Egypt. J. Soil Sci. 42, No. 2 , pp. 267- 275 (2002)

Biotransformation of Organic Fraction of Municipal Solid Waste to Compost and Its Manural Effect on Wheat Growth

H.K. Abdel-Maksoud, M.A. Azzazy and R.A. Abdel-Aziz
Agricultural Microbiology Dept., National Research Center, Dokki,Cairo, Egypt.

LARGE AMOUNTS of municipal solid waste (MSW) are generated from different sources reaching 30,000 ton / day, however, their potential value is almost ignored. It should be considered as an valuable renewable energy resource for recycling, composting, and ensilage. Aerobic composting of the organic fraction MSW was carried out to raise its fertilizing value using different accelerators. A field experiment was conducted in Santa town, Gharbia governorate, using wheat as an indicator plant to evaluate the produced compost as organic manure to reduce the heavy doses of chemical fertilizers. Results clearly showed that the composting process raised the fertilizing value as indicated by the increase of nutrient availability. Data also revealed significant increases in grain yields as well as the grain N and P contents of wheat fertilized with composted MSW as compared to chemical fertilizer treatment. This application also improved wheat quality, as indicated by the increase of grain nitrogen content. From the environmental point of view, the problem of MSW accumulation can be partially solved and its polluted effect will be diminished to a certain level in order to improve the surrounding environment.

Keywords: Organic fraction, municipal solid waste, wheat growth.

Municipal solid waste (MSW) is considered to be one of the most valuable renewable resources for recycling, composting, ensilage and acceptable foodstuff for livestock (El-Boushy and Vander Poel, 1944). In Egypt, MSW is characterized by its high organic content, reaching 60 % (Saber *et al.*, 1994). Disposal of the organic fraction of MSW through composting is considered to be one of the most safe and environmentally sound practices. The produced

compost might partially fill the gap in organic manure required for enriching new soils and fertilizing the old ones. Composting of MSW has proven to be a useful technique for different purposes, such as horticulture (Fitzpatnch & Carter, 1983; and Wooten *et al.*, 1981) and reforestation (Bengtson and Cornette, 1973).

El-Santa town is located in a rural area in the middle of the Nile Delta in Gharbia governorate, Egypt. Its population is about 30483 (according to the population carried out at 1999). The annually increasing rate is around 2.8 %. The daily-generated amount of solid wastes reached 24 and 28 tones in summer and winter seasons, respectively, with a mean value of 26 tones per day. About 75 % of the produced wastes are generated from households and the rest from the other sources, *i.e.* streets, workshops, stores, and markets.

The present work aims at evaluating the bioconvertion of organic fraction of MSW under different accelerators and its manural effect on the growth of wheat plants grown in Santa soil.

Material and Methods

Composting process

The collected municipal solid wastes were sorted to fractionate the different components. The organic fraction of MSW was used to construct heaps to be bioconverted to compost. Three heaps, two tones each, were built up in windrows system. One heap was treated with a chemical accelerator composed of 50 kg ammonium sulfate, 14 kg superphosphate, 2.5 kg potassium sulfate and 50 Kg calcium carbonate. The second heap was treated with 1200 liter sewage effluent (60 % w/v) as an organic accelerator. The last heap did not receive any accelerator. Each heap was built up in ten layers. The heaps were moistened to the proper level (60 % w/v) for initiating microbial proliferation. The surface of the heaps was covered with a thin layer of mud and left for 120 days. During this period the heaps were turned over 3 times at 30, 60, and 90 days from initiating time. The temperature of the heaps was frequently measured to control the biodegradation of organic fraction, through adjustment of moisture level until heaps were matured.

Three samples were taken from the different treatments at 0, 45 and 120 days from initiation for assaying the counts of fecal coliform using Eijkman test at 44 for 48 hrs (Allen, 1959).

Evaluation of manural value of MSW compost

A field experiment was carried out to evaluate the manural value of the

produced MSW compost. Wheat plant was used as indicator plant in a clay loam soil at Santa region. Physical and chemical analyses of the soil are given in Table 1. Fifty kg N fed^{-1} were added equally at 30 and 60 days of sowing. Superphosphate was added at rate of 25 kg P_2O_2 and broadcasting at soil preparation. Whereas, 20 kg K_2O per fed of potassium sulfate was added 3 months after sowing. The different composted MSW were added at soil preparation at the rate of 20 m^3 fed^{-1}. Wheat grains, var. Sakha 69, were sown at the rate of 40 kg fed^{-1}. A complete randomized block design, with four replicates, was used. Plot area was 21 m^2 (1/200 fed). The treatments were as follows:

1-NPK chemical fertilizer.

