SOIL TOTAL NUTRIENTS: ANALYSIS & INTERPRETATION

N.B. This technical note refers to elements other than Carbon and Nitrogen .Please see our Technical Note – "Assessing Soil Quality: The Organic Soil Profile" for a discussion on total Carbon and Nitrogen.

Background

Agronomic soil tests generally have been developed to try and extract the plant available fraction of a nutrient, or at least, a fraction that is strongly correlated to the plant available fraction. There has been less interest in the total levels of nutrients in the soil from an agronomic viewpoint, as they are often poorly correlated with plant availability.

Measuring soil totals also has some challenges, primarily because of the silicate minerals present. These are resistant to most acid digestions, and require more complex digestion procedures to solubilise the elements incorporated into these minerals.

To analyse for true total levels, the laboratory must either use a hydrofluoric acid digestion (which poses significant health risks to staff and is difficult to handle) or an alkaline fusion procedure (which is time consuming and expensive). There are instrumental techniques that can measure true totals, i.e. X-ray fluorescence and neutron activation analysis, but these are expensive and not widely available. True total levels tend to be performed in specialist laboratories only.

Most laboratories that undertake analyses for total levels have compromised by using conventional acid digestions (e.g. Aqua-Regia, Nitric-Perchloric acids). While they will extract virtually all of some elements, those incorporated into the refractory minerals will be under-estimated. Environmental and geochemistry (mining) laboratories often utilise these "So-Called Totals" methods because of their ease and low cost. They also rationalise that if the elements are not solubilised in hot mineral acids, then they are unlikely to be of concern for the environment, or be extractable by the mining companies, and can, in effect, be ignored.

Analytical chemists often use the terms **True Totals** and **So-called Totals** to differentiate between these two types of totals levels. The So-called Totals are also sometimes referred to as **'Totals'** (in parentheses) or **Acid Extractable Totals**. This latter term is perhaps the more correct, but is still ambiguous, as different acids at different temperatures will extract differing amounts of the elements.

Soil total nutrient analyses at hill laboratories

Since it's formation in 1984, Hill Laboratories has undertaken a limited number of soil total analyses. Initially, the Nitric-Perchloric acid digestion[1] was used, as this was the digestion also being used for totals in plant material and foods. In January 2001, this was changed to an EPA Aqua Regia digest[2] based on a recently published paper and the knowledge that most geochemistry laboratories routinely used this method. It was also more environmentally friendly, and safer for laboratory personnel.

This Aqua-Regia method was further modified in January 2005, to reflect changes to US-EPA 200.2. The changes to the method were validated and while there were small differences, the variations were deemed to be within expected error and would not affect the end user

There were some interesting exceptions, i.e. Potassium, Sodium and Boron, which were markedly lower than their true totals, in all digestions used. There is evidence that these elements may be interstitially bound to the silica matrix and cannot be leached out by heating with mineral acids. The original premise still holds, that if the elements do not solubilise under these hot acidic conditions, then they can be safely ignored for environmental and agronomic considerations.

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Interpretation

Setting “medium range” levels for soil total nutrient levels presents a problem to the laboratory because a number of factors influence the levels of ‘total’ nutrients present e.g. soil type, fertiliser history, land management.

Until recently, pasture production trials “calibrated” against measured ‘total’ nutrients have not been done. However, current field trial work being carried out by AgResearch measuring pasture production in relation to ‘Total’ Sulphur allows better interpretation for this element at least. AgResearch have supplied notes to assist with interpretation of this test and these appear as an analyst note underneath the table of results. It should be noted that Sulphur (like Nitrogen) is present in the soil almost entirely in the organic form – so that the amount of plant-available sulphur mineralised is dependent on levels of organic matter, soil temperature and moisture. Please refer to Technical Note— “Laboratory Tests for Soil Sulphur in Pastoral Soils” for further information on 'Total' Sulphur.

As already noted, soil ‘totals’ do not provide information on the amount of the total nutrient level that is plant available. Soil ‘totals’ are useful, however, for comparison with plant available nutrient levels as reported in standard soil tests. This may provide information on nutrient cycles and perhaps prompt management decisions that might influence the rate that nutrients become plant available.

Table 1. Ranges representing typical levels

‘Total’ Nutrient	**mg/kg (or ppm wt/wt)**
Phosphorus	700 - 2000
Sulphur	600 - 1000
Calcium	2000-10000
Cobalt	2 - 5
Selenium	0.5 – 1.5
Molybdenum	0.3 – 1.0

Table 2. Biogro Limits for heavy metals in soils

‘Total’ Metal	**mg/kg (or ppm wt/wt)**
Arsenic	20
Cadmium	2
Chromium	150
Copper	60
Lead	100
Mercury	1
Nickel	35
Zinc	300

Conclusion

Unless one of the rigorous methods is being used, soil total levels will invariably under-estimate the True Total. However, for convenience, safety, cost and “fit for purpose”, the alternative methods provide an attractive alternative. It is Hill Laboratories’ intention to continue to use procedures based on the EPA methodology, reporting results as ‘Total’ nutrients on the analysis report.

Interpretation must take into account many factors as these tests do not relate to plant available nutrients. Rather they attempt to measure the whole pool of nutrients contained in the soil.

References

1. A.I.Vogel, "A Textbook of Quantitative Inorganic Analysis", 3rd Ed.,p 230, (1961).
2. T.D. Martin, J.T. Creed, and C.A. Brockhoff Method 200.2 “Sample preparation procedure for spectrochemical determination of total recoverable elements.” Environmental Monitoring Systems Laboratory, Office of Research and Development. US Environmental Protection Agency, Cincinnati, Ohio. Revision 2.8 (1994).
3. Biogro Standard 2009 Appendix A Residue levels in Certified products, Water, Soil and Composts.