Middle East Journal of Applied Sciences
ISSN 2077-4613
Volume : 05 | Issue : 04 | Oct.-Dec.| 2015
Pages: 879-892

Chemical and Microbiological Evaluation of Compost from Sugarcane Wastes.

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ABSTRACT

Evaluation of the possibility and feasibility of producing fertilizers from the wastes generated from agro-industrial of sugarcane was established. Composting process was carried out using five wooden boxes (4.5 m3 capacity) with five mixtures of residues beside two windrow with two types of mixtures. Composting process was lasted for 16 weeks. Changes in temperature degree at different depth were recorded. The physical and chemical analyses of the pre-compost and mature compost including bulk density, moisture, pH, EC, organic matter, organic carbon, C/N ratio, total nitrogen and ash contents were monitored. Total counts of fecal coliform, Salmonella and Shigella were recorded along composting process time. The temperature monitoring of the composting mixtures revealed that all treatments passed through mesophilic and thermophilic stages. Data also revealed that changes in bulk density of composting mixtures were depended on the physical characteristic of the fermented mixture. The percentage of organic matter of mature compost in all tested treatments were decreased result from CO_2 losses and subsequently ash content of mature compost, thus increased. The nitrogen content increased for the treatments containing dry leaves or bagasse, but it decreased in the treatments containing manly filter mud. Results revealed at the end of composting time, the C/N of all treatments were dropped. The ones high in fibers dropped to range of 34: 1 to 30: 1, which would be suitable to be used as soil conditioner. However, treatments containing filter mud recorded C/N ranging from 23: 1 to 11: 1, which make them a suitable to be used organic fertilizers.

Key words: Sugarcane, compost, chemical and microbiological

Introduction

Sugarcane industry is one of the oldest in Egypt. Cane plantations are located in the area of Upper Egypt specifically in Menia, Sohag, Qena, Luxor and Aswan. Sugarcane is produced and harvested in Egypt for production of cane sugar in the large scale mills and production of black honey in smaller scale factories. The total amount of sugar cane production inUpper Egypt is about 16 million tons per year.

All eight mills are owned and managed by the Egyptian Sugar and Integrated Industries Company (Chauhan *et al.,* 2011).

The residues of sugarcane consist of "green tops" (20% of the total harvest) and dry leaves (5% of the total harvest). It is estimated that these residues amount to 2.5-3 million tons per the five months of harvest.

During the sugar production process in the mill, a number of by-products and residues are generated. These are Bagasse, which is the fibrous material remaining after chopping and milling from juice extraction. Filter mud resulting from cane juice filtration. Furnace ash, in case the bagasse is burnt in the boiler for steam and electricity generation.

The green tops are directly fed to the farmers' livestock in its raw form but it is not completely consumed due to size and form. The unconsumed portion wilts and dries and is left to deteriorate. Green tops are also available as fodder only during the sugar harvesting season. As for the dry leaves, it represents a burden due to its volume and fire hazard and so it is daily burnt in the fields causing considerable air pollution. Bagasse, on the other hand, is currently used as fuel to generate the mill's steam and electricity or as fiber to make fiberboard and paper. In addition, filter cake/mud and furnace ash are currently applied directly on reclaimed lands to act as soil additive. However, direct incorporation of raw agro-industrial waste into the soil may cause undesirable outcomes as "phytotoxicity and soil nitrogen immobilization" (Meunchang *et al.,* 2005).

It is thus proposed to produce bagasse to provide the farmer with a secure supply of natural fodder that is of acceptable quality. It is also anticipated to make compost from a combination of dry leaves, bagasse, filter mud and ash to produce organic fertilizer that is more safe and environmental friendly than chemical or artificial fertilizers.

The objective of the content research was to evaluate the possibility and feasibility of producing organic fertilizer from the waste streams generated from the agro-industrial of sugarcane manufacture, as an

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environmentally friendly reuse alternative. Wastes processing were included green tops, dry leaves, bagasse, filter mud and furnace ash.

Material and Methods

Composting was carried out using two methods: in vessel composting and windrow composting. Vessel composting was carried out using five mixtures and windrow composting using two mixtures. Composting was also carried out in a 1 m^3 bag for a mixture due to the availability of its raw material in limited quantities. Five wooden boxes of 4.5 m^3 capacity were constructed specifically for this research. The material mixtures were proportioned based on weight. Cow dung that was added to some mixtures was purchased from a livestock farm in Menofeya Governorate. The percentages of mixtures of the different raw material were chosen based on assumed scenarios as follows.

Treatments for composting

1. Compost N0. 1 (C1): Dry leaves + Cow dung
2. Compost N0. 2 (C2): Dry leaves + filter mud
3. Compost N0. 3 (C3): Bagasse + Cow dung
4. Compost N0.4 (C4): Bagasse + filter mud
5. Compost N0.5 (C5): Bagasse + filter mud
6. Compost N0.6 (C6): Bagasse + filter mud
7. Compost No.7 (C7): Filter mud
8. Compost No. 8 (C8): Filter mud + furnace ash

Analysis of raw materials used in composting process are shown in table (1).

Temperature degree was recorded every 2 days at three different depths (20, 40 and 60cm). The physical and chemical analyses including bulk density, moisture content, EC, pH, dry matter, organic matter (OM), organic carbon (OC), C/N ratio and contents of ash, total nitrogen (TN), ammonical-nitrogen (NH_4^+-N), nitrate (NO_3^-—N), total and fecal coliform bacteria and Salmonella & Shigella were also counted at all sampling time.

Methods of Analyses

Temperature Measurement:

Temperature in piles was measured at different places and depths through the composting period by a thermo-couple thermometer.

Bulk Density:

Bulk density was determined using the core method according to Vomocil (1965).

pH value:

The pH values of compost were determined in 1:10 compost-water suspension using a glass electrode of Orion Expandable ion analyzer EA920 according to Jodice, (1982).

Electrical Conductivity (EC):

Electrical conductivity measurements were run in (1:10) compost: water extract (Richards, 1954), using EC meter ICM model 71150.

Organic Matter (OM):

Organic matter content of compost materials was determined by glowing the compost dried samples at 550 $^{\circ}$C to a constant weight, as recommended by Page *et al*. (1982).

Organic Carbon (OC):

Organic carbon in both raw organic materials and compost samples was determined according to Page *et al*. (1982).

Total Nitrogen (TN):

Total nitrogen was determined in compost materials using Kjeldahl digestion method reported by Jackson (1973).

Soluble nitrogen (ammonium and nitrate-nitrogen):

Soluble nitrogen forms in compost i.e. NH_4^+, NO_2^-, and NO_3^- were determined according to the methods outlined by Page *et al*. (1982).

Total Phosphorus (TP):

Acid solution of the digested compost samples were used for determined total phosphorus content using ascorbic acid as a reluctant (Page *et al*. 1982).

