RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

4.1. Co-composting of rice straw, banana wastes and poultry litter: as affected by some additives i.e. microbial inoculants, compost tea and natural rocks

4.1.1. Physical and chemical changes during composting process.

4.1.1.1. Temperature evolution and variations:

Changes in temperature during the composting period for the five piles at depths of 20, 40 and 60 cm are shown in Fig. (2a, b). The ambient temperature variations throughout the composting period (September to October, 2003) were between 22 and 30 °C at daylights and ranging from 14-23 °C at night times. The composting process for the tested piles exhibited a classical temperature pattern, where it was possible to distinguish three different phases: mesophilic, thermophilic and cooling down phase, which continues later as compost maturation stage. This temperature feature was observed more clearly for the 40 and 60 cm temperature curves. The temperature level at depth of 20 cm (surface layer) is not only greatly influenced by temperature variations of surrounding air but also by the heat developed inside the compost matrix. Therefore the 20 cm temperature curve behaved similar to those of the 40 and 60 cm curves, but its temperature levels were mostly found to be in the mesophilic range.

The initial mesophilic stage (up to 45 °C) showed a short duration of 2 days. A progressive increase in piles temperatures (high thermophilic phase) has been measured at a depth of 60 cm reaching above 60 °C for few days (7 and 9 days) before cooling down gradually and slowly leading to a stationary thermophilic phase with an optimum temperature range (45-55 °C). The second optimal Thermophilic phase stayed for periods of 11 and 9, 12 and 10, 10 and 8, 12 and 8 and 13 and 10 days for piles mix 1, 2, 3, 4 and 5 at depths of 40 and 60 cm, respectively. Both thermophilic phases are optimum for thermophilic microbial activities in the degradation of cellulose

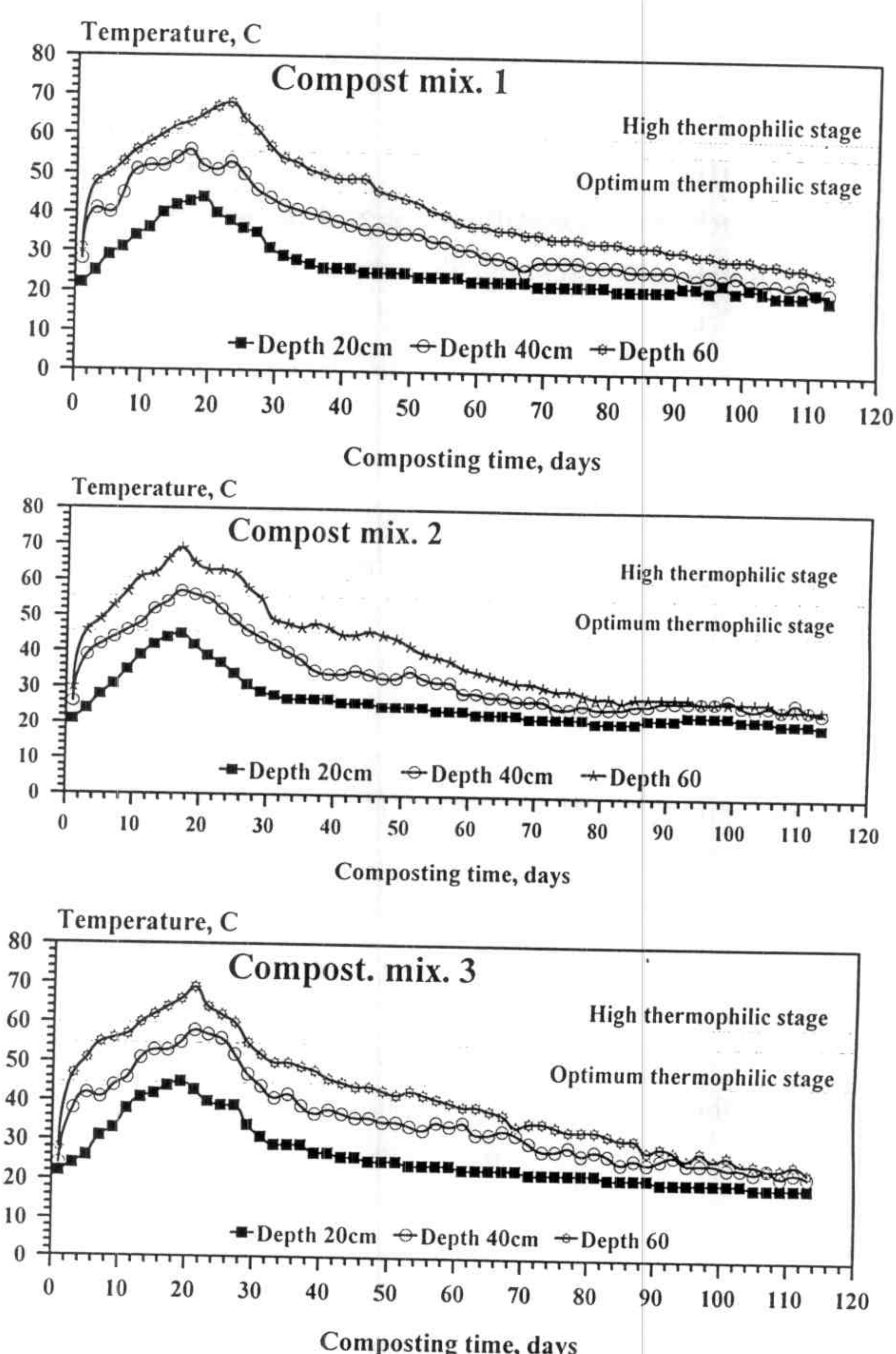
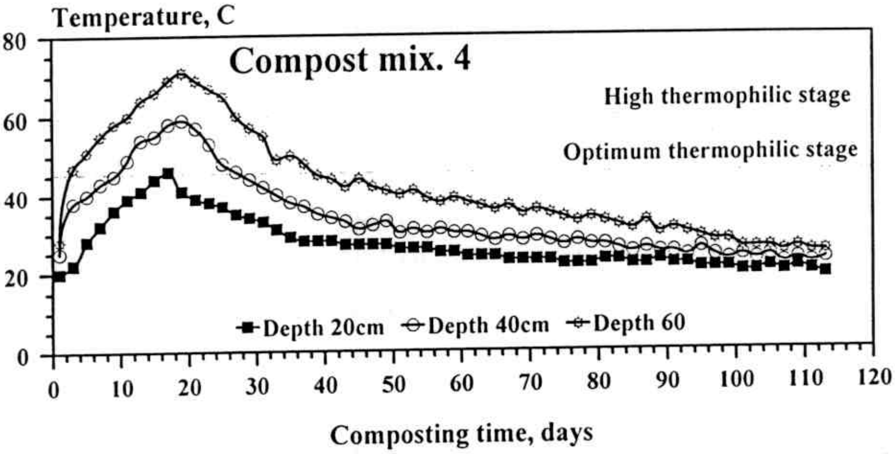


