FAO European Cooperative
Research Network

RAMIRAN

Recycling of Agricultural, Municipal and Industrial Residues in Agriculture

Network Coordinator: José Martinez, Cemagref, Rennes (France)

RAMIRAN 2002

Proceedings of the 10th International Conference of the RAMIRAN Network

General Theme: Hygiene Safety

Štrbské Pleso, High Tatras, Slovak Republic
May 14 - 18, 2002

Edited by Ján Venglovský and Gertruda Gréserová

ISBN 80-88985-68-4

University of Veterinary Medicine
Research Institute of Veterinary Medicine
Hlinkova 1/A
040 01 Košice
Slovak Republic

MICROBIAL PARAMETERS AS A TOOL TO EVALUATE COMPOST STABILITY

MONDINI C[1]., INSAM H.[2] AND LEITA L.[1]

[1] *Istituto Sperimentale per la Nutrizione delle Piante, division of Gorizia, Via Trieste 23, I-34170 Gorizia (Italy)*

[2] *Institute of Microbiology, Technikerstrasse 25, A-6020 Innsbruck (Austria)*

ABSTRACT

The aim of the present work was to investigate the reliability of the application of microbial biomass size and activity as a tool for the evaluation of compost stability in compost samples.
Compost samples with different age (10, 20, 35, 60 and 100 days old) were analyzed for the following parameters: total organic C (TOC), total N (N_{TOT}), CO_2-C evolution, microbial biomass ninhydrin-reactive N (B_{NIN}) and β-glucosidase activity.
Results showed no significant differences in TOC, N_{TOT} and TOC/N_{TOT} ratio among samples with different age. Conversely, microbial parameters showed a significant and inverse relationship with time of composting. According to microbial parameters analysis of variance classified compost samples in 3 different groups of maturity. B_{NIN}/N_{TOT} ratio, proposed as parameter to evaluate compost stability, showed a decrease during the process more prominent in the first 35 days of the process. Results showed that size and activity of microbial biomass could represent important parameters for the characterization of the composting process and the evaluation of compost stability.

Key words: compost stability, microbial biomass, microbial activity, B_{NIN}/N_{TOT} ratio

INTRODUCTION

Micro-organisms play a crucial role in the composting process and therefore microbial related parameters could be expected to be a valuable tool for the evaluation of compost stabilility. Nevertheless, no reliable easy and fast microbiological test for compost maturity has been developed to date. The holistic concept of soil microbial biomass introduced by Jenkinson (Powlson, 1994) considers the soil micro-organisms as a unique functional entity. Measuring the whole size and activity of soil micro-organisms by means of easily determined parameters has been shown to be very useful to predict long term effects of soil pollution and changed soil management (Leita et al., 1999)
Therefore, application to compost of soil microbial biomass concept may be expected to give important informations for the optimization of the process and the characterization of the end products. However, application of the microbial biomass technique to composting substrates requires special care to obtain realistic and reproducible results, because of the particular properties of compost substrates, such as the fast changes in physico-chemical and microbiological properties, the high spatial heterogeneity, the coloration of the extracts and the problems related to representative sampling and storage of samples. The aim of the present work was to investigate the reliability of the application of microbial biomass size and activity as a tool for the evaluation of compost stability in compost samples.

MATERIALS AND METHODS

Compost samples were taken from the composting plant of the Consorzio Tergola (Padua, Italy). The starting material of the process was a mixture of sewage sludge, green wastes

and fruit and vegetable wastes. The bio-oxidative phase of the process was performed indoor with forced aeration and turnings (10) during one month. Afterwards the maturation phase was carried out for two months in open air windrows turned every 15 days. The water content of the composting material was never adjusted throughout the whole process. Samples were taken in triplicate from 10, 20, 35, 60 and 100 days old windrows. The compost windrow temperature was measured on site with a special sensing device stuck in the windrow at a depth of 60 cm. Samples were air dried and ground to pass a 2 mm sieve. Total organic C (TOC) and N (N_{TOT}) were measured on air died sample with an elemental analyzer (NA 1500 Fisons). The air dried samples were then brought to 40% of their available water capacity. CO_2-C evolution was measured every hour by means of an IRGA once the CO_2 flush following the rewetting was over. Microbial biomass ninhydrin reactive N (B_{NIN}) and β-glucosidase activity were analyzed after equilibration of remoistened samples for 5 days at 25 °C by the fumigation extraction method (Vance et al., 1987) and according to Alef and Nannipieri (1995), respectively.

