Die Festwoche der Abfallwirtschaft und Altlasten der TU Dresden: 26.-30. September 2005

1. Fachtagung "Perspektiven von Deponien – Stilllegung und Nachnutzung nach 2005" am 26.-27. September 2005
2. Mischen oder Trennen ? –Grenzen der Technik und Nachweisführung nach ElektroG und VerpackV" am 28.September 2005
3. Festakt zur 10-Jahres-Feier (29.September 2005) Altlasten-rechtlicher Rahmen und regionale Praxis (30. September 2005)

Co-Composting Solid Wastes and Sludges of City İZMİR

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Summary

Composting is a biological treatment method widely used for solid wastes and sewage sludges. In this study, co-composting of solid waste and sludges originating from Izmir city was investigated.

In experimental part of the study, 12 reactors were set up in the laboratory. Reactors were loaded with solid waste taken from Uzundere composting plant and sludges taken from Cigli and Guneybati wastewater treatment plants. Solid wastes and sludges were mixed in different ratios.

Experimental studies were carried out in three series. In Series 1, solid wastes taken from Uzundere composting plant were mixed with sludges taken from Cigli wastewater treatment plant. In Series 1, up to 22% of weight loss was gained in 42 days. Initial temperature of composting material was about 19.5 ºC and 24 hours later, temperatures in reactors increased up to 44-51 ºC, while the ambient air temperature was about 24.0 ºC.

In Series 2, solid wastes taken from Uzundere composting plant were mixed with sludges taken from Guneybati wastewater treatment plant. In Series 2, up to 50.00% of weight loss was gained in 42 days. Average organic reduction was about 47.14% for the mixture with 3/1 solid waste sludge ratios. In this series, temperatures reached up to 59.2 ºC.

In Series 3, solid wastes taken from Uzundere composting plant were mixed with sludges taken from Guneybati wastewater treatment plant. In Series 2, up to 50.50% of weight loss was gained in 42 days. Almost 60% of organic reduction was achieved. In this series, temperatures reached up 53 ºC. Results of experimental studies showed that if moisture and C/N ratio is arranged accurately, solid waste and sludge can be co-composted successfully. The compost product may improve the plant growth.

Keywords: Solid waste, sludge, composting, co-composting

Introduction

Solid waste and sludge disposal is a great problem that must be solved by municipalities. Izmir, with its 3 million populations, generates 2500-3000 tones of solid waste every day (Coban, 2004) and at least 40% of this solid waste is organic. In addition to solid waste, 343-640 tones/day of wastewater treatment plant sludge (Altinbas et al., 2004), which also has high organic content, is generated at the wastewater treatment plants of Izmir.

In last decades, composting has been controlled and directly utilized for sanitary recycling and reclamation of organic waste material. Such organic materials as vegetable matter, animal manure, wastewater sludge (biosolids) and other organic refuse can be converted from otherwise wasted materials to a more stable form for use as a soil amendment by this process. This process is called “composting” and the final product of composting is called “compost”.

There are many alternatives for disposal of solid wastes and sewage sludges. Composting is one way to manage and recycle organic waste and to manufacture humus like material for improving soils properties. Composting may also reduce the volume of organic materials by about 80% as they decay. Co-composting that produce valuable product from organic fraction of solid waste and sewage sludge can be a good disposal alternative for both waste types.

Composting of wastewater treatment plant sludge has been practiced but co-composting of wastewater treatment plant sludge and municipal solid waste is not wide spread. Mixing the sludge with municipal solid waste is beneficial, as sludge may provide nutrients and moisture for optimum composting and also overall heavy metal content of the composted material would be considerably less than the composted sludge alone. In addition to solid waste, wastewater treatment plant sludge can be co-composted with agricultural, forestry and some agro-industry residues such as tobacco residue. These residues would behave as bulking agent and may improve the pile structure by allowing air circulation.

According to the EU direktives , if our country aims to be a member of European Union, we have to adapt to the directives and reduce the amount of biodegradable municipal waste. This can be achieved by the application of composting process effectively. (Mechanical-biological- treatment of solid wastes).

Municipal wastewater treatment plant sludges can also be composted either alone or together with municipal solid waste (co-composting). Thus, sludge can be stabilized and converted to a valuable product.

Materials and Methods

Sampling Procedure

Wastewater treatment plant sludge and pre-processed solid waste were required for the experimental studies. Sludge samples were taken from

Cigli and Guneybati wastewater treatment plants while pre-processed solid waste samples were taken from Uzundere composting plant.

Experimental studies were carried out as three series. In first series, sludge samples were taken from Cigli wastewater treatment plant. In this plant, polymer is added to the sludge taken from sludge storage tank and then sludge is mechanically thickened. Thickened sludge is dewatered using a belt press system and after lime addition (lime stabilization), it is stored in sludge cake storage area. Sludge samples were taken from sludge cakes prior to lime stabilization process. In second and third series, sludge samples were taken from Guneybati wastewater treatment plant. In this plant, polyelectrolyte is added to sludges removed from aeration and final sedimentation tank. Sludge is thickened in trays and then dewatered in belt press. There isn't any sludge stabilization system in this plant. Sludge samples were taken from mechanically dewatered sludge cakes.

Solid waste samples were taken from Uzundere composting plant in all series. Pre-processed solid waste is conveyed to fermentation area and it drops to newly forming windrow part. Solid waste samples were taken from al least 3 different part of windrow as it represents the solid waste in windrow. Depth of the sampling points were abut 0-50 cm. A schematic illustration of sampling points is given in Figure 1.

