SHIMADZU
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Application News

No. O80

Total Organic Carbon Analysis

Analysis of TOC and TN in Fertilizers

Various nutrients are necessary for plant growth. The most important of those nutrients are nitrogen, phosphorous, and potassium, which are also called the "three major nutrients" of plants. Because large quantities of these nutrients are necessary in the growth process, they are generally supplemented with fertilizers. Among these nutrients, nitrogen plays the most crucial role in growth because it is a constituent component of the proteins and nucleic acids that are essential in the plant body.

Soil also contains large amounts of organic matter, which is formed by decomposition of plant residue by microorganisms, and this is useful in improving and stabilizing crop productivity by maintaining good chemical and biological conditions in the soil.

Thus, organic carbon (C) in soil and nitrogen (N) in fertilizer are necessary and indispensable elements for plant growth. The contents of these elements can be obtained by total organic carbon (TOC) measurement and total nitrogen (TN) measurement, and can be expected to provide useful indicators for stable growth of agricultural crops and plants.

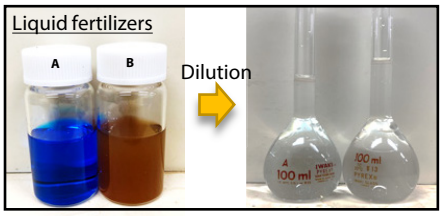
Application News No. O78 introduced an example of measurement of the total carbon contents in soil and compost in solid form using a TOC solid sample measurement system. This article introduces an example of simultaneous measurement of TOC and TN in liquid fertilizers and compost extract by using a system consisting of TOC-L and TNM-L, as shown in Fig. 1.

A. Goto

Fig. 1 TOC-L and TNM-L (Total Nitrogen Measurement Unit)

Analysis Method

Two types of commercial liquid fertilizers (A, B) and one type of compost were prepared for this experiment (Fig. 2). The liquid fertilizers are normally diluted by approximately 200 to 2,000 times when used. Here, we measured the TOC and TN of samples diluted by 1,000 and 2,000 times. Compost samples were prepared by mixing the compost and water at mass ratios of 1 : 100 and 1 : 200, stirring, and allowing the samples to stand and settle. The supernatant solution was then sampled, filtered with a syringe filter, and used as the extract.



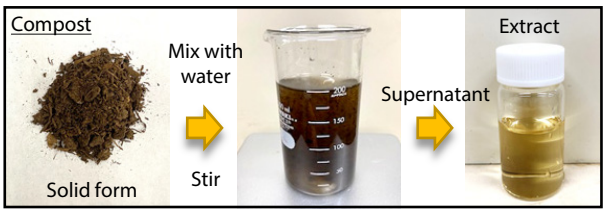


Fig. 2 Samples (Top: Liquid Fertilizers A, B, Bottom: Compost)

Table 1 Measurement Conditions

Instrument	:	TOC-L_{CPH} total organic carbon analyzer + TNM-L total nitrogen measurement unit
Catalyst	:	TOC/TN catalyst
Measurement items	:	Simultaneous measurement of NPOC (non-purgeable organic carbon) (TOC measurement after acidification and sparging) and TN
Calibration curves	:	<Liquid fertilizers> TOC : Two-point calibration curve by 0 - 50 mgC/L potassium biphthalate (aq) TN : One-point calibration curve by 100 mgN/L of potassium nitrate (aq) <Compost> TOC : One-point calibration curve by 100 mgC/L potassium biphthalate (aq) TN : Two-point calibration curve by 0 - 50 mgN/L potassium nitrate (aq)
Injection volume	:	40 µL
Samples	:	Liquid fertilizer A (Guaranteed component amounts: N : P : K = 6 : 10 : 5) Liquid fertilizer B (Guaranteed component amounts: N : P : K = 4 : 7 : 5) Compost

Sample Measurement Results

Table 2 shows the results of measurements of the two types of liquid fertilizers (A, B) when diluted at rates of 1/1,000 and 1/2,000. Because liquid fertilizer B has a low blending ratio of nitrogen in comparison with liquid fertilizer A, its TN concentration was lower. It was also found that the TOC concentrations of the two liquid fertilizers were different. Fig. 3 shows the correlations of the dilution rates of liquid fertilizers A and B and their TOC/TN concentrations. Good correlations were obtained, as the coefficient of correlation between the dilution rate and the measured concentration was 0.999 or higher in all cases. From this, it can be understood that measurement unaffected by other components contained in the samples is possible.