Total Potassium (TK):

Digested solutions of compost samples were used for determination of total potassium content by flame photometrically (Chapman and Pratt, 1961).

Table 1: Characteristics of sugarcane residues generated during harvesting and milling

Parameters	Dry leaves	Cow dung	Milling Residues		
			Bagasse	Filter Mud	Furnace Ash
Density (kg/m^3)	110	750	112	650	195
Moisture content (%)	18	60	53	76	41
pH (1:10)	-	7.35	5.46	5	8.39
EC (1:10) (ds/m^2)	-	4.40	2.13	1.9	1.46
Total nitrogen (%)	0.54	1.38	0.35	1.84	0.42
Ammoniacal Nitrogen (ppm)	-	44	-	53	Nil
Nitrate Nitrogen (ppm)	-	12	-	28	Nil
Organic matter (%)	89.47	74.72	98	67.74	46.22
Organic carbon (%)	51.90	43.34	56.84	39.29	26.81
Ash (%)	10.53	25.28	2.00	32.26	53.76
C/N ratio	96:1	31.41	162:1	21.4:1	63:1
Total phosphorus (P_2O_5) %)	0.06	0.61	0.04	1.98	1.00
Total potassium (K_2O) (%)	0.54	0.88	0.1	0.28	0.99
Calcium (mg/kg)	9270	-	906.8	47961	17047
Magnesium (mg/kg)	1881	-	397.8	2296	6850
Iron (mg/kg)	809.7	-	471.2	5627	5774
Manganese (mg/kg)	50	-	17.2	177.3	143.9
Copper (mg/kg)	11.3	-	7.7	44.8	40.4
Zinc (mg/kg)	47.2	-	7.7	52.7	40.6
Total Coliform bacteria(Cfu/g)	Nd	$8x10^4$	Nd	$40 x 10^4$	Nd
Fecal Coliform bacteria(Cfu/g)	Nd	$3x10^4$	Nd	$20 x 10^4$	Nd
Salmonella & Shigella Bacteria (Cfu/g)	Nd	12	Nd	$3X10^3$	Nd

Nd: Not detected, Cfu: Colony forming unit

Table 2: Characteristics of the compost treatments at the start of the experiment.

Parameters	Treatments							
	Dry Leave:Dung 5:1	Dry Leaves: Mud	Bagasse :Dung 5:1	Bagasse :Filter Mud	Bagasse :Filter Mud	Bagasse :Filter Mud	Filter Mud	Filter Mud: Ash
Abbreviation	C1	C2	C3	C4	C5	C6	C7	C8
Density (kg/m^3)	100	280	197	181	296	347	794	588
Moisture content %	57	63	61	63	60	69	76	72
pH (1:10)	7.39	7.15	7.65	5.12	5.8	5.45	5	5.52
EC (1:10) (dS/m)	2.20	1.4	0.83	0.66	0.2	0.9	1.9	1.93
Total nitrogen (%)	0.58	1.37	0.47	0.44	0.85	1.10	1.84	1.54
Ammoniacal nitrogen (ppm)	112	357	119	63	378	441	53	25
Nitrate Nitrogen (ppm)	21	Nil	28	Nil	Nil	35	28	Nil
Organic matter (%)	79.58	75.62	80.45	96.18	87.77	82.71	67.74	63.12
Organic carbon (%)	46.16	43.87	46.66	55.76	50.91	47.97	39.26	36.61
Ash (%)	20.42	24.38	19.55	3.82	12.23	17.29	32.26	36.88
C/N ratio	79:1	32:1	100:1	127:1	60:1	43:1	21:1	24:1
Total phosphorus (P_2O_5) (%)	0.09	1.28	0.08	0.16	0.7	1.02	1.98	1.77
Total potassium (K_2O) (%)	0.67	0.37	0.41	0.11	0.16	0.19	0.28	0.43
Calcium (mg/kg)	9220	33923	2914	3730	16812	24682	47961	41329
Magnesium (mg/kg)	2415	2145	1599	512	1039	1357	2296	3273
Iron (mg/kg)	1343	3879	1388	781	2214	3076	5627	5659
Manganese (mg/kg)	56	131	34	27	71	98	177	170
Copper (mg/kg)	12	33	10	10	20	26	45	44
Zinc (mg/kg)	47	51	17	10	23	30	53	50
Free living Nematode (Larve/2000g)	Nd	Nd	80	20	Nd	20	Nd	Nd
Plant pathogenic N ematode Larve/200g)	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Total Coliform Bacteria (cfu/g)	$5 x 10^4$	$180x10^4$	$8 x 10^4$	$15 x 10^5$	$295x10^4$	$12 x 10^5$	$40x10^4$	$14x 10^5$
Fecal Coliform Bacteria (Cfu/g)	$3 x 10^4$	$80 x 10^4$	$6 x 10^4$	$3 x 10^4$	$50 x 10^4$	$4 x 10^4$	$20x10^4$	$2 x 10^4$
Salmonella & Shigella Bacteria (Cfu/g)	15	$25 x 10^3$	14	$13 x 10^3$	$15 x 10^3$	$19 x 10^3$	$3X10^3$	$11x 10^3$

Nd: Not detected   *Cfu: Colony forming unit*

Total Micronutrients:

Total contents of Fe, Zn, Mn and Cu in compost samples were determined by using an atomic-absorption spectrophotometer Perkin Model 3300 as described by Hesse (1971).

Microbiological Determinations:

Changes in the total counts of bacteria, fungil and actinomycets (mesophilic and thermophilic) counts throughout the composting period were extenuated according to (Allen, 1959). Total and Feacal coliform bacteria were determined on Macconky media *Salmonella* and *Shigella* bacteria were counted on SS agar medium according to Difico Manual, (1985).

Results

Temperature

Temperature ambient changes during the composting process for all mixtures are shown in Figures 1 to 8 ambient temperature ranged between 35 and 24 ^{0}C at day light and from 28 to 20 ^{0}C at night. In all composting mixtures, the temperature increased to over 60^{0}C during the first month of composting, and then gradually decreased down to 45-60 ^{0}C. The temperature of mixtures thereafter, fluctuated within a range from 25-34 ^{0}C till the end of composting period. It was clear that the composting process exhibited classically known temperature pattern, in which three different phases could be recognized: (mesophilic, thermophilic and cooling down phases) which lasted to the end of compost maturation stage. Results of temperature monitoring showed that all treatments passed through the mesophilic and thermophlic stages were in the curing stage which resulted in stable and mature compost as shown in Figures 1 to 8.