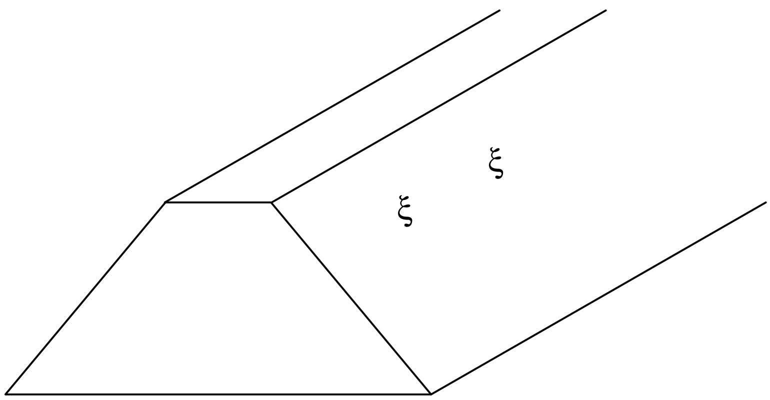

Figure 1 Schematic illustration of sampling points in windrows

Sludge and solid waste samples were brought to laboratory in 30 L containers.

Preparation of Reactors

Firstly, some samples were taken from sludge and solid waste samples for initial analyses. Solid waste and sludge were weighed using a steelyard capable of weighing up to 30 kg with minor unit of 10 g and mixed in a large washbowl as previously determined ratios. Composting material of each reactor was prepared separately. Then solid waste and sludge mixtures were placed in reactors. Weight of solid waste and sludge mixtures placed in each reactor was about 2 kg.

Modified 5 L thermoses were used as reactor. A schematic illustration of reactors is given in Figure 2. Aquarium air pumps were used to aerate the reactors. Different air flowrates were applied in each series.

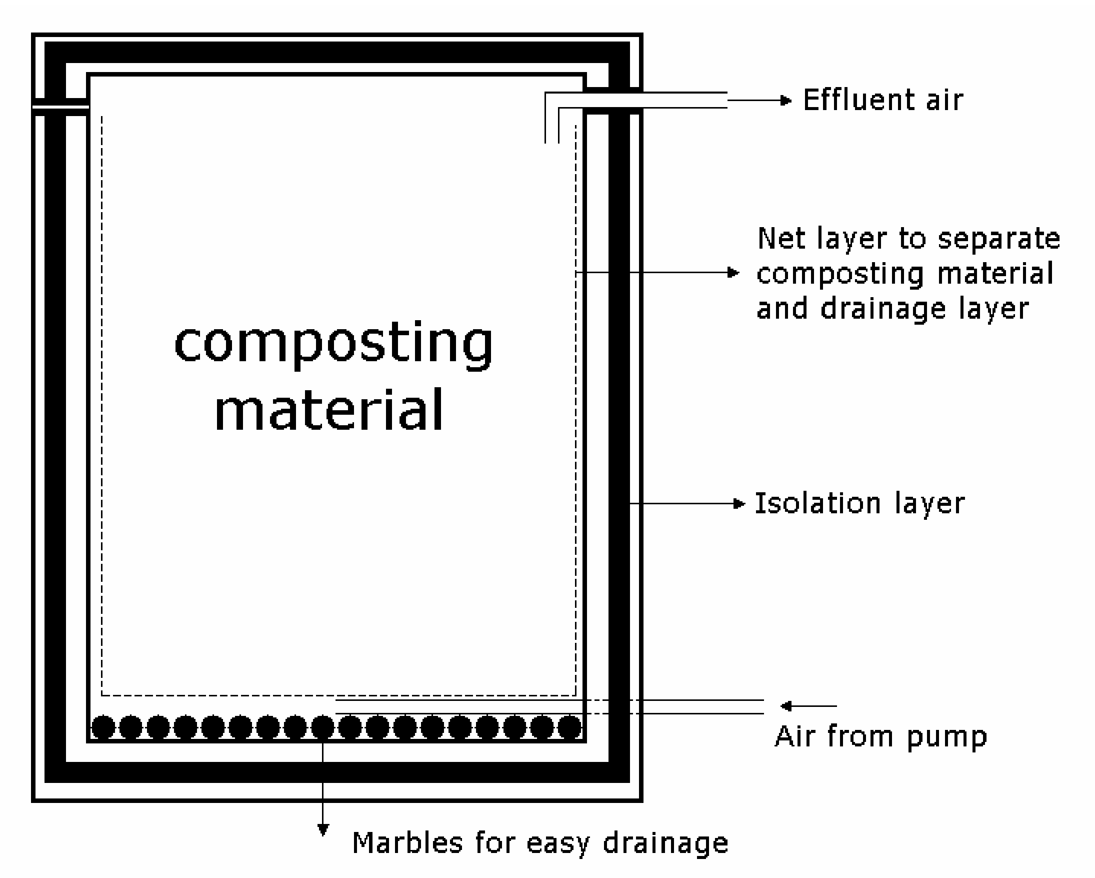

Figure 2 A schematic illustration of reactors

Measurements during Composting Period

Temperature of composting materials was measured daily using a digital thermometer. Temperatures were measured in different part of reactor and average value was accepted as the temperature of composting material. In addition to the temperature of composting material, ambient air temperature was also measured to see its effect.

