RESULTS AND DISCUSSION

4- RESULTS AND DISCUSSION

4.1. Physical and Chemical Changes During Composting Process.

4.1.1. Temperature profiles and degree of composting:

The temperature rise of the row materials during composting process is considered as an action indicative of the degree of microbial decomposition activity. The temperature also giving the optimal activity in samples incubated at a variety of temperature during the assay tended to increase as the composting time progressed.

Composting process essentially takes place within the two ranges known as methophilic phase (10-40 °C) and thermophilic phase (greater than 40 °C). Although mesophilic temperatures allow effective composting, most experts suggest maintaining temperatures between 43 and 70 °C (thermophilic phase).

Temperature changes during the composting period for the three piles at depths of 20, 40 and 60 cm were recorded. The ambient temperature variations throughout the composting period (August to October, 2005) were between 15 and 31 °C during daylights and ranging from 10 and 22 °C at night times. The changes in temperature values of composted piles (static and turned) at different periods are shown in Tables (2 and 3) and Figure(4.1). For static composting as aeration was performed through the piping system, it found that the initial temperature was 18 °C then gradually increased from 41 °C after 1 day to 71 °C at the 8th day and remained almost constant (between 68 °C to 64 °C) till the 15th day. After 15 days composting piles were turned and water was added to ensure homogeneity and moisture content were adjusted to be around 60%. After one day from turning the pile (on 17th day), the temperature was found to be nearly 59 °C, then increased to the range of 57 to 65 °C until 35 days of composting. Turning and watering were performed twice at 26th and 50th days mainly for homogeneity. After 40 days, the temperature was gradually decreased and reached to 35 °C at the 90th day, (the end of composting process); the ambient temperature was 31 °C at that day.

The data presented in (Table 3) revealed that temperature changes in the case of turned composting, at the beginning it was 19 °C, then reached to 73 °C after 5 days from starting composting process and remained in the range of 68 and 71 °C until the 10th day. At that stage, the process of turning and watering were performed, consequently temperature decreased to 58 °C at the 11th day. Then it increased again to reach 70 °C at the 13th day. After which the temperature decreased to 64 °C and decreased again to 63 °C after 19 days composting. From the data of Fig (2), it could be noticed that the pile temperature changes during the first 3 weeks of composting showed 4 fluctuation cycles. Hence it was noticed that the temperature of the piles decreased and then increased every turning and watering until the 19th day. Then temperature did not increase any more and gradually decreased to reach 33 °C at 68 days composting. This temperature increase could be explained on the basis of the metabolic biochemical reactions of the decomposing microflora. On the other hand, the temperature decrease could be due to the entrance of cold air resulting in turning. The above-mentioned data agree with **Kaloosh (1994)** and **Vournin and Saharinen (1997)** who reported that the temperature in heaps rose to nearly 60 °C and decreased to temperature close to ambient temperature within two to three months. Similarly, the above-stated results are in a close agreement with those observed by **Harada *et al.,* (1981),** who mentioned that the temperature was correlated to the biochemical activity in composted materials hence, the heat of reaction evolved in the cellular metabolism causes a temperature increase in the composted wastes. Temperatures of composting materials follow a pattern of rapid increase to reach 55 to 60 °C and remain near this thermophilic level for several weeks **(Rynk 2000).** Temperatures gradually drop to 38°C (100°F) and finally drop to ambient air temperature. This characteristic pattern of temperature change over time reflects the types of decomposition and stabilization as composting proceeds **(Rynk, 2000).**

4.1.2. Carbon dioxide (CO2)

Carbon dioxide is positively related to the presence of the anaerobic conditions. Data presented in Tables (2 and 3) and Figure (4.2) show the changes in CO_2 % in both static and turned piles with composting periods.

In static compost carbon dioxide percent was 0.03 at the beginning of composting and it reached to 0.2 % after one day and gradually increased to reach 8.1% after 15 days, CO_2% then dropped to 1.6% on the 16th day and increased again to reach 11.1% at the 11th day. By repeating turning and watering cycles, the CO_2% gradually decreased, then increased. The magnitude of CO_2 cycle was gradually decreased till the CO_2 % reached 2.3% at the 90'^{h} day. The c02% trend was similar in static compost system to that of temperature. It means that there are a positive relation between co$_t$ and temperature of compost pile.

In turned compost, turning is an important process in composting to prevent oxygen depletion and carbon dioxide accumulation in compost piles due to the increase of biological activities. Table (3) shows 4 fluctuation cycles, hence it increased and decreased, following temperature changes in most cases. The highest temperature (73 °c) was recorded on the 5^{th} day (figure 4.2) compared with as the lowest figure noticed on the r day during composting process (Fig 3). It was found that CO_2 % reached 8.9% at the 3^{rd} day and sharply increased to reach 18.7% after 7 days composting. After turning the piles, CO_2 % decreased to 2.8% then sharply increased again to 16.7% after 10 days, then decreased again to 4.3% by turning and water addition. The CO, was slowly decreased to reach to 2.1% at the 65^{th} day. The previous data show the decline in CO_2 % to less than 2.3% in the final stage (humus formation). These results are in closed agreement to those reported by **(Rynk, 2000).**

