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Research Paper

Comparison of composts quality prepared by wide range of organic wastes

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Abstract. Composting has become progressively a popular way and suitable option for recycling the different organic wastes with economic and environmental profits. However, the design of composting systems for farmers is limited due to the low information on the basic concepts of the composting process and how manure characteristics can influence its performance. The present paper summarized the factors affecting the quality of composts produced by using different manures as organic activator. Special attention has been paid to the relevance of pH; Electrical conductivity EC temperature; CO_2 concentration; organic carbon (%); NH_4 (ppm); NO_3 (ppm); C:N ratio; changes in total macro and micro-nutrients and oxygen levels during composting process and the necessity of standardizing the maturity indices due to their great importance amongst compost quality criteria. Microbiological changes during composting process i.e., Total counts of bacterial, Mesophilic and Thermophilic aerobic cellulose decomposer were also considered. Results revealed that a negative correlation was found between temperatures and composting time. Agricultural waste which was treated with10% poultry manure showed rapid degradation than the two other manures and recorded the least bacterial counts, while the treatment of agricultural waste +10% mixture of camel and sheep manure as organic activator gave the highest bacterial counts and higher EC than either treated with cow or poultry manure. Finally, all these parameters are considered as a good indicator for the end of the biodegradation phase in which the compost achieves maturity.

Keywords: Composting, organic wastes, bacterial counts.

INTRODUCTION

One of the most important ways to achieve the goals of sustainable agriculture is to extend the application of bio-organic farming systems. Bioorganic farming systems have low cost and eco-friendly inputs that have remarkable potential for providing nutrients which can reduce the chemical fertilizer dose by 25 to 50 percent (Vance, 1997). After harvesting the economic part, a great amount of crop residues remain unused and it creates environmental risks. These large quantities of bio residues are potentially nutritious and may be utilized for the production of valued compost (Zakarya *et al*., 2018).

Composting of animal manures cannot be considered a new technology. It has been traditionally carried out by farmers after manure collection for better handling, transport and management. Frequently the wastes were mounded up with little regard to control the process conditions (aeration, temperature, ammonia loss, etc.) and rudimentary methodology. Huge amounts of organic wastes, i.e., bio solids, animal manures and household wastes, are produced in Saudi Arabia. The suitable option for recycling these wastes is to convert to compost. Efficient composting will overcome the cost of chemical fertilizers with economic and environmental profits. The application of compost not only offers extra organic carbon and nutrients but also improves the soil physical and chemical properties (Yadav *et al*., 2000; Bhandari *et al*., 2002). Thus, the application of inorganic fertilizers with organic manure would have a better effect

Table 1. Chemical properties of raw wastes used in the composting process.

Physio-chemical properties	Palm trees waste	Wheat straw	Shoots of vegetable crops
pH	8.19	8.27	8.32
EC (dSm^{-1})	0.93	1.23	0.86
Organic matter %	89.90	94.19	81.45
Organic carbon %	52.14	54.63	47.24
Total N %	0.61	0.56	0.81
Total P %	0.08	0.22	0.19
Total K %	0.17	0.19	0.11
C/N ratio	85.48	97.55	58.32

on soil health, soil organic matter and related soil properties than the application of inorganic fertilizers. However, combined application of inorganic fertilizers with manure may not result in an increase of soil organic carbon (SOC) because organic matter accumulation depends on the net incorporation of organic matter in the soil, which in turn depends on the cropping and management system employed (Dick, 1992; Paustian *et al*., 1997; Yadav *et al*., 2000b; Bhandari *et al.*, 2002; Edmeades, 2003; Gutieŕrez-Miceli *et al*., 2007; Peyvast *et al*., 2007,: Peyvast *et al*., 2008a, b, c, d; Olfati *et al*., 2009; Shabani *et al*., 2011; Ayyobi *et al*., 2013; Ayyobi *et al*., 2014).