These results are in agreement with those reported by Keener *et al.* (2000), Hess *et* al. (2004), Hanajima *e t al.* (2006) and Saludes *et al.* (2008). Subsequently, the rate of bio-degradation decreased as a result of decreasing the temperature. Pourcher *e t al.* (2005) reported that such gradual decrease in temperature toward the end of composting process indicated that the nutrients were depleted and the process reached to the stability state. The rate of such decrease was different, depending on the composted materials. This trend was also reported by Rashaci *et al.* (2010).

Bulk density

The change in bulk density depends on the physical characteristics of the fermented mixture. The higher the fiber content of the mixture, the more it increases in density with time. The fiber structure breaks with time and the particle size decreases causing the porosity of the mixture to decrease. The opposite effect was observed with mixtures containing. The filter mud which produced from the mill is high water containing material but as the moisture content decreases and the material is aerated; it becomes more porous and light.

Mahmoud, (2010) mentioned that as the composting process lengths the general particale size shifted from larger to smaller particles this is most probably due to the breaking down of fiber structure of cellulosic and lignocellulosic 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.

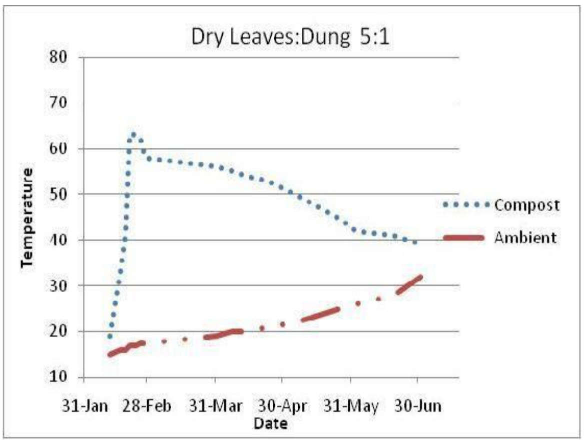

Fig. 1: Temperature monitoring for C1 (5:1)

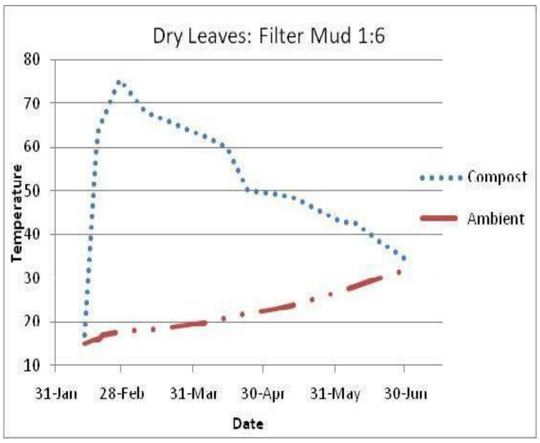

Fig. 2: Temperature monitoring for C2 (1:6)

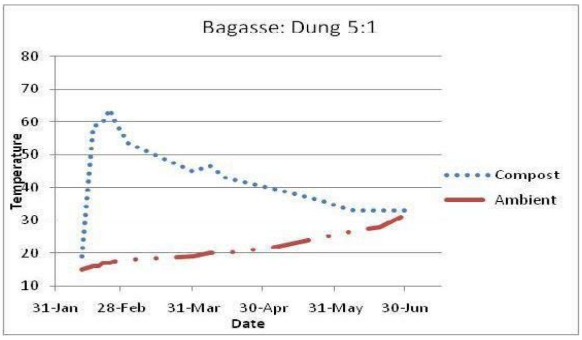

Fig. 3: Temperature monitoring for C3 (5:1)

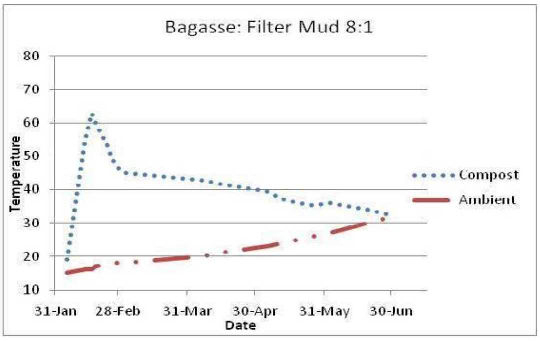

Fig. 4: Temperature monitoring for C4 (8:1)

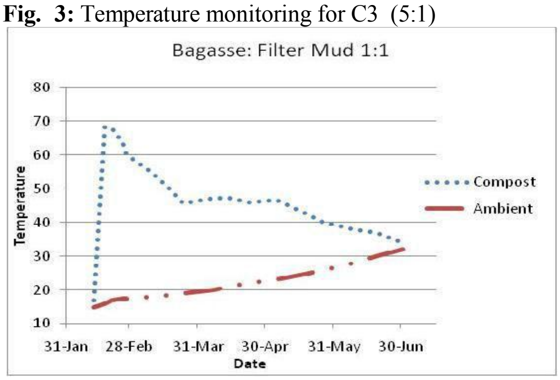

Fig. 5: Temperature monitoring for C5 (1:1)

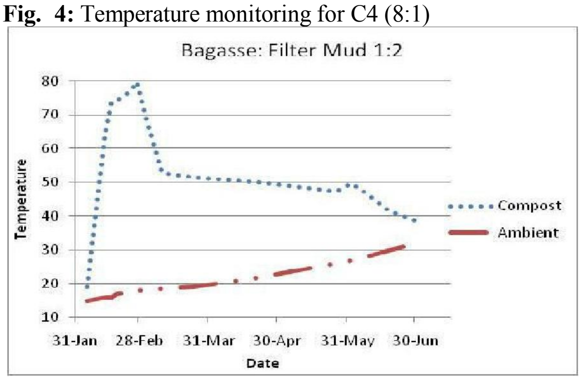

Fig. 6: Temperature monitoring for C6 (1:2)

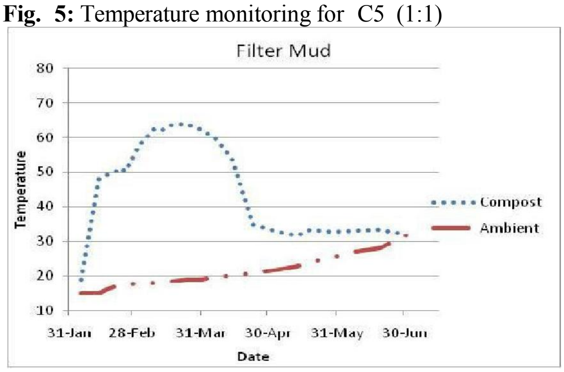

Fig. 7: Temperature monitoring for C7

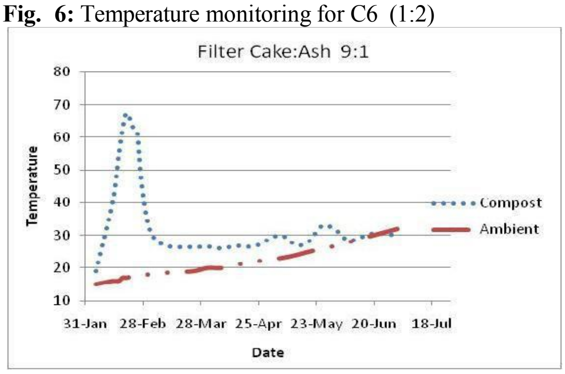

Fig. 8: Temperature monitoring for C8 (9:1)

