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Agricultural Wastes Recycling : Composting Process and Maturity Characters

H .M . EL – Kouny

Soil Salinity Department, Soils, Water and Environment Research Institute , Alexandria , Agricultural Research Center , Alexandria, Egypt .

CATTLE MANURE utilization as a peat substitute in both green house and under field conditions has been proposed . This alternative requires certain preparatory procedures including composting. Composting of cattle manure was carried out in one cubic meter perforated boxes for 100 days . The aims of this work were to study the composting process , changes occuried in the product during composting and product properties of relevance to its potential , and to evaluate possible criteria indicating compost maturity. Most of physical and chemical properties appeared at high rate of changes during the first 30 to 60 days of composting time . Total soluble salts (EC) exhibited a constant value for the first 40days followed by a sharp increase in EC (from 3.70 to 5.90 dSm^{-1}) . Nitrate Levels increased (from 0.1 to 0.31 mg/ gm)due to nitrification at temperature degree less than 40°C. Although most changes took place at the first high temparature stage (thermophilic stage) , slowdown decomposition persisted after temperature returned to ambient level as a measured in the compost water extract . Plant bioassays also , indicated that 40 to 60 days . old compost inhibited growth and limited response to fertilization for container media. Both of these factors were eleminated after 80 d . of composting time . Chemical properties of water extracts may therefore serve as indicators of compost maturity and of the material suitability as an organic component .

Keywords : Cattle manure, Peat substance compost, Nitrate, Temperature degree, Water extract, Bioassays, Maturity and fertilization .

Cattle manure is a major waste product of agroecosystems, Inappropriate disposal of manure can create environmental problems such as odor and leaching of No^-_3 and other pollutants into ground water (Inbar *et al* ., 1993). Separation and composting of the solids from sulurry under controlled conditions may provides a useful tool for manure management . Well composted organic waste is traditionally used as a source of nutritional elements and / or soil conditioner directly in the field (EL-Kouny , 1999) . In the last decade , the demand for peat as a potting medium in horticulture has increased ,while its avail- ability has decreased . The nutrition value of Cattle manure composting depends on the nature of raw material used and a controlled microbial acrobic decomposition proces (Rynk, 1992). The main products of aerobic composting are CO_2 , water , mineral ions and stabilized organic matter (OM) often called humuic substances (HS) (Inbar *et al*., 1993). Many of organic wastes such as town wastes , bark , leaf mold and animal excreta have been introduced as a peat substitutes in container media after proper composting (EL- Eghball *et al*., 1997) . The well matured composts have been found to suppress soil – borne plant pathogens when utilized as container media (EL- Eghball *et al*., 1997).

The composting of feedlot manure produces a stabilized product that can be stored or spread on land with little or no odor , palhogens and weed seeds (Rynk, 1992) . Larney *el al*. (2000) observed N loss via NH_3 volatilization of 10 – 25 of total N, C loss as CO_2 between 30 – 40 % of total C and volume and mass decrease between 30-45 % during feedlot manure composting . In recent studies , compost produced from the solid fraction of cattle manure has been to be a high quality and disease suppressive peat substitute for plants growth (Inbar *et al*., 1993).

The objectives of this research were to study the changes in physical and chemical properties of cattle manure during composting process and to describe the proces and relate the findings to bioassays performed on plants

Material and Methods

Compost preparation

Cattle manure was collected from EL- Mahallawi organic farm, EL – Hosinia district , EL- Sharkia Governorate . Properties of the cattle manure are presented in Table 1 .

TABLE 1 . Properties of the cattle manure used .