Although manures generally slowly decrease the release of SOC content, and there is less convincing indication that long-term manure application has accumulated effects on yield increase (Dawe *et al*., 1982). The application of manures is generally seen as a key practice for maintaining soil fertility and agricultural sustainability in different cropping systems (Yadav *et al*., 2000a, b; Bhandari *et al*., 2002; Regmi *et al*., 2002; Ladha *et al*., 2003; Sarkar *et al*., 2003; Saleque *et al*., 2004; Yadvinder *et al*., 2004; Jiang *et al*., 2006).

Although previous research (Duplessis and MacKenzie, 1983; Richards *et al*., 1999; Moss *et al*., 2001; Malik *et al.*, 2006; Khan *et al*., 2008; Recep İrfan *et al*., 2014) discussed the effects of poultry litter, cattle manure, and leonardite on the yield potential of some crops, so far there has been no side-by-side comparison of these organic manures with regard to their effects on quality of compost produced as well as time of composting. Therefore, further research is needed to clarify which organic manures should be chosen to achieve high quality compost. Hence, the present investigation has been undertaken the objective of this study is to determine the effects of three organic materials on the quality of compost produced.

MATERIALS AND METHODS

Site description

The field experiments were conducted at the Agriculture Research Station, College of Food and Agriculture Sciences, King Saud University, Dirab, South of Riyadh region, Saudi Arabia (24.42°N latitude and 46.44°E Longitudes, Altitude 600 m). The region is under arid climate conditions, with high temperatures and truncated rainfall during the summer and low temperatures and little rainfall during the winter.

Collecting and decomposing organic wastes for producing compost

All available organic materials were collected i.e. crop residues, wheat straw, palm trees wastes, and vegetables wastes. Chemical properties of raw material (wastes) used in preparing compost were determined, results are presented in (Table 1). Three kinds of manure were used in the present study for preparing compost namely; poultry litter, cow manure and a mixture of sheep and camel manures. Chemical properties and nutrients content of the organic materials used in producing compost were monitored according to standard protocols specified by the US Composting Council (TMECC, 2002). Results are presented in Table 2.

All wastes were decomposed separately in layer in three heaps (25 × 10 × 1.5 m) under medium-high temperatures with adequate moisture through the action of microorganisms hasten the process of composting. Calcium carbonate was added by equal dose to the three heaps (at rate of 2%). Each layer was also inoculated with a mixture of 1 × 10^{8} *Streptomycs aurefaciens, Trichoderma viridie, T. harzianum, Bacillus subtilis, B. licheniformis* (1 L/ton) as microbial activators to fasting decomposition in all treatments and then moistened. Changes in temperature that occurred during the composting process were determined using thermometer. Water was added to all windrows to readjust the moisture content to 50 to 65%. Every 15 days, composting mass of the three heaps were mechanically turned upside down. During composting process, samples from the surface area and the central parts of the heaps were taken manually after 0, 4, 8, 12 and 16 weeks, mixed thoroughly and four replicates

Table 2. Physio-chemical composition and nutrients content of the organic materials used.

Physio-chemical properties	Poultry manure	Cow manure	Mixture of sheep and camel manure
Organic matter %	50.1	29.20	36.40
Organic carbon %	29.06	16.94	21.11
EC (dS m^{-1})	7.36	5.95	7.19
pH	7.81	7.97	7.35
Moisture %	12.2	12.50	13.40
Total N %	2.05	7.97	1.35
Total P %	1.06	0.32	0.63
Total K %	1.56	0.62	0.84