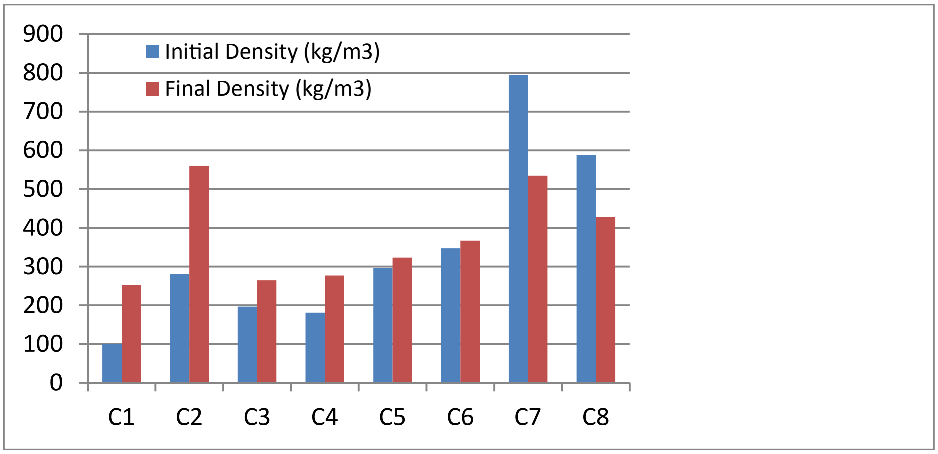

Fig. 9. Change in bulk density of different compost treatments

pH and EC

The heaps C1 , C2 and C3 were have pH neutral while C4 to C8 were in starting heaps a acidic, C7 recorder the lowest pH it is C5 on the other hand, all treatments were nearly neutral as shown in figure (10).

The pH of mature compost typically approaches neutral, which is the case in all treatments as shown in Figure 10. The treatments composed filter mud started off with low pH however, the ones mixed with animal dung or filter mud started the experiment with higher pH due to their alkali nature. The pH values of the mature compost (C1 and C2), reached 8.2 and 7.2 in respective order, which are considered in the recommended range of good compost as reported by Hogg *et al.* (2002) and Bord na Mona (2003).

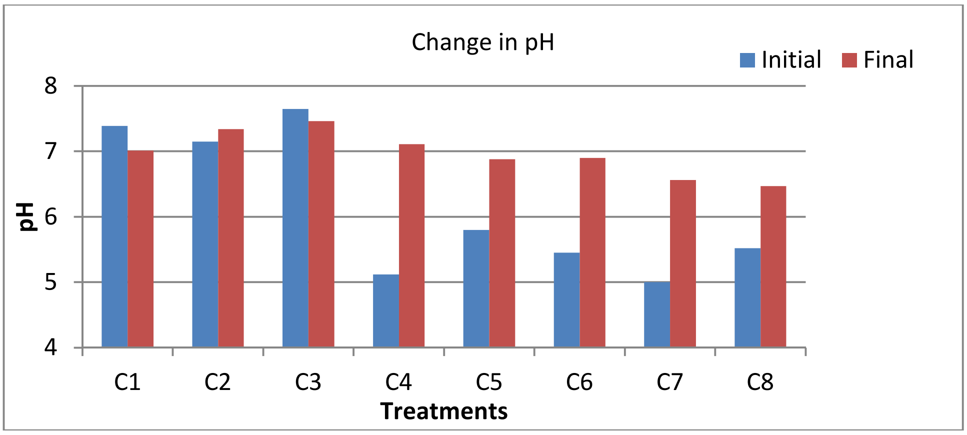

Fig. 10. Change in pH of different compost treatments

The electrical conductivity (EC) increased in all treatments except C4, which showed a decrease in electrical conductivity, as shown in (Figure 11). The increase in electrical conductivity could be attributed to the high concentration of nutrient ions released during the mineralization of organic matter.

Its worthily to mention all treatments contained filter mud alone or bagasse mixed with filter mud exhibited law pH value. However, treatments contained cow dung or dry leaves mixed with filter mud showed neutral pH. (Mahmoud 2010) reported that the electrical conductivity (EC) increased in all treatments from initial to final EC was in started heap ranged from 0.2 to 2.20 ds/m. However in final heap reached 0.45 to 4.98 ds/m. The increase as shown in electrical conductivity could be attributed to high concentration of nutrient ions released during the mineralization of organic matter.

Ammoniacal and nitrate-nitrogen

The large decrease in ammoniacal nitrogen and increase in nitrate nitrogen during composting are related to the nitrogen transformation that occurred during composting. In treatments C1, C2 and C3, the ammoniacal nitrogen decreased and the nitrate nitrogen increased but the ammoniacal nitrogen remained higher than the nitrate nitrogen. The same occurred with treatment C6, whereas , the nitrate nitrogen reached higher values than ammonium nitrogen. However, in treatments C7 and C8 both the ammoniacal and nitrate nitrogen increased. Treatments C4 and C5 were poor in nitrate nitrogen before and after composting and its ammoniacal nitrogen decreased during composting (Fig, 11 & 12). During the composting process, the concentration of ammoniacal nitrogen increased through the four weeks in both treatments. As a results, observed through ammonification process all nitrogenous organic compounds converted to NH_4^+ **(**Selim *et al.,* 2012).