RESULTS AND DISCUSSION

Results of chemical and microbiological analyses are reported in table 1.

Table 1. Chemical and microbiological properties of compost samples

Days of compos.	Temp. (°C)	Water content (%)	TOC (%)	N_{TOT} (%)	C/N	B_{NIN} (μg g^{-1})	CO_2-C evolution (μg CO_2-C)	ß-glucosidase activity (μg $PNPg^{-1}$ h^{-1})
10	59.5 ab	63 a	26.6 a	2.1 a	12.7 a	844 a	96 a	1923 a
20	36.3 b	47 b	27.4 a	2.2 a	12.5 a	359 b	48 b	1422 ab
35	49.7 ab	26 c	26.9 a	2.2 a	12.2 a	142 c	13 c	879 ab
60	63.0 a	32 c	26.3 a	2.1 a	12.5 a	120 c	12 c	1072 ab
100	57.3 ab	28 c	22.7 a	1.8 a	12.6 a	87 c	4 c	426 b

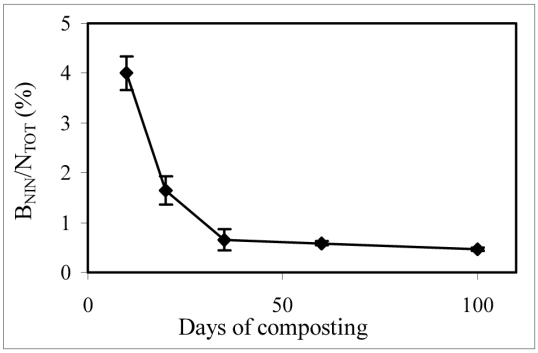
Lower case letters within the same column indicate significant differences at $p<0.05$ using SNK test

Total organic C and N content were practically constant during the process with a slight, but not significant, decrease recorded in the end products. The content of organic C in the end products was slightly lower than the threshold value required by italian law for mixed composted amendment (25%). As a consequence of C and N dynamics the C/N ratio remained practically the same during the process and therefore it is not possible to use this ratio as a maturity parameter in the considered process.

Biomass content showed a marked decrease during the process. End products presented a B_{NIN} content that was about 10% of that presented after 10 days. Similarly, CO_2-C evolution and β-glucosidase activity showed a decreasing trend. B_{NIN}/N_{TOT} ratio was proposed as parameter to evaluate compost stability (De Nobili et al., 1996) on the assumption that the quantity of microbial biomass in compost reflects the quantity of available substrate. An increase of the amount of available substrate for micro-organism due to addition of organic matter to soil had been shown to increase the percentage of microbial biomass N with respect to the total N (Powlson et al., 1987). Similarly in the early stage of composting, characterized by a high content of easily degradable substrate, it could be expected that the microbial content of N represents an higher percentage of total N compared to the stabilized compost, were the substrate availability is greatly

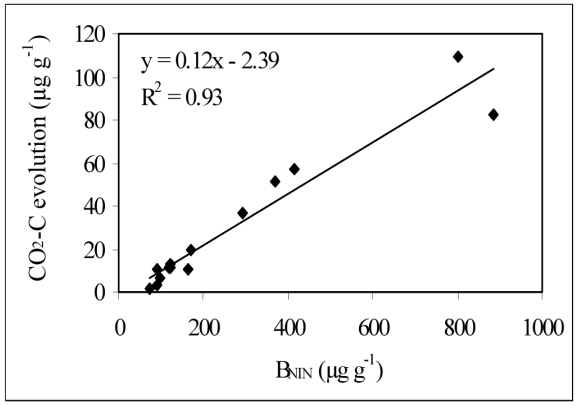
decreased. Furthermore, reference to the content of total N allows a more correct comparison with different processes and starting materials. Results of the above ratio in 11 different composting processes showed a decreasing trend and the values recorded in the end products ranged from 0.5 and 1.3 % (De Nobili et al., 1996, Mondini et al., 1997; Mondini et al., 2002 and unpublished). In the present work this ratio was 4.0 % in the samples collected after 10 days and decreased to 0.5% at the end of the process (Fig. 1).

Fig. 1. Values of B_{NIN}/N_{TOT} ratio (%) in compost samples with different age. Bars represent standard deviation.



