ASSESSING THE IMPACT OF FIRE USING SOIL AND PYROLYSIS-GC-MS

bushfire&natural HAZARDSCRC

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SOIL ORGANIC MATTER HAS STRONG EFFECTS ON SOIL PROPERTIES SUCH AS WATER HOLDING CAPACITY, SOIL STRUCTURE AND STABILITY, NUTRIENT AVAILABILITY AND CATION EXCHANGE CAPACITY. BUSHFIRE CAN CHANGE THESE PROPERTIES DEPENDING ON INTENSITY AND DURATION OF HEATING. PYROLYSIS COUPLED TO GAS CHROMATOGRAPHY-MASS SPECTROMETRY (PYR-GC-MS) IS A NOVEL TECHNIQUE THAT CAN BEEN USED FOR SOIL CHARACTERISATION.

BACKGROUND

Soil organic matter (SOM) is a complex, heterogeneous mixture of organic materials derived from plants and animals at different stages of decomposition and degree of association with the soil mineral matrix (Buurman and Roscoe 2011). SOM is a major terrestrial carbon pool and an essential component of the global carbon cycle (Eglin et al. 2010). Precise characterisation of SOM is necessary to determine the mechanisms involved in its stabilisation and predict its dynamics to be able to provide recommendations for improving soil management. Fire affects the carbon balance of terrestrial biomes through the consumption of fuel (Urbanski et al. 2009) and by modifying and redistributing carbon stocks in the soil (Possell et al. 2015). Pyr-GC-MS is a powerful analytical tool of SOM but it generates large amounts of information which does not allow fast, high throughput data analysis. This hinders our ability to identify compounds in SOM that could be useful for predicting its characteristics.

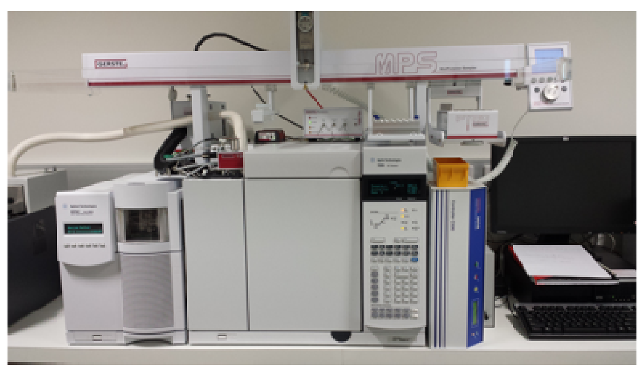
AIM

- To investigate the possibility for rapid and simple identification of differences among pyr-GC-MS data of soil from burnt and unburnt areas.
- To develop a quantitative measure of fire impact (intensity or severity) on soil.

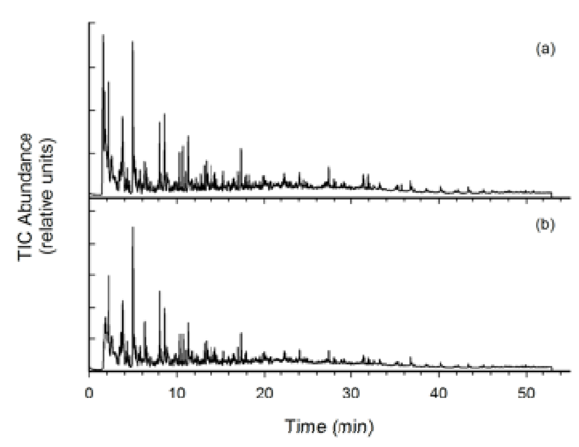
SITES

Four sites were identified within prescribed burns conducted in 2015 in the Australian Capital Territory, Australia. Sites were classified as low woodland and tall open forest dominated by several species of eucalypts. Soils at all sites are categorised as Kurosols according to the Australian Soil Classification (Isbell 2016).