2-Accelerator free MSW compost.

3-Composted MSW with chemical accelerator (NPK and $CaCO_3$).

4-Composted MSW with organic accelerator (Sewage effluent).

TABLE 1 . Physicochemical analyses of soil .

Item		Value
Sand	%	43.8
Silt	%	27.5
Clay	%	28.7
Soil Texture		Clay loam
PH		8.2
E.C	dS/m	3.41
Organic matter	%	1.32
$CaCO_3$	%	5.16
Total nitrogen	%	0.12
Total phosphorus	%	0.09
Total potassium	ppm	199

Vegetative plant characters, *i.e.* root length, plant height, number of tillers and dry weight of whole plant were estimated after 90 days of sowing. At harvesting time, yield of straw and grain, as well as their N- content were determined (Jackson, 1973). Data were statistically analyzed according to the method given by Little and Hills (1977), using a microstate program (1985).

Results and Discussion

Data of MSW sorting showed that the organic fraction amounted to 54 %, whereas the recyclable items and dust reached 30 and 11 %, respectively. These results are similar to the findings of Saber *et al.* (1997). The laboratory analyses of MSW organic fraction is shown in Table 2. A result showed that the organic fraction had high moisture content (29.8 %), and was slightly alkaline. The organic fraction was also characterized by its high content of organic carbon, nitrogen, phosphorus and potassium (Table 2). Because of the high amount of nitrogen, it was expected that the biodegradation of these organic residues during the composting process would be fast until the maturity phase. These findings are in accordance with those obtained by Xin-Tao He *et al.* (1992).

TABLE 2. Chemical analysis of MSW organic fraction.

Item		Value
PH		8.3
Ashes	%	39.0
Organic carbon	%	35.4
Organic matter	%	61.0
Total nitrogen	kg/ton	157.0
Total phosphorus	kg/ton	18.0
Total potassium	kg/ton	12.0
C/N		22.5

Chemical analysis of the three-composted organic fraction is shown in Table 3. Data showed that sewage effluent as organic accelerator led to a slight decrease in pH compared to that prepared without addition of any accelerator. In contrast, the same treatment increased the electrical conductivity from 4.9 to 5.5 dS/m. This decrease in pH, or that increase in EC, after the addition of sewage effluent may be attributed to the release of different organic acids throughout the biodegradation of MSW, and also its relatively high content of soluble salts. It was observed that addition of accelerator, either chemical or organic, reduced the organic content. This reduction was more pronounced in the case of using an organic accelerator, compared to that prepared without any additives.

TABLE 3. Chemical analysis of the composted MSW organic fraction.

Item	Without accelerator	Chemical accelerator	Organic accelerator
PH	7.8	7.9	7.4
EC (dS/m)	4.9	5.4	5.5
Organic matter %	40.9	38.9	38.2
Total nitrogen %	1.84	1.94	2.14
Total phosphorus %	0.21	0.22	0.25
Total potassium %	0.09	0.09	0.14
Total Fe (ppm)	4250	4522	4810
Total Mn (ppm)	318	322	322
Total Zn (ppm)	600	615	604
C/N ratio	12.9	11.6	10.4

With regards to the nutrient content, the only noticeable variation between the three types of compost was detected in total N %. It is likely that addition of sewage effluent enriched the N-content of MSW more than the chemical accelerator did. No appreciable differences were obtained in P and K, except the little increases that occurred in K-content of the organic accelerator treatment. On the other hand, slight differences were found between their micronutrients (Fe, Mn and Zn) content. From a compost technology point of view, it is well known that addition of accelerator, either chemical or organic enhances microorganisms to perform the biodegradation process and the reaction proceeds faster to maturity. Therefore, the compost prepared by addition of both accelerators could be more homogeneous and contains more available forms of nutrients, compared to that prepared without any accelerators (Wooton *et al.*, 1981).

The microbiological analysis of fecal coliforms in the composted MSW moistened with swage effluent revealed that the counts were 3.3×10^6 cells g^{-1} directly after mixing, then the population sharply decreased to 1.3×10^2 cells g^{-1}, after 45 days, while it completely disappeared at the end of composting (120 days). Whereas, the counts of the tested organism in the free and chemically accelerated compost disappeared before the first 45 days. Therefore, this composted MSW can be safely used as organic fertilizer, without any environmental restrictions.

