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COMPOSTING OF SUGARBEET RESIDUES.(1) A STUDY ON CONDITIONS AND PERIOD OF COMPOSTING

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Abstract

A laboratory work was conducted to monitor two composting systems, aerobic and anaerobic for 9 months. Sugarbeet residues whether resulted from haulms, preparation the roots in field and before squeezing to obtain sugar were collected, air dried and chopped into pieces one inch long. The whole quantity was divided into two portions. One of them was composted under aerobic and the other under anaerobic conditions. Samples of each system were taken after 0, 7, 15 days then monthly up to 9 months.

Results showed that organic matter content decreased with time of composting in a rate higher in case of aerobic compost than in anaerobic one. Humus and organic acids increased with time of composting. Their concentrations under anaerobic conditions were higher than those under aerobic when the period of composting was longer than 6 months. Total nitrogen increased. In the same time, C/N ratio narrowed gradually by time of composting. That ratio was more wide in anaerobic than in aerobic compost. Ammonification process was active through time and produced more ammonia in anaerobic case. Nitrification activity was detected only in aerobic conditions. Total phosphorus and total potassium followed the same trend of total nitrogen. Ratios of C/P and C/K were almost similar to those of C/N. Ash per cent of decomposed material increased. pH of compost decreased slowly in aerobic case but under anaerobic condition, It was more acidic after 9 months. Total soluble salts in the mixture at 0 time was about 2.1%. That percentage increased gradually recording more high salinity in compost of anaerobic condition up to times of its beginning. Soluble sodium and potassium behaved in similar trend of total soluble salts. The increases in total soluble salts resulted from more soluble Ca^{++}. Water holding capacity in composting samples revealed gradual increases under two composting systems up to 15 days in aerobic versus 60 days in anaerobic system followed by a decrease in both cases. As for moisture content, it gradually increased with time of composting under both systems, but it was higher under anaerobic conditions.

INTRODUCTION

Research for suitable organic matter resources is one of the important issues in agriculture. The technique of preparing these resources to be available manure differs according to several factors. Compost as one of the organic manures could be prepared under aerobic or anaerobic conditions in ratios of 1:4 or 1:10 mass to water, respectively where the rate of decomposition, and loss of added ammonia is higher in aerobic composting than in anaerobic one (Acharya, 1935 a and b). According to Allison (1973) an aerobic decomposition process is likely to be delayed, if only limited amounts of oxygen were present, but eventually the normal aerobic break down products; chiefly CO_2, ammonia and water plus the resistant lignin-like materials and microbial cells; will be formed. If oxygen was completely absent, only anaerobic organisms would be active and the products would be organic acids, some CO_2, hydrogen, methane, hydrogen sulfide in addition to the resistant plant materials that anaerobic microorganisms could not be utilized. Abo-Sedera (1995) found that pH values of composted sugarbeet houlms had gradually decreased towards acidity as the decomposition process increased to reach 7.4, the whole loss in organic carbon during 150 day decomposition period amounted to 49%, 42% of this loss occurred within the first 50 days during composting. The inorganic N decreased and organic N increased by 71.7 and 50.7% of the original amount, respectively. C/N ratio were started with 38 then decreased to 18. The humus content increased gradually during composting period. Similar results were obtained by Abou El-Naga *et al.* (1997). The present work aims at identifying the suitable technique for preparing a good compost from sugarbeet residues.

MATERIALS AND METHODS

Sugarbeet residues resulted from preparation of roots in field (haulms) and before squeezing to obtain sugar in El-hamoul Factory at Kafr El-Shaikh. Governorate, were collected, thoroughly mixed, air dried and chopped into pieces of about one inch. The bulk quantitý was divided into two potions, one was composted aerobically and the other was composted under anaerobic conditions. The chemical analysis of the used organic material is shown in Table 1.