According to water content, CO_2-C evolution, biomass ninhydrin reactive N and B_{NIN}/N_{TOT} ratio analysis of variance classified compost samples in 3 different groups of maturity i.e. samples 10, 20 and 35 or more days old (Tab. 1). According to β-glucosidase activity, analysis of variance categorized two different groups of compost maturity. These results showed that the microbial parameters considered were able to detect changes in the composting process not recorded by chemical parameters and that these changes were more prominent in the first 35 days of the process. All the microbial parameters considered and the water content showed a significant and inverse relationship with the time of composting. CO_2-C evolution, B_{NIN}, and β-glucosidase activity were highly correlated among them ($r > 0.87$, $P = 0.01$) and with the compost water content at sampling. The correlation between B_{NIN} and CO_2 evolution is reported in fig. 2.

Fig. 2. Correlation between B_{NIN} and CO_2-C evolution in compost samples with different degree of stabilization.



The good correlation of parameters measuring different aspects of the microbial pool could imply that all the parameters depend on a common factor such as the availability of easily degradable substrate. In the first stage of the composting process the more readily degradable substances such as sugars, fats, starch and proteins are rapidly consumed and degraded. With the ongoing of the process the cellulose, emicellulose and other polymers are attacked and humifications occurs in the residual organic matter (Chen et al., 1997). Therefore, during the process there is a decrease of the substances that could be readily utilized by microrganism and an increase of substances more recalcitrant to microbial decomposition. It is probable that this substrate availability dynamics have a remarkable effect on the behaviour of the size and activity of microbial biomass.

Microbial parameters were determined on dried-rewetted samples and therefore it could be questionable if they could give an indication of the real microbial size and activity of compost samples. Nevertheless, the aim of the present work was not to study microbial dynamics in compost, but to investigate if microbial parameters could give useful informations on the degree of maturity of compost. In this view it is important to assess the reliability of microbial parameters application on dried compost samples since, from a practical point of view, is more easy to work on samples with low water content and it is not always possible to operate on fresh samples.

In conclusions results showed that size and activity of compost microbial biomass could represent important parameters for the chatacterization of the composting process and the evaluation of compost stability. Furthermore, results suggest that useful informations on the compost stability degree could be obtained also by air dried samples, provided they are brought to an adequate water content before analyses.

REFERENCES

Alef K. and Nannipieri P. (1995): β-glucosidase activity. In: Alef K. and Nannipieri P. (Eds.), *Methods in applied soil microbiology and biochemistry*. Academic Press, London, pp. 350-352.

Chen, Y., Inbar, Y., Chefetz, B., Hadar, Y., (1997): Composting and recycling organic waste. In: Rose D., Tel-Or E., Hadar Y., Chen Y. (Eds.), *Modern agriculture and the environment.* Kluwer Academic Publishers, Dordrecht, pp. 341-362.

De Nobili M., Baca M.T., Fornasier F. and Mondini C. (1996): Ninhydrin-reactive nitrogen of $CHCl_3$ fumigated and non fumigated compost extracts as a parameter to evaluate compost stability. In: de Bertoldi M., Sequi P., Lemmes P. and Papi T. (Eds.), *The Science of Composting*. Blackie Academic & Professional, Glasgow, pp. 255-261.

Leita L., De Nobili M., Mondini C., Muhlbachova G., Marchiol L., Bragato G. and Contin M., (1999): Influence of inorganic and organic fertilization on soil microbial biomass, metabolic quotient and heavy metal bioavailability. *Biol. Fertil. Soils*, 28: 371-376.

Mondini C., Sanchez Monedero M.A., Leita L., Bragato G. and De Nobili M. (1997): Carbon and ninhydrin-reactive nitrogen of the microbial biomass in rewetted compost samples. *Commun. Soil Sci. Plant Anal.*, 28: 113-122.

Mondini C., Contin M., Leita L. and De Nobili M. (2002): Response of microbial biomass to air-drying and rewetting in soils and compost. *Geoderma*, 105: 111-124.

Powlson D.S., Brookes P.C. and Christensen B.T. (1987): Measurement of soil microbial biomass provides an early indication of changes in total organic matter due to straw incorporation. *Soil Biol. Biochem*., 19: 159-164.

Powlson D.S. (1994): The soil microbial biomass. Before, beyond and back. In: Ritz K., Dighton J.and Kuller K.E.(Eds.), *Beyond the biomass*. J. Wiley and Sons, Chichester, pp. 3-20.

Vance E.D., Brookes P.C. and Jenkinson D.S. (1987): An extraction method for measuring soil microbial biomass. *Soil Biol. Biochem*., 19: 703-707.