Bisley Community Composting Scheme Report

Chemical analysis results of decomposition phases

Completed by: Yolande Booyse

University of Gloucestershire

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Contents

Introduction

The University of Gloucestershire was approached by a Community Composting Scheme (CCS) via a council run Waste Management Department (WMD) to assess the quality of a soil conditioner produced on site in order to compare it to the soil conditioner produced at their Waste Management Disposal Unit (WMDU).

A sample was taken on the 25th of March 2019 at the CCS site from organic waste piles consisting of green garden waste which are at various stages of decomposition. They were labelled as follows (table 1) albeit a rough estimation.

Table 1: Sample Number and Description

Sample No.	Description
1	3 - 6 months old
2	+- 6 months old
3	6 - 12 months old
4	12 - 24 months old
5	Packaged soil conditioner

These samples were then taken back to the laboratory for analyses. The parameters used were moisture content, total carbon content, pH, phosphate content, nitrogen content as well as ammonium content. Carbon dioxide (CO_2) flux rates were also calculated from the soil conditioner piles in June 2019.

In this report, soil conditioner is also referred to as compost as they are the same in composition, however legal stipulations (Wrap, 2014) are set regarding the supply of compost to the public and have to adhere to regular testing in order to comply with such regulations. However, for the purpose of this report, they are viewed as the same which is essentially soil organic matter.

Methods and Results

Moisture Content

The moisture content is a key element in the decomposition process and needs to be high enough to transport nutrients and supply microbes with both nutrients and moisture, but not so high that it reduces the supply of oxygen needed for aerobic microorganisms (Madejón *et al*., 2002). Optimum moisture content is described as between 25% and 80%, but more conventionally accepted as between 40% and 60%. Samples were oven dried at 105°C for 24 hours to measure moisture content which is described as a percentage in figure 1.

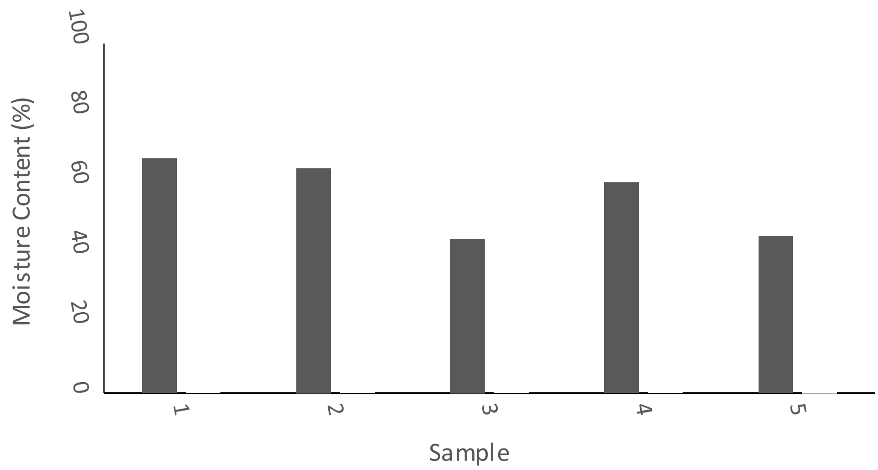

Figure 1: Moisture content of soil samples presented as a percentage.

Moisture content is at its highest (67%) at the beginning phase of the decomposition process, and at 45% at the end of the decomposition process.

Total Organic Carbon Content

Carbon acts as a form of energy for microorganisms which is obtained through soil organic matter (compost). In addition, much of the energy acquired by the plant comes from the oxidisation of carbon-containing compouds, thus establishing carbon as a key indicator of compost health. The total carbon content of the soil organic matter (SOM) can be measured through loss on ignition of combustable carbon (Bengtsson & Enell, 1986).

A loss of ignition test was conducted by way of placing a dried sample in a furnace and heating for 4 hours at 550°C. The samples were then weighed to establish total carbon loss which has been described as a percentage in figure 2.