Weight of composting materials was measured twice a week using a steelyard described above.

Moisture, organic and inorganic contents were measured weekly on the day reactor contents were turned. In moisture analyses, a representative sample was weighed and then placed in a drying chamber. Samples were dried at 105 ºC up to a constant weight (24 hours as a rule) as described by German Federal Compost Quality Assurance Organization (1994). In organic content analyses, dried samples are burned at 550 ºC in a furnace until the weight is constant (Federal Compost Quality Assurance Organization, 1994). Inorganic content is the weight of remaining ash.

Total nitrogen contents of solid wastes and sludges placed in reactors were measured. Also, total nitrogen contents of compost products were measured to evaluate the maturity level of compost. For total nitrogen analyses, extraction procedure (Method 1310A) of EPA was followed. Total nitrogen concentrations in extracts were measured using MERCK test kits as its procedure.

In composting systems, temperature may increase up to 65-70 ºC as a result of biological degradation of organic materials in solid waste or other organic matter in first days of composting process. During our experimental studies, especially on initial days, we could get temperatures up to 60 ºC. Temperatures around this value may be enough for pasteurization if it lasts more than 5 days. Unfortunately, temperatures did not last so long. On the other hand, in all series, there were 5 ºC differences between ambient temperature and reactor temperatures. These differences indicate that microbial activity goes on in the reactor.

Moisture content and low amount of composting material mass were the reasons for low temperatures. In all series, our initial moisture contents were not suitable for optimum start up of composting process. The initial moisture content must be 45-60%. The reactors were loaded with about 2 kilograms of composting material which is too low compared to materials in windrow or in-vessel systems. Low amount of composting material could not produce enough heat and it lost the heat it produced easily.

Water, product of degradation, was expected to vaporize to atmosphere. But system was a closed system and the water condensed on inside of cover and remained in the system. This resulted in an increase in moisture content of composting material. This was a reason affecting system performance adversely.

In Series 1, up to 22% of weight loss was gained in 42 days. Reactor 1 (raw solid waste) and Reactor 7 (10/5 solid waste sludge ratio) gave the best results of weight loss. On the other hand, best organic reduction was gained in Reactor 5 (10/3 solid waste sludge ratio). It may be concluded that organic decomposition was higher in Reactor 5, while evaporation was higher in Reactor 1 and 7.

In Series 1, initial temperature of composting material was about 19.5 ºC and 24 hours later, temperatures in reactors increased up to 44-51 ºC, while the ambient air temperature was about 24,0 ºC. Temperatures above 30 ºC continued about for 6 days and then temperatures in reactors became lower than 30 ºC. On the other hand, there were still about 5 ºC differences between reactor temperatures and ambient air temperature during first 14 days of composting period.

In Series 2, up to 50.00% of weight loss was gained in 42 days. Reactor 2 (3/1 solid waste sludge ratio) and Reactor 5 (1/3 solid waste sludge ratio) gave the best results of weight loss. Best organic reductions were gained in the same reactors and Reactor 3 (1/3 solid waste sludge ratio). If we look at the average organic reduction of same loading ratios, reactors loaded with 3/1 solid waste sludge ratios have the best average value of 47.14%. Reactors loaded with 1/3 solid waste sludge ratios have a similar average value of 46.98%.

In Series 2, initial temperature of composting material was about 24.5 ºC and 24 hours later temperatures in reactors increased up to 43.8-59.2 ºC, while the ambient air temperature was about 20.8 ºC. After about 24 hours, temperatures in each reactor increased up to 43.8-59.2 ºC, while the ambient air temperature was about 20.8 ºC. Temperatures above 30 ºC continued about for 4 days and then temperatures in reactors became lower than 30 ºC. 5 ºC differences between reactor temperatures and ambient air temperature lasted about 20 days.

If we interpret the C/N ratios of Series 2, it can be said that composting material with higher sludge content matures more easily.

In Series 3, temperature of composting material was about 29 ºC initially. 48 hours later, temperatures in reactors increased up to 53 ºC, while the ambient air temperature was about 28 ºC. Temperatures above 30 ºC continued about for 25 days and then temperatures in reactors became lower than 30 ºC. Differences between reactor temperatures and ambient air temperature became lower than 5 ºC after 15th day. Due to the high ambient temperature, temperatures in reactors were always higher than 28 ºC.

In Series 3, up to 50.50% of weight loss was gained in 42 days. Best weight loss was gained in Reactor 1 (3/1 solid waste sludge ratio) and Reactor 5 (1/3 solid waste sludge ratio). Best organic reductions were gained in Reactor 1 (1/3 solid waste sludge ratio) and Reactor 7 (1/3 solid waste sludge ratio). If we look at the average organic reduction of same loading ratios, reactors loaded with 3/1 solid waste sludge ratios have the best average value of 59.71%. Reactors loaded with 1/1 and 1/3 solid waste sludge ratios have average value of 56.56% and 50.72% respectively. These organic reduction ratios were higher than the ratios in Series 1 and 2. This may be because of higher ambient temperatures and increased aeration.

C/N ratios of Series 2 indicated that decomposition may continue in reactors loaded with 3/1 solid waste sludge ratio.Plant test showed that utilization of compost may increase the amount of product.