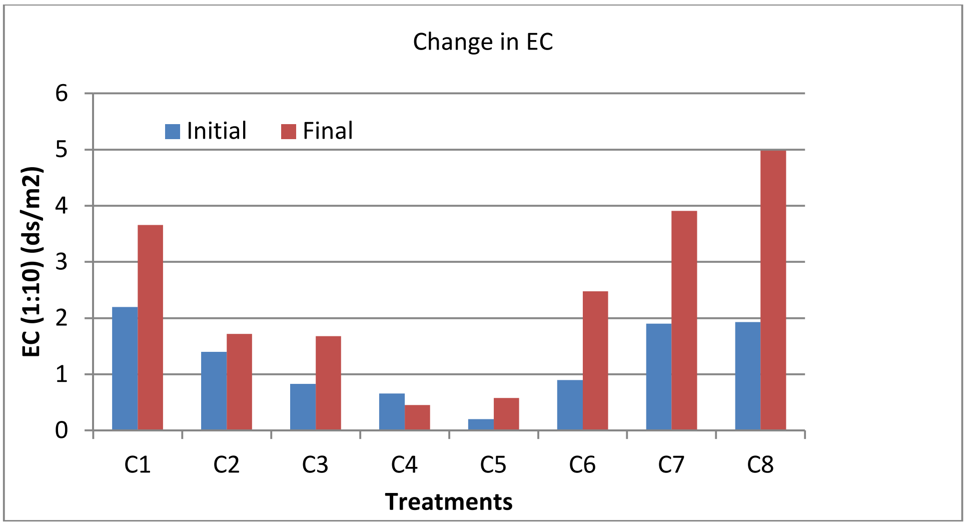

Fig.11. Change in electric conductivity of different compost treatments

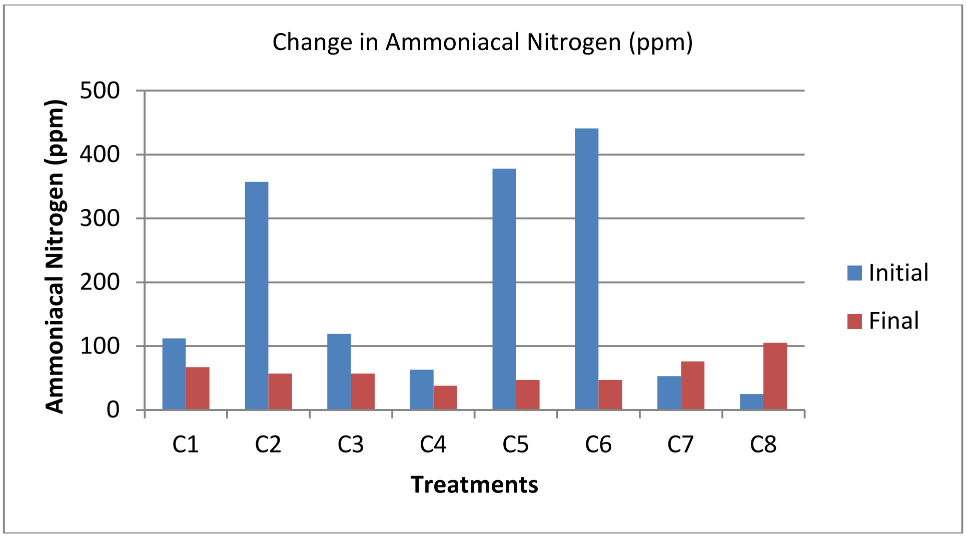

Fig.12: Change in ammoniacal nitrogen of different compost treatments

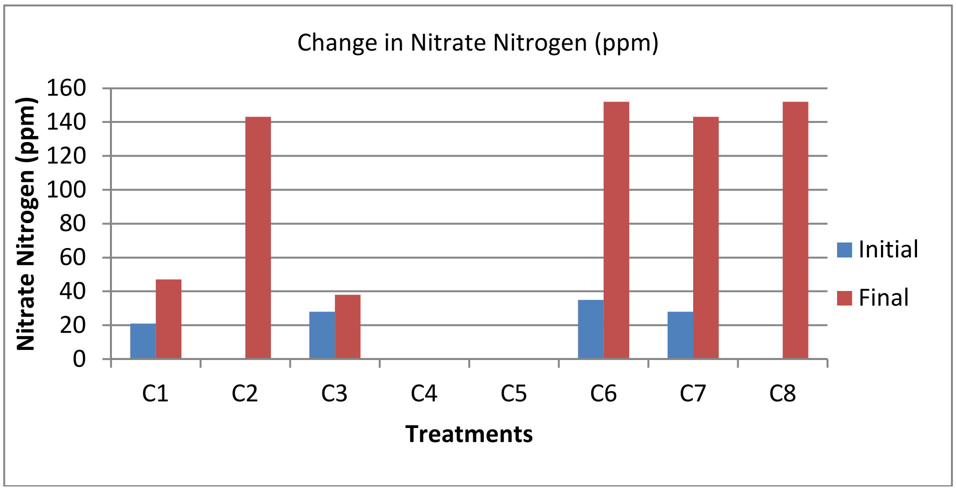

Fig. 13: Change in nitrate nitrogen of different compost treatments

This may be the mixtures of ratio was the limit of process where quantity of filter mud was not enough so, its late in maturation phase. On the other hand, nitrate the reflect the ammonia behinds where all treatments in started compost was low but in final process was high this gave indicial on nitrification microorganism were active to content ammonia to nitrate, C2, C4, C5 and C8 were in started process not detected but the final process gave values of nitrate. Treatment content bagass with filter mud by ratio 1:2 was the highest values 152 ppm while C5 and C4 content bagass with filter mud by ratio 1:1 or 1:2 nitrate was not detected.

Organic matter

The percentage of organic matter of mature compost in all treatments was decreased resulting from the loss of carbon dioxide during composting as shown in Table 4. Therefore, ash content of mature compost thus increased.

Dry matter loss percentage were high in treatments which contents filter mud and cattle dung (Table 4). While treatments contained plant residues (baggasse, dry leave and furnce ash) in mixtures gave low percentage of loss (C4) (bagasse : filter mud 8:1) while, the highest percentage of loss reached 65%.

Also, data showed the organic matter contents decrease in final products. The rate of decrease reached its maximum in C5 and C2 (79.83% & 83.4% respectively). However, treatment contained filter mud and furnace ash (C8) recorded the lowest reduce of organic matter (57.97%). The organic matter of the final compost reached 63.2% for treatment (1) and 83.22% for treatment (2).The organic matter contents of both treatments were greater than the critical level (30-70%) as reported by US Composting Council (2003).These results could be attributed to the absence of appropriate microbial populations which are responsible for biodegradation of organic matter. It is well known that the ash (%) is calculated as 100- OM, consequently the ash (%) in treatments 1 and 2 will be also lower than the recommended range (Bera *et al.,* 2013).

Table 4: Change of loss percentages of dry matter, organic matter and total nitrogen

Compost piles	Dry weight (Kg)			Organic matter (Kg)			Total nitrogen (Kg)			C/N ratio	
	Initial	Final	Loss %	Initial	Final	Loss %	Initial	Final	Loss %	Initial	Final
C1	273.3	150	45cd	217.48	79.61	63.4bcd	1.59	1.55	2.52 e	79:1	30:1
C2	1356	585	57ab	1025.4	172.09	83.22 a	18.58	9.36	49.6b	32:1	11:1
C3	313	134	57ab	251.8	85.65	65.99bc	1.47	1.45	1.36 e	100:1	34:1
C4	280	259	7e	269.3	109.82	59.22d	1.23	1.19	3.25 e	127:1	32:1
C5	1420	497	65a	1246.33	251.38	79.83a	12.07	6.96	43.3c	60:1	21:1
C6	370.5	204	45cd	306.44	116.44	62cd	4.08	2.94	27.9d	43:1	23:1
C7	600	273	54bc	406.44	124.11	69.46b	11.04	4.23	61.5a	21:1	17:1
C8	137.5	86	38d	86.79	36.48	57.97d	2.12	1.07	49.5b	24:1	20:1
LSD(0.05)			9.925			5.765			3.585		

Total nitrogen

The nitrogen percentage in terms of mass decreased for all treatments except treatment contained bagasse mixed with low amount of filter mud (C4, C5 and C6 Fig. 15).