were examined for microbiological analyses (total count of aerobic mesophilic bacteria, aerobic mesophilic and thermophilic cellulose-decomposing bacteria) by serial dilution plate count technique (Difco, 1966) and aerobic mesophilic and thermophilic cellulose - decomposing bacteria by using Doubs' cellulose medium procedure (Allen, 1982). Microbial counts were expressed as colony-forming units per gram of compost material (cfu/g). After 0, 30, 60, 90 and 120 days, homogenized samples were manually taken for physically analysis for EC (Chen *et al*., 1988) and chemically analyzed for organic carbon CO % (AOAC, 1970), pH, organic matter OM%, C/N ratio, NH_4–N, NO_3–N and total nitrogen by Kjeldahl method (Page *et al*., 1982), total P and K (Cottenie *et al*., 1982). At the end of decomposing C:N ratio as well as density and toxicity were observed. The values of C:N ratio for the three heaps viz., Agricultural wastes+10% cow manure; Agricultural wastes+10% poultry manure and Agricultural wastes+10% mixture of camel and sheep manure were 18.76, 15.68 and 18.65, respectively. Temperature in the central parts of the heaps was determined at intervals and considered satisfactory when a handful of material would wet the hand but not drip (about 60 to 70% WHC). Water was added if necessary to keep the moisture content inside the heaps at 60% of the weight through the experiment. During composting process, interaction amongst physical, chemical and biological factors that occurs such as bulk density, porosity, particle size, nutrient content, C/N ratio, temperature, pH, moisture and oxygen supply have demonstrated to be key for composting optimization since they determine the optimal conditions for microbial development and organic matter OM degradation (Agnew and Leonard, 2003; Das and Keener, 1997; de Bertoldi *et al*., 1983; Haug, 1993; Miller, 1992; Richard *et al*., 2002).

Microbiological and physio-chemical analyses of the decomposing organic wastes

Microbiological analysis

Representative samples of the surface and the central parts of the heaps were taken manually after 0, 4, *8,* 12 and 16 weeks, mixed thoroughly and four replicates homogenized samples were examined microbiologically for the total count of aerobic mesophilic bacteria by serial dilution plate count technique (Difco, 1966), aerobic mesophilic and thermophilic cellulose- decomposing bacteria by using Doubs' cellulose medium procedure (Allen, 1982). Microbial counts were expressed as colony forming units per gram of compost material (cfu/g).

Chemical analyses

The EC was examined according to Chen *et al*. (1988) and OC % was followed as described by (AOAC, 1970); pH was recorded using pH meter; OM %, C/N ratio, NH_4–N, NO_3–N and total N by Kjeldahl method were determined according to Page *et al*. (1982), whereas total P and K were determined by the methods described by Cottenie *et al.* (1982).

RESULTS AND DISCUSSION

Temperature

Temperature is an important factor in composting efficiency, due to its influences on the activity and diversity of microorganisms (Finstein *et al*. 1986). The optimum temperature range for composting is 40 to 65°C (de Bertoldi *et al*., 1983; Zakarya *et al*., 2018), while temperatures above 55°C are required to eliminate pathogenic microorganisms. Changes in temperature that occurred during the composting process are shown in Table 3. In general, the outside temperature was about 37°C in the day and 27°C in the night. Three periods were distinguished: a phase of latency which correlates to microbial population adapted in the compost conditions, a phase of sudden rise in temperature up to 64°C and a phase of cooling in which the temperature decreased progressively and returned to its starting values. At the beginning, the temperature was between 36-38°C and start to increase to 40-42°C (the end of mesophilic stage). After 6 days, temperature reached

Table 3. Mean of temperature variations during composting process.

Treatments	Time in weeks									
	0	1	2	3	4	6	8	10	12	16
	Temperature °C									
Agricultural wastes + 10% cow manure	36	53	57	64	63	54	47	42	36	33
Agricultural wastes + 10% poultry manure	38	56	58	65	64	56	48	44	38	35
Agricultural wastes + 10% mixture of camel and sheep manure	37	54	56	63	64	55	46	42	37	34

Table 4. Microbiological changes during composting of agricultural wastes treated with different rates of organic manure.