As a conclusion; solid waste and sludge can be co-composted. Mixing ratios must be arranged according to their moisture contents and C/N ratios. A special attention must be paid to aeration. Isolation may be important in in-vessel systems in order to save the heat of reactor. In order to evaluate the quality of compost product, heavy metal analyses and plants tests must be done.(Figure 3).

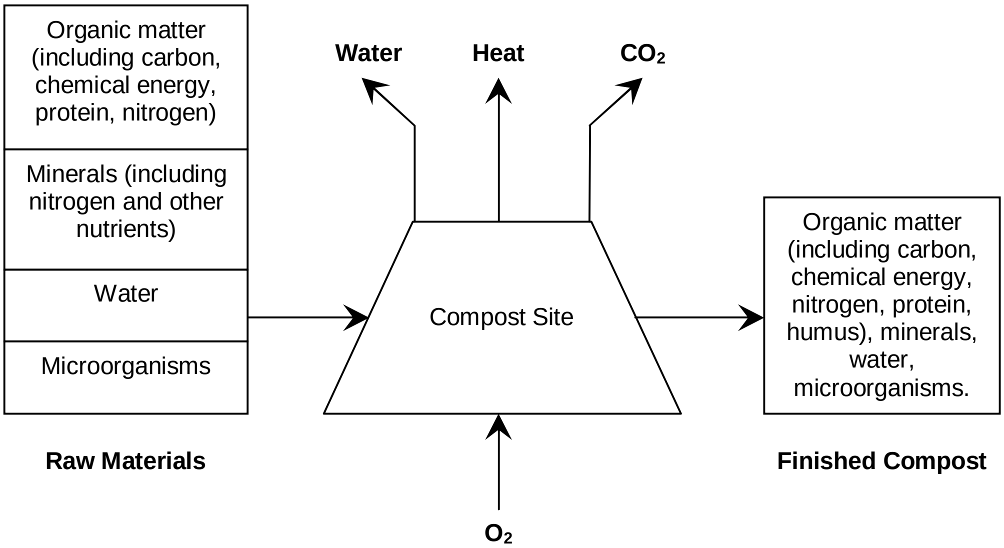

Figure 3 : Schematic illustration of composting process

Some Selected Results and Discussions

In the first part of experimental studies, co-compostability of solid waste and sludges was investigated. Mechanically pre-processed (separated and sorted) solid waste taken from Uzundere Composting Plant and wastewater treatment plant sludges taken from Cigli and Guneybati wastewater treatment plants were used in the experimental studies. Experimental studies were carried out as three series.

In composting systems, temperature may increase up to 65-70 ºC as a result of biological degradation of organic materials in solid waste or other organic matter in first days of composting process. During our experimental studies, especially on initial days, we could get temperatures up to 60 ºC. Temperatures around this value may be enough for pasteurization if it lasts more than 5 days. Unfortunately, temperatures did not last so long. High moisture content and low amount of composting material mass were the reasons for low temperatures. In all series, our initial moisture contents were not suitable for optimum start up of composting process. The initial moisture content must be 45-60%. The reactors were loaded with about 2 kilograms of composting material which is too low compared to materials in windrow or in-vessel systems. Low amount of composting material could not produce enough heat and it lost the heat it produced easily. On the other hand, in all series, there were 5 ºC differences between ambient temperature and reactor temperatures for about 15 to 20 days. These differences indicated that microbial activity was going on in the reactors. Water, product of degradation, was expected to vaporize to atmosphere through the effluent gases. In some of the reactors water condensed on inner surface of cover and remained in the system. This resulted in an increase in moisture content of composting material. This was a reason affecting system performance adversely.

In Series 1, sludge sample was taken from Cigli wastewater treatment plant. In this series, up to 22% of weight loss was gained in 42 days. Reactor 1 (raw solid waste) and Reactor 7 (10/5 solid waste sludge ratio) gave the maximum weight losses. On the other hand, maximum organic reduction was gained in Reactor 5 (10/3 solid waste sludge ratio). The reactors were operated under the same environmental conditions and aerated with same air flow rate. The maximum weight losses in Reactor 1 and 7 can be explained with the losses of moisture through effluent gases. In these reactors, temperatures increased up to 50-55 ºC in the first days of the composting period. These high temperatures might be the reason of high water loss through effluent gas. It may be concluded that organic decomposition was higher in Reactor 5, while evaporation was higher in Reactor 1 and 7. In Series 1, initial temperature of composting material was about 19.5 ºC and 24 hours later, temperatures in reactors increased up to 44-51 ºC, while the ambient air temperature was about 24,0 ºC. Temperatures above

30 ºC continued about for 6 days and then temperatures in reactors became lower than 30 ºC. On the other hand, there were still about 5 ºC differences between reactor temperatures an ambient air temperature during first 14 days of composting period. In Series 2, sludge sample was taken from Guneybati wastewater treatment plant.
In this series, up to 50,00% of weight loss was gained in 42 days. Reactor 2 (3/1 solid waste sludge ratio) and Reactor 5 (1/3 solid waste sludge ratio) gave the maximum results of weight loss. Maximum organic reductions were gained in the same reactors and Reactor 3 (1/3 solid waste sludge ratio). If we look at the average organic reduction of same loading ratios, reactors loaded with 3/1 solid waste sludge ratios have the best average value of 47,14%. Reactors loaded with 1/3 solid waste sludge ratios have a similar average value of 46,98%. In this series, leachates were removed from Reactors 1, 2, 3, 4, 5 and 6 on turning days, while leachates were mixed with composting materials in Reactors 7, 8, 9, 10, 11 and 12. When we look at the weight losses of the same loading rates, it can be seen that average values were higher in first 6 reactors (from where leachate were removed) than second 6 reactors. This indicates that removal of excess moisture from reactors has a positive effect on system performance.