Property	Value
Dry Bulk Density , Kg/m^3	160
Moisture content , %	42.5
Dry Matter , %	57.5
Ash Content % dry weight	12.6
Organic Matter % dry weight	87.40
Organic Carbon % dry weight	50.69
Total Nitrogen % dry weight	1.69
C / N Ratio	31.48
Total phosphorus % dry weight	00.35
Total potassium % dry weight	00.65
pH	7.85

Cattle manure was composted in two ($1.m^3$) perforated plastic boxes for 100 days . The material was turned , mixed thoroughly for 24 hr 0, 10, 20, 30, 40, 60, 80 and 100 days. The temperature inside the boxes was measured by thermometer probe . 25 litters of a composite sample from each box at an original moisture level , were stored at – 4 °C . Sub - samples (one letter) were taken, dried at 65°C , passed after grinding through a 0.2 mm sieve and stored in a desecrator under vacuum . All measurements were conducted in triplicate for each composting box. Analysis of variance was performed with SAS , 1985 (on the $LSD_{0.05}$)

Compost analysis

Physical determinations

The physical properties were bulk density (D_b) , particle density (D_p) total porosity , air capacity , water capacity . The compost samples were analyzed for physical properties according to standard methods of compost analysis (Bertran & Andreas, 1994). Also , in this study the physical properties were calculated according to the following relationships (Inbar *el al* ., 1993) to compare with analyzed physical properties previously measured .

$$D_b\ (kg/m^3) = \text{dry weight} / \text{volume}$$

$$D_P\ (Kg / m^3) = \frac{1}{[OM\ \%\ (100 \times 1.55) + ash\ \%\ (100 \times 2.65)]}$$

$$\text{Total porosity (\% volume)} = \left(1 - \frac{D_b}{D_P}\right) \times 100$$

$$\text{Water capacity (\% volume)} = \frac{\text{wet . weight} - \text{dry weight}}{\text{Volume}} \times 100$$

"Container capacity"

$$\text{Air capacity (\% volume)} = (\text{porosity} - \text{water capacity}) \times 100$$

Where : 1.55 and 2.65 are the average particles densities of soil organic and mineral mater , respectively .

Chemical analysis

The chemical properties were total soluble salts (TSS) , pH , O M , total nitrogen (T-N), total phosphorus (T – P) , total potassium (T- K) , NO^3 – N , elemental composition (Fe , Mn , Zn) and ash content and determined according to standard methods of compost analysis (Bertran & Andreas , 1994 and El – kouny , 1999) . Dried and ground compost samples were wet digested according to wet ashing techique of Okalebo (1985) using concentrated H_2SO_4 and H_2O_2 .

T – N and NO_3-N were determined using an automatic kjeldahl. T –P was determined colorimetrically by a Spectrophotometer. T – K was measured by flame photometer .Elemental composition (Fe , Mn and Zn) were determined by atomic absorption spectrophotometer (AAS). The pH and EC were determined in a samples of the wet compost were extrated with distillation water (1 : 10 w / w) . OM and ash content of the compost samples were determined by loss upon ignition at 550 °C for 8 hr. Dissolved organic carbon (DOC) was determined by dichromate acid oxidation methods . Optical density at 465 nm was measured in a compost extract with a Philips Pye Unican PU 860 UV/VIS (ultraviolet . visible) spectrophotometer (Pye Unican lid., Cambri) .

Bioassay tests

Germination test with compost substrate

One gram of radish seeds (*Raphanus sativa* Lam.) was cultivated in 0.5 letter pots on cattle manure compost at various stages of decomposition and covering it with a thin layer of fine Illite to prevent drying (Sphon,1978) . Salinity of the compost varied with time to eliminate salinity differences. The plants were irrigated daily with equal amounts of a nutrient solution containing (mg/L): NO_3 – N = 120 , K = 110 , Fe = 0.5 Mn = 0.5 , Zn = 0.2 = B= 0.1 Cu = 0.03 Each treatment consisted of three replicates.The plants were harvested 18 days after sowing Dry weight obtained from each pot was measured and a factorial statistical anolysis was performed .

