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CO - COMPOSTING OF MUNICIPAL SOLID WASTES AND SLUDGE.

S.M. SHEHATA AND B.E. ALI

Soils and water Research Institute. Agricultural Research Centre, Giza, Egypt.

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Abstract

A demonstration experiment was conducted at damietta composting plant, to evaluate the potentional for co-composting of sewage sludge with municipal solid wastes. Three trial mixtures of different rates of sludge to solid waste were fermented in windrows.

The results show that co-composting is possible. A suitable mixture ratio of sewage sludge to municipal solid waste would range from 1:2 to 1:4 (by volume). and the that resultant product is suitable for land reclamation.

INTRODUCTION

Refuse collection, treatment and disposal is one of the major problems facing urban planners and operators in many developing countries today, in addition to the problems associated with inadequate treatment and disposal of human wastes. Indeed, proper refuse and human waste management is fast becoming a priority in many cities that are rapidly growing in size (Letito and Frederick, 1987).

Presently in Egypt there are six facilities for composting municipal solid wastes (MSW). After sorting, MSW is mixed and shredded in a rotating drum where water is added. The non-compostable fraction is removed and disposed by landfilling. The compostable fraction is stacked in windrows which are turned weekly by a special turning machine. After four weeks of aerobic fermentation the composted materials left for two weeks for further maturation. This product is mature coarse compost which could be used directly as a soil amendment or screened to produce mature fine compost (Shehata and Ali, 1990).

The choice of co-composting as a waste treatment alternative for garbage and sewage sludge must be considered in the light of other existing treatment alternative such as landfilling, incineration and dumping of sludge. Where , it is too difficult to compost sewage sludge alone because of its high moisture content. Successful operation introduced amendment such as wood chips, sawdust , rice hulls, straw and or co-compost the sludge with municipal solid wastes, (Pereira-Neto *et al.,* 1986).

The aim of this investigation is to develop an acceptable ratio of sludge to municipal solid waste for co-composting.

MATERIALS AND METHODS

Materials

Sewage sludge was obtained from a waste water treatment plant near Damietta. The municipal solid waste (MSW) compostable fraction was obtained from the composting system plant at Shata , Damietta, where this experiment was carried out.

This raw compostable fraction was mixed with sludge 2:1 and 1:1 by weight, respectively. While the third trial consists of a mixture between raw compostiable fraction of MSW, mature compost and sludge, 1:1:1 by weight, respectively. Table 1 sumarizes the three trial mixtures.

Table 1. summary of the trials mixtures .

	Trials		
	1	2	3
Ratio	Sludge	Raw Msw	Compost
By Weight	1:1.9:0	1:1.1:0	1:1:1
By volume	1:2.8:0	1:1.9:0	1:2:2
Mixture weight, Kg	4450	4440	8040
Mositure content,%	54%	43%	46%
Dry matter, Kg	2047	2530	4341

These mixtures were heaped by bucket loader. The Buhler windrow turning machine was used for mixing . Mixtures were turned twice a week and moisture was adjusted automatically. After four weeks, the mixtures were transferred to the compost maturing area for another five weeks.

Methods

Samples were analyzed using the standard methods as follows: Moisture content was determined in the fresh samples according to WHO (1978) . While pH values were estimated in the 1:50 water extract according to Richard *et al.*, (1970) . Oven dry samples were used for chemical analysis. Total and soluble nitrogen were determined according to the methods in Black *et.al.* (1965). While total and available phosphorus were determined colourmetrically according to Olsen *et al.* (1954) . The total micronutrient and heavy metals were estimated in the digested samples using LI 457 Atomic Absorption, according to the methods in WHO, (1978).

RESULTS AND DISCUSSION

Odor and Physical properties

A demonstration experiment was conducted at Damietta composting plant to evaluate the potential for co-composting of sewage sludge with municipal solid waste (MSW) . Three trial mixtures of different ratios of sludge to solid waste were formed into windrows. During the four week fermentation phase, the mixtures were turned at least once a week by a special windrow turning machine.

