# Determining the Value of Waste Materials as Fuel Feedstock Using CHN Microanalysis

**Traditionally, landfill has been extensively used for the disposal of many waste materials. Now that many sites are nearing capacity, pioneering methods are being employed to reduce the volume of waste. In more recent years government regulations have encouraged the re-use of wastes that are now considered a valuable commodity. Typically, wastes are treated in a Materials Recycling Facility (MRF) where materials that can be readily recycled, e.g. metals and plastics, are separated for re-use and the residual waste can then be used for Refuse Derived Fuel (RDF) or Secondary Recovered Fuel (SRF). RDF or SRF can be used as a feedstock for Energy from Waste plants incorporating a variety of technologies to recover energy and generate electricity. These technologies include incineration, gasification and pyrolysis. SRF is increasingly being used as a feedstock for cement manufacture as a replacement for conventional fossil fuels to give environmental and cost benefits.**

*"CHN microanalysis offers an invaluable analytical tool for organisations involved with identifying the most suitable waste materials to act as secondary recovered feedstock."*

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In order to assess the suitability of a waste material as a fuel a variety of parameters are tested on a wide variety of materials by MSSL. Marchwood Scientific Services Ltd is an independent laboratory based in Southampton, UK. The company has two laboratories and undertakes a wide range of contract analytical work specialising in the analysis of dioxins and associated pollutants. A large proportion of the analysis work is for companies operating in the renewable energy sector with analysis of waste and residues being regularly undertaken.

Traditionally, tests routinely undertaken to determine the value of waste as feedstock have included proximate analysis, ultimate analysis and calorific value. Other useful analytical measurements used in waste materials analysis include determination of heavy metals, halides and the Biomass content.

As with most types of chemical analysis, the sampling and preparation of the sample (in order to provide a representative sample) are of prime importance. For waste samples, once the sample size has been selected and has arrived in the laboratory the first stage is to separate any materials which cannot be ground down, such as metal cans, large stones etc. that may damage the mechanical shredding equipment used for the next stage. These types of materials are separated manually, weighed, and this data used to correct final analysis data to an "as-received" basis where required. The sample is then dried and milled to provide a sample with a particle size of a few millimetres. Sub-samples of the milled sample are then taken for analysis.

Employing the above type of approach, coupled with a carefully designed sampling protocol, minimises any risk of an unrepresentative sample being submitted for final analysis.

Key though to the determination of the value of a waste material as a potential fuel feedstock is the Carbon, Hydrogen and Nitrogen content.

The carbon concentration when measured in conjunction with the calorific value gives a measure of the energy content and therefore the usefulness of a material as a renewable energy source. The hydrogen concentration is another key parameter to be measured and is used to calculate the net calorific value of fuels.

*Figure 1: An example of a typical sample received for analysis by MSSL*

## Selecting a CHN analyser

The ability to identify waste materials with higher percentage CHN content and charge more for use of these feedstock materials as a secondary recovered fuel were the prime driving forces for investing in a CHN analyser. With an increasing number of waste samples requiring analysis of carbon, hydrogen and nitrogen, MSSL elected to purchase a Model 440 CHN analyser from Exeter Analytical, as the unique horizontal furnace design on the system allows for the removal of residues between sample runs and prevents cross contamination leading to improved data quality. This is of particular importance when analysing waste materials which typically produce a considerable amount of incompletely combusted residue after each analysis.

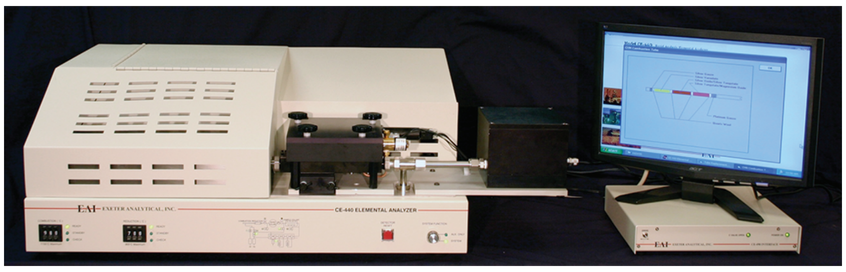

*Figure 2: Exeter Analytical Model 440 CHN analyser*

Other factors that were of importance to MSSL in choosing the Model 440 were that it used proven technology, offered the ability to handle a wide range of sample types, produce excellent quality data as well as being highly reliable and easy to use.