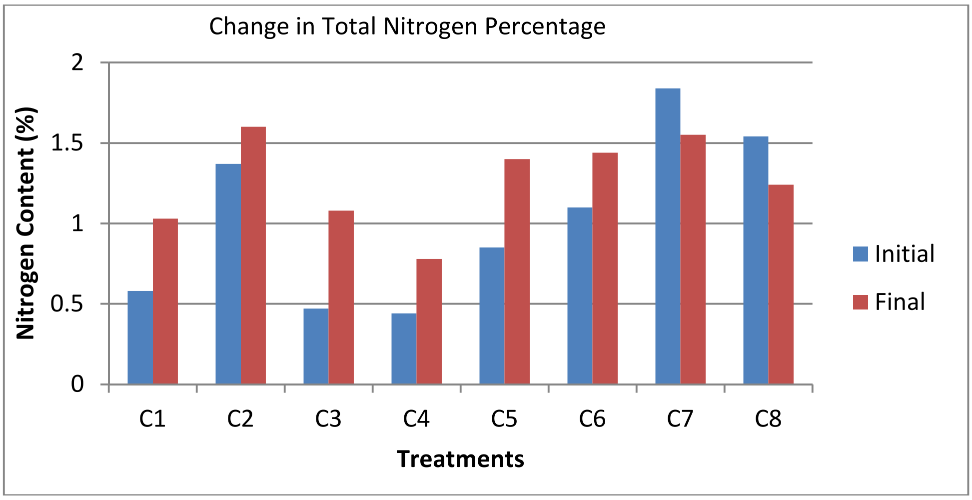

Fig. 15: Change in the percentage of total nitrogen in different compost treatments

The nitrogen content, as percentage of dry matter, increased for the treatments containing dry leaves or bagasse as they contained cellulosic material but decreased in the treatments containing mainly filter mud (Fig. 16). The significant drop in the nitrogen content in kg of nitrogen in (C2) could be attributed to excessive watering of the windrow which lead to leaching of the nutrients during the composting process, Aml M. Abd El-Satar, (2014) found that the total nitrogen gradually increased to reach 2.4% in treatment 1, while treatment (2) exerted 0.82% which is lower than the recommended concentration of good compost as stated by Barker (1997) and Watson (2003).The mean contents of organic matter in both treatments, at initial time, were 97.9 and 99.5% respectively.

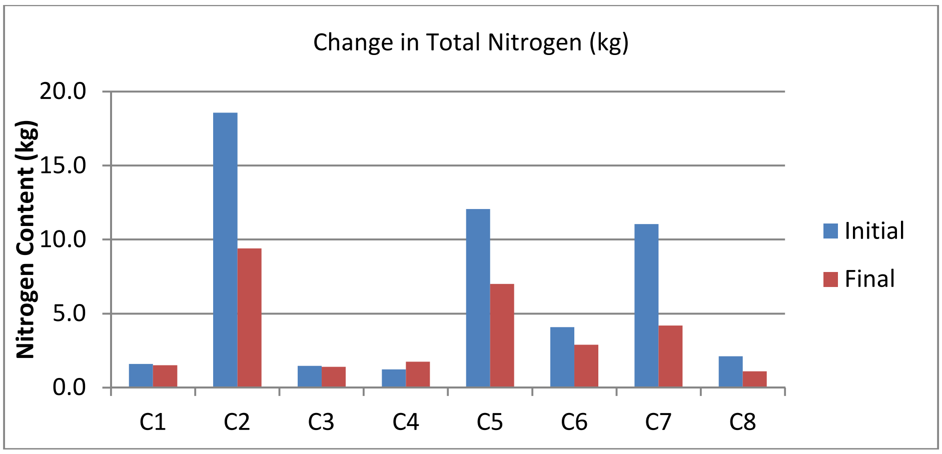

Fig. 16. Change in the mass of total nitrogen in different compost treatments

The treatments that were high in fiber content started with very high C/N ratio such as with treatments C1, C3, C6 and C2 which had C/N ratios of 79:, 100:1, 127:1 and 60:1 respectively. These were followed by C6 and C2 having C/N ratios of 43:1 and 32 : 1, respectively, as they had lower fiber and more filter mud. The treatments with no fiber at all, started off with low C/N ratio of 21:1 and 24:1 which were C7 and C8. However, by the end of the composting procedure, the C/N of all treatments dropped. The ones high in fiber dropped to a range of 34:1 to 30:1. These will be suitable to be used as soil conditioner, which includes treatments C1, C3 and C4. However, treatments containing filter mud which are C2 , C4, C6, C7 and C8 had a C/N ratio ranging from 23:1 to 11:1, which mak them suitable to be used as organic fertilizer. Changes in the C/N shown in Figure (18).

Mature compost of treatment (C1) was similar to the recommended range of good quality compost as reported by Biey *et al.* (2000) &Cabanas – vargas and Stentiford (2003). While the value in treatment (2) was still so far from the recommended range.

Data illustrated in Fig. (18 & 19) show phosphorus and potassium percentage of mature compost derived from different treatments. Data revealed that total phosphorus and potassium percentage of all the tested treatments were increased in range of 0.08 to 3.87% for phosphorus and from 0.112 to 1.14% for potassium. However, decrease in potassium percentage of mature compost of C2 and C5 were determined. These results confirmed by Bord & Mona (2003).

