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Cannabis Origin Determination
Using Plant and Soil Elemental Profiles

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A thesis submitted in partial fulfilment of the requirements for the degree of
Master of Science in Forensic Science,
The University of Auckland, 2000
Abstract

Forensic laboratories examining *Cannabis* may be asked to determine if a sample is from a particular geographical location. They may also be asked to determine if two separate seizures of cannabis were once part of one larger sample. A variety of methods have been published for investigating these two related origin determination questions. This thesis presents an examination of the elemental profiles of cannabis plant material and the soil the plants were grown on, as a method for origin determination.

*Cannabis* plants were cultivated on three different soil profiles under controlled conditions. Plant samples, harvested at various stages of growth, were subjected to a nitric acid digestion procedure developed specifically for this investigation. The soil samples were extracted with dilute acetic acid to determine the plant available concentration of soil elements. Both the plant and soil samples were analysed on a HP 4500 Inductively Coupled Plasma-Mass Spectrometer (ICP-MS) operated in the semiquant mode. Fifty-eight different elements were quantified in every sample. Plant and soil samples were also subjected to total element analysis methods.

A high level of precision was achieved for both the plant and soil analysis procedures. The accuracy of the plant digestion process was determined with the analysis of a standard reference material and showed good agreement with certified and recommended values. The accuracy of the soil extraction method was not determined, as a reference soil extraction sample was not available.

From the comparison of plant results it was possible to conclude that plants grown on the same soil display the same element profile. This was true for plants of different sex and plants material harvested at different stages of development all from the same soil. In addition to this, plants from different soils had different elemental profiles. Twenty-two elements were identified as being significantly different between plants from different soils with the ANOVA univariate statistical test. These differences lead to clear group separation when samples were analysed with the canonical discriminant analysis multivariate statistical test.
The comparison of plant concentrations and extracted soil elements identified a limited number of positive correlations between plants and the soil they were grown on. These results indicate that a relationship does exist between Cannabis plants and the soil it was grown, however the acetic acid soil extracted process does not precisely represent the elements absorbed by Cannabis.

The elemental method for the origin determination of cannabis presented in this thesis answered one of the two questions posed. It was possible to identify cannabis plants that had been grown on the same soils and to separate plants from different soils. However, using the correlation between plant elements and extracted soil elements it would not be possible to offer strong conclusions about the relationship between a cannabis sample and possible soil origin.
Acknowledgements

A large number of people have made valuable contributions towards this thesis. Of particular importance was the guidance and support of my supervisor, Dr Gordon Miskelly. Thank you for always offering solutions to the endless stream of questions and for reading all of those drafts. I would also like to thank Dr Harry van Enckevort for suggesting the initial Cannabis origin determination question.

I am grateful to those who assisted with the preparation and analysis of samples. Thank you Dr Ann Coxon and the staff of the ESR Drugs Laboratory for assisting with the production of the cannabis crop. Thank you Dr Mark McKeage and Dr Peter Galettis for allowing me to use the ICP-MS and for assisting with the instrument set up and analysis of samples. Thank you Mr Glenn Boyes for assisting with the AAS analysis and for loaning glassware and other equipment. Thank you Mr Lawrence Pickston for performing the ICP-MS analysis of total digested plant and soil samples. Thank you Mr John Wilmshurst for performing the XRF analysis of the soil samples.

I also wish to thank Monique McKenzie and Carl Donovan for helping me to come to grips with the statistical interpretation of my data.

Finally a special thanks goes my friends and my family. In particular Sally, Mum, Dad, Cameron, Amanda and Clayton. Thank you for all your love and support. Without you this would not have been possible.
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Glossary of Terms and Abbreviations

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<tr>
<td>AAS</td>
<td>Atomic absorption analysis</td>
</tr>
<tr>
<td>Cannabinoid</td>
<td>Group of chemical compounds found exclusively in <em>Cannabis</em></td>
</tr>
<tr>
<td>CBD</td>
<td>Cannabidiol. Cannabinoid chemical found in <em>Cannabis</em></td>
</tr>
<tr>
<td>CBN</td>
<td>Cannabinol. Cannabinoid chemical found in <em>Cannabis</em></td>
</tr>
<tr>
<td>CEC</td>
<td>Cation exchange capacity</td>
</tr>
<tr>
<td>Dioecious</td>
<td>A plant with male and female flowers on separate plants</td>
</tr>
<tr>
<td>HNO₃</td>
<td>Nitric acid</td>
</tr>
<tr>
<td>ICP-MS</td>
<td>Inductively Coupled Plasma-Mass Spectrometry</td>
</tr>
<tr>
<td>LA-ICP-MS</td>
<td>Laser ablation-inductively coupled plasma-mass spectrometry</td>
</tr>
<tr>
<td>m/z</td>
<td>Mass to charge ratio. Used to separate ions for ICP-MS analysis</td>
</tr>
<tr>
<td>Monoecious</td>
<td>A plant with male and female flowers on the same plants</td>
</tr>
<tr>
<td>NAA</td>
<td>Neutron activation analysis</td>
</tr>
<tr>
<td>ppb</td>
<td>Parts per billion</td>
</tr>
<tr>
<td>REE</td>
<td>Rare earth elements. A group of 16 elements that have similar chemical</td>
</tr>
<tr>
<td></td>
<td>properties. Includes the elements from La to Lu, and Y and Sc.</td>
</tr>
<tr>
<td>THC</td>
<td>Tetrahydrocannabinol. Psychoactive cannabinoid chemical found in <em>Cannabis</em></td>
</tr>
<tr>
<td>TLC</td>
<td>Thin layer chromatography</td>
</tr>
<tr>
<td>torr</td>
<td>Pressure measurement. 1 torr = 1/760 atmosphere</td>
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<tr>
<td>XRF</td>
<td>X-ray fluorescence analysis</td>
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<tr>
<td>μg</td>
<td>1 x 10^-6 grams (one millionth of a gram)</td>
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