Germination test with compost extract

Water extracts from cattle manure compost at various stages of composting were diluted until the same total ion concentration was achieved (EC = $2dSm^{-1}$) . N – NO3 was deter mined and adjusted to 120 mg/l with $Ca(NO_3)_2$. The solutions were used as nutrient solution bioassay test.The bioassay consisted of five Tomato (*Lycopersicon esculentum* L . cv Marmande) seeds placed on a layer of cotton wool in a petri dish . Five petri dishes were used for each compost extract and were placed in plastic containers and covered with a transparent polyethelene sheet to reduce evaporation . The cotton wool was saturated with 3.0 ml of the compost extract solution and applied (I m I) twice per week after germination .The plastic containers with the seeds incubated in a dark room for 5 days at 24 °C until germination and then transferred to a green house . Plant grown in a nutrient solution with the same composition as previously described served as a control . The seedling were harvested 21 days after sowing and fresh weight and height were measured . Data were statistically analyzed (SAS,1985) .

Results and Discussion

Composting of cattle manure

Temperature

Figure 1 shows temperature variation during composting time . Initially, heat was generated and the temperature increased rapidly during the first 5 days from 30 to 50 °C (mesophilic stage I) . The temperature then remained > 65°C for at least the five days (thermophilic stage) necessary for achieving sanition through reduction of pathogen population below levels that threaten health and to kill all weed seeds and diseases causing organisms (Zucchini *et al*., 1981) . The temperature then remained almost at an average of 50 °C for about 40 days after which it gradually decreased to reach atmosphere leves after Day 100 (maturity stage) It was a slow and long about 65 days) with no measurable temple arature changes This temperature modern is considered ideal for achieving maximum rates of on decom position (Murillo *et al*., 1995 and El – kouny , 1999) . Owing to CO_2 evaluation water evoporation , and particle size reduction during composting process , a marked reductionin volume (55- 60 %) and an increase in ash content (from 12.60 to 33.6 % by weight) The volume was reduced by about 10 % during the rest process (Fig . 2) .

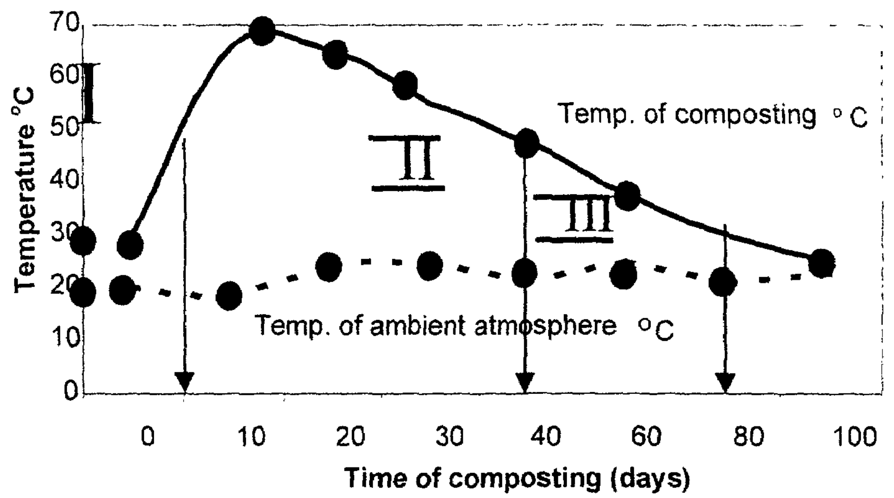

Fig. 1. Ambient atmospher and compost temperature during the composting process of cattle manure .