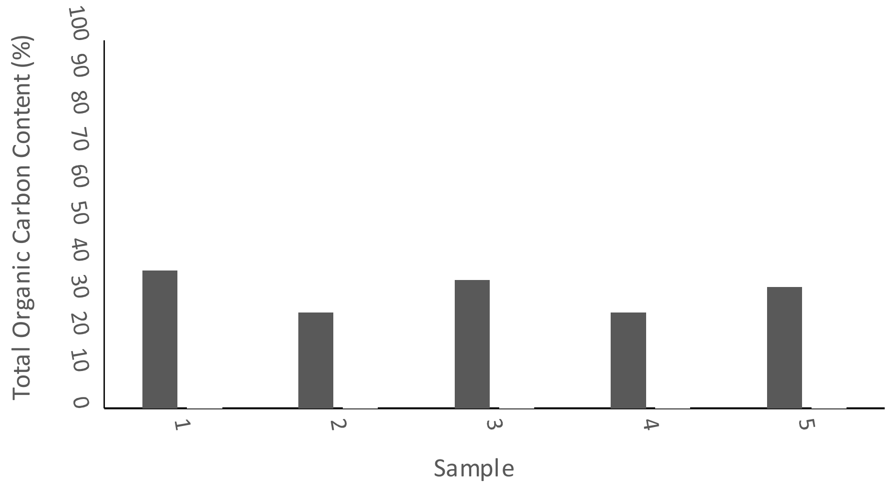

Figure 2: Total carbon content of soil samples presented as a percentage.

The total organic carbon content is fairly stable throughout the decomposition process thus intimating minimal loss to carbon content.

pH

pH is a measure of the hydrogen ion activity and indicates the acidity or alkalinity of an environment. Most plants flourish in a pH of 6 - 6.5, with expected variances depending on species. The pH measurements of all 5 samples were taken by diluting samples in Ultra Pure water, placing them on a roller for half an hour, filtrating them through a qualitative filter and taking measurements using a calibrated pH meter. The results produced varied between 6.84 and 7.61 and are depicted in figure 4 below.

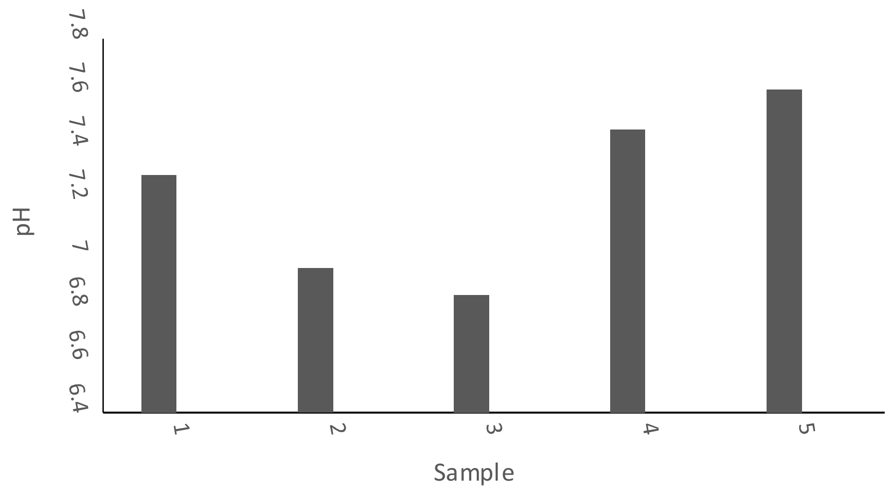

Figure 3: pH of dry weight soil samples.

The pH count in all 5 samples are high thus indicating a neutral to slightly alkaline environment (7.2 – 7.6 pH) (Division of Soil Survey, 1993).

Electrical Conductivity

Electrical conductivity is a measure of the amount of salts in the SOM thus indicating the salinity which is an important indicator of soil health. Plants are reliant on soluble salts as an essential nutrient, however excessive amounts suppress growth (Shrivastava and Kumar, 2015).

Samples were diluted in Ultra Pure water and placed on a roller for half an hour, sediments were separated by way of a qualitative filter in order to conduct a conductivity test by way of an electric conductivity meter. The results indicated a differentiation of between 13.73 mS/m and 52.80 mS/m.