Table 2: Temperature, moisture content and carbon dioxide Changes during

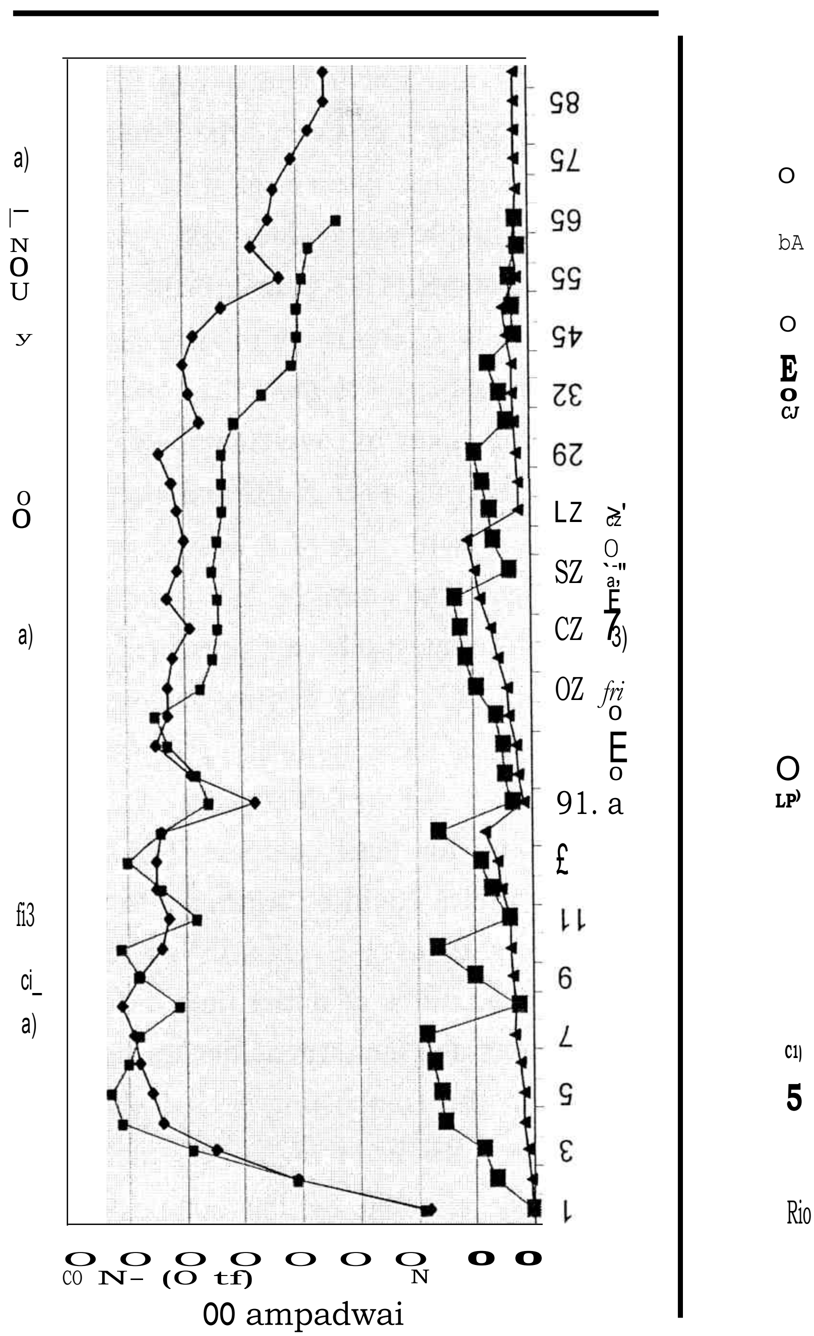
Composting time, days	Temperature		M sture Content %	Carbon Dioxide %	Processing
	Ambient	Compost			
1	15	18	65	0.2	
2	18	41	65	0.7	
3	20	55	63	1.2	
4	21	64	61	1.7	
5	22	66	61	1.9	
6	24	68	61	2.5	
7	24	69	60	3.5	
8	24	71	60	3.2	
9	21	68	60	3.6	
10	21	64	59	3.9	
11	22	63	58	4.1	
12	22	65	58	5.4	
13	24	65	55	6.0	
15	23	64	52	8.1	Turned + water
16	23	48	54	1.6	
17	25	59	56	2.5	
18	25	65	59	2.8	
19	25	63	56	3.9	
20	25	63	55	4.4	
22	26	62	54	5.7	
23	26	59	54	6.9	
24	25	63	53	8.9	
25	27	61	50	9.9	
26	26	60	49	11.1	Turned + water
27	28	61	52	2.1	
28	27	62	51	2.2	
29	29	64	50	2.4	
30	29	57	47	2.9	
32	28	59	45	3.1	
40	28	60	43	3.2	
45	27	58	40	3.9	
50	30	53	39	4.6	Turned +water
55	28	43	45	2.1	
60	28	48	43	2.6	
65	26	45	41	2.5	
70	26	44	38	2.2	
75	27	41	32	2.4	
80	29	38	30	2.5	
85	28	35	28	2.4	
90	31	35	22	2.3	

Ambient CO_2 % = 0.03

Table 3: Temperature, moisture content and carbon dioxide Changes during turned composting process.

Compostin time, days	Temperature °C		Moisture Content %	Carbon Dioxide %	Processing
	Ambient	Compost			
	15	19	65	0.2	
2	18	41	61	6.6	
3	20	59	58	8.9	
4	21	71	56	15.7	
5	22	73	55	16.2	
6	21	70	55	17.5	
7	24	68	55	18.7	Turned
8	24	61	46	2.8	
9	21	68	43	10.3	
10	21	71	41	16.7	Turned water
11	22	58	58	4.3	
12	22	64	55	7.3	
13	24	70	54	9.1	
15	23	64	53	16.4	Turned water
16	23	56	55	3.8	
17	25	58	53	4.9	
18	25	63	53	5.3	
19	25	65	51	6.4	
20	25	57	48	9.8	
22	26	55	47	11.7	
23	26	54	45	12.6	
24	25	54	45	13.4	Turned water
25	27	55	50	4.0	
26	26	54	48	6.8	
27	28	53	48	7.4	
28	27	53	45	8.6	
29	29	53	43	9.8	Turned water
30	29	51	42	4.2	
32	28	46	40	5.6	
40	28	41	38	7.4	Turned
45	27	40	35	2.6	
50	30	40	33	3.1	
55	28	39	28	3.6	
65	26	38	26	2.1	Turned
68	28	33	24	2.3	

Ambient CO_2 % = 0.03


1
3
5
7
9
11
29
32
45
55
65
75
85

4.1.3. Changes in compost bulk density.

The density is the mass of undried material in Kg, and the volume occupied by the material before it was dried in cubic meter .During composting process, the microorganisms transform organic raw materials into compost by breaking down the row materials into simple compounds and reforming them into new complex compounds. This transformation changes the nature of the raw materials. Composting process also leads to a volume reduction of one — quarter to more than one — half of the initial volume depending upon the raw materials .Part of this volume reduction represents the loss of co2 and moisture content to the surrounding atmosphere. Part of it occurs as loose, bulk raw materials are changed into crumbly, fine textured compost. Data of bulk density for compost piles are presented in Table (4) and illustrated by Figure (4.2). Bulk density values for all piles showed gradual increases as the composting proceeds. The bulk densities increased from 0.314 to 0.569 g/cm^3 for turned and from 0.314 to 0.648 g/cm^3 for static compost. The variations in the initial bulk density values could be attributed to the physical characteristics and weights of the organic wastes used for making the composting mixtures at initial time before heaping. Particle sizes of the wastes and there capacities for holding water and porosity throughout the composting period also effect on bulk density of compost. **Raviv *et al.* (1987)** mentioned that density bulk was highly affected by the composting process lengths. This is most probably due to the breaking down of fiber structure of celullosic and lignocelullosic compounds. Similarly, the increase of compost weight per unit of volume as the composting process proceeds reflects the high percentage of fine particular in the particle size distribution and may give some indication about compost maturity.