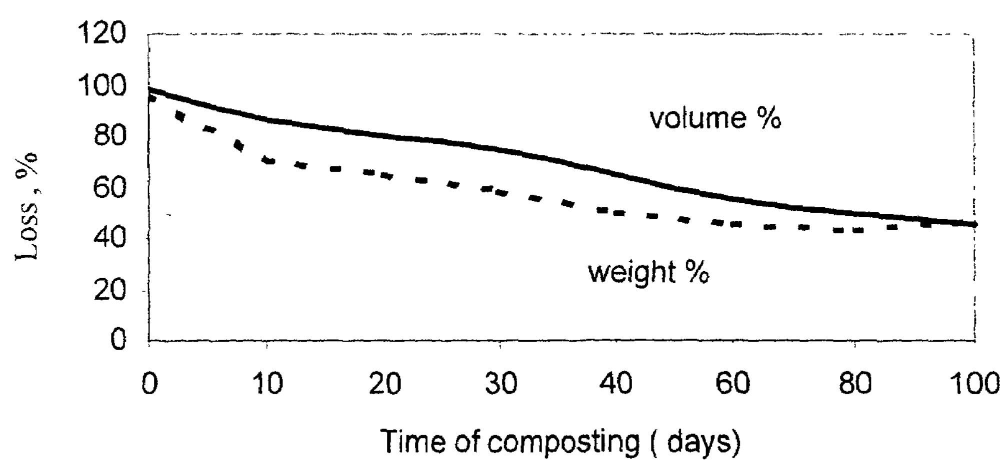

Fig. 2. Relative volume and weight (% of initial) loss VS composting time of cattle manure.

Physical properties

A composting substrate can be likened to a network of soild particles consisting of voids and intervals of various sizes voids between particles are filled with air , water , or both when the voids are completely filled with water . Oxygen (O_2) transfer is limited and aerobic composting become impractical (Haug, 1980) . The physical properties of compost enabled an evaluation of its suitability as the organic component of container media horticulture (Inbar *et al* ., 1993) and indicated that of the air water ratios at various stages of the composting process (Table 2) . Bulk density was increased (100 %) and consequenlty total porosity decreased (from 90 – 80 %) . Major changes in the physical properties were recorded ducing the first 60 d of the composting process paralleling OM decomposition and transformation , such as in humic substances and ash cnotent (Inbar *et al.,* 1993). The physical properties at the end of the process were indicate to those an ideal substrate of plant growth and peat as suggested by De Boodt & Vendonck (1978). Also, can serve, a water – retaining component Gagnon *et al* . (1999) and larney *et al.* (2000) .

TABLE. 2 . Physical properties of cattle manure during the composting process .

Composting time(day)	Bulk density, kg / m^3	Particle density, kg / m^3	Total porosity, cm^3 (P)	water capacity, % (W)	Air space, % (A)
0	160	181	91.35	97.80	2.20
10	185	186	90.5	96.66	3.34
20	204	187	89.10	93.25	6.75
30	201	188	89.34	84.40	15.60
40	263	192	86.30	81.40	18.62
60	307	189	83.79	89.10	10.00
80	355	189	81.70	86.10	13.90
100	395	194	79.63	84.50	15.50
LSD $_{(0.05)}$	21	59	0.67	00.45	0.08

De Boodt & Vendonck (1978), Gagnon *et al.*, (1999), cited that the normal of D_b, D_p, P,W and A were 460 kg/m^3 , 156 kg/m^3, 85%, 55-75% and 20-30% , respectivily

Chemical properties

Chemical properties determined were electrical conductivity (EC) pH , NO_3 –N, total nitrogen (T –N) , total carbon (T . C) total potassium (T – K) , total manganese (T – Mn), total Zinc (T – Zn) and ashcontent (Table 3) . The sum of soluble ions in the water extracts, as indicated by EC measurements increased slightly at the beginning of composting due to the release of easily decomposable compounds into the solution (Saviozzi *et al.,* 1988) .

During the first 40 days no significant change insoluble ion concentration occurred . During maturation the EC increased sharply in the solution reaching a maximum at 80 days or more (Liang *et al.,* 1996) .

TABLE 3. Chemical properties of cattle manure compost during the composting process (on a dry matter basis) .

Composting time (day)	NO_3, mg / g	pH	EC, dSm^{-1}	OM, %	T-N, %	T-P, %	T-K, %	Fe, %	Mn, pp m	Zn,pp m	C / N ratio	Ash content, %
	(1 : 10 Soild : water)											
0	0 10	7 85	3 35	87 40	1 61	0 35	0 65	0 62	0 62	145	31 48	12 60
10	0 15	7 82	3 50	89 30	1.72	0.45	0 72	0 65	0 65	170	28 25	16 80
20	0 25	7 75	3 20	79 50	2.02	0 54	0 82	0 66	0 66	175	22.83	20 50
30	0 32	7 50	3 55	74 25	2 12	0.62	0 85	0 70	0 70	190	20 52	25 75
40	0 99	7 89	3 70	72 10	2.34	0 75	0 90	0 75	0 75	200	17 87	27 90
60	1 65	7 45	4 65	71 40	2.74	0.78	0.95	0 78	0 78	190	15 21	28 10
80	2 90	7 15	5 10	66 50	2 77	0 88	1 16	0 89	0 89	210	13 92	33 50
100	3 25	6 70	5.90	66 40	2 79	0 95	1 20	0 85	0 85	210	13 80	33 60
$LSD_{(0\ 05)}$	0 31	0 25	0 35	2 95	0 12	0 020	0 05	0 05	0 05	17	1 16	2 3