Fig. (2a): Changes in compost temperature degrees at different depths from pile surface during composting a mixture composed of rice straw, banana residues and poultry litter under different additive materials for 112 days (piles mix 1, 2 and 3).



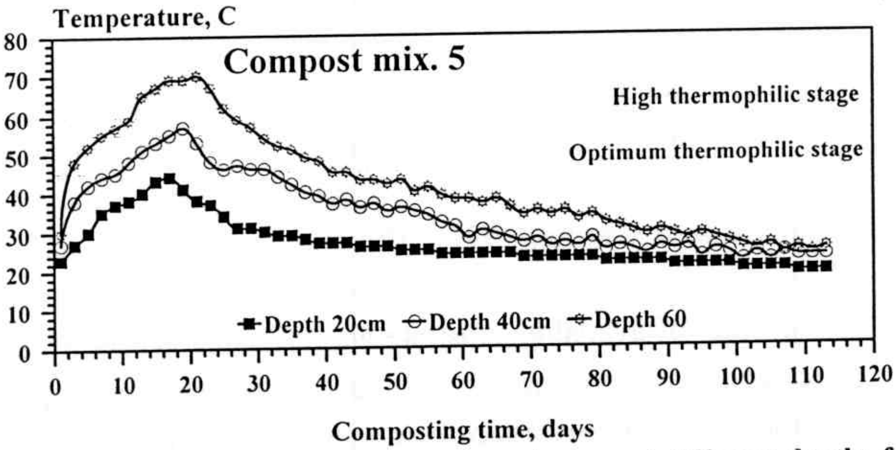


Fig. (2b): Changes in compost temperature degrees at different depths from pile surface during composting a mixture composed of rice straw, banana residues and poultry litter under different additive materials for 112 days (piles mix 4 and 5).

and lignocelluloses materials. In the high thermophilic phase, the maximum temperatures were 68, 70, 69, 71 and 70 °C for piles mix 1, 2, 3, 4 and 5. The cooling down and maturing phase take place for all tested piles after approximately 50 days from composting process for all piles. From this time on, a slow temperature decrease was noted until the 90th day of composting. Thereafter, the composting materials were approximately as same as temperature the atmospheric (about 27 °C) and the piles passed to the maturation phase by the end of the experimental period.