Regardless the method of compost preparation, manuring wheat plants with any of the three composts, improved all plant characters, *i.e.* root length, plant height, tiller number and whole plant dry weight (Table 4). It is clearly seen that

the organic fraction of MSW, composted without any additives had the least favorable effect on plant growth whereas, the other treatments receiving chemical and organic accelerators were more promising. However, manuring wheat plants was preferable than the chemical fertilization with NPK. Significant differences in root length were recorded as a result of manuring wheat, compared to NPK fertilized plants. Whenever, these differences were highly significant in other plant parameters (plant height, tillers number and plant dry weight).

TABLE 4. Growth characterization of wheat plant (90 days old) manured with various composted MSW organic fractions.

Treatments	Root length (cm)	Plant height (cm)	Tillers (No/plant)	Whole plant dry weight (g/m^2)
NPK	12.4	11.3	5.3	593
composts				
Accelerator free	16.6	12.1	7.7	697
Chemically accelerated	19.3	12.9	7.8	763
Organically accelerated	21.5	14.3	8.6	850
LSD at 0.05	2.82	8.14	0.37	67.1

The use of compost amended with sewage effluent significantly increased whole plant dry weight compared to chemical treatment. These data are in complete agreement with those recorded by Jokela *et al.* (1990) who indicated that the growth of slash-pine manured with garbage compost accelerated with sewage sludge was significantly greater than garbage composted without any accelerator addition.

The yield parameters of wheat plants treated with the different types of compost and NPK are shown in Table 5. Generally, application of the organic fraction of MSW regardless their method of preparation, resulted in highly significant increases in grain and straw yields compared to that of the NPK treatment. In this respect, increases in yield parameters of manured plots over that of the NPK fertilized treatment ranged between 41.7 and 49.4 % for the biological yield, 40.7 and 49.4 % for the straw yield and 43.5 and 54.5 % for the yield of grains which was being higher with those manured by the organically-accelerated compost. Within the treatments of organic manures, there were no significant variations in straw yield between the three treatments. Whereas, a significant difference in grain yield was seen between accelerator free compost and organically accelerated one. In addition, there was no significant variation between chemically- accelerated and the untreated compost and also between the organically and chemically accelerated one. However, these variations were magnified between the non-additives and the organically treated compost leading

to high significant differences. Different increases over NKP treatment in N % of straw and grains were detected due to the use of composts. In general, it was also noticeable that all composting treatments were more efficient, improving all wheat yield parameters compared to the chemical fertilizers (NPK). Moreover, different increases in N-content were detected in both grain and straw, which reached 36.9 in the former and 31.8 % in the later. Data herein are in accordance with those obtained by Chattopadbyay (1992) who stated that organic manuring of rice plants with composted MSW improved yield and nutrient uptake.

TABLE 5. Yield parameters of wheat plants manured with various composted MSW organic fractions.

Treatment	Biological yield (ton/ fed)	Straw yield (ton/ fed)	Grain yield (ton/ fed)	N % of	
				Straw	Grains
NPK	6.09	4.02	2.07	0.22	1.68
compost					
Accelerator free	8.63	5.66	2.97	0.24	1.89
Chemically accelerated	8.98	5.89	3.09	0.26	1.95
Organically accelerated	9.10	5.90	3.20	0.29	2.30
LSD at 0.05	0.44	0.28	0.13		

It can be concluded that in addition to the beneficial effects of organic materials on improving soil properties, the pronounced increase in both the grain and straw yields of wheat crop were obtained by applying composted MSW as organic manures particularly those prepared by using any accelerator. The organically- accelerated composted MSW treated with sewage water, showed the most beneficial effects on the growth parameters of wheat plant as well as, grain and straw yields. On the other hand, the use of such a simple composting technique may contribute to solve the problem of MSW accumulation and could reduce environmental pollution.

References

Allen, O.N. (1959) *Experiment in Soil Bacteriology*. Ins. Ed. Burgess Publ., USA.

Bengtson, G.W. and Cornette, J. J. (1973) Disposal of composted municipal waste in a plantation of slash pine. *J. Environ. Qual.* 2,441.

Chattopadhyay, N., Dutta Gapta, M. and Gupta, SK.(1992) Effect of city waste compost and fertlizers on the growth, nutrient uptake and yield of rice. *J. Indian Soc. Soil Sci.* **40**, 464.