Table 2 Measurement Data of Liquid Fertilizers

Sample	Liquid fertilizer A		Liquid fertilizer B	
	TOC (mgC/L)	TN (mgN/L)	TOC (mgC/L)	TN (mgN/L)
2000× dilution	6.476	38.96	19.3	26.45
1000× dilution	12.65	79.6	37.4	52.32

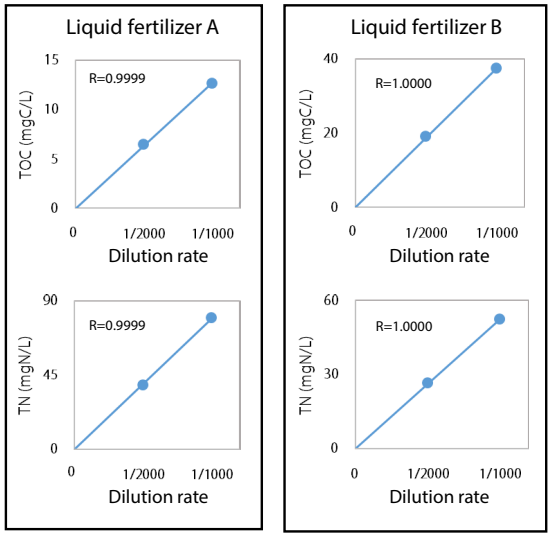


Fig. 3 Correlations of Dilution Rate and Measured Concentration of Liquid Fertilizers A and B

Next, Table 3 and Fig. 4 show the measurement data and measurement charts of the compost extract, respectively. Measurement with good repeatability was possible in all cases, as the coefficient of variation CV was 2 % or less. Fig. 5 shows the correlation of the mass ratio of the compost and water used in extraction and the TOC/TN concentrations. Good correlations were obtained in both cases, as the coefficient of correlation between the mass ratio and the measured concentration was 0.999 or more. Based on these results, it was found that the TOC and TN concentrations can be evaluated by extracting solid compost in water.

Table 3 Measurement Data of Compost

Sample	Compost	
	TOC (mgC/L)	TN (mgN/L)
1 : 200 extraction	48.76	21.05
1 : 100 extraction	103.9	39.72

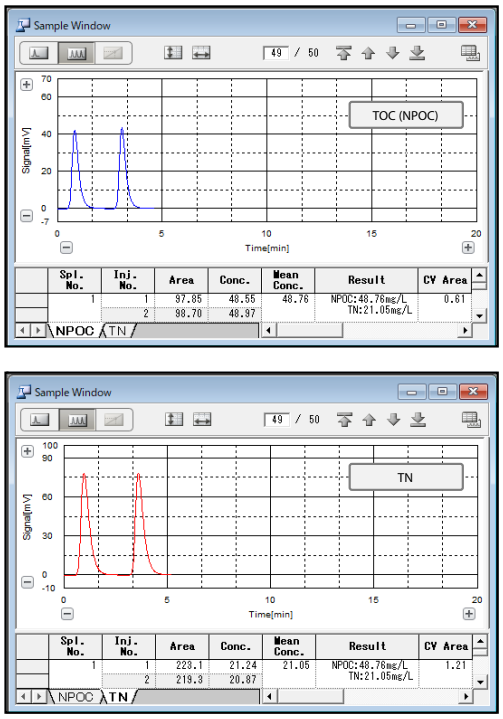


Fig. 4 Measurement Chart of Compost (Compost : Water = 1 : 200 Extraction)

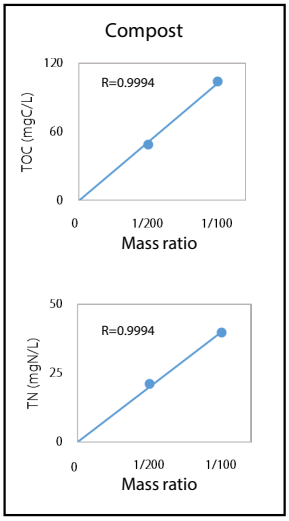


Fig. 5 Correlation of Mass Ratio and Measured Concentration of Compost Extract

Conclusion

Simultaneous measurement and evaluation of TOC (total organic carbon) and TN (total nitrogen) contained in fertilizers was possible by using a system consisting of TOC-L_{CPH} and TNM-L. TOC and TN measurements of solid compost samples were also possible by extracting liquid samples. This quick and simple analysis of the TOC and TN concentrations of fertilizers can be expected to be useful in improvement of the productivity of agricultural crops.

First Edition: Aug. 2020

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