4.1.4. Changes in the pH during composting:

The composting process is relatively insensitive to hydrogen ion concentration (pH), within the range commonly found in mixtures of organic materials, largely owing to the broad spectrum of microorganisms involved. Composting may proceed effectively at pH levels between 5.5 to 9.0.However,it is likely to be less effective at 5.5 or 9.0 than it is at pH near natural (pH of 7). The changes in pH values during different periods of composting were presented in Table (4) and Figure (4.3). These data indicated that no significant difference was noticed between static and turned composting methods. However, the pH slightly changed through the time course of composting. In static compost, the pH value was 8.03 at the beginning and decreased to 7.98 at the 30th day, and then increased to reach 8.05 at the 50th day, followed by a slight decrease to be 7.89 at the 80th day. Mean while at the 90th day the pH value was 8.06. While in turned compost the values of pH were 8.03 at the beginning and significantly changed to 7.81, 7.92 and 7.94 after 30, 60 and 90 days composting, respectively. The decrease in pH could be explained due to the production of CO_2 and organic acids result in microbial activity **(Elvira *et* 1998). Diaz-Ravia *et* al., (1989)** showed that during the cooling and maturation stages, the pH dropped close to neutral value (pH of 7) , then stabilized. The decrease in the pH could be a consequence of degradation of easily decomposable polysaccharides and the production of organic acids during biooxidative phase. The subsequent increase in the pH may be referred to the metabolic degradation of these organic acids or their loss by volatilization and furthermore, due to the intensive proteolysis liberating ammonia compound **(Faure and Deschamps, 1990).** Similar pH behavior curves were observed in the previous works conducted by **Godden and Penninckx (1986); Hanafy** *et al.* **(1990), Shehata and Ali (1990) and Jimenez and Garcia (1989).**

4.1.5. Odour

Odour was recorded during the composting process as it is becoming one of the drawbacks of the system. It was found that the unpleasant odour of composting materials decreased with time. The unpleasant odour disappeared after 20 and 30 days during the turned and static compost, respectively. At the end of the composting process, the odour of composts was similar to the odour of earth. This observation is in agreement with those reported by **Haug (1980),** who stated that the odour emission rate dropped significantly during the first stage and then fluctuated some what during the remainder of the composting period. The odour emission rate increased immediately after turning, but within about 1 h returned to the rate before turning. At the end of the composting process, when optimal maturation is achieved, the unpleasant odour was absent in the heap, and do not appear with turning of the material **(Ciavatta** *et al.,* **1988). Haug (1980), and Mondini** *et aL,* **(1996),** related the unpleasant odour that appear during the mesophilic phase of composting to the presence of lower fatty acid such as acetic, propionic, butyric, valeric and caproic acids, aldhydes and ketons, while the unpleasant odour during the thermophilic phase was attributed to the presence of volatile compounds malodorous gasses like pyridine and pyrazine, and also to the volatile sulfur compounds such as dimethyl sulfide, dimethyldisulfide and dimethyltrisulfide. Lax ***et al.,*** (1987) stated that the final material of composting should be odourless or having a slightly earthy odour or musty odour of moulds and fungi.

4.1.6. Changes in the electrical conductivity:-

The effects of 16 weeks of composting on the electrical conductivity (EC) of static and turned piles are present in Table (4) and Figure (4.4). Generally, it was found that salinity showed a significant increase during composting processes. In static compost, the EC value at the beginning was 2.71 dSm"" and significantly increased to reach 7.04 dSm' after 90 days composting, while in turned compost, it was 2.71 dSm' at the beginning and significantly increased to reach to 11.34 dSin $^{-1}$ after 60 days composting, then slight EC increases were observed. These increases in EC of composted materials could be related to the high concentration of ammonia and other nutrients ions released during the rapid mineralization of organic matter. The relative fluctuation observed at the end period of composting could also be attributed to the nutrient ions release and/or fixation through the changes in proliferation of the aerobic microbial populations. Similar results were obtained by Raviv ***et al.*** (1987).The high values of electrical conductivity (EC) at the end of composting process could be due to the effect of the concentration of salts as a consequence of the degradation of organic matter.

4.1.7. Cation Exchange Capacity (CEC):

Cation exchange capacity (CEC) is an important horticultural standard characterizing a material's ability to act as a regulator for nutrient supply for plant growth **(Raviv *et al,* 1987),It** is also mentioned that decomposition of organic matter such as plant residues and manures is closely correlated with the CEC. Consequently, measurements of CEC are considered useful for estimating the degree of compost maturity. Data of CEC for static and turned compost under this study are listed in Table (4) and presented in Figure (4.5) The CEC profiles of all piles showed gradual increase throughout the composting process. In static compost, The CEC values increased from 36.11 meq/100 g dry weight at initial time to 68.93 meq/100 g dry weight after 16 weeks of the composting course. In turned compost, The CEC values increased from 36.11 meq/100 g dry weight at initial time to 88.98 meq/100 g dry weight after 16 weeks. The greater increase in values of CEC occurred in turned compost than static compost and may be attributed to turning frequency. **Harada *et al.* (1981)** reported that the CEC of city refuse increased from 40 to 80 meq/100 g during 12 weeks composting and thereafter the CEC showed approximately constant value. **Galler and Davey (1971)** composted poultry manure with sawdust and showed that CEC rase from 35 to 65 meq/100 g **TS** in 8 weeks, and this also displayed a constant value at the 20th week. Similar trend of results was obtained by **Jimenez and Garcia (1989).** Several investigators reported that the CEC constitutes an index of the degree of humification of compost; they concluded that the minimum CEC value needed to assure an acceptable maturity is higher than 60 meq/100 g on an ash-free material basis **(Harada *et* a1.1981 and Roig *et* a1.1988).The** increase in CEC during composting might be explained not only by the accumulation of materials bearing a negative charge such as lignin derived product, but also by an increase of carboxyl and /or phenolic hydroxl groups in the material **(Lax *et* a1.1987).**

4.1.8. C/N ratio:

Carbon (C) and nitrogen (N) are the primary nutrients required to the microorganisms involved in composting materials. Many organic materials, including manures and plant residues contain amply quantities of nutrients. Excessive or insufficient carbon or nitrogen is most likely to affect the composting process. Microorganisms use carbon for both heat energy generation and growth, while nitrogen is essential for protein and reproduction. A blance C/N ratio usually ensures that other required nutrients presented in adequate amounts .The changes in C/N ratio during composting period are shown in Table (5) and are illustrated by Figure (4.6).The values of C/N ratios showed higher reduction during the first 6 weeks of composting process, and low decreases towards the end of composting period were observed. This finding occurred in all piles under this study, the changes in organic carbon content (OC %) during composting process presented in Table (5) and Figure(4.7) where a significant decrease from 43.54 at the start of composting process to 27.72% after 15^{th} weeks in static compost was recorded. While the organic carbon content in the turned compost 43.54. at zero time and reduced to 21.92% after 10^{th} weeks, then slightly changes (from 21.92 to 23.09% after

15'h weeks). The decrease in organic carbon may be due to the loss of carbon as CO_2 via microbial oxidation during the composting process. During composting process, organic carbon was oxidized and converted into carbon dioxide (co_2), water (H_2o), and new microbial biomass. The rate of organic carbon loss is an indictor of the overall composting rate. The organic carbon content was evidently decreased when the compost materials were unturned than in mechanically stirred treatment ,since a substantial loss of total organic carbon occurred during composting process. These results are in agreement with those obtained by **Kaloosh (1994) and Wong *et al.,* (2001).**