One concern with purchasing any analytical instrument is whether it will perform reliably and what happens if it breaks down. An advantageous feature of the service offered by Exeter Analytical is that if the analyser breaks down and the client is unable to analyse samples within the required timeframe then they will analyse samples in their own laboratory to assist. However, the reliability of our instrument has meant this service has never been utilised since installation. The staff at Exeter Analytical are very experienced in elemental analysis and are able to provide a wealth of information on the subject, plus they can offer advice on suitability for a wide range of analysis applications.

## Results & Discussion

Using an Exeter Analytical Model 440 CHN analyser, Marchwood Scientific Services has established some simple and rapid methods to determine percentage Carbon, Hydrogen and Nitrogen content in a wide variety of waste materials potentially suitable for use as a fuel. The composition of waste samples analysed and processed by Marchwood Scientific varies considerably with widely ranging CHN concentrations.

Waste materials analysed to date for their CHN content include typical household refuse, paper and cardboard, waste textiles, biomass/wood, plastics, dried sewage sludge, pyrolysis residues, poultry litter and food waste.

Each material presents its own challenges for CHN analysis as they arrive into the laboratory with widely ranging properties. The carbon content can range from a < 5% up to 70% although most materials analysed with the Model 440 unit have been in the 30-60% range. Samples can have very high moisture and/or ash contents and can have a large particle size. As the CHN analyser needs a relatively small, very finely prepared sample for introduction into the instrument a number of preparation stages were required to ensure that the result obtained is representative of the received material. The Model 440 analyser has demonstrated its capability in reproducibly analysing waste samples of 2-20mg in weight.

CHN results are often used in conjunction with other tests such as proximate analysis and calorific value to assess the suitability of a material as a fuel. The data is often used for the selective blending of materials to create an optimum fuel.

*The table below contains results from typical samples tested by MSSL. All results stated are an average of 3 runs and on a dry sample basis*

| Sample | Carbon % | Hydrogen % | Nitrogen % | Notes |
|---|---|---|---|---|
| Refuse Derived Fuel-lower energy content material | 31.4 | 3.8 | 1.4 | Samples produced from residue from a materials recycling facility to be used as fuel for a power station |
| Secondary Recovered Fuel (SRF)-higher energy content material | 48.9 | 6.3 | 2.0 | Sample is shredded waste to be used as a replacement fuel for a cement kiln |
| Mixed Waste | 39.7 | 5.0 | 1.6 | Sample is mixed waste-paper/plastics from shredding of documents. Tests were requested to assess suitability of material as a fuel |
| Carpet cut-offs | 48.3 | 6.5 | 2.1 | Manufacturer wanted to know suitability of waste materials as a fuel for an on- site boiler |
| Catering waste/plastic packaging | 41.6 | 5.7 | 2.2 | Tested on behalf of a large energy from Waste plant operator to assess suitability of material as feedstock |

## Conclusions

CHN microanalysis offers an invaluable analytical tool for organisations involved with identifying the most suitable waste materials to act as secondary recovered feedstock.

The Exeter Analytical Model 440 CHN analyser has been proven to reliably and reproducibly generate the highest quality percentage Carbon, Hydrogen and Nitrogen content data from a wide range of waste materials.

With increasing sample numbers it will at some point be necessary to purchase another instrument. We are also receiving enquiries for new applications on an ongoing basis which we hope to develop with the assistance of Exeter Analytical (www.exeteranalytical.co.uk).