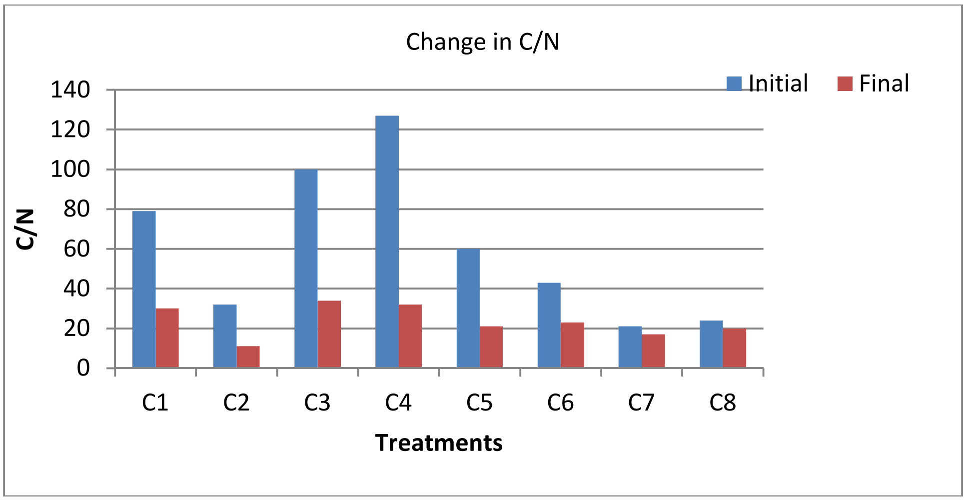

Fig. 17. Change in C/N of different compost treatments

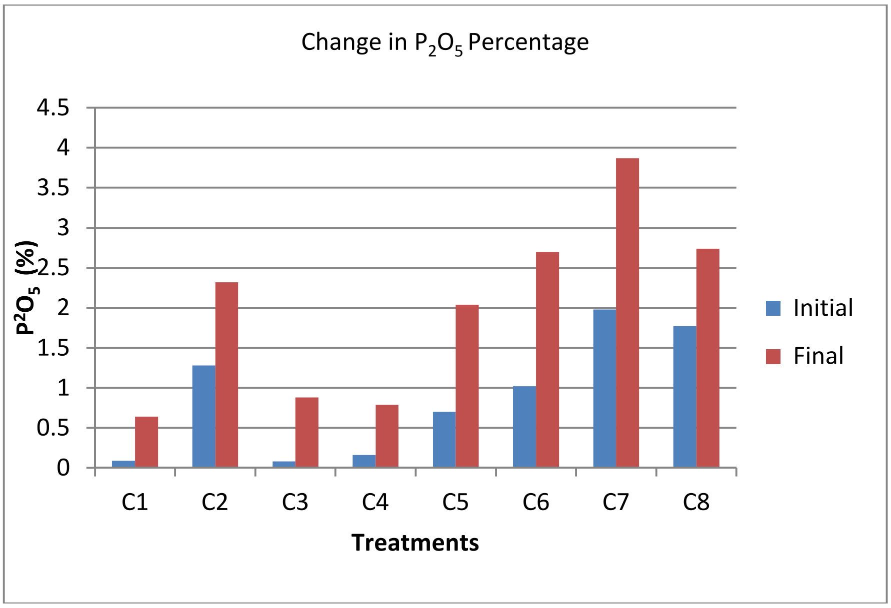

Fig. 18: Change in percentage of phosphorus in different compost treatments

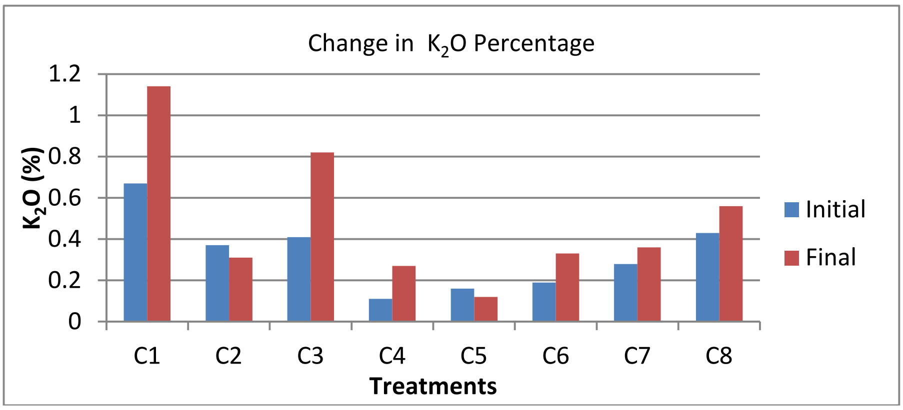

Fig. 19: Change in percentage of potassium of different compost treatments

Changes in the microbial populations during composting process.

The changes in the bacteria, fungi and actinomycetes counts and survival of pathogenic indicators (total and fecal coliform bacteria) as well as the pathogenic microorganisms (*Salmonella & Shigella*) were followed throughout composting period.

Changes in the total mesophilic and thermophilic counts throughout the composting period are shown in Table (5). The numbers of mesophilic at initial time for all mixtures were ranged between (0.70) and (2.6X10^8) cfu/g dry weight (dw). The bacterial counts decreased during the 4 first weeks of composting process ranging between 0.028 and 0.111 X10^8 cfu/g dw.

Table 5: Change of total count bacteria in different heaps.

Compost mixtures	Composting periods, weeks		
	1	4	16
Misophilic bacteria count X 10^8 cfu/g dw			
C1	0.70	0.028	1.26
C2	2.4	0.098	1.82
C3	1.0	0.058	1.53
C4	0.90	0.048	1.46
C5	1.0	0.061	1.56
C6	1.5	0.070	1.64
C7	2.6	0.111	1.98
C8	2.20	0.099	1.72
Thermophilic bacteria count X 10^8 cfu/g dw			
C1	22	53	0.24
C2	60	80	0.50
C3	52	75	0.38
C4	37	68	0.30
C5	55	76	0.42
C6	58	78	0.46
C7	62	82	0.55
C8	60	79	0.52

As the temperature decreased during the decline and maturation phase, the mesophilic bacterial counts proliferated rapidly and thier numbers increased and reached to the counts ranged between 1.26 to 1.98 X 10^8 cfu/g dw. In contrast the thermophilic counts at initial time was found in numbers lower than those of mesophilic counts, where their numbers ranged between 22 to 62 X 10^8 cfu/g dw.

During the first 4 weeks of composting process in which the temperature degree was higher than 45^{0}C the thermophilic counts proliferated rapidly and showed maximum peak at the fourth week of composting period for all tested mixtures . In the curing and maturation phase numbers of thermophilic bacterial decreased gradually towards the end of the composting process to be in numbers ranged between 24 to 55 X 10^8 cfu/g dw. These results are in agreement with those reported by Keener *et al.* (2000); Tiquia (2002); Hess *et* al. (2004); Hanajima *et al.* (2006) and Saludes *et al.* (2008).

Fungal counts Changed in the numbers of mesophilic and thermophilic fungi throughout the composting course of eight different mixtures are illustrated in Table (6). Initially the numbers of mesophilic fungi were higher than those of thermophilic species. The mesophilic counts recorded in numbers ranged between 3.2 X 10^6 and 5.1 X 10^6 cfu/g dw. Subsequently, with the rise in temperature (4^{th}) there was a rapid reduction in the counts of mesophilic fungi which gave a range of 1.9 X10^6 to 3.6 X10^6 cfu/g dw at the fourth week of composting period for all tested mixtures. After 4 weeks, as the temperature start to drop towards the maturation phase, the mesophilic fungi counts began to increase in the end of process and reached 3 to 4.6 X 10^6 cfu/g dw.