Table 1. Chemical analysis of sugarbeet residues.*

Mois %	E.C. dS/m	O.M. %	O.C %	C/N ratio	Total N %	Inorganic N %		p %	K %
						NH_4^+	NO_3^-		
58.7	6.6	73.11	42.40	35.0	1.21	0.280	0.014	0.17	1.15

* on dry weight basis

The aerobic composting process was carried out in open dishes keeping the ratio of mass: water at about 1:4 by adding the water regularly (Acharya, 1935b). The heap consisted of the following portions according to the method described by Abou El-Fadl (1970); 100 parts of residues material, 2.5 parts of each of ammonium sulphate, calcium superphosphate and fine calcium carbonate and 10 parts of fine clay. The total mixture (heap) was turned over after taking a sample for analysis on the 7^{th} and 15^{th} days from starting and every month up to the 9^{th}, in addition to zero time sample.

A similar heap of sugarbeet residues with similar potions of those under aerobic conditions was prepared and put in stoppered containers. The ratio of mass: water was 1:10. Each container was used for sample analyses on the 7^{th} and 15^{th} days from starting and every month up to the 9^{th}.

The physical properties of the periodical compost samples namely humidity and water saturation were estimated according to Black *et al.* (1965). The chemical properties of compost included pH in 1:10 compost: water suspension, total soluble salts in 1:5 compost: water extract, total organic matter by Schollenberger oxidizable organic carbon method, isolation and purification of humus extracted by 0.5 N NaOH solution, fractionation humus to humic acid precipitated by HC1 at pH1 and determined gravimetrically and fulvic acid as organic carbon according to Page *et al.* (1982) were determined. Total nitrogen content in compost samples, nitrate-N and ammoniacal-N were extracted, with distillation and determined in 4% boric acid solution using micro-kjeldahl technique, (Page *et al,* 1982). Total phosphorus in compost digest by mixture of acids was determined colourimetrically as described by Jackson (1973). Total potassium was extracted by 6 N HC1 from compost combustion and was flame-photometrically determined (Jackson, 1973).

RESULTS AND DISCUSSION

Organic matter

Table 2a indicates that organic matter content in manure decreased with time of composting under either aerobic or anaerobic conditions. The rate of decomposition was more rapid under the former. These results are in accordance with those of Ehsan *et al.*, (1990) who reported that the rate of decomposition of organic matter was rapid during the first period and then continued at comparatively slower rates during the last period of composting. Humus and organic acids (humic and fluvic), increased with time to reach their maxima after 270 days in anaerobic conditions while in aerobic reached their maxima after 180 days then gradually decreased. This may be due to the oxidation effect on this organic acids obtained under aerobic conditions. This might be attributed according to El-Sirafy (1978) to the development of some microorganisms which can utilize difficulty-decomposable components of different organic manures along with newly formed humus substances. Also, Ruchko (1984) mentioned that fulvic acids are more readily mineralized by microorganisms than humic acids under aerobic conditions. The obtained results may be due primarily to increasing counts of thermophilic bacteria at the beginning followed by mesophilic ones which later survive and act (Tesic *et al.*, I966; Abou El-Naga,1997).

Nitrogen content and fractions

In the same table, nitrogen percentage in compost was increased as a percentage of gradual decreased bulk of compost where the stable quantity shaped with relative increased percentage. Similar results were obtained previously by Abd El-Malek *et al.* (1961). and Abo-Sedera (1995). The rate of mineralization of nitrogen decreased with time. Under aerobic conditions, it tended to be less in its amount and slower in rate compared with composting under anaerobic conditions.

Ammonification started just after composting whether under aerobic or anaerobic conditions but the rate under the latter was higher, these results are confirmed with those obtained by (Acharya, 1935b). Organic nitrogen gradually increased with time of composting against the continuos decrease in the whole non-nitrogenous materials. Alexander (1977) confirmed these results, claiming that nitrogen immobilization resulted form the microbial assimilation of inorganic nitrogen in microbial bodies. On the other hand, Broadbent and Nakashima (1970) stated that in the usual aerobic situation, net immobilization of nitrogen by plant residues reaches a maximum. corresponding to 1.2-1.7% N in the original material (within a few days or one week) while under anaerobic conditions, loss of gaseous nitrogen may occur as a result of denitrificattion. Also, similar results were obtained by Abd El-Malek *et al.* (1961).

Values of C/N ratio at different composting periods (Table 2a) clarify that the ratio became narrower with time of composting due to organic matter decomposition where the rate of C/N reduction under aerobic conditions was higher than that under anaerobic case, which agree with results obtained by Khalil (1979).