Treatments	Time in weeks				
	0	4	8	12	16
Total bacterial counts (Counts $\times 10^7$ CFU/g)					
Agricultural wastes + 10% cow manure	34	64	95	85	63
Agricultural wastes + 10% poultry manure	27	76	89	81	48
Agricultural wastes +10% mixture of camel and sheep manure	49	99	104	94	77
Mesophillic aerobic cellulose decomposer (Counts $\times 10^4$ CFU/g)					
Agricultural wastes + 10% cow manure	139	32	98	63	54
Agricultural wastes + 10% poultry manure	158	60	117	86	75
Agricultural wastes +10% mixture of camel and sheep manure	160	66	128	97	82
Thermophillic aerobic cellulose decomposer (Counts $\times 10^5$ CFU/g)					
Agricultural wastes + 10% cow manure	39	81	102	78	54
Agricultural wastes + 10% poultry manure	38	85	113	69	41
Agricultural wastes +10% mixture of camel and sheep manure	41	92	123	86	55

54-56°C with little variations till the second week. The maximum values of temperature between 63-65°C were found after 3 and 4 weeks. Then the temperature gradually decreased and reached 33-35°C by the end of composting. The high temperature inside the heaps is necessary to eliminate pathogenic microorganisms. However, temperature should not exceed 65°C, as this would harm almost all microorganisms and cause the process to cease. The rising of temperature during composting is mainly due to the activity of microorganisms in the degradation of agricultural wastes. These results are in agreement with the findings of Stentiford (1996), El-Meniawy (2003), Abdel-Aziz and Al-Barakah (2005) and Eida (2007). The obtained results revealed that a negative correlation was found between temperatures and composting time, and this was due to decrease in temperature by the end of composting. Generally, the increase in temperature may be also attributed to the suitability of composting conditions (C/N ratio, moisture content, aeration, particle size) for microbial and enzymatic activities. On the other hand, the decrease in temperature was attributed to the decrease in microbial and enzymatic activities. This finding is supported by the results of Noguerira *et al.* (1999).

Microbiological changes

Table 4 show that total bacterial counts increased gradually and reached its maximum rate after 8 weeks initially, then decreased until the end of the composting period at 16 weeks. These results indicated the importance of mesophilic bacteria at the beginning of composting as they used the readily decomposable constituents of organic wastes. The obtained results are similar with those obtained by Khalil *et al*. (2001), who demonstrated that bacteria flourish because of their ability to grow rapidly on soluble protein and other readily available substrates and because they are more tolerant to high temperature. They added also that, mesophilic microorganisms are responsible for the initial decomposition of organic materials and the generation of heat responsible for the increase in compost temperature. These sharply decreases in microbial population at the maturity stage, and could be deduced to the diminution of moisture and depletion of organic matter at this later stage of composting process. The treatment of agricultural waste +10% mixture of camel and sheep manure gave the highest bacterial counts, while the treatment of agricultural waste +10% poultry manure recorded the least one. These results are in line with those of Abo-Sedera (1995) and Radwan and Awad (2002). Table 4 shows sharp decrease in counts of mesophilic aerobic cellulose decomposing bacteria at the third week of composting followed by an increase till the end of the composting process. These results indicated the importance of mesophilic aerobic cellulose decomposing bacteria at the beginning of composting as they breakdown cellulytic materials as a part of decomposable constituents of organic wastes. The decrease in mesophilic aerobic cellulose decomposing bacteria after 3 to 4 weeks was due to the high temperature recorded at 63 to 65°C. These results were in harmony with those obtained by El-Meniawy (2003) and Eida (2007). Counts of thermophilic aerobic cellulose decomposing bacteria in the composted materials showed a marked increase after 4 weeks of composting reaching its maximum counts at the 8 week (Table 4). This also was mainly due to the high temperature of the heap during this period of composting. Thermophilic aerobic cellulose decomposing bacteria, thereafter, decreased with the fall of temperature until the end of the composting period. This decline in numbers could confirmed to the postulates mentioned by Ryckeboer *et al*. (2003), that during the curing and maturity phase, the cellulose may become inaccessible to enzymatic activity because of low water content or association with protective substrates such as lignin. These results also indicated that changes in temperature of the composted heaps govern the types and development of microorganisms concerned in the decomposition process (Abdel-Aziz and Al-Barakah, 2005; Eida, 2007). In general, aerobic cellulose decomposing bacteria were deferent as type of manure and rend of total bacterial counts.