During the first weeks of composting processin which the temperature degree was higher than 45^{0}C the thermophilic fungi proliferated rapidly and showed maximum peak at the fourth week of composting for all mixtures under study achieved numbers between 3.2 to 6.5 X 10^6 cfu/g dw. On the other hand, Goyal *et al.* (2005) reported that the serotinous growth of fungi may be referred to their activity in the decomposition of recalcitrant organic substances such as cellulose, hemicelluloses and lignin in the later stage of composting process when temperature dropped to mesophilic condition. It is therefore necessary as reported by Saludes *et al.* (2008) to control the process temperature particularly during the cooling phase in order to maximize the effectiveness of fungi and other main decomposers for breaking down the lignocellulosic components.

Table 6: Change in total count of fungi in different heaps.

Compost mixtures	Composting periods, weeks		
	1	4	16
Misophilic fungal count X 10^6 cfu/g dw			
C1	3.2	0.19	3.0
C2	4.8	0.34	4.4
C3	4.5	0.28	4.0
C4	4.2	0.22	3.8
C5	4.6	0.24	4.1
C6	4.8	0.28	4.3
C7	5.1	0.36	4.6
C8	4.9	0.35	4.5
Thermophilic fungal count X 10^6 cfu/g dw			
C1	3.2	27	0.07
C2	6.2	50	0.60
C3	5.7	42	0.30
C4	5.2	38	0.20
C5	5.8	44	0.40
C6	6.0	48	0.50
C7	6.5	53	0.64
C8	6.3	51	0.62

Actinomycetal counts

As shown in Table (7) the mesophilic actinomycete numbers dropped down after the first week and then increased gradually reaching its maximum count after sixteen weeks. On the other hand, the thermophilic actinomycete numbers reached maximum count after four weeks of composting period in all mixtures as shown in Table (7). This could be contributed to increase of temperature during composting period. Similar results were reported by Michel *et al.,* 2002 and Tiquia *et al.,* 2002.

Its worthily to mention, all heaps were matured so, all heaps in final process total, fecal coliform and Salmonella & Shigella of compost heaps were matured because the high temperature distroged all pathogenic microorganismis. The heaps treatment C6 was the highest number 295X10^4 cfu/g in initial process, while treatment C1containd the lowest number of total coliform bacteria 5X10^4 cfu/g. Fecal coliform in treatment C2reached 13.5X 10^4 cfu/g but, treatment C8 attained the lowest numbers (12.2 X10^4 cfu/g). Salmonella & Shigella reached the highest number in treatment (C7) (20X10^4 cfu/g) followed by treatment (C2) (25X10^4 cfu/g) as showen in table (8).

Table 7: Change in total count of actinomycetes in different heaps.

Compost mixtures	Composting periods, weeks		
	1	4	16
Misophilic actinomycetal count X 10^6 cfu/g dw			
C1	0.58	0.57	7.0
C2	1.20	1.3	12
C3	0.85	0.89	9.2
C4	0.70	0.76	7.8
C5	0.90	0.94	9.8
C6	1.0	1.1	11
C7	1.4	1.5	13
C8	1.2	1.3	12.4
Thermophilic actinomycetal count X 10^6 cfu/g dw			
C1	0.74	42	0.036
C2	3.35	92.5	0.099
C3	2.50	83	0.087
C4	1.80	70	0.073
C5	2.7	86	0.090
C6	3.0	88	0.096
C7	3.38	93	0.112
C8	3.36	92.4	0.098

Table 8: Change in total, fecal coliform and Salmonella and Shigella in different heaps.

Compost mixtures	Composting periods, weeks		
	1	4	16
Total coliform count X 10^4 cfu/g dw			
C1	5	6.3	Nd
C2	180	1.5	Nd
C3	8	1.1	Nd
C4	15	2.0	Nd
C5	295	5.80	Nd
C6	12	4.10	Nd
C7	40	8.7	Nd
C8	14	4.3	Nd
Faecl coliform count X 10^4 cfu/g dw			
C1	16.1	3.3	Nd
C2	13.5	0.5	Nd
C3	14.8	1.0	Nd
C4	6.4	1.4	Nd
C5	11.5	2.22	Nd
C6	8.8	1.64	Nd
C7	12.2	3.51	Nd
C8	7.5	1.55	Nd
Salmonella and Shigella count X 10^4 cfu/g dw			
C1	15	2.3	Nd
C2	25	7.0	Nd
C3	14	5.0	Nd
C4	13	6.3	Nd
C5	15	7.4	Nd
C6	19	5.2	Nd
C7	20	8.6	Nd
C8	11	6.2	Nd

It can be also concluded from results of the analyses that at the start of the experiment, all treatments containd coliform bacteria (total and fecal), Salmonella and ShigellaIn addition, all pathogenic bacteria were destroyed during the composting process due to high temperature reached during the thermophilic stages.

Similar results were observed for the survival fecal coliform counts and Salmonella & shigella counts. They have has been suggested that temperatures exceeding 550C for at least 3 days throughout the composting material should be sufficient to produce a pathogenically harmless material (El-Housseini *et al.*, 2000).

Moreover, all treatments after composting possessed a high water holding capacity (WHC) percentage as shown in Table (9). This is a favorable characteristic of composted material used as soil conditioner or organic fertilizer. Treatments containing fibers possessed high WHC as shown in Table (9).

Table 9: Measured water holding capacity of compost mixtures

Treatment	C1	C2	C3	C4	C5	C6	C7	C8
WHC (%)	434	212	448	771	492	689	303	331

Conclusion

Based on results of the pilot experiment, it could be recommended to the farmers shred the dry leaves and mix them with dung produced by their livestock and make compost out of the mixture to be used as a supplement to the synthetic fertilizers added to the soil.

The pilot experiment has also demonstrated that a variety of compost types and organic fertilizers can be produced from a combination of the residues generated from the sugar mills which are bagasse, filter mud and furnace ash. It depends on the amounts available in each sugar mill from each type residue. In all cases, the generated residues should undergo aerobic composting before being added to the soil as to improve its physical, chemical and biological properties as demonstrated in this research. The compost or organic fertilizer produced in the sugar mills should be returned back to the sugarcane agricultural fields to replace a portion of the synthetic fertilizers currently used by the farmers.

Results of the pilot scale composting in terms of amount of nitrogen-phosphorus- potassium (NPK) associated with the production of each type of compost will be used in the life cycle assessment study. The improvements to the environmental impacts associated with the sugarcane industry throughout its life cycle due to composting of the residues instead of their current disposal or reuse options will be identified and assessed.

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