The pH of the fresh manure was 7.85 , then the pH decreased slightly at the beginning of the compositing process due to accumulation of organic acids as reflected by increased alkalinity . After this , the acids were ulilized as substrates by other aerobic microbes and the pH increased during the mesophilic stage(first stage). During the maturation stage the pH dropped close to neutral values , then stabilized . This pattern is typical for the composting process (Diaz *et al* ., 1982). Optimum pH levels for composting within the range of 5 to 7.90. The NH^{4+} concentration was negligible . The enhancement of NO_3 formation (from 0.10 to 3.25 mg / g) was due to an increase in the activity of nitrifying bactria . Really, this activity is known to be inhibited at high temperature above $40C^o$ (Saviozzi *et al.,* 1988). Total elemental composition was determined (T-N, T-P,T-K,T Fe , T-Mn and T – Zn) by wet digestion and is shown in Table 3 . The concentration of most of the elements determined were increased with the corresponding loss of OM . The main changes occurred during the first 40 days as has already has been reported for the narrowly C / N ratio (from 31.48 to 13.80) and increasing ash content (from 12.60 to 33.60 %) Inbar *et al.* (1993) ; Gagnon *et al.* (1994) and EL –kouny (1999). Thereafter the elemental composition stabilized The stapilization of NO_3 in compost over time may be valid indicator of compost maturity (Liang *et al.,* 1996).

Water –soluble organic carbon

The water extract of cattle manure compost was light to dark brown. These changes were monitored as absorbance at 465 nm . A typical curve also was obtained when soluble organic C was measured (Fig. 3) . The C compounds are more avialable to microbes (*e.g.,* soluble sugars , hemicellulose , amino acidsi and proteins) were degraded during the thermophilic stage of composting time and they transformed into either CO_2 or insoluble and stable OM , as a result in a reduction in soluble C. The color of water extract used as a rapid indicator for dissolved organic C (DOC) concentration .

The absorbency at wave length 465 nm was observed between water -solubte organic C extracted from the compost providing a simple procedure for the determination of dissolved OM (Liang *et al*., 1996 and EL-kouny , 1999)