pH

In the present study, pH values of raw materials of the different materials (wastes) used at initial time of composting were slightly alkaline 8.41, 8.33 and 8.48 for the treatments of agricultural wastes + 10% cow manure; agricultural wastes + 10% poultry manure and agricultural wastes +10% mixture of camel and sheep manure respectively (Table 5). A pH of 6.7 to 9.0 supports good microbial activity during composting (Zakarya *et al*., 2018). Optimum values are between 5.5 and 8.0 (de Bertoldi *et al*., 1983; Miller, 1992). Usually, pH is not a key factor for composting since most materials are within this pH range. However, this factor is very relevant for controlling N-losses by ammonia volatilization, which can be particularly high at pH >7.5. During composting, pH values gradually decreased due to the formation of organic acids during the metabolism of relatively readily available carbohydrates, consumption of ammonia by microorganisms and as a result of volatilization of free ammonia to the air. Finally, the pH tended to stabilize due to humus formation with its buffering capacity at the fermentation of composting activity as also mentioned by Khalil *et al.* (2001), and Abdel-Aziz and Al-Barakah (2005).

EC

It was observed that organic activator was higher in EC of agricultural waste treated with 10% mixture of camel and sheep manure, than either treated with cow or poultry manure at the initial time and during composting process (Table 5). Although a gradual increase in the EC during the composting process of the different treatments was observed, but the EC value did not exceed over the recommended limits. This increase in EC values may be attributed to loss of biomass through the biotransformation of organic materials and also to release some of its content as mineral nutrients. The present results are in line with the results obtained by Abd El-Maksoud *et al.* (2002) and Abdelhamid *et al*. (2004), as they reported an increase in EC values during composting process. Furthermore, Lasaridi *et al.* (2006) suggested that a value of 4.0 dSm^{-1} for EC is a level considered tolerable by plants whereas values from 6 to 12 dSm^{-1} indicate a toxicity level due to salts for most plants up to the Greek standers.

Dry matter content

The optimum water content for composting varies with the waste materials in the compost process, but generally it should be at 50 to 60% (Gajalakshmi and Abbasi, 2008). When the moisture content exceeds 60%, the O_2 movement is inhibited and the process tends to become anaerobic (Das and Keener, 1997). During composting a large quantity of water can evaporate, then dry matter content of the different treatments decreased gradually during the whole period of composting (Table 5). The total losses of the dry matter amount recorded 48.76, 49.92 and 47.21% from the initial amount of the three treatments viz., agricultural wastes + 10% cow manure; agricultural wastes + 10% poultry manure and agricultural wastes + 10% mixture of camel and sheep manure, respectively. These results are in line with those found by Wallace (2003) and Eida (2007). Results also clearly indicates that there is rapid degradation of agricultural waste treated with10% poultry manure as organic activator compared to those treated with10% of cow manure or 10% mixture of camel and sheep manure. This may be due to the low C/N ratio and availability of nitrogen in poultry manure which increase the microorganism's activity in biodegradation of agricultural waste in the presence of poultry manure as organic activator compared to other two treatments.

Available and total nitrogen

As shown in Table 6, NH_4-N was decreased as the result of decomposition process, while NO_3 and the percentage

Table 5. Physicochemical changes during composting of agricultural wastes treated with different organic manures.