ASH:

Ash in all cases of composting was stable in quantity but its relative percentage

Table 2a. Changes in chemical and physical properties of compost through 9 months of aerobic and anaerobic composting as percentage of dry weight.

Content %	Cond.	Decomposition period (in days) 0	7	15	30	60	90	120	150	180	210	240	270
Organic matter	Aerobic	73.11	69.83	66.48	63.60	60.75	58.11	55.68	53.45	51.37	49.40	47.55	45.67
	Anaero.	73.11	72.61	71.70	70.70	69.45	68.05	66.59	64.90	63.07	60.97	58.65	56.00
Organic carbon	Aerobic	42.40	40.50	38.56	36.89	35.24	33.70	32.29	31.00	29.79	28.65	27.58	26.49
	Anaero.	42.40	41.94	41.59	40.93	40.28	39.47	38.62	37.64	36.58	35.36	37.58	32.48
Humus	Aerobic	-	2.04	4.93	8.49	12.11	15.63	17.55	18.85	20.03	21.00	19.80	18.45
	Anaero.		1.30	2.75	4.28	6.64	9.42	12.10	14.21	15.90	7.20	18.90	20.00
Humic acid	Aerobic	-	0.63	1.80	3.13	4.69	6.41	7.35	8.00	8.55	9.00	8.32	7.60
	Anaero.		0.47	1.05	1.70	2.56	3.48	5.00	6.10	6.67	7.20	8.00	8.95
Fulvic acid	Aerobic	-	1.41	3.13	4.87	7.42	9.22	10.20	10.85	11.48	12.00	11.48	10.85
	Anaero.		0.83	1.70	2.41	4.08	5.94	7.10	8.11	9.23	10.20	10.90	11.05
Total-N	Aerobic	1.210	1.321	1.460	1.630	1.811	1.923	1.990	2.062	1.121	2.160	2.201	2.230
	Anaero.	1.210	1.260	1.311	1.373	1.465	1.602	1.730	1.864	1.950	2.072	2.125	2.170
Organic-N	Aerobic	0.916	1.082	1.255	1.445	1.653	1.783	1.847	1.976	2.056	2.103	2.140	2.166
	Anaero.	0.916	0.657	0.726	0.805	0.922	1.082	1.235	1.396	1.513	1.659	1.733	1.790
Inorganic-N	Aerobic	0.294	0.239	0.205	0.185	0.158	0.141	0.116	0.086	0.065	0.057	0.061	0.064
	Anaero.	0.294	0.603	0.585	0.568	0.543	0.520	0.495	0.468	0.437	0.413	0.392	0.380
NH_4-N	Aerobic	0.280	0.230	0.190	0.163	0.130	0.103	0.074	0.038	0.012	Nil	Nil	Nil
	Anaero.	0.280	0.603	0.585	0.568	0.543	0.520	0.495	0.468	0.0437	0.413	0.392	0.380
NO_3-N	Aerobic	0.014	0.009	0.015	0.022	0.028	0.037	0.042	0.048	0.053	0.057	0.061	0.064
	Anaero.	0.014	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
C/N ratic	Aerobic	35.0	30.7	26.4	22.6	19.5	17.5	16.2	15.0	14.0	13.3	12.5	11.9
	Anaero.	35.0	33.3	31.7	29.8	27.5	24.6	22.3	20.2	18.8	17.1	16.0	15.0
Ash	Aerobic	26.89	30.17	33.52	36.40	39.25	41.89	44.32	46.55	48.63	50.60	52.45	54.33
	Anaero.	26.89	27.69	28.35	29.43	30.55	31.95	33.41	35.10	36.93	39.03	41.35	44.00

of the whole compost quantity increased due to organic matter decomposition. That ash % in both methods of decomposition progressively increased with time, but at a higher rate under aerobic conditions, than that under anaerobic conditions at the same period. This is in agreement with the findings of Abd El-Malek *et al.* (1961) and Abo-Sedera (1995) who reported that the increase in the percentage of ash content in the sugarbeet compost haulms was paralleled to the loss in the total materials throughout the decomposition periods. The latter author noticed also that the increments in ash percentage might be an indirect indication of the higher rate of decomposition of the materials as a whole.