In Series 2, air flow rate was higher than the Series 1. This higher air supply increased decomposition rate and as a result, higher organic reductions were gained. In Series 2, initial temperature of composting material was about 24,5 ºC and 24 hours later temperatures in reactors increased up to 43,8-59,2 ºC, while the ambient air temperature was about 20,8 ºC. After about 24 hours, temperatures in each reactor increased up to 43,8-59,2 ºC, while the ambient air temperature was about 20,8 ºC. Temperatures above 30 ºC continued about for 4 days and then temperatures in reactors became lower than 30 ºC. 5 ºC differences between reactor temperatures and ambient air temperature lasted about 20 days. If we interpret the C/N ratios of Series 2, it can be said that composting material with higher sludge content matures more easily. C/N ratios of Series 2 also indicate that decomposition may continue in reactors loaded with 3/1 solid waste sludge ratio.

In Series 3, sludge sample was taken from Guneybati wastewater treatment plant again. In Series 3, up to 50,50% of weight loss was gained in 42 days. Maximum weight losses were gained in Reactor 1 (3/1 solid waste sludge ratio) and Reactor 5 (1/3 solid waste sludge ratio). Maximum organic reductions were gained in Reactor 1
(1/3 solid waste sludge ratio) and Reactor 7 (1/3 solid waste sludge ratio). If we look at the average organic reduction of same loading ratios, reactors loaded with 3/1 solid waste sludge ratios have the best average value of 59,71%. Reactors loaded with 1/1 and 1/3 solid waste sludge ratios have average value of 56,56% and 50,72% respectively. These organic reduction ratios were higher than the ratios in Series 1 and 2. Main reasons of these differences were the higher ambient temperatures and increased aeration. Higher aeration rates results in better organic reductions but also loss of heat and consequently lower temperatures of composting material. This may affect the reduction of pathogenic microorganisms. In Series 3, temperature of composting material was about 29 ºC initially. 48 hours later, temperatures in reactors increased up to 53 ºC, while the ambient air temperature was about 28 ºC. Temperatures above 30 ºC continued about for 25 days and then temperatures in reactors became lower than 30 ºC. Differences between reactor temperatures and ambient air temperature became lower than 5 ºC after 15th day. Due to the high ambient temperature, temperatures in reactors were always higher than 28 ºC.

Last C/N ratios of Series 3 indicate that more aeration gives more stable products. If we compare the C/N ratios of Series 2 and Series 3, it can be concluded that higher ambient temperatures and air flow rates facilitates the stabilization. In second part of the study, qualities of the composts produced were evaluated. For the evaluation of compost quality, heavy metal contents were analyzed and plant tests were done.

In Table 1 maximum values heavy metal concentration in compost products and some standards are given. These results show that concentrations of all parameters in Series 1 and Series 2 are under even the strictest standards. These products can be used for all purposes. Concentrations of all parameters in Series 3 are under the

Greeks and Italian standards, while some parameters are over the German standards. These results show that compost products can be used safely.

Table 1 given maximum values of heavy metal in series and some standards In case compost product is not suitable for agricultural use, co-composting may be used as mechanical-biological pretreatment for volume and organic reduction. With a composting period of about 40 days, the amount of sludge originating from Izmir city may be reduced to the half. With a simple calculation, it means that 110000 m3/yr less landfill volume will be required. In future studies, utilization of compost for different purposes must be evaluated. Thus, compost products can be utilized and there would not be any need for disposal of them.

Table 1:Maximum values of heavy metal in series and some standards

Standards and Maximum Values in Series	Parameters (mg/kg dry weight)						
	Pb	Cd	Cr	Cu	Ni	Hg	Zn
Greece	500	10	510	500	200	5	2000
Italy	500	10	500	600	200	10	2500
Germany	150	1.5	100	100	50	1	400
Max values in Series 1	130	1.3	92	84	46	0.29	370
Max values in Series 2	140	1.3	82	78	44	0.92	390
Max values in Series 3	89	1.8	98	196	166	NA	470

Table 2 : Inıtial conditions of compostıng materials placed in reactors in Series 1

Reactors	Solid Waste / Sludge Ratio (unit/unit)	Weight of Material (gram)	Moisture (%)	Dry Matter (%)	(on dry basis)	
					Organic Content (%)	Inorganic Content (%)
Reactor 1	Raw solid waste	1770	65,80	34,20	65,50	34,50
Reactor 2	Raw solid waste	1900	65,80	34,20	65,50	34,50
Reactor 3	10 / 1	2200	67,31	32,69	66,10	33,90
Reactor 4	10 / 2	2180	68,60	31,40	66,60	33,40
Reactor 5	10 / 3	2050	69,70	30,30	67,02	32,98
Reactor 6	10 / 4	2120	70,64	29,36	67,38	32,62
Reactor 7	10 / 5	2250	71,45	28,55	67,70	32,30
Reactor 8	10 / 6	2300	72,17	27,83	67,97	32,03