Odors were presented when the mixtures were first farrowed but disappeared after three weeks . Vander Hoeck and Oosthoeck (1985) described the odor emission from city refuse composting. During the mesophilic phase of the bio-oxidation phase fatty acids are the most frequently formed intermediates metabolites, followed by alcohols, aldehydes and ketones. The natural ventilation of the compost windrow induces and ascending airflow which contains, among other substances, ethanol an diacetyl and acetone. During the thermophilic phase, thermal-chemical reactions, take place, which give rise to volatile compounds like pyridine and pyrazine. The volatile sulphur compounds which appear in greatest amount are dimethylsulphide, dimethyldisulphide and dimethyltrisulphide. Hydrogen sulphide only appears under completely anaerobic conditions. While Chanyasak *et al.* (1982)state that volatile fatty acids are one of the major compounds causing the obnoxious odor of domestic refuse. The lower fatty acids in the refuse decrease significantly during the course of composting , especially in the later stage. Acetic acid is the main component detected , other acids detected are propionic, butyric, valeric and caproic.

Typically the exterior of the windrow appeared dry light brown in color, while the inside appears moist and darker brown in color. Compared to MSW treatment (control) , these mixtures had a darker richer brown color and appeared more moist. Trial 2 was the most difficult to mix due to the higher proportion of sludge. The mixture caused the windrow turning machine to plug due to the stickiness.

Temperature and biological changes

The temperature changes observed during the fermentation and maturation stages (Fig.1) could be used as indication of the proper functioning of the process. Temperature is perhaps a more reliable indicator than moisture, aeration or nutrient concentrations, since it directly affects pathogen control , which is important to the production of safety compost.

The temperature in the compost windrow increases during the first few days, remains fluctuated between 60 & 70 C for several days after turning. Consequently this parameter may be considered a good indicator of the end of the bio-oxidative phase in which the compost achives some degree of maturity. On this point, Stickelberger (1975) stated that a compost is matured enough when its temperature remains or less constant and does not vary with the turning-over of the material.

During the composting process microorganisms create elevated temperatures which can kill pathogens so the product is not health hazard. It could be observed from Fig.1, that the recorded temperatures in the windrows during the fermentation phase satisfy the regulations of Environmental Protection Agency (Letito and Frederick 1987). Processes to significantly reduce pathogens as pile temperatures of 40C for five days with temperature of 55C for at least four hours. For windrow composting process to further reduce pathogens require that the pile temperature reaches 55C for 15 days and the piles be turned over at least five times. Thus according to EPA definitions, the compost and co-compost produced would be considered safe for unrestricted direct contact use.