Total P and K :

Table 2b shows that the total amounts of P and K in manure are mostly stable but their concentrations in bulk organic matter gradually increased. In other words, C/P and C/K ratios became narrow with time. In this respect, Tesic *et al.* (1966) found that total P and K increased slightly by composting time of fissured vine shoots due to the continuous release of P and K from their organic compounds.

pH of compost:

pH of compost initially was alkaline (8.4) but tended to be gradually shifted towards neutrality due to organic acids and nitrate formation through composting. Meanwhile pH of aerobic compost reached 7.25 after 9 months of composting, the anaerobic one reached 5.95 after 9 months of the process giving more acidic manure than that under aerobic conditions. Similar results were obtained by Abd El-Malek *et al.* (1961) and Abo-Sedera (1995), who observed gradual decreases in pH values towards slight acidity and they referred this depression to the activity of thermophilic bacteria and actinomycetes.

Soluble salts

Total soluble salts (TSS) of the original residues, activating fertilizers, added calcium carbonate and soil caused a concentration of 2.1.% of manure at zero time. That percentage increased gradually due to continuous release through organic matter decomposition beside that due to continuous reduction of the bulk of matter. Salinity under anaerobic conditions was higher due to the more humid media which reached by the end of 9 months to about 2 times of its initial concentration. Soluble sodium and potassium took place as the same total soluble salts behaviour under any of composting methods. Generally soluble Na^+ and K^+ represented 1/3 to 1/2 of total soluble

Table 2b. Changes in chemical and physical properties of compost through 9 months of aerobic and anaerobic composting as percentage of dry weight.

Content %	Cond.	Decomposition period (in days)											
		0	7	15	30	60	90	120	150	180	210	240	270
Total P %	Aerobic	0.170	0.182	0.200	0.220	0.238	0.260	0.285	0.315	0.340	0.369	0.395	0.410
	Anaero.	0.170	0.176	0.187	0.200	0.215	0.225	0.245	0.263	0.282	0.303	0.318	0.330
C/p ratio	Aerobic	249.4	222.5	192.8	167.7	148.1	129.6	113.3	98.4	87.6	77.6	69.8	64.6
	Anaero.	249.4	238.3	222.4	204.7	187.3	175.4	157.6	143.1	129.7	116.7	107.0	98.4
Total K %	Aerobic	1.15	1.25	1.40	1.60	1.72	1.80	2.00	2.30	2.50	2.85	2.95	2.90
	Anaero.	1.15	1.20	1.28	1.42	1.55	1.70	1.80	1.95	2.12	2.30	2.93	2.55
C/K ratio	Aerobic	36.9	32.4	27.5	23.1	20.5	18.7	16.1	13.5	11.9	10.1	9.3	9.1
	Anaero.	36.9	35.0	32.5	28.8	26.0	23.2	21.5	19.3	17.3	15.4	11.6	12.7
pH in (1:10) compost-water susp.	Aerobic	8.40	8.25	8.15	7.90	7.90	7.80	7.70	7.65	7.53	7.40	7.30	7.25
	Anaero.	8.40	7.92	7.60	7.35	7.10	6.86	6.70	6.55	6.35	6.17	6.05	5.95
EC dS/m	Aerobic	6.6	6.9	7.3	7.7	8.1	8.3	8.9	9.3	9.6	10.0	10.3	10.7
	Anaero.	6.6	6.7	6.8	7.0	7.5	8.2	9.1	9.8	10.5	11.3	12.0	12.8
T.S.S. %	Aerobic	2.1	2.2	2.3	2.5	2.6	2.7	2.9	3.0	3.1	3.2	3.3	3.4
	Anaero.	2.1	2.1	2.2	2.2	2.4	2.6	2.9	3.1	3.4	3.6	3.8	4.1
Soluble Na^+ %	Aerobic	0.044	0.046	0.050	0.053	0.052	0.049	0.046	0.042	0.049	0.053	0.057	0.060
	Anaero.	0.044	0.047	0.046	0.046	0.044	0.042	0.037	0.041	0.044	0.048	0.052	0.058
Soluble K^+ %	Aerobic	0.048	0.053	0.056	0.063	0.061	0.057	0.055	0.051	0.055	0.058	0.061	0.068
	Anaero.	0.048	0.054	0.048	0.045	0.039	0.037	0.034	0.033	0.033	0.038	0.048	0.058
W.H.C. %	Aerobic	269	294	305	280	250	242	219	225	225	227	219	220
	Anaero.	269	300	370	332	345	337	291	315	264	261	237	237
Moisture %	Aerobic	58.7	59.3	59.8	60.6	61.5	62.2	63.0	63.7	64.2	64.6	64.9	65.0
	Anaero.	340.5	369.5	431.9	455.6	455.6	478.0	498.8	517.3	532.9	549.4	557.9	557.9