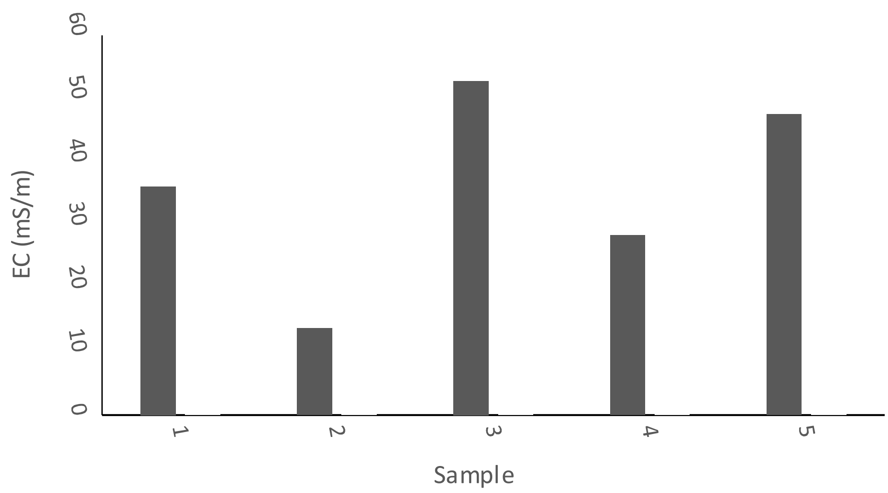

Figure 4: Electrical conductivity of soil samples measured and presented as milil Siemens per cm of dry soil.

The requirement for compost standards is for the EC reading to be below 15 milli Siemens per cm (Wrap, 2014), however no standards for EC are set for soil conditioners.

Phosphate

Phosphate is the measure of available phosphorus to plants from the soil. Phosphorus is critical to the growth of plants and is superseded only by nitrogen in list of importance. Most phosphorus in soils however are unavailable (not absorbable) to plants and is of particular concern when fertilisers are introduced to growing environments as they tend to "fixed" thus remaining unavailable (Brady, 1974).

In line with the standardised methods illustrated in Radojevic and Bashkin (2007), a calibration graph was constructed using known quantities and then used to plot the sample data with the results indicated in figure 5.

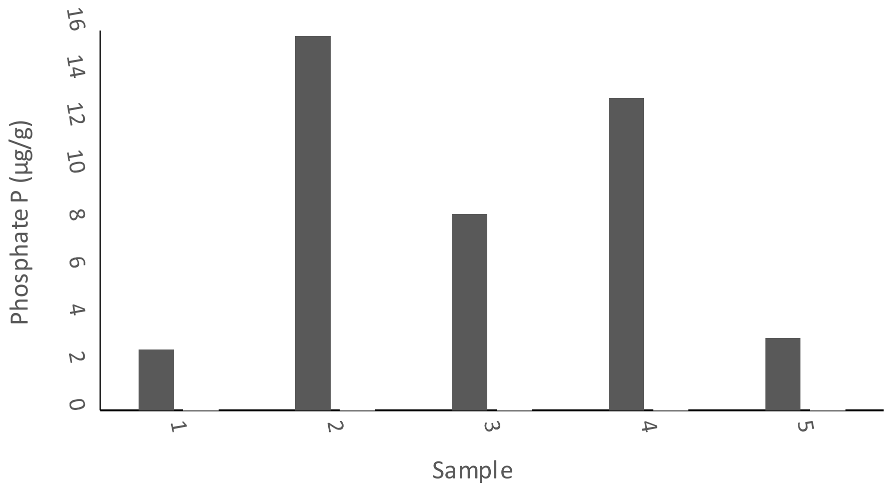

Figure 5: Phosphate readings of soil samples presented as micrograms of P per gram of dry weight soil.

No comparable data was found regarding phosphate readings, however it is stipulated in Defra's Fertiliser Manual (2010), that acceptable readings were between 3 and 3.8 (kg P2O5/t).