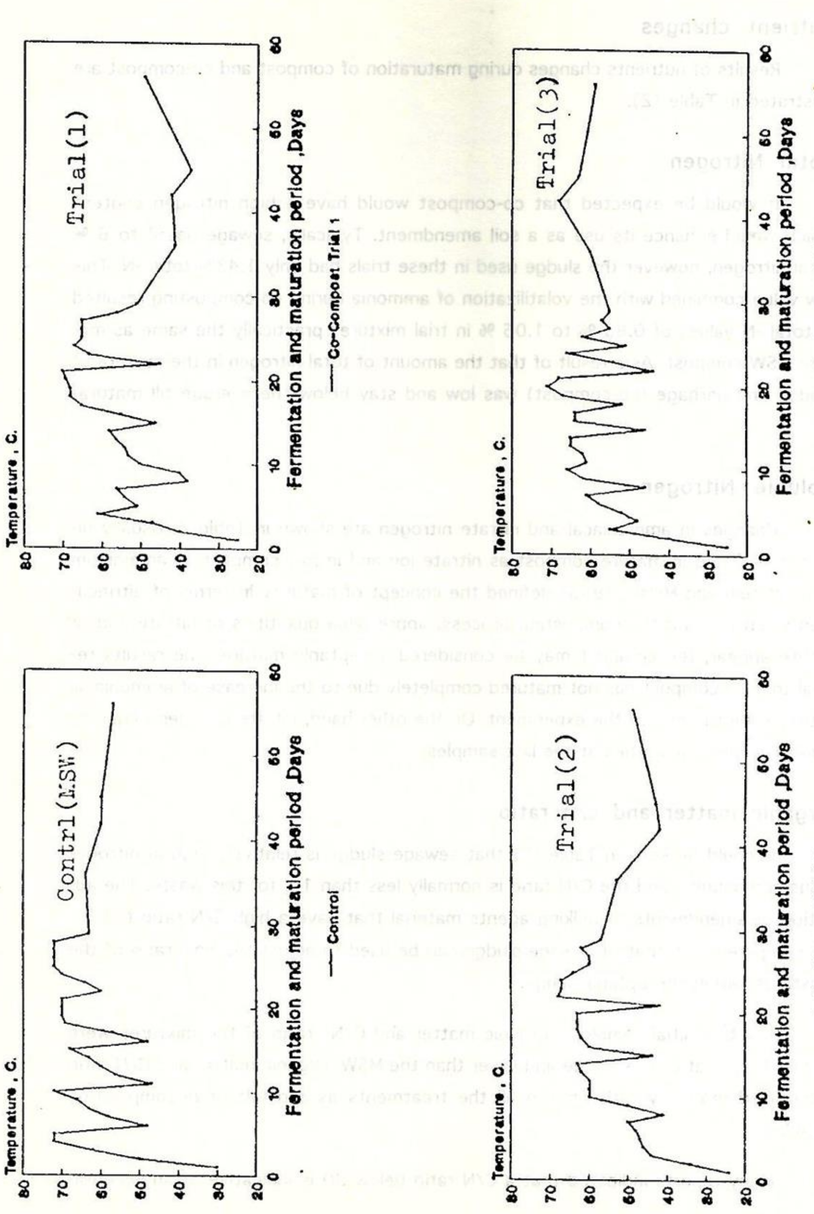

Fig. 1: Temperature changes during co-composting of municipal solid wastes (MSW) and sludge.

Nutrient changes

Results of nutrients changes during maturation of compost and co-compost are illustrated in Table (2).

Total Nitrogen

It would be expected that co-compost would have a high nitrogen content which would enhance its use as a soil amendment. Typically, sewage has 2 to 6 % total nitrogen, however the sludge used in these trials had only 1.43% total -N. This low value combined with the volatilization of ammonia during co-composting resulted in total -N values of 0.83 % to 1.06 % in trial mixtures practically the same as mature MSW compost. As a result of that the amount of total nitrogen in the mixture of sludge and garbage (co-compost) was low and stay below the average till maturation.

Soluble Nitrogen

Changes in ammoniacal and nitrate nitrogen are shown in Table 2. Usually nitrogen is found in mature compost as nitrate ion and in raw compost as ammonium ion. Finstein and Miller (1985) defined the concept of maturity in terms of nitrification when , during the composting process, appreciable quantities of nitrate and or nitrite appear, the compost may be considered acceptably mature. The results reveal that co-compost has not matured completely due to the increase of ammoniacal nitrogen till the end of the experiment. On the other hand, nitrate nitrogen began to appear in small quantities at the last samples.

Organic matter and c/n ratio

It could be seen in Table (2) that sewage sludge is relatively high in nitrogenous compounds, and the C/N ratio is normally less than 10, for this waste. The addition of amendments or bulking agents material that have a high C/N ratio (35.3 : 1) compared with that of sewage sludge can be used to adjust the final ratio of the mixtures within the optimal range.