salts. Therefore, the increased T.S.S. under anaerobic. conditions may be due to formation of soluble Ca from the added superphosphate and decomposition of Ca in plant tissues e.g. calcium pectate.

Hydraulic parameters

The two studied hydraulic parameters were moisture content and water holding capacity (WHC) in a prepared compost (Table 2b). As to moisture content, it gradually increased with time of composting under aerobic or anaerobic process, but it was the highest in the latter. This probably due to the closed nature of the system. Obtained data agree with those of Acharya (1935b) and Abd El-Malek *et al.* (1961) who mentioned that the increase in moisture is probably due to composting in closed jars. WHC followed the same trend where reductions under both systems and reduced after 60 days were in gradual steps till 9 months of composting.

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كمر مخلفات بنجر السكر (١) دراسة عن كيفية ومدة الكمر

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إشتمل بحث معملى على نظامى كمر هوائى ولا هوائى تسعة أشهر، حيث جمعت مخلفات بنجر السكر سواء الناتجة من بقايا النباتات أو بعد تنظيف الجذور وإعدادها أو الألياف الناتجة من عملية العصير وجففت هوائياً وقطعت إلى قطع بطول بوصة واحدة. وجزئت لجزئين أحدهما كمر تحت الظروف الهوائية والآخر تحت الظروف غير الهوائية ثم أخذت عينات من كل نظام بعد ٠، ٧، ١٥ يوماً ثم شهرياً حتى ٩ أشهر، ويمكن تلخيص النتائج المتحصل عليها فى الآتى:–

قل محتوى المادة العضوية مع وقت الكمر وبمعدل أعلى فى حالة الكمر الهوائى عنه فى حالة غير الهوائى. وزاد الدبال والأحماض العضوية بطول فترة الكمر وكانت كمياتها أعلى فى حالة الكمر الهوائى حتى مدة ستة أشهر. وإزداد النيتروجين كنسبة مئوية نسبياً لتناقص المحتوى العضوى بإستمرار وفى نفس الوقت تضيق النسبة بين ك: ن تدريجياً مع الوقت وكانت هذه النسبة أكثر إتساعاً فى حالة الكمر الهوائى، وقد نشطت عملية النشدرة مع الوقت وأنتجت أمونيا أكثر فى حالة الكمر غير الهوائى أما التحول لنترات فقد رصد تحت ظروف الكمر الهوائى فقط، وسلك الفوسفور الكلى والبوتاسيوم الكلى نفس سلوك النيتروجين الكلى وكذلك نسبتا ك: فو، ك: بو كسلوك نسبة ك:ن، وإزداد الرماد كنسبة مئوية كقيمة منسوبة لقيمة تتناقص بإستمرار بالتحلل، وأزداد رقم يد ببطء فى حالة الكمر الهوائى أما غير الهوائى فقد إتجه نحو الحموضة ببلوغه ٩ أشهر، وكانت الأملاح الكلية الذائبة عند بدء الكمر حوالى ٢,١٪ لكنها إزدادت بالتدريج وكان الكمر غير الهوائى أشد تركيزاً للأملاح حيث وصل مع نهاية مدة الكمر لضعف ما كان عليه فى البداية، وسلك الصوديوم والبوتاسيوم الذائبان كذلك نفس السلوك إلا أن زيادة الأملاح الكلية كانت ناتجة كذلك عن ذوبان الكالسيوم وقد دلت قياسات السعة المائية العظمى فى العينات المكمورة على زيادة تدريجية فى كلا النظامين.

وبالنسبة لنسبة الرطوبة فى السماد فقد زادت بصورة تدريجية مع الوقت ولكنها كانت نسبتها عالية فى الكمر الغير هوائى.