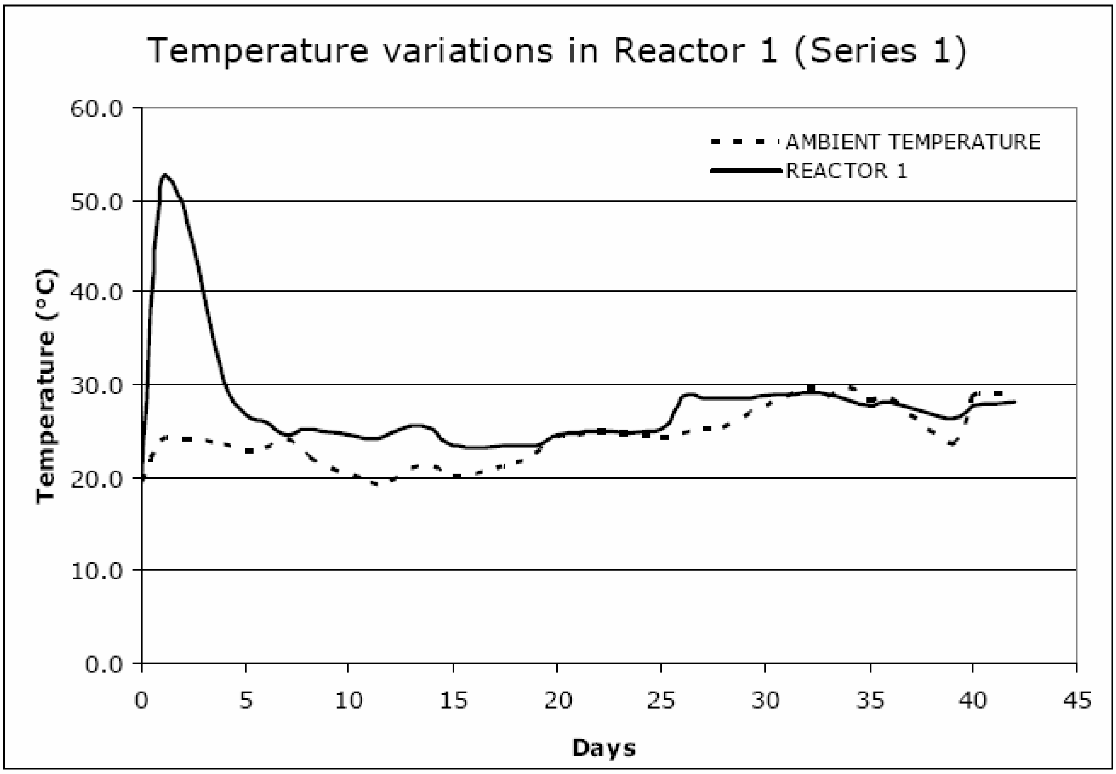

Figure 4 : Temperature variations in Reactor (Series 1)

Table 3 : Inıtial conditions of compostıng materials placed in reactors in Series 2

Reactors	Solid Waste / Sludge Ratio (unit/unit)	Weight of Material (gram)	Moisture (%)	Dry Matter (%)	(on dry basis)	
					Organic Content (%)	Inorganic Content (%)
Reactor 1	3 / 1	2000	68,10	31,90	64,75	35,25
Reactor 2	3 / 1	2000	68,10	31,90	64,75	35,25
Reactor 3	1 / 1	2000	70,82	29,18	64,90	35,10
Reactor 4	1 / 1	2000	70,82	29,18	64,90	35,10
Reactor 5	1 / 3	2000	73,55	26,45	65,07	34,93
Reactor 6	1 / 3	2000	73,55	26,45	65,07	34,93
Reactor 7	3 / 1	2000	68,10	31,90	64,75	35,25
Reactor 8	3 / 1	2000	68,10	31,90	64,75	35,25
Reactor 9	1 / 1	2000	70,82	29,18	64,90	35,10
Reactor 10	1 / 1	2000	70,82	29,18	64,90	35,10
Reactor 11	1 / 3	2000	73,55	26,45	65,07	34,93
Reactor 12	1 / 3	2000	73,55	26,45	65,07	34,93