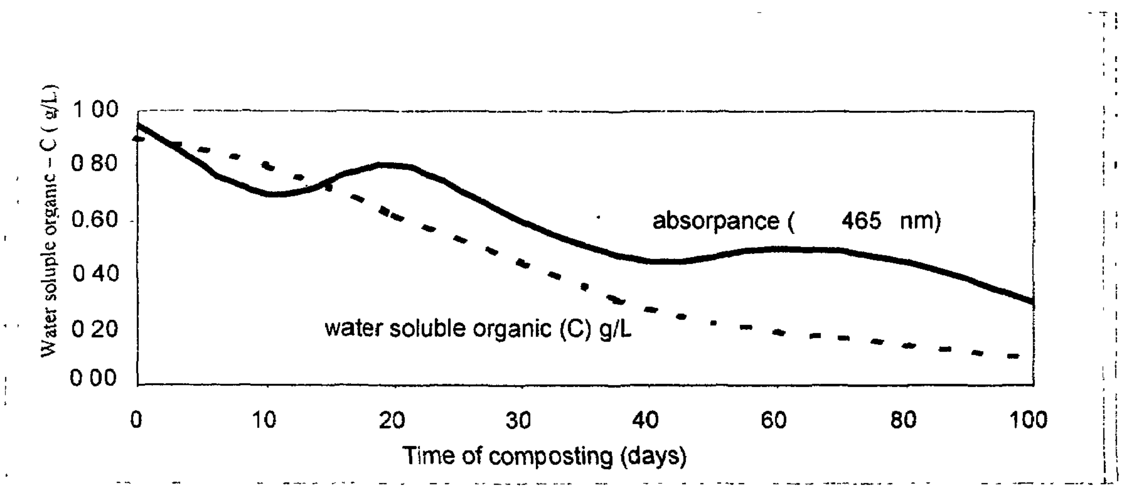

Fig. 3. Water-soluble organic C (1:10 solid/ water extract) and the absorpance at 465 nm of the extract VS composting time of cattle manure.

Plant bioassay

First experiment

The dry -weight of radish plants grown in compost sample at various stages of composting process with and without fertilizer are shown in (Fig . 4) . During the first 30 days of composting growth of the unfertilized plants were inhibited , plant yield was improved at 30 to 40 days old compost , and maximum yield was achieved at least 80 days old compost . Fertilizer improved plant growth on cattle manure compost at 60 days old compost . Maximum yield were obtained in the fertilized treatments from 60 to 80 days of composting time. This experiment indicated that the immature compost has an inhibitory effect on radish growth . These results are in harmony with those of Zucchini *et al.* (1981) ; EL-Eghball *et at*. (1997) and EL - Kouny (1999) .

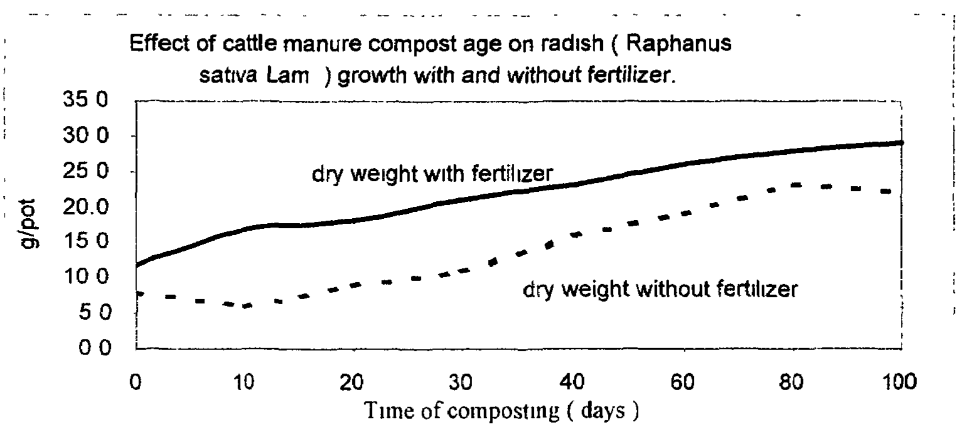

Fig. 4. Effect of cattle manure compost age on radish (*Raphanus sativa* Lam.) growth with and without fertilizer.

Second experiment

A second experiment, using tomato plants was carried out with water extracts from compost. Plant growth was similar with the radish experiment . Tomato seedlings were inhibited in water extracts at 10 days old compost. (younger compost) . Higher inhibition was observed when compost sampled during thermophilic stage of composting was tested. After 30 days , growth in compost extract was better than that in a standard solution (Fig. 5). Phytotooxic compounds and competition for O_2 in the immature compost are assumed to be responsible for the inhibition of plant growth .Zucconi *et al.* (1981) found that all plants were inhibited by immature compost and growth usually improved in mature compost . In the other hand , Hirai *et al* . (1986) and El-kouny (1999) found that low molecular weight organic acids (*e.g.,* acetic , propionic, and butyric acids) were the most toxic compounds during the early stages of composting as well as , may induce O_2 and nutrient deficiencies due to high rates of decomposition .

