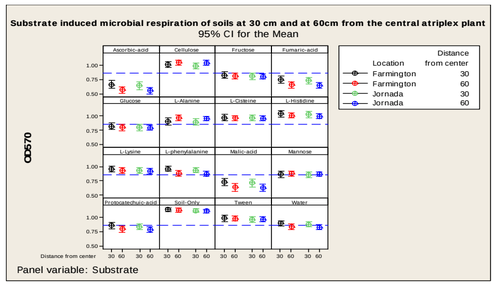
Results

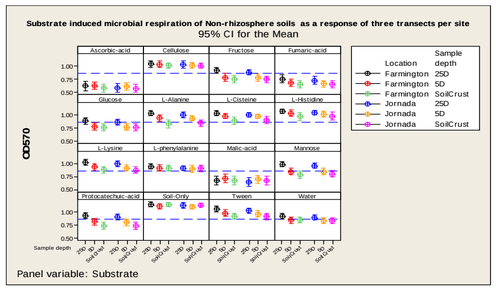
CO2 Respiration Rates

Note: OD_{570} results are inversely related to respiration (i.e. the larger the OD_{570} values the less CO_2 respired).

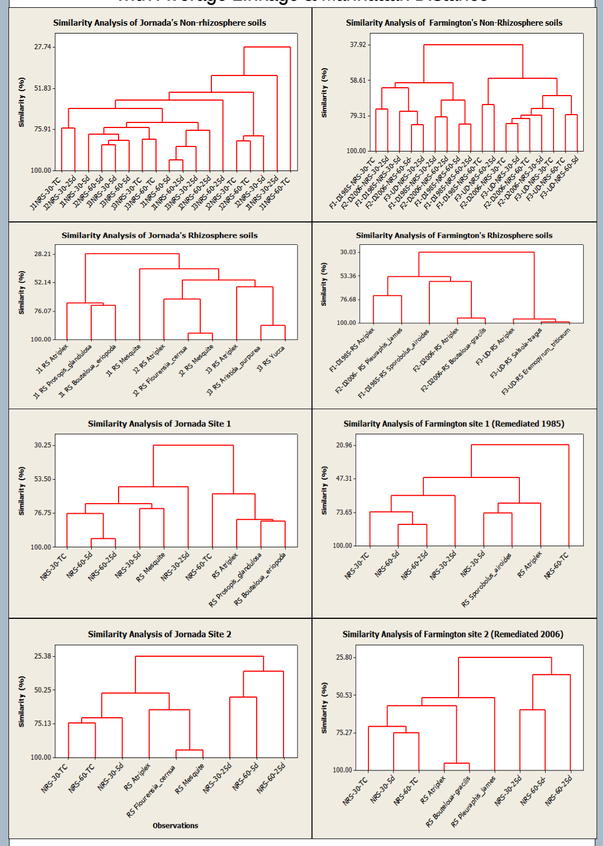


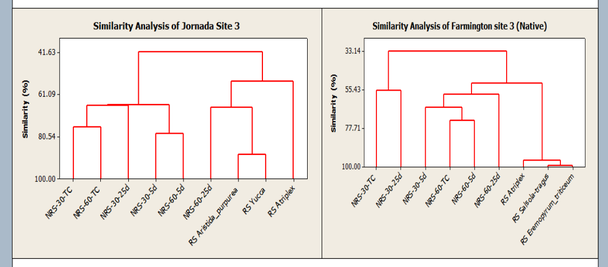






Similarity Analysis Dendrograms with Average Linkage & Manhattan Distance





Site designation labels for the Similarity Analysis Dendrograms include abbreviated descriptors separated by hyphens. Abbreviations specify:

- *Location* (F = Farmington, J = Jornada)
- *Disturbance Regime* (UD = native or undisturbed, D_year = Disturbed_year remediated)
- *Sampling zone* (RS = Rhizosphere, NRS = non-rhizosphere)
- *Depth* (TC =top soil crust, 5D = below TC to 5cm, 25D = > 5 – 25 cm).
- *Plant species* (Genus only or genus and species separated by underscore.)

Summary

❑ Various carbon sources induced responses in microbial activity regardless of rhizosphere status of the soil.

❑ In general, there were no significant differences in the overall complexity of catabolic activity profiles between Northern Chihuahuan desert (Jornada) and Arizona/New Mexico Plateau (Farmington) samples.

❑ Microbial catabolic activity of soils taken at the two distances away from the plant at the center of the sampling unit was not significantly different.

❑ The divergence in enzymatic activity from from the plant at the center of the sampling unit was greater for the top soils/crust than for the deep ones.

❑ Catabolic activity profile divergence between the R and NRS soils was generally greater for native undisturbed areas than for the remediated areas

❑ Catabolic activity profiling showed high intra-site similarity and lower inter-site similarity

❑ Clustering of the Farmington samples indicates that soil disturbance caused by remediation of surface coal mining areas has long-term effects on the soil microbial activity.

❑ While more recently remediated soils (4 years) had uniformly lower microbial activity than the older remediated soils (25 years) the differences were minimal indicating that restoring degraded arid land soils occurs at a very slow pace

Acknowledgment

We are thankful to the International Arid Lands Consortium and the US-Department of Agriculture for their financial support of this project. Our special thanks to Lori Kae Schwab, Jesus Sigala and Helena Deswood for their technical support.

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