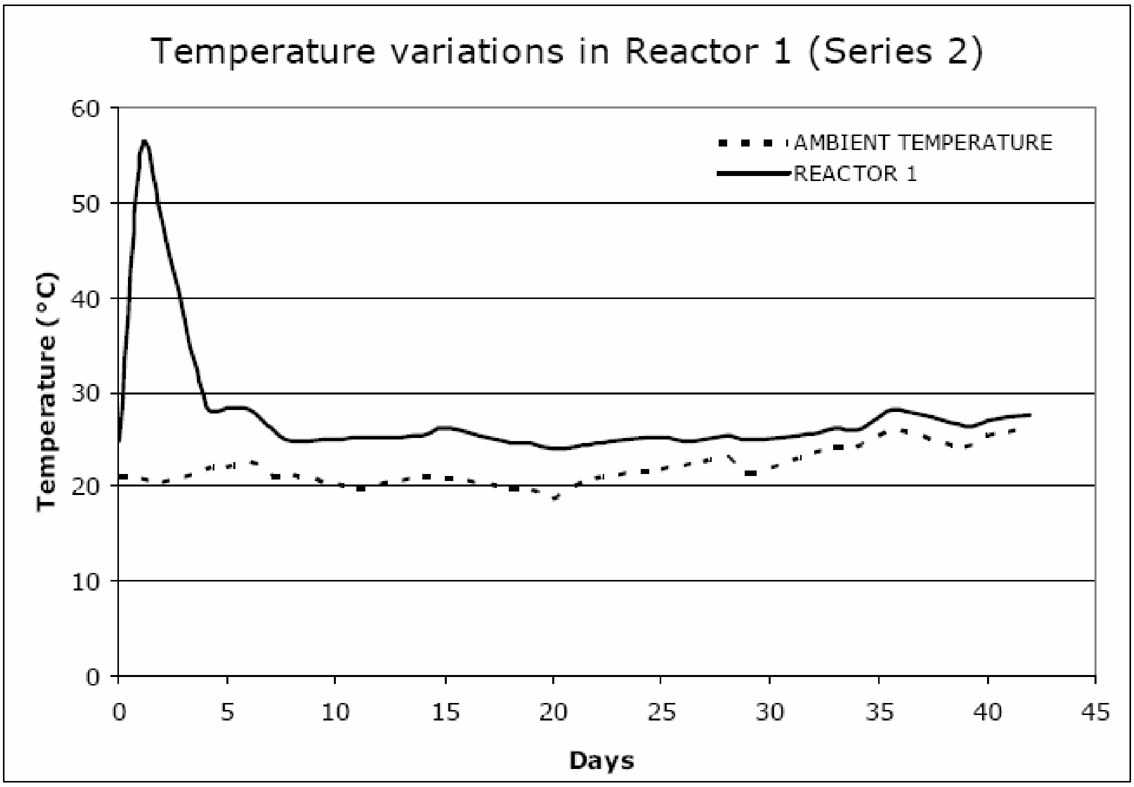

Figure 5 : Temperature variations in Reactor (Series 2)

Table 4 : Inıtial conditions of compostıng materials placed in reactors in Series 3

Reactors	Solid Waste / Sludge Ratio (unit/unit)	Weight of Material (gram)	Moisture (%)	Dry Matter (%)	(on dry basis)	
					Organic Content (%)	Inorganic Content (%)
Reactor 1	3 / 1	2000	71,19	28,81	71,39	28,61
Reactor 2	3 / 1	2000	71,19	28,81	71,39	28,61
Reactor 3	1 / 1	2000	72,77	27,23	67,98	32,02
Reactor 4	1 / 1	2000	72,77	27,23	67,98	32,02
Reactor 5	1 / 3	2000	74,35	25,65	64,56	35,44
Reactor 6	1 / 3	2000	74,35	25,65	64,56	35,44
Reactor 7	3 / 1	2000	71,19	28,81	71,39	28,61
Reactor 8	3 / 1	2000	71,19	28,81	71,39	28,61
Reactor 9	1 / 1	2000	72,77	27,23	67,98	32,02
Reactor 10	1 / 1	2000	72,77	27,23	67,98	32,02
Reactor 11	1 / 3	2000	74,35	25,65	64,56	35,44
Reactor 12	1 / 3	2000	74,35	25,65	64,56	35,44

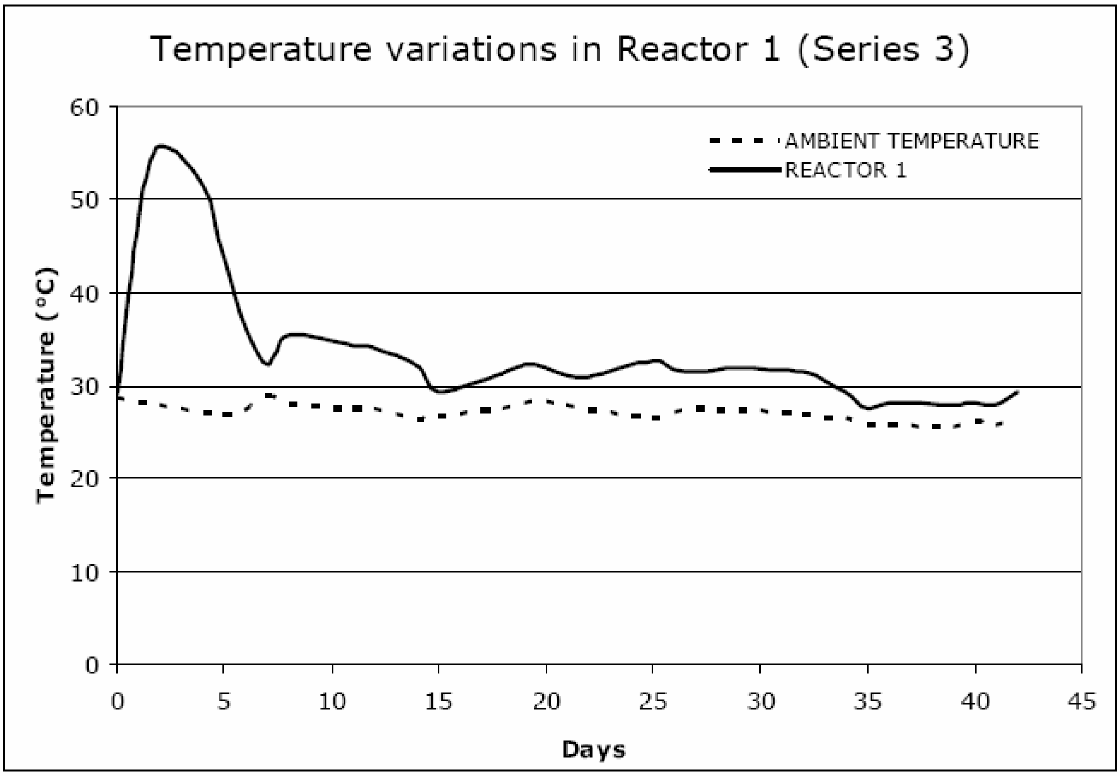

Figure 6 : Temperature variations in Reactor (Series 3)