The changes in total nitrogen percent (TN %) during composting process, presented in Table (5) and Figure(4.8) indicate that total nitrogen slightly increased from 1.457% at zero time to 1.795% after 14th weeks during static composting process, then to 1.911 %after 15` h weeks. On the other hand, in turned composting process, total nitrogen percent decreased from 1.457% at the beginning to 1.314% after 2"d weeks, then increased to 1.695% after 12th weeks composting, Slight increases was noticed after 90 days. This increase could be due to either the reduction in weight of composted wastes or to mineralize of organic nitrogen and biological nitrogen fixation by some non-symbiotic microbes in compost. These fmdings are similar to those obtained by **Mondini *et al.,* (1996), Vourinen and Saharinen (1997) and Wong *et al.,* (2001).**

As a result of decreasing organic carbon and increasing total nitrogen percentages during the progress of composting process, a narrow in C/N was observed. Data in Table (5) and Figure

(4.9) show that highly significant decrease in C/N ratio from 29.88 at the start of composting to 14.51 after 16 th weeks for static compost and from 29.88 to 13.44 for turned compost. Similar findings were obtained by **Kaloosh (1994) and Abdel Wahab (1999)** who indicated that C/N ratio tended to be narrow with time in compost heaps due to gaseous loss of carbon as COz while the nitrogen remained more tightly bounded in organic combination. The results also are in agreement with that of **Mondini *et al.,* (1996) and Wong *et A,* (2001).**

Parameters	BullgD (/c)		pH (0:7s)		EC dS/m (1:2.5)		CEC mei Colin	
Period we- s	Turned	Static	Turned	Static	Turned	Static	Turned	Static
o	tIE•0	t7I	£0 8	£0 8	ILZ	1L'Z	1 9	11'9£
eN1	g9E 0	EL17 0	EZ*8	ILL	179't	887	89'917	'L£
'1'	Z6E 0	EZC 0	86'L	6S'L	·17L'S	I1'£	8Z'ES	8L'6E
VD	I Z17 0	0'SZS	18'L	86'L	trt:/9	gt £	88 8g	£g717
00	Z917 0	£8C0	Z6'L	cos	9 17'L	CL'E	8L'99	8Z'L17
oI	9I5 0	EZ9'0	8LL	C67,	170'01	9E't	81'8L	Egig
ZI	1 9ES*0	ZE9'0		681.	179'01		Z'6L	1.17'17g
tI	ELS °	17C9 0		I6'L	Z'II	16'9	85 6L	Eg'6g
	69C 0		t76'L	90'8	17E11	tO'L	86'88	E6'89

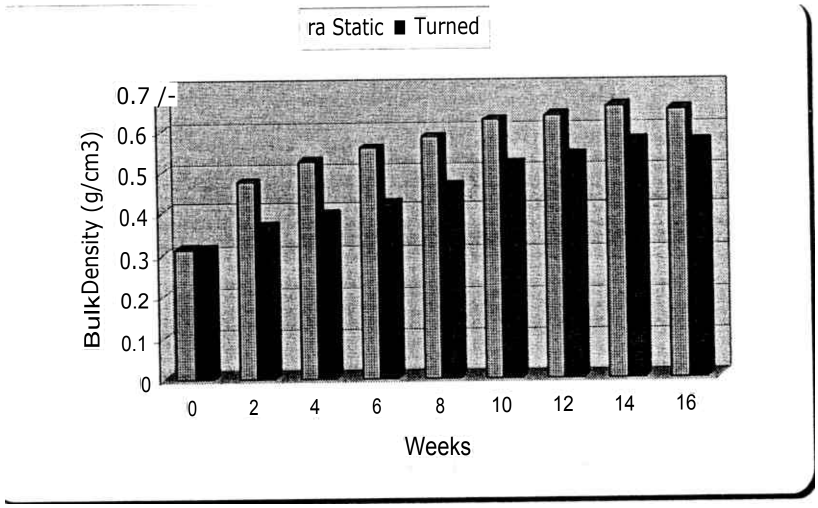


Figure (4.2): Bulk density changes during static and turned composting processes.

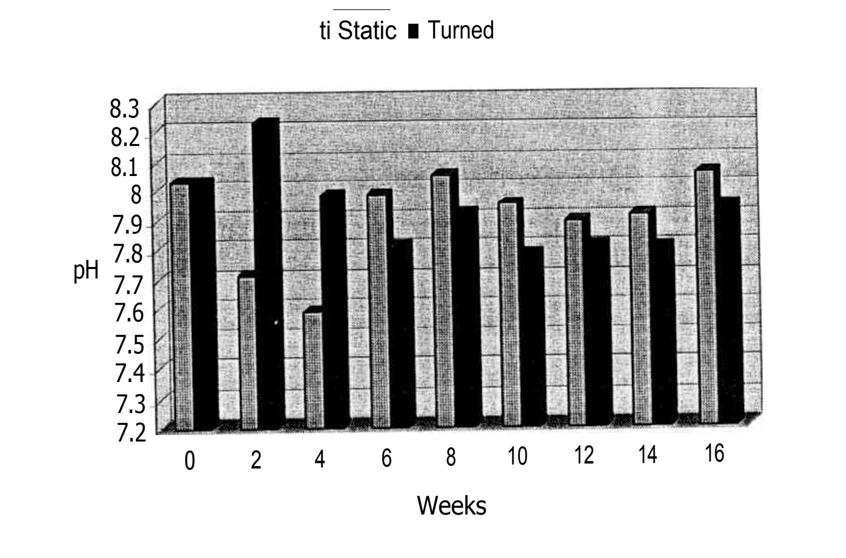


Figure (4.3): pH changes during static and turned composting processes.

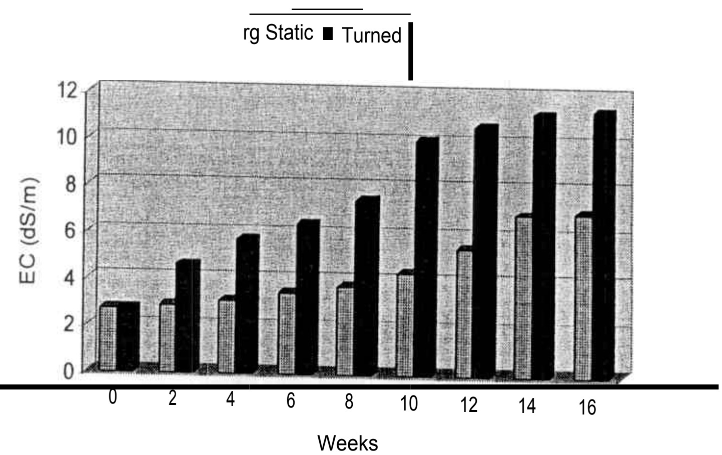


Figure (4.4): EC changes during static and turned composting processes.