Ammonium

Ammonium is viewed as an essential nutrient, not because the plants absorb the ammonium but rather that the plant absorbs nitrogen in ammonium form (the N in NH_4) which is metabolised by the roots (Brady, 1974).

A standardised ammonium test (Radojevic and Bashkin, 2007), was conducted using a Palintest© and resulted in readings of between 2.8 and 6.25 mg/l of N.

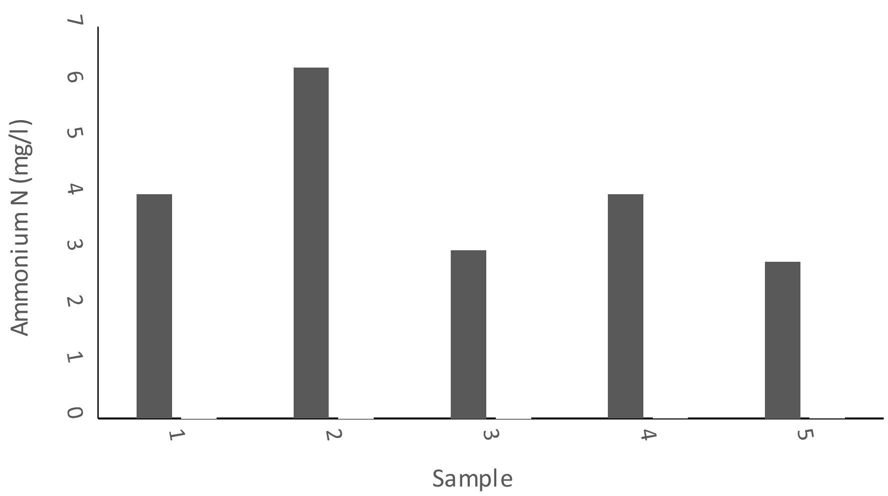

Figure 6: Ammonium N readings of soil samples presented as milligrams per litre of dry weight soil.

Carbon Dioxide Flux

CO_2 flux was measured using a Licor 8100 Survey Chamber. Values of CO_2 flux in mmol m^{-2} s^{-1} were converted to mmol g^{-1} d^{-1} using an estimated bulk density value of 0.3 g cm^{-3}. Although carbon dioxide flux was measured for all ages of compost, only values for the older 12-24 year old compost at BCCS are shown as these are the most comparable to the 10 week old commercial compost. Both the commercial compost and the BCCS compost fluxes were measured during the summer months but we have no information on temperature and rainfall during the time of measurement. These are important considerations that should not be overlooked.

Results not Determined

After several attempts, the nitrate tests were aborted thus rendering them unsuccessful. As no results were produced, I was unable to establish a C:N (carbon to nitrogen) ratio nor could I establish a NH_4:NO_3 (ammonium to nitrate) ratio.

As soil organic matter is a key composition of nutrients due to decomposition of decaying plant and animal material, it is of vital importance to the energy and nutrient supply to the soil's inhabitants in particular its carbon to nitrogen ratio. This ratio has been shown to directly affect plant growth (Charman and Murphy, 2007) and therefore an important parameter when considering compost quality. Optimal C:N ratios are considered to be between 25 and 30 to 1 (Verdonck,1997).

The NH_4:NO_3 ratio gives us an indication of the nitrification capacity of the compost. Nitrification is an important process of enzymic oxidation that takes place in order to make nitrogen available to plants. The author has been unable to locate a reliable source of accepted standards for this ratio.

Summary Findings

In general, soil properties in the BCCS Current Analysis were comparable to previous analysis of BCCS soil conditioner (Table 2). As this was a pilot study, only descriptive statistics are shown as raw data and measures of variability were not available for the commercial compost scheme. Without a measure of variability, we are unable to state whether there is a statistically significant difference in the measured properties. Even so, there are some notable differences in average values displayed in Table 2.