Treatments	Time in days				
	0	30	60	90	120
Dry matter (kg)					
1. Agricultural wastes + 10% cow manure	8218	5381	4844	4385	4211
2. Agricultural wastes + 10% poultry manure	8011	5201	4289	4023	4012
3. Agricultural wastes +10% mixture of camel and sheep manure	8359	5489	4987	4527	4413
pH					
1. Agricultural wastes + 10% cow manure	8.41	7.51	7.43	7.31	7.27
2. Agricultural wastes + 10% poultry manure	8.33	7.39	7.30	7.15	7.11
3. Agricultural wastes + 10% mixture of camel and sheep manure	8.48	7.66	7.48	7.36	7.32
EC (dSm^{-1})					
1. Agricultural wastes + 10% cow manure	2.50	2.94	3.15	3.61	3.79
2. Agricultural wastes + 10% poultry manure	2.33	2.68	3.01	3.36	3.52
3. Agricultural wastes+10% mixture of camel and sheep manure	3.02	3.20	3.61	3.79	3.91
Organic matter (%)					
1. Agricultural wastes+ 10% cow manure	79.96	61.53	51.25	44.37	42.98
2. Agricultural wastes+ 10% poultry manure	75.04	58.14	46.82	42.60	41.65
3. Agricultural wastes+10% mixture of camel and sheep manure	87.56	63.53	54.25	47.37	46.96
Organic carbon (%)					
1. Agricultural wastes+ 10% cow manure	46.38	35.69	29.73	25.74	26.09
2. Agricultural wastes+ 10% poultry manure	43.83	25.42	27.16	24.71	24.16
3. Agricultural wastes+10% mixture of camel and sheep manure	50.78	36.84	31.47	27.47	27.24

Table 6. Changes in N-forms and C/N ratio during composting of agricultural wastes treated with different organic manures.

Treatments	Time in days				
	0	30	60	90	120
Total N (%)					
Agricultural wastes + 10% cow manure	0.66	1.09	1.20	1.25	1.39
Agricultural wastes + 10% poultry manure	0.78	1.19	1.31	1.36	1.54
Agricultural wastes + 10% mixture of camel and sheep manure	0.69	1.12	1.24	1.29	1.46
NH_4 (ppm)					
Agricultural wastes + 10% cow manure	439	269	189	137	130
Agricultural wastes + 10% poultry manure	497	291	221	161	149
Agricultural wastes +10% mixture of camel and sheep manure	462	273	231	149	138
NO_3 (ppm)					
Agricultural wastes + 10% cow manure	67	372	415	435	452
Agricultural wastes + 10% poultry manure	81	432	467	506	519
Agricultural wastes +10% mixture of camel and sheep manure	72	417	434	452	469
C/N ratio					
Agricultural wastes + 10% cow manure	70.27	32.74	24.77	20.59	18.76
Agricultural wastes + 10% poultry manure	56.19	21.36	20.73	18.17	15.68
Agricultural wastes + 10% mixture of camel and sheep manure	73.59	32.89	24.38	21.29	18.65

Table 7. Changes in total macro and micro-nutrients during composting of agricultural wastes treated with different organic manures.

Treatments	Macro-nutrients			Micro-nutrients			
	N (%)	P (%)	K (%)	Fe ppm	Mn ppm	Zn ppm	Cu ppm
Initial							
Agricultural wastes + 10% cow manure	0.66	0.478	0.328	4358	41	22	18
Agricultural wastes + 10% poultry manure	0.78	0.597	0.419	5487	64	31	21
Agricultural wastes + 10% mixture of camel and sheep manure	0.69	0.605	0.412	4841	58	29	19
30 days							
Agricultural wastes + 10% cow manure	1.09	0.504	0.362	5215	76	31	22
Agricultural wastes + 10% poultry manure	1.19	0.614	0.448	6176	99	37	28
Agricultural wastes +10% mixture of camel and sheep manure	1.12	0.631	0.429	5694	91	35	26
60 days							
Agricultural wastes + 10% cow manure	1.20	0.516	0.417	6213	84	35	24
Agricultural wastes + 10% poultry manure	1.31	0.639	0.481	6819	132	41	28
Agricultural wastes +10% mixture of camel and sheep manure	1.24	0.645	0.462	6764	121	46	28
90 days							
Agricultural wastes + 10% cow manure	1.25	0.539	0.442	6956	99	37	27
Agricultural wastes + 10% poultry manure	1.36	0.685	0.517	7830	139	49	30
Agricultural wastes +10% mixture of camel and sheep manure	1.29	0.678	0.489	7194	132	46	29
120 days							
Agricultural wastes + 10% cow manure	1.39	0.568	0.472	6986	118	41	28
Agricultural wastes + 10% poultry manure	1.54	0.695	0.535	7938	142	51	31
Agricultural wastes +10% mixture of camel and sheep manure	1.46	0.708	0.518	7695	138	49	30