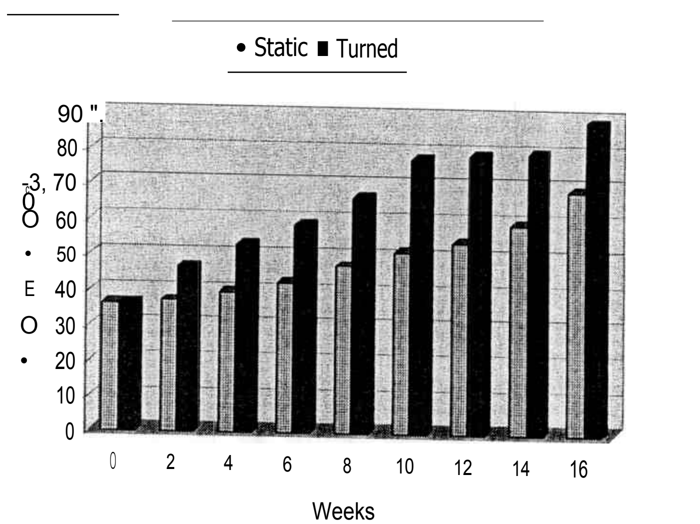


Figure (4.5): CEC changes during static and turned composting processes.

Parameters 'eriod weeks	Organic Carbon %		Total Nitrogen °A		Carbon I Nitrogen Ratio	
	Static	Turned	Static	Turned	Static	Turned
O	tg' Et	tg	Lg1/	Lgt/ I	88 6Z	88 6Z
C\I	517 8 £	LE•t7E	L9t I		I Z 9Z	66"ZZ
71	8t/L£	LL'6Z	I ZS' I	17ZS I	t79 17Z	CS 6 I
VD	96 ££	L9' SZ	99C I	t£S 1	69 1Z	£L 9 I
o0	1797£	LL" £Z	Z I 9'1	119'1	SZ 0Z	9L 171
OI	611£	Z6' I Z	OS9'1	17Z9* I	06'81	8 ti
Z I	60 O£	LUZZ	SZL I	S69 1	t7t71, I	80'
t71	ZS•8Z	9L:ZZ	g6L: I	17U I	SS'S'	Z I I
91	ZL LZ	6(YEZ	II i	8IL: I	I g* 171	ft

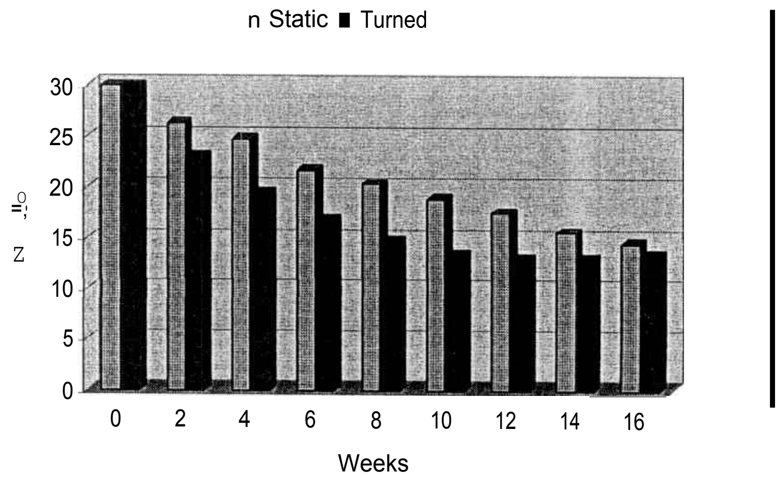


Figure (4.6): C/N ratio changes during static and turned composting processes.

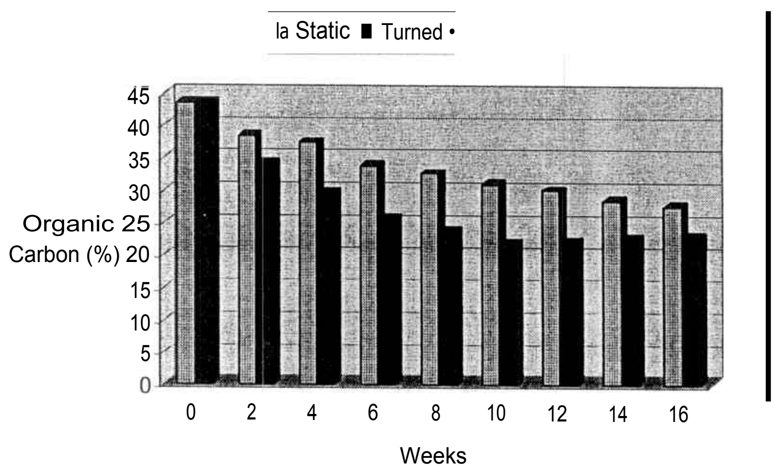


Figure (4.7): Organic Carbon (%) changes during static and turned composting processes.

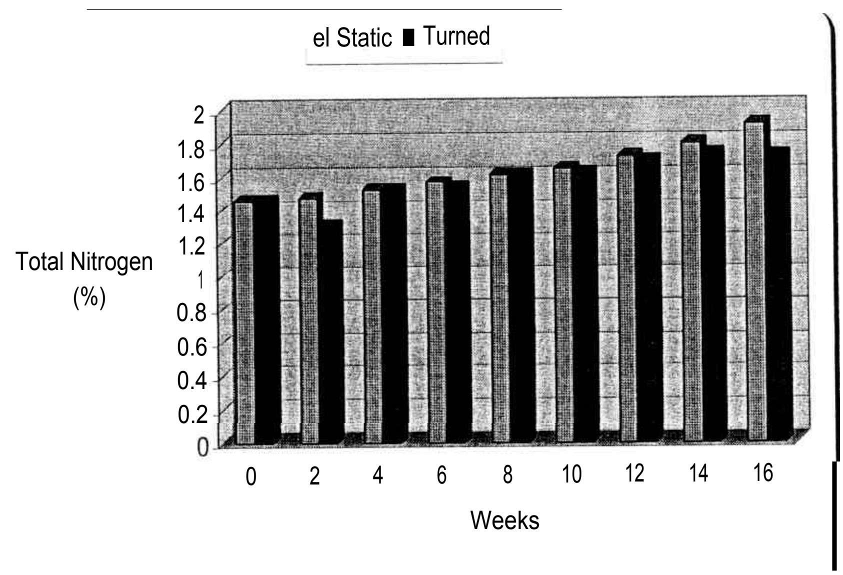


Figure (4.8): Total Nitrogen (%) changes during static and turned composting processes.

4-2- Available nutrients

4-2-1- Available NPK

a) Nitrogen

Changes in soluble nitrogen NH_4-N and NO_3-N as affected by composting time are presented in Table (6) and Figures (4.9 and 4.10). NH_4-N showed a significant decrease from 481 at zero time to 48 mg/kg after 90 days in case of static compost. The same turned was also noticed in turned compost; hence it decreased from 481 mg/kg at the start to 217 mg/kg and 31 mg/kg after 60 and 90 day, respectively. The decreases of NH^+_4 concentration with composting time could be or partially due to the accumulation increasing of NO_3 and volatilization of ammonia at high temperature in the thermophilic stage and oxidation at mesophilic stage a pronounced increase was observed.