For the initial samples , organic matter and C/N ratio of the mixtures were higher than that of the sludge and lower than the MSW. Organic matter and C/N ratio decreased gradually with time in all the treatments as a result of decomposition (Table 2).

Many reports indicated that a C/N ratio below 20 is indicative of an accepta-

Table. 2. Chemica analysis of matured compost generated from Municipal solid wastes (MSW) and different Co-compost trials.

Samples	Raw Materials			Treatments (Trials)		
Parameter	Sludge	MSW	Control	1	2	3
Weight,kg	1052	536	600	612	664	826
Moisture,%	44.9	39.6	23.2	37.2	29.1	20.9
pH	7.15	6.49	8.6	7.7	7.9	8.8
Total-N,%	1.43	1.00	0.81	1.06	0.85	0.83
NH - N, mg/kg	319	125	536	739	1088	10.72
No - N, mg/kg	0.0	0.0	12	0.0	60	49
Organic M,%	22.5	57.4	35.3	28.7	25.2	26.9
Orgnic C,%	13.1	33.0	20.5	16.62	14.6	15.58
C/N ratio	9.1:1	33.5:1	25.3:1	15.7:1	17.2:1	18.9:1
Total P,%	0.6	0.54	0.6	0.95	0.52	0.85
Total K,%	0.75	1.69	1.44	1.23	1.29	1.51
Soluble P,ppm	898	298	643	1020	512	621
Soluble K, ppm	448	2062	1880	1704	1904	1704
Iron	15360	12380	9650	13650	14780	9500
Manganese	275	149	157	570	460	357
Copper	108	100	224	70	120	45
Zinc	241	286	321	376	390	596
Lead	90	217	248	341	350	269
Cadmium	8	11	16	30	27	22
Cobalt	24	27	16	20	22	19
Lithium	0.1	0.3	0.9	0.5	0.6	0.4
Boron	92	50	63	71	82	58
Molybdenum	1.5	7.6	1.8	2.5	1.8	2.3
Nickel	5.9	2.4	4.0	5.1	2.8	4.2

ble maturity (Golueke, 1981). While Hirai et al. (1983) state that , the C/N ratio of compost cannot be used as an absolute indicator of the state of maturation since C/ N ratio found in well - composted materials presents great variability due to the type of original material. Because of this fact, Morel *et al.* (1985) noted that it is necessary to carry out a periodic monitoring of the C/N ratio during omposting until stability is reached to establish more certainly compost maturity.

Phosphorus and potassium

The results revealed an increase with time in both phosphorus and potassium either total or available . These nutrients are usually available in refuse in more than sufficient quantities.

Micronutrient and Heavy metals

Table 2 illustrate the changes in total micronutrient (Fe, Mn, Cu, and Zn) and total heavey metals (Pb, Cad, Co, Li, B, Mo, and Ni). The concentrations vary due to the heterogeneous nature of the raw materials. It is therefore difficult to provide typical data for these raw materials. Certain metal contents can vary between wide limits, it should be noted that all figures are at the mg/kg level , i.e. less than 1% . The major element present in these materials is iron. Concentrations of micronutrient and heavey metals are still within the permissible limits which mentioned in concowe (1980)

In conclusions, results show that co-composting is possible. A suitable mixture ratio of sewage sludge to municipal solid waste would range form 1:2 to 1:4 (by volume) , and that the resultant product is suitable for land reclamation.

Co-composting is advantageous because the two waste materials complement each other well. Sewage sludge is high in organic matter and has good bulking quality. Furthermore, both waste materials could be converted to a useful product free of pathogens (El-Nawawy 1988)

REFERENCES

1 . Black , C,A. *et al.* (1965) Methods of soil analysis. Part 2. Chemical and microbiological properties. Amer. Society of Agr. Inc. Madison, Wisconsin, USA.

2 . Chanyasak, V., M. Hirai, and H. Kubota, (1982). Changes of Chemical components and nitrogen transformation in water extracts during composting of garbage. J. Ferment. Technol., 60, 439-446.