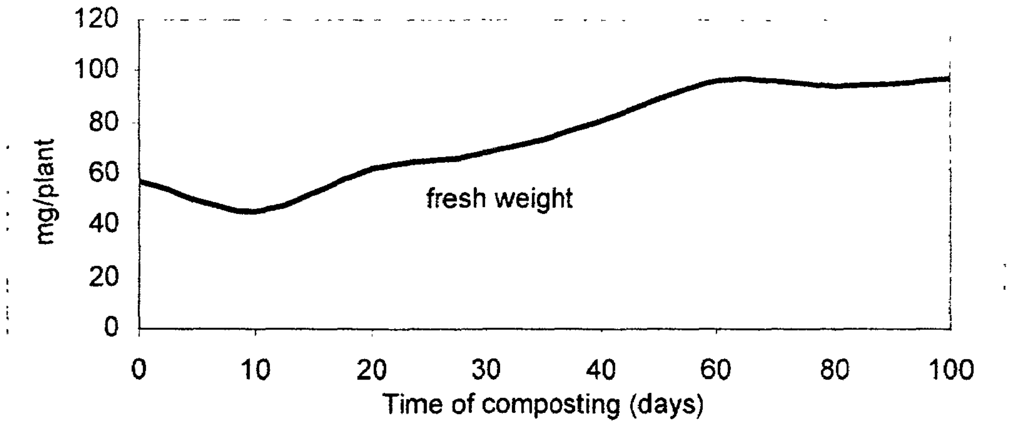

Fig. 5. Effect of water extracted from cattle manure compost at different stages of composting process on the fresh weight of tomato seedlings.

Conclusion and recommendation

In this research, high rate of changes during the first 50 days was obtained for volume and weight. In the case of plant bioassay tests, the 60 days old compost was immature. The parameters measured in the cattle manure compost water extract combined with plant bioassays could potentially serve as indicators of compost maturity. Quality control measurement may therefore enable the use of cattle manure compost as container media.

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تدوير المخلفات الزراعية : عملية الكمر ومواصفات النضج

حامد مبروك القوني
قسم بحوث الأراضي الملحية والقلوية – معهد بحوث الأراضي والمياه والبيئة – إسكندرية- مصر .

روث الأبقار (cattle manure) ذات فائدة في الاستخدام كبديل مادة البيت في كل من الصوب الزجاجية وتحت الظروف الحقلية ، هذا البديل يتطلب إجراءات تمهيدية معينة متضمنة عملية الكمر . حيث تمت عملية كمر الروث الحيواني في صناديق مثقوبة ذات سعة متر مكعب لمدة ١٠٠ يوم وكانت أهداف هذا العمل دراسة عملية الكمر والتغييرات التي تحدث في المنتج خلال عملية الكمر وصفات المنتج المتصلة به وتقييمه بالمعايير القياسية المتاحة والدالة على نضج الكمبوست .

معظم الصفات الفيزيائية والكيمائية ظهرت عند المعدل المرتفع للتغييرات خلال ٣٠ – ٦٠ يوم الأولى لوقت الكمر. حيث تم ثبات قيمة الأملاح الكلية الذائبة (EC) خلال ٤٠ يوم الأولى من الكمر تلى ذلك زيادة حادة في قيمة EC من ٣,٣٥ إلى ٥,٩ ديس سيمنز لكل متر (dSm^{-1}) . أما مستوى النترات (No_3^-) فقد زاد من ٠,١٠ - ٣,٢٥ مللي جرام / جرام نتيجة عملية التأزت (Nitrification) عند انخفاض درجة الحرارة أقل من ٤٠ درجة مئوية . رغم أن كل التغييرات تمت خلال المرحلة الأولى لارتفاع درجة الحرارة فإن عملية التحلل تقاوم وتبطئ بعد عودة درجة الحرارة إلى الوسط المحيط والتى تقاس في المستخلص المائي للكمبوست . أيضاً الاختبارات الحيوية على النبات بعد ٤٠ – ٦٠ يوم من عملية الكمر ثبطت النمو وحددت الاستجابة للتسميد لكن هذه العوامل أزيلت بعد ٨٠ يوم من وقت الكمر .

أما الصفات الكيمائية للمستخلصات المائية يمكن أن تكون دلالات على نضج الكمبوست والمواد العضوية المناسبة للاستخدام .