According to NO^-_3-N, during the first three weeks in both static and turned compost (thennophilic stage), then a gradual increase was recorded. In static compost it increased from 157at 30 days composting to 473 mg/kg after 90 days. While in turned system, it increased from 152 at 30 days to 423 mg/kg after 70 days composting. While the oxidation form decreased by inhibition at the thermophilic and increased at mesophilic stage. The enhancement of oxidized form (NO_3) with time was due to increase the activity of nitrifying bacteria. Indeed, it is well known that this activity is inhibited at temperatures above 40 °C **(Alexander, 1982).**

b) Phosphorus

Data presented in Table(6) and Fig (4.11) show the values of available phosphorus both static and turned compost. In static compost the values decreased from 5.12 to 4.66 g/kg during the first 50 days, and then significantly increased to 5.64 at the 70th day. On the other hand in turned compost, the available phosphorus values decreased from 5.12 to 4.76 g/kg during the first 20 days then slightly increased to 6.17 at the 70th day. It is noticed that, at maturation stage, the available phosphorus values remain constant in turned compost, while in static compost it slightly decreased. The decreases of phosphorus concentration in the first stage of composting (thermophilic) could be due to the microbial immobilization of available phosphorus **(Jackson, 1973),** while the increase of phosphorus during the further stages of composting (mesophilic) could be due to either the microbial mineralization of organic phosphorus or the chelation of unavailable phosphorus with the organic acids, that found during the microbial decomposition of organic wastes. These data are in agreement with those of **Elvira** *et at,* **(1998), Singh and Sharma (2002).**

c) Potassium

Data presented in Table (6) and Figure (4.12) show values of available potassium. In static compost the values were decreased from 12.85 to 11.06 g/kg during the first 30 days, and then increased to 16.19 at the 60th day, while in turned compost, the available potassium values decreased from 12.85 to 11.57 g/kg during the first 20 days then increased to 16.42 at the 80th

day. This increase may by due to high activity of microorganisms which led to increase the mineralization rate of organic compounds in compost. At maturation periods, the extractable potassium values remain approximately constant in both static and turned compost. These data are in harmony with those of **Singh and Sharma (2002)** who found that the significant increase in potassium concentration by the end of vermi-composting period could be due to the mineralization of organic matter.

Parameters / Period days	NH_4-N mg/kg		NO3-N mg/kg		Ext. P g/kg		Ext. K g/kg	
	Static	Turned	Static	Turned	Static	Turned	Static	Turned
0	481	481	62	62	5.12	5.12	12.85	[illegible]
20	735	684	811	125	5.04	4.76	5671	7.5
30	671	598	751	152	4.95	5.01	9011	67.11
40	485	471		189	4.81	5.22	77.01	2 22
50	377	543	173	246	4.66		8 177	68 31
60	25 1	217	286	316	5.16	5.98	16.19	[illegible]
70	173	136	358	423	5.671	[illegible]	15.64	16.12
80	67	57	304	71 32	4.76	5.85	1 5.45	24.61
90		rn	473	531	3.19	6 02	[illegible]	35.51

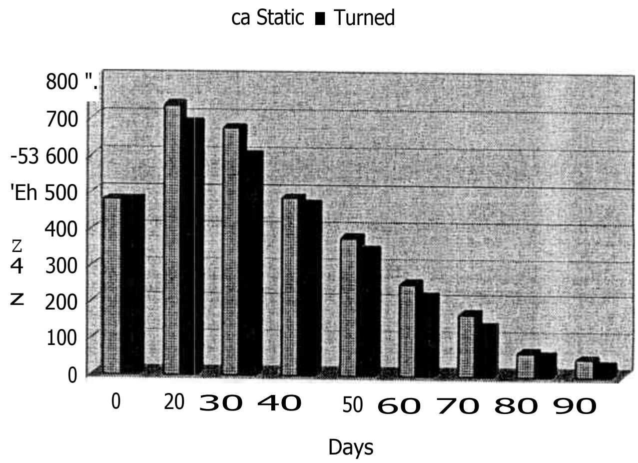


Figure (4.9): NH_4-N changes during static and turned composting processes.

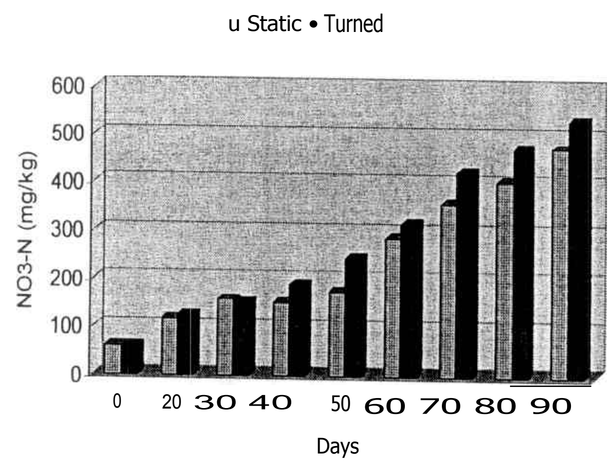


Figure (4.10): NO_3-N changes during static and turned composting processes.

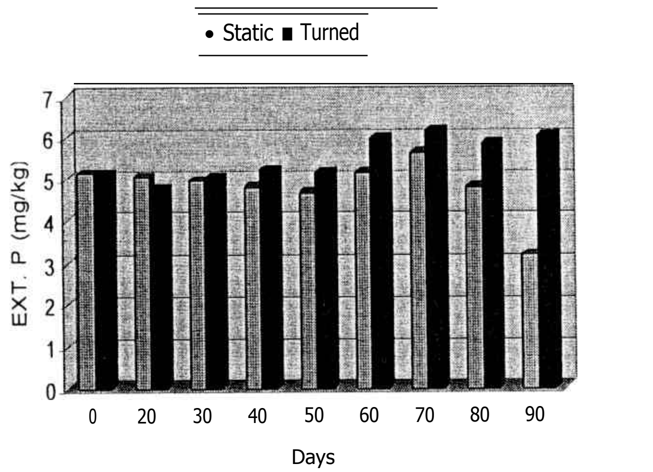


Figure (4.11): Phosphorus changes during static and turned composting processes.

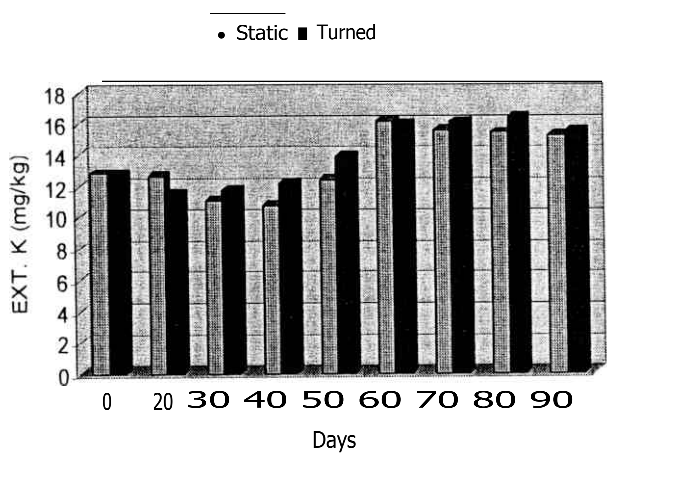


Figure (4.12): Potassium changes during static or turned composting processes.