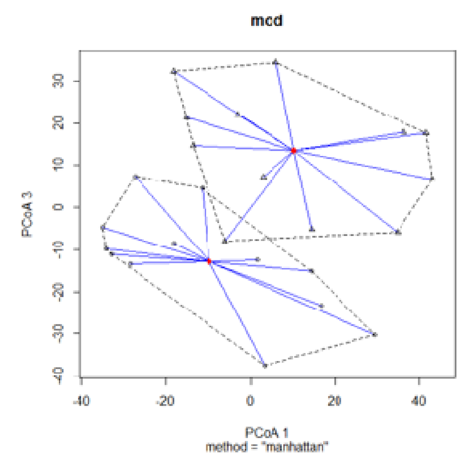
METHODS AND RESULTS



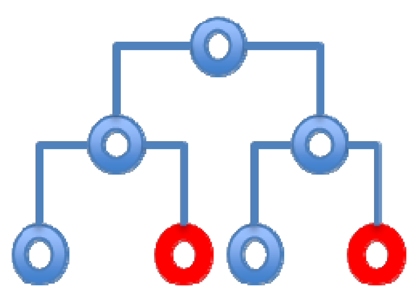
1. Pyrolysis GC-MS



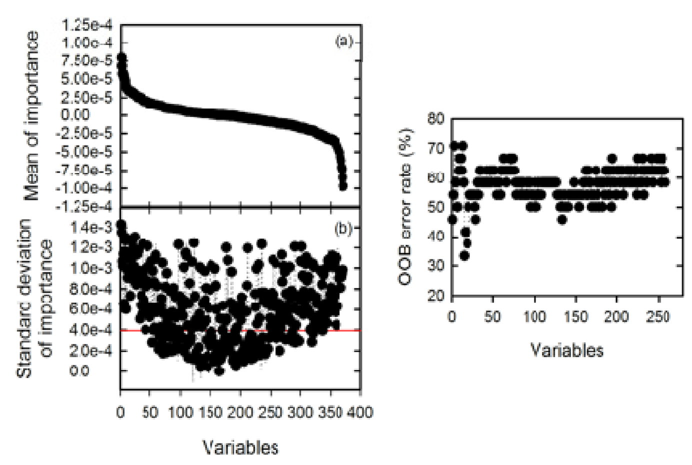
2. Generation of mass-spectral data



3. Cluster analysis and pMANOVA



4. Ensemble learning method



5. Isolating important classifiers

Cluster ID	Importance ($\times 10^{-5}$)	Compound name
117	7.9578	1-methyl-4-(1-methylethyl)-2,3-Dioxabicyclo[2.2.2]oct-5-ene
26	6.7576	Ethylbenzene
29	5.7148	Methylenecyclooctane
43	5.6922	(Z,Z,Z)-9,12,15-Octadecatrienoic acid

6. Identifying important compounds

- Pyrolysis-GC-MS of soil from burnt and unburnt plots produced chromatograms containing up to 388 peaks (Figs. 1 & 2).
- Unsupervised data mining using the clustering method of MSeasy (Nicole et al. 2012) identified ~400 distinct compounds.
- Multivariate analysis of variance, showed that there were significant differences in the pyrolysate generated from those soils (Fig. 3).
- Prescribed burning accounted for about one-seventh of the difference between soil from burnt and unburnt plots.
- An ensemble machine learning method (Random Forests) identified 15 candidate compounds that could distinguish between the burnt and unburnt soils (Figs. 4 & 5).
- Candidate compounds were identified using a mass-spectral database (Fig. 6).

SUMMARY

Pyr-GC-MS was able to distinguish between soils from the burnt and unburnt areas without time-consuming or complex sample preparation (e.g. solvent extraction or acid digestion). Only 15 compounds needed to be analysed to identify burnt and unburnt soils. Hence, pyr-GC-MS can be optimised to be a sensitive and relatively quick technique for this characterisation process.

END USER STATEMENT

Felipe Aires, Fire and Incident Management, Office of Environment and Heritage, NSW

The complexity of SOM makes methodologies for identifying its components expensive and time consuming. This study demonstrates the potential of a rapid automated method to identify compounds important in characterising soil from burnt or unburnt areas. Future work will focus on producing operational products capable of using this technology to assess post-fire severity and intensity, and its impacts on soil carbon.

REFERENCES

Buurman & Roscoe (2011) *European Journal of Soil Science* 62, 253–266; Eglin et al. (2010) *Tellus Series B-Chemical and Physical Meteorology* 62, 700–718; Isbell (2016) The Australian Soil Classification, CSIRO Publishing; Nicole et al. (2012) *Bioinformatics* 28, 2278-2280. Possell et al. (2015) *Biogeosciences* 12, 257–268; Urbanski et al. (2009) Wildland Fires and Air Pollution, Developments in Environmental Science Volume 8, Elsevier BV

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