3 . Concawe. (1980). Sludge farming: Atreatment for the disposal of oily refinery wastes. Report No.3/80.

4 . El-Nawawy , A.S. (1988). Orgianic wastes bioconversion systems, composting. (Lecture notes). Regional training course on "Integrated system for organic wastes utilization". Oct. 29- Nov.2 safat, Kuwait.

5 . Finstein, M.S. and F. C. Miller, (1985) Principles of composting leading to maximization of decomposition rate, odor control , and cost effectiveness. In "Composting of agricultural and other wastes " ed. Gasser, J.K.R. Elsevier Applied Science pub. London, New York, P 13-26.

6 . Golueke, C.G. (1981). Principles of biological resource recovery. Biocycle , 22, 36-40.

7 . Hirai, M., V. Chanysak, and H. Kubota, (1983) A standard measurement f composting maturity . Biocycle, 24, , 54- 56.

8 . Letito, A.O. and W. W. Frederick, (1987) Integrated resource recovery. The cocomposting of domestic solid and human wastes. World Bank Technical papers . No. 57. Washington, D.C.

9 . Morel, J. L., F. Colin, J. C. Germon, P. Godin and C. Juste, (1985). Methods of the evaluation of the maturity of municipal refuse compost. In "Comosting of agricultural and other wastes" ed. Gasser, J.K. Elsevier Applied Science pub. London, New York, P. 56-72.

10 . Olsen, S. K. Cole , C.V., F. S. Watanabe and L. A. Dean, L.A. (1954). Estimation of available phosphorous in soils by extraction with sodium bicarbonate. U.S. Dep . Agric. Circ. 939.

11 . Pereira - Neto, J. T., E.I. Stentiford and D. D. Mara, (1986). comparison of windrows and aerated static piles for refuse / sludge composting. International symposium on Compost Production, Quality and Use. Udine, Italy. 11p.

12 . Richard , A. C. and D. L. Richard, (1970). An investigation of the pH characteristics of compost . Compost Science Vol. 11, No.5.

13 . Richard, L.A. (1954). Diagnosis and improvement of saline and alkali soils . U.S. Dep. of Agr. Handbook No. 60.

14 . Shehata, S.M. and B. E. Ali. (1990) Composting of municipal solid wastes. Agric. Res. Review. (in press)

15 . Stickelberger, D. (1975). Survey of city refuse composting. In organic matter as fertilizer . FAO Soils Bulletin 27, Rome. p. 185 - 209.

16 . Van-der Hoeck, K. and J. Oosthoeck, (1985). Composting odor emission and odor control by biofiltration. In "Composting of agricultural and other wastes. ed. Gasser, J. K. Elsevier Applied Science Pub. London, New York.

17 . WHO (1978). Methods of analysis of sewage sludge solid wastes and compost . CH - 8600 Dubendorf, Switzerland.

خلط قمامة المدن مع حمأة المجاري لانتاج سماد عضوي

سامي محمد شحاته ، بهجت السيد علي

معهد بحوث الاراضى والمياه – مركز البحوث الزراعية – الجيزة

اقيمت تجربة ارشادية موسعة في مصنع دمياط لانتاج السماد العضوي وذلك لتقييم امكانية خلط القمامة مع حماة المجاري لانتاج سماد عضوي . تم تجهيز ثلاثة خلطات بنسب مختلفة مع الحماة والقمامة في مصفوفات التخمير الخاصة بالمصنع مع اتباع نفس نظام التقليب المتبع وذلك طريقة انضاج السماد.

واسفرت النتائج عن امكانية خلط قمامة المدن مع حمأة المجاري . وكانت نسب الخلط المناسبة من حمأة المجاري الى القمامة هي من ٢:١ الى ٤:١ (حجما) . وكان المنتج النهائي سماد عضوي مناسب وجيد لاصلاح الاراضي الجديدة.