4-2-2- Available micronutrients

Data presented in Table (7) and Figure (4.13) show an increase in micronutrients (Fe, Zn, Mn and Cu) extracted by DTPA during the composting process in both static and turned heaps. The magnitude of the increase in case of turned composting was higher than that of static compost. The values of extracted (Fe) increased from 128.50 to reach 976.12 and 1024.0 ppm at the end of composting periods for static and turned composting, respectively. (Zn) values increased from 68.38 ppm to 311.00 and 327.54 ppm in both static and turned composting processes, respectively. Similar trends were observed for both(Mn) and (Cu) values in static compost, as it increased from 48.56 and 28.00 ppm to reach 281.00 and 68.00 at the end of static composting for both(Mn) and(Cu), respectively. While in turned compost, these values significantly increased to reach 183.00 and 85.00 at the same periods for both (Mn) and (Cu) respectively. The data of microelements extracted by DTPA indicated a five fold enhancement of available Fe, Zn and Mn as a result of the decomposition of organic materials, while Cu concentration increased by two fold only. These data are in agreement with **Inbar *et al,* (1993)** who reported that the DTPA extractable micronutrients were increased with composting times.

Generally, in both static and turned compost it was noticed that estimated available nutrients as NH_4-N, NO_3-N, available phosphorus, available potassium and extractable Fe and Mn initially decreased during thermophilic stage or the breakdown of composed materials, followed by gradual increases during the mesophilic stage or build up stage then, remain constant during the maturity stage. In other words, during composting time, the different available nutrients were subjected to immobilization in the initial stage followed by significant mobilization and finally, remain constant at maturation stage.

Table (7): Changes in availability of micronutrients extracted by DTPA during static and turned composting process.

Period days	Fe ppm		[illegible]		Mn ppm		Cu ppm	
	Static	Turned	Static	Turned	Static	Turned	Static	Turned
0	[illegible]	[illegible]	[illegible]	[illegible]	48.56	48.56	28.00	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

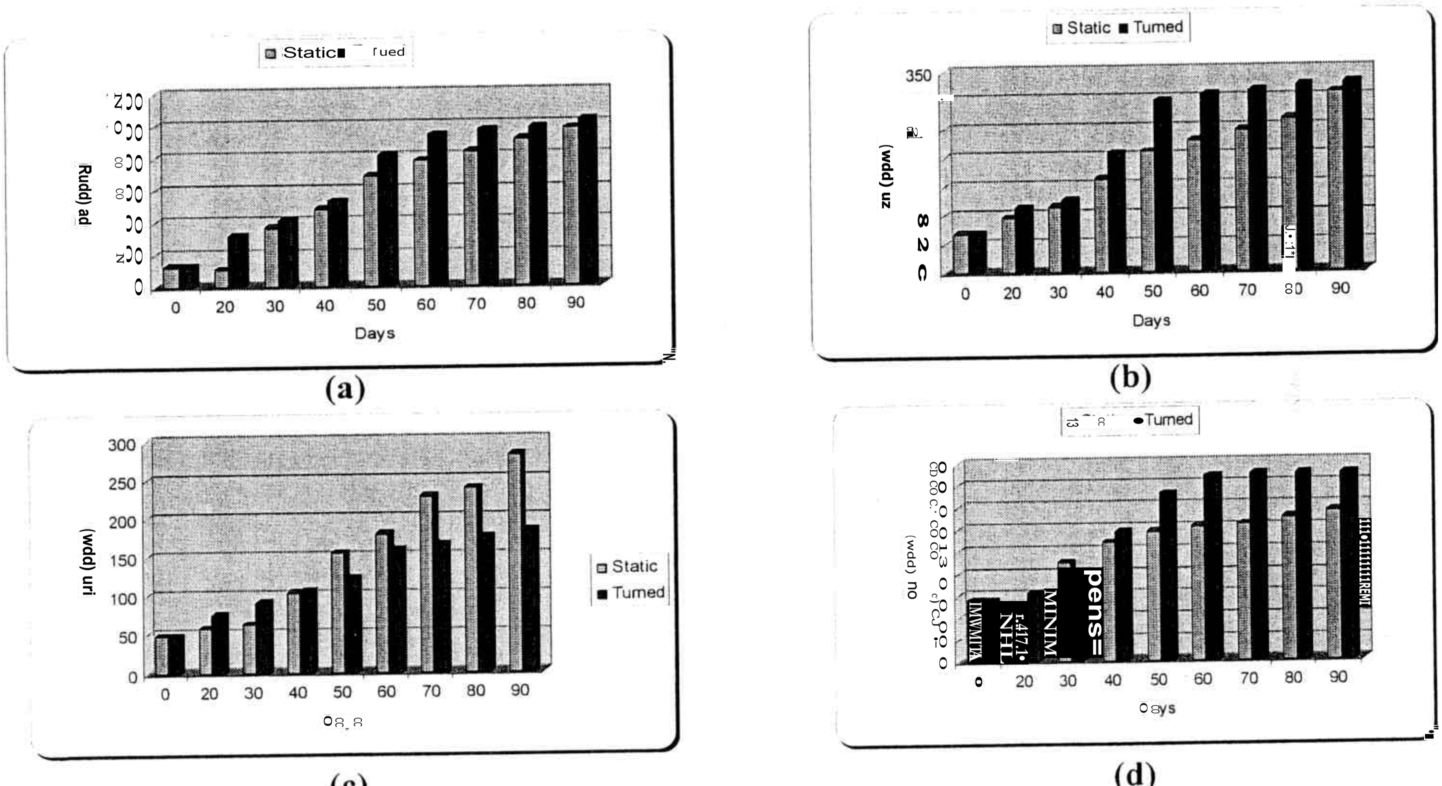


Fig.15: Changes in availability of micronutrients extracted by DTPA during static and turned Composting process

4-2-3- Microbial load & compost:

Data presented in Table (8) shows the change of beneficial and pathogenic microorganisms during composting process. The studied beneficial microorganisms were (a) *Azotobacter, Azospirillum, Klebsiella,and* clostridium as free living nitrogen fixers (b) *Bacillus* as phosphorus solubilizing bacteria, (c) *Nitrosomonas and Nitrobacter* as nitrifying bacteria and (d) *Thiobacilhis* as sulfur oxidizers formation. It was noticed that, after 10 days composting, the inoculated wastes used in static composting contained $2.4x10^2$, $1.7x10^2$, $0.8 x10^2$, $2.1x10^2$, $0.6 x10^2$, $0.8x10^2$, $0.7 x10^2$ and $1.7x10^2$ CFU/g dw of mentioned stated microorganisms respectively. After 90 days increased to reach $5.9x10^5$, $4.1x10^5$, $2.9x10^3$, $1.4x10^3$, $3.9x10^4$, $2.5x10^3$, $3.8x10^5$ and $2.7x10^5$ cfu/g respectively. In turned composting, similar trend was noticed for these studied beneficial organisms with higher numbers. Table (8) also revealed, that the compost contained $0.4x10^2$, $0.5x10^2$and $0.2x10^2$ at the 10^{th} day for *Escherichia coli, Salmonella and Shegella,* in static compost. The corresponding figures for turned compost were $0.5x10^2$, $0.3x10^2$ and $0.4x10^2$ The disappearance of pathogenic microorganisms occurred suddenly after 10 days in case of turned compost, while in static compost they decreased gradually to disappear after 70 days composting.