The BCCS compost appears to be approximately 3 times higher in organic carbon content when compared to the commercial compost. Nutrient content (nitrogen and phosphorus) contents are also higher: This supports anecdotal evidence that the BCCS compost is of a high quality that provides good plant growth. Compost pH values range from 7.61 to 8.12 for the BCCS compost and is slightly higher at pH 8.7 for the commercial compost. Optimum compost pH values are between pH 5.2 and 7.3 (Bunt 1988). Accordingly, the BCCS compost values are closer to the ideal for plant health.

Table 2: Nutrient, Physio-Chemical Properties and Stability Parameter Comparison Chart

Measure	Commercial Compost Scheme	BCCS Previous Analysis	BCCS Current Analysis
pH	8.7	8.12	7.61
EC	1.32 mS/cm	1.78 mS/cm	4.75 mS/cm
Phosphate	N/D	N/D	3.03 mg/g
Moisture Content	31.40%	54.60%	45%
Organic Carbon	8.50%	21.90%	32.95%
Nitrogen	1.09%	1.62%	N/D
Phosphorus	0.19%	0.29%	N/D
C:N Ratio	14.7	13.5	N/D
Organic Matter	14.60%	38.30%	56.67%
Ammonium	223 mg/kg	N/D	140 mg/kg
CO_2	2.8 mmol g organic matter/day	N/D	6.48 mmol g organic matter/day

Ammonium values in the current analysis were lower than that of the commercial compost. There is no data for nitrate in the current analysis, but it may be that much of this ammonium has been converted to nitrate. This view is supported by the higher nitrogen content of the BCCS compost in the previous analysis. Accordingly, plant available nitrogen (i.e. ammonium and nitrate) are likely to be comparable in both composts.

Electrical conductivity values in the current analysis are considerably higher than both previous analysis and the commercial compost scheme. The value of 4.75 mS/cm found in the current analysis is similar to values in animal waste (Khater 2015). Optimum values would be in the range of 2 – 4 mS/cm (Hanlon 2012), so samples are within the broad range of what can be expected.

CO_2 flux is relatively high at the BCCS site and is almost double that released by the commercial compost. As a comparison, these values are slightly lower or similar to those that you would find in a moderately fertile UK forest for this time of year. This indicates that at the time of sale, both composts are well-decomposed and not releasing significantly high CO_2. However, there are important differences in both measurement techniques and in composting process that might explain the higher carbon release from the Bisley compost. Firstly, the equipment used to measure flux from BCCS is a more accurate chamber-based method that traps the CO_2 prior to sending it to the analyser. The commercial compost scheme operates an open-air probe to measure CO_2. Accordingly, it is likely that there is some underestimation of the actual CO_2 flux values from the commercial site. Secondly, the commercial site operates a rapid composting scheme where raw organic matter is composted to commercial soil improver within 10 weeks. This method is optimised to speed decomposition. By contrast, BCCS operate a slower scheme where organic matter is allowed to decompose naturally. As a result, there may be much greater variability in CO_2 flux in the BCCS site. To capture this variability, a more systematic sampling of the compost piles is recommended. The limitations of the current sampling lead to the following recommendations if this work is to be continued in future:

1. A systematic sampling of the compost throughout the different stages of decomposition will allow a more accurate measurement of CO_2 flux. To ensure that this is done effectively, it is important to have an accurate age for the compost being measured.
2. Multiple time and space samples should be collected at both sites. This is only possible with a research student who is able to make repeat visits to a site in different weather conditions and through the different seasons.
3. Access will need to be granted to a commercial site to take similar measurements. This is not an easy problem to resolve. Most commercial sites will be happy to give you the data subject to certain confidentiality requirements, but they are unlikely to allow access to an independent researcher for safety reasons. Furthermore, the methods that they use to collect the data are aimed at meeting regulatory requirements. Accordingly, commercial operators consider this sensitive data. Finally, methods employed by contractors to measure CO_2 are unlikely to be comparable to the methods used by university researchers. In order to be useful as a comparison, the same methodology should be used for both sites.
4. The work required to obtain a useful set of measurements would suit an MSc student provided that a commercial contractor would be happy to come on board. This may be something that you would wish to pursue with the local authority in partnership with the University of Gloucestershire.

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