Table 5 : changes in C/N ratios in series 3

Reactors	Air flow rate (L/day)	Initial C/N	Last C/N
Reactor 1	4800	55,5	17,2
Reactor 2	2400	55,5	22,1
Reactor 3	4800	35,5	15,2
Reactor 4	2400	35,5	20,8
Reactor 5	4800	24,7	12,2
Reactor 6	2400	24,7	16,2
Reactor 7	4800	55,5	17,0
Reactor 8	2400	55,5	27,4
Reactor 9	4800	35,5	16,6
Reactor 10	2400	35,5	19,3
Reactor 11	4800	24,7	13,9
Reactor 12	2400	24,7	14,3

Table 6 : Heavy metal contents of composts produced from series 1 (mg/kg dry weight)

REACTOR	Pb	Cd	Cr	Cu	Ni	Hg	Zn
Reactor 1	130	1,1	76	82	46	0,29	320
Reactor 2	120	1,2	71	69	34	0,12	360
Reactor 3	130	1,1	88	84	42	0,09	330
Reactor 4	84	0,9	51	58	28	0,08	180
Reactor 5	110	1,2	77	66	36	0,14	260
Reactor 6	110	1,3	82	64	41	0,16	220
Reactor 7	130	1,1	74	76	38	0,29	370
Reactor 8	120	1,0	92	81	32	0,21	190

Table 7 : Heavy metal contents of composts produced from series 2 (mg/kg dry weight)

Table 8 : Heavy metal contents of composts produced from series 2 (mg/kg dry weight)

REACTOR	Pb	Cd	Cr	Cu	Ni	Hg	Zn
Reactor 1	87	1,4	86	129	59	NA	290
Reactor 2	89	1,4	98	195	64	NA	390
Reactor 3	59	1,3	84	171	65	NA	380
Reactor 4	51	1,2	90	160	166	NA	390
Reactor 5	41	1,6	80	151	65	NA	450
Reactor 6	43	1,8	80	156	67	NA	470
Reactor 7	68	1,0	85	169	61	NA	300
Reactor 8	68	0,8	92	196	74	NA	360
Reactor 9	56	1,1	96	179	86	NA	380
Reactor 10	56	1,2	90	154	73	NA	390
Reactor 11	45	1,4	85	138	61	NA	410
Reactor 12	42	1,6	88	145	68	NA	430

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Figure 4 shows “In-Vessel Composting System”.

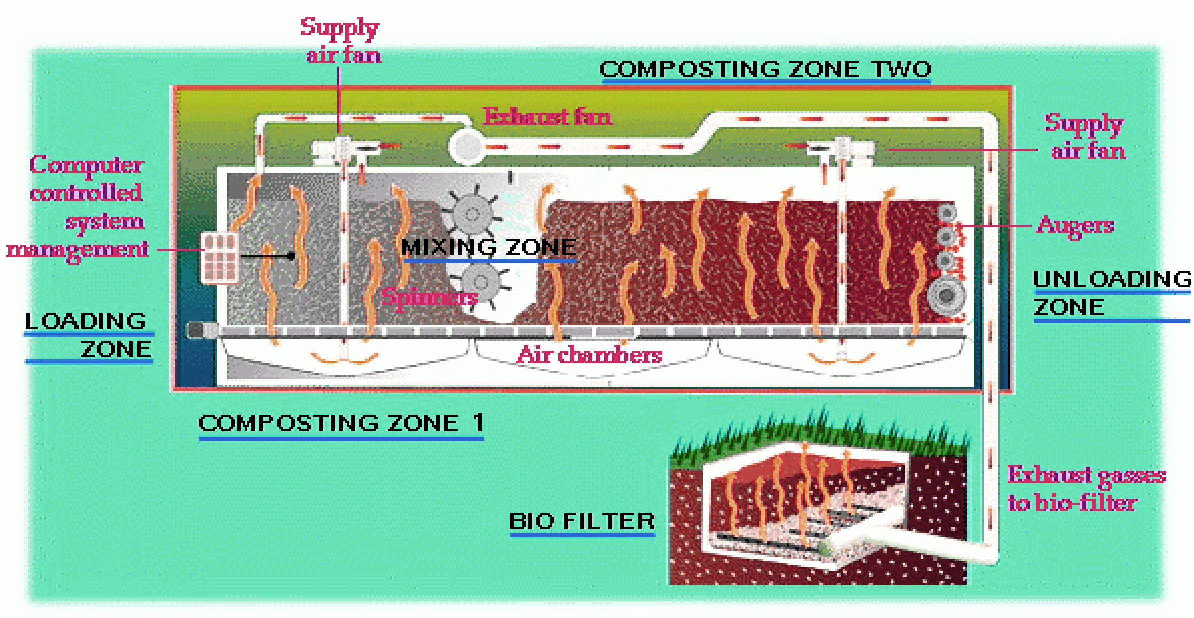

Figure 4 In-vessel composting system of Wright Environmental Management Inc. (WEB_1, 2000)