of total nitrogen were increased in all treatments. The increase in total nitrogen percent may be due to the higher oxidation of non-nitrogenous organic materials and partially to the N_2-fixation by non-symbiotic nitrogen fixers as indexed by the increase in organic nitrogen. This indicates that the immobilization of nitrogen taken place during composting conserved the nitrogen from loss.

C/N ratio

The C/N ratio is one of the main parameters that describe the composting process. It is often used as an index of composting maturity, despite many pitfalls associated with this approach, but it seems to be a reliable parameter for following the development of the composting process (Khalil *et al*., 2001). Changes in the ratio of organic carbon to nitrogen during composting of agricultural wastes treated with different organic manure as organic activators are recorded in Table 6. The C/N ratios were first 70.27, 56.19 and 73.59 for treatments of agricultural wastes + 10% cow manure; agricultural wastes + 10% poultry manure and agricultural wastes +10% mixture of camel and sheep manure, respectively. As the result of the changes in the amount of nitrogen and the loss of organic carbon during composting process, a progressive narrowing in the C/N ratios of the composted materials was observed reaching to 18.76, 15.68 and 18.65 in respective order for treatments of agricultural wastes + 10% cow manure; agricultural wastes + 10% poultry manure and agricultural wastes +10% mixture of camel and sheep manure, respectively. The changes in C/N ratio could be taken as evidence of the degradation rate of the organic materials and the maturity of compost. These results are in line with those of Abdelhamid *et al*. (2004) who stated that, when C/N value is around or below 20, it could be considered satisfactory. Khalil *et al.* (2001) demonstrated that the C/N ratio of mature compost should ideally be about 10 but this is hardly ever achievable due to the presence of recalcitrant organic compounds, or materials which resist decomposition due to their physical or chemical properties. Some other authors reported that a C/N ratio below 20 is an indicative of acceptable maturity. However, Moldes *et al*. (2007) stated that compost might be considered mature when C/N ratio is approximately 17 or less, unless lingocellulolytic materials remain.

Macronutrients

The quantity and form of N in particular, present in manure or compost is important in shaping the quality of the material and for its agronomic uses and are increasingly more often defined in compost specification (Lasaridi *et al*., 2006; Moldes *et al*., 2007). Definitely, the macronutrients N, P and K are the most consumed elements by plants at the all stages of growth. The concentrations of NPK were increased during the composting process in all treatments (Table 7). Generally, the increase in total NPK during composting may have been due to the net loss of dry mass as loss of part of organic C as CO_2. Moreover, total N can also be increased by the activities of associative N-fixing bacteria at the end of composting process (Abdelhamid *et al*., 2004). These results are in similar with those obtained by different authors (Abd El-Maksoud *et al*., 2001, 2002; Kaviraj, 2003; Eida, 2007).

Micronutrients

It was seen that the Fe content was higher than the other elements in all treatments (Table 7). Conversely, the other three elements, Mn, Zn and Cu recorded moderate increases until the maturity stage. Thus, composting can concentrate micronutrients (Zorpas *et al*., 2002). Micronutrients in poultry manure treatment were higher than the other manures at initial and end of composting.

CONCLUSION

The mixture of camel and sheep manure can be used as microbial activation to fasting decomposition process of composting the agricultural waste organic materials with caution of the toxicity of salts.

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