El-Boushy, A.R.Y. and Van Der Poel, A.F.B. (1994) *Poultry Feed from Waste Processing and use.* Chapman & Hall, London, Glassgrow, Weinheim, New York, Tokyo, Melboune, Madras.

Fitzpatrick, G.E. and Carter, N.S. (1983) Assessment of sewage sludge compost mixtures as container growing media. *Proc. Fla. State Hortic. Soc* . **96**, 257.

Jackson, M.I. (1973) *Soil Chemical Analysis.* Prentice Hall, New Delhi.

Jokela E.J., Smith, W.H. and Colbert,S.R. (1990) Growth and elemental content of slash pine 16 years after treatment with garbage composted with sewage sludge. *J. Environ. Qual.* **19**, 146.

Little, T.M. and Hills, F.J. (1977) *Agricultural Experimentation, Design* and *Analysis.* John Willy and Sons Inc., New York.

Saber, M. *et al* (1994) *Monograph on Solid Waste Management* (6 volumes). Environmental Research Council, Academy of Scientific Research and Technology, Egypt.

Saber, M., Abdel-Maksoud,H.K., Azzazy,M., Abdel-Zaher, R.A and Radwan,S. (1997) Characterization of MSW production and disposal options in Tala, Egypt. *Six International Landfill Symposium, Sardina* 1997, Italy. pp. 427-433.

Wooton, R.D., Gouin, R.R. and Stark, F.C. (1981) Composted digested sludge as a medium for growing flowering annuals. *J. Am. Soc. Hortic. Sci.* **106**, 46.

XinTao.HE, Traina, S.J. and Logan, T. J. (1992) Chemical properties of municipal Solid Waste Composts. *J. Environ. Qual.* **21**, 318.

(*Received* 7 / 2000)

تحويل المخلف العضوى للنفايات البلدية الى سماد عضوى صناعى وتأثير قيمتة السمادية على نمو القمح

حسين كامل عبد المقصود، محمد عبد الجواد عزازى و رضا عبد الظاهر عبد العزيز
قسم الميكروبيولوجيا الزراعية -المركز القومى للبحوث - الدقى - القاهرة - مصر.

تتوالد كميات كبيرة من النفايات البلدية فى أنحاء جمهورية مصر العربية تقدر بحوالى ٣٠٠٠٠ طن / يوم ومع ذلك لا تستغل الإستغلال الأمثل مما يؤدى الى كثير من المشاكل البيئية نتيجة لتراكمها ولكن بإستخدام إحدى التقنيات الحيوية الحديثة يمكن تحويل هذه المخلفات الى سيلاج أو سماد عضوى صناعى وقد أختيرت مدينة السنطة - محافظة الغربية لإجراء دراسة على تحويل المخلف العضوى للقمامة البلدية المتولدة بالمدينة الى سماد عضوى عن طريق التكمير الهوائى للمخلفات العضوية فى وجود نوعين من المنشطات إحداهما كيميائى والاخر عضوى لزيادة فاعلية الميكروبات القائمة بالتحلل وتقصير الوقت اللازم لعملية نضج السماد. كما أجريت تجربة حقلية بإستخدام نبات القمح فى تربة طينية طميية لتقييم السماد العضوى الصناعى الناتج من عملية التكمير الهوائي مقارنة بالتسميد بالأسمدة الكيمائية . وقد أوضحت النتائج أن عملية التكمير أدت الى زيادة القيمة السمادية للسماد العضوى الناتج وإنخفاض نسبة ال ك / ن به وزيادة نسبة العناصر الغذائية الصالحة لإمتصاص النبات كما أوضحت النتائج أيضا أن السماد الناتج عن إستخدام المنشط العضوى (مياه المجارى) كان الأفضل من ناحية القيمة السمادية مقارنة بالمنشط الكيميائى أو الغير معامل بأى من المنشطات وقد أنعكس ذلك فى شكل زيادة معنوية فى كمية المحصول (قش وحبوب) الناتج مع زيادة واضحة فى محتواة من النيتروجين والفوسفور مما يعنى تحسين إنتاجية القمح كما ونوعا بإستعمال مثل هذه النوعية من الأسمدة وعلى ذلك فإنه بإستخدام هذه التقنيات المساهمة فى حل بعض المشاكل البيئية الناتجة عن تراكم هذه المخلفات مع تحقيق عائد أقتصادى منها وكذلك تقليل التلوث الناتج عن سوء إستخدام الأسمدة الكيميائية .