It was found that both static and turned compost were free from pathogens after 90 days composting. In other word all studied pathogenic species were completely disappeared at the end of composting periods, which mean that the composting cycle is auto-sterilizing. The disappearance of pathogens could be explained on the basis that when a beneficial microbe fills an ecological niche that would otherwise be exploited by a pathogen. For example, a beneficial organism may out-compete a pathogen for energy, nutrients, or "living space," thereby decreasing the survival of the pathogen. **(Brinton *et. al.,* 2001).**

DISCUSSION

4-3- Sifting Evaluation:-

4-3-1- Change in bulk density:-

Data presented in Table (9, 10) show physical and chemical properties of turned and static compost as affected by size of waste granules., The bulk density of compost granules for less than 10 mm, compost granules for less than 2 mm, compost reject for 10 mm and compost reject for 2 mm decreased from 0.648 g/cm^3 to 0.581, 0.514, 0.627, 0.594 g/cm^3 respectively for static compost. On the other hand in the corresponding figures for turned compost were 0.569 g/cm^3 to 0.434, 0.419, 0.547and 0.512 g/cm^3.

4-3-2. Changes in the pH:-

The result clearly indicated that the pH values were slightly affected by different size of granules where pH ranged from 7.94 to 8.13 for static compost and from 7.12 to 8.05 for turned compost.

4-3-3- Changes in the electrical conductivity:-

The effects of sifting process on the electrical conductivity (EC) are shown in (Table 9, 10) The EC value was 7.04 for the final compost and decreased to 6.12, 3.15, 5.13 and 6.81 for granules less than 10mm, Granules less than 2 mm compost reject at 10mm and compost reject at 2 mm respectively. On the other hand in Turned compost the EC value was 11.34 for the final compost and decreased to 9.14, 7.19, 10.01 and 11.15 for granules less than 10 mm, granules less than

2 nun compost reject at 1 Omm and compost reject at 2 mm , respectively during sifting process.

4-3-4- Cation Exchange Capacity (CEC):-

Data presented in (Table 9, 10). show that the CEC values were gradually decreased throughout the sifting process of composting static compost or turned compost methods. The CEC value was 68.93 for the final compost and decreased to 67.12, 63.15, 68.13 and 67.77 for granules less than 10 mm, granules less than 2 nun compost reject at 10 mm and compost reject at 2 mm respectively. On the other hand in turned compost the CEC value was 88.98 for the final compost and decreased to 85.17, 81.27, 88.16 and 86.04 for Granules less than 10 mm, granules less than 2mm compost reject at 10mm and compost reject at 2 nun respectively during sifting process.

4-3-5. C/N Ratio:-

The data of the changes in organic carbon content (OC%) during sifting process presented (Table 9.10) showed a significant decrease from 27.72% for the final compost to 26.67,26.24,26.69% and 26.75% for granules less than 10 mm, granules less than 2 mm compost reject at 10 mm and compost reject at 2 mm respectively. On the other hand in turned compost the organic carbon content was 23.09% for the final compost and decreased to 22.56, 22.31, 22.78% and 22.94% for granules less than 10 mm, granules less than 2 mm compost reject at 10 mm and compost reject at 2 mm respectively during sifting process.

The changes in total nitrogen percent (TN %) during sifting process, presented (Table 9.10) indicated that a significant decrease from 1.91% for the final compost to 1.68,1.01,1.41% and 1.76% at granules less than 10 mm, granules less than 2 mm compost reject at 10 mm and compost reject at 2 mm respectively. On the other hand in turned compost the total nitrogen content was 1.72% for the final compost and decreased to 1.42, 0.82, 1.32% and 1.491% for granules less than 10 mm, granules less than 2 mm compost reject at 10 mm and compost reject at 2 mm respectively during sifting process.

As a result of decreasing organic carbon and increasing total nitrogen percentages during the progress of composting process, a narrow in C/N was observed.

It is clear that sift process to remove granules greater than 10 mm in this granules mines containing part-degradable or humus and organic matter and the main reason to reduce the quality and content of the final elements in the final product.

sample	weight kg	Bulk Density (x/cm3)	Moisture Content "A)	CEC meq/100g com ost	Da tu/SP (I:Z:S)	pH (g*Z1)	O -1 ;;;Z	D*O			NH_4 -N mg/kg	
)so wo3	I00	0 6†8	ZZ	68 9£	NYL	8.06	8L:L†	ZCLZ	16 1		817	£I†'
Less than 10mm	80.ZE	I8C0	ZI 6	Z1 "L9	Z.19	10 8	86517	L9 9Z	89 1	88*CI	917	Z817
Less than I 2mm	170 EZ	†1 S*0	I0.Z	grE9	I 'E	t6'L	EZ gt	i7r9Z	DIY I	86 5Z	tt	1617
wiuz u11110]	oc O a 1	LZ9.0 176c0	£0 1Z	EI 89	EI 'S	£1 '8 C6'L	Z0 9t Z1'917	69 9Z SC9Z	I17 1 9L'1	£6 81 OZ:SI	St	S -zt 0817

Cl) E V 1:1 cle O O L V O Cl V E a) V EC Cl V A Qr Ct ed

;ample	eig kg	Bulk Density (g/cm3)	Moisture Content	CEC meq/1.00g com ost	WISP D3	pH (c7:1)		D'O			NH mg	
Final ompost	)01	69.00		88.98	tE 11	t76"L	017 6E	60'CZ	ZL 1	tvEi	re)	1 £5
uum wtu01 unn	1"g	tEi7 0	617Z	L	171 6	L 7/5	86 8E	9S ZZ	Z17"1	Z6 5 1	8	LEs
wun umn ss;		61 1'0	C81	LZ*18	61"L	Z11	917 8C	1CZZ	18'0	I t Lz		Zts
Z uiw WWi0T	o o	Z1C O L17g 0	SS I Z	88'91	IWO -	S0'8 t797	LZ 6E g£ 6E	SC ZZ t'94	617 1	1Z L1 6C"g1	6 ("4	VD Ecs