The rapid passage to the high thermophilic phase for all tested piles (few days) could be elucidated on the basis of the great richness of indigenous microorganisms present in the poultry litter which provoke a rapid attack on the easily decomposable organic matter, the high content of available nutrient in the poultry litter and the relatively small size of the particles of the organic fraction **(Sommers, 1977 and Jimenez and Garcia, 1991).** The continuous decline of temperature during the last cooling and maturing phase could be attributed to the exhaustion of available substrate and the replacement of thermophilic microorganisms by the mesophilic one, which continues the partial degradation of bio-resistant compounds, fundamentally cellulose and lignin **(De Bertoldi *et al.*1983)**. The fluctuations in temperature throughout the composting period may be due to heap moistening and/or heap turning over. The piles were turned-over every one-week during the thermophilic phase but every 2 weeks during rest period of composting.

4.1.1.2. Changes in compost bulk density.

Data of bulk density for compost piles are presented in Table (8a, b). Bulk density values for all piles show gradual increases as the composting proceeds. The bulk densities increased from 329.6 to 570.1 kg/m^3, 331.8 to 583.9 kg/m^3, 340.2 to 580.3 kg/m^3, 342.5 to 589.5 kg/m^3 and from 333.5 to 580.1 for piles mix 1, 2 and 3, 4 and 5, respectively. The variations in the initial bulk density values could be

Table (8a): Some analytical parameters of 5 different compost piles over 16 weeks of composting.

Periods (week)	Bulk Density (kg/m^3)	Moist. Content %	Dry Matter %	Organic Matter %	Ash %	Total N %	Soluble N (mg/kg)		Organic Carbon %	C/N Ratio	PH (1:5)	EC (1:5) dSm^{-1}	C.E.C meq/100g
							NH_4^+	NO_3^-					
Pile mix 1													
0	329.6	54.03	45.97	78.66	21.34	1.521	421	62	45.62	30.01	8.31	2.02	37.10
1	350.5	60.10	39.90	77.60	22.40	1.536	818	116	45.01	29.30	8.02	2.29	38.12
2	389.7	62.00	37.40	75.91	24.09	1.52	943	154	44.03	28.74	7.76	2.42	39.75
3	413.6	57.20	42.80	73.05	26.95	1.535	590	151	42.37	27.60	7.61	2.52	42.50
4	452.2	60.12	39.88	71.14	28.86	1.566	450	169	41.61	26.57	7.64	2.63	44.90
6	485.1	53.70	46.30	68.46	31.54	1.619	357	254	39.71	24.53	7.96	2.85	48.65
8	500.5	51.02	48.98	66.09	33.91	1.670	217	290	38.33	22.95	7.94	3.31	52.90
10	520.8	49.55	50.45	63.49	36.51	1.740	143	373	36.82	21.17	8.16	3.75	55.78
12	539.4	47.68	52.32	61.57	38.43	1.795	88	408	35.71	19.89	8.28	4.01	59.90
16	570.1	43.70	56.30	58.69	41.31	1.919	55	460	34.04	17.74	8.42	4.32	69.30
Pile mix 2													
0	331.8	52.27	47.73	78.83	21.17	1.516	491	103	45.72	30.2	8.17	2.15	31.30
1	356.2	54.93	45.07	77.70	22.30	1.515	730	125	45.07	29.75	7.99	2.35	32.52
2	393.3	57.75	42.25	76.00	24.00	1.512	975	153	44.08	29.15	7.65	2.88	34.37
3	419.0	55.49	44.51	73.40	26.60	1.524	662	164	42.57	27.93	7.59	3.10	37.67
4	458.3	57.66	42.34	71.45	28.55	1.552	482	197	41.44	26.70	7.84	3.18	39.90
6	493.0	55.18	44.82	66.84	33.16	1.641	375	261	38.77	23.63	7.82	3.27	45.23
8	517.3	49.69	50.31	62.91	37.09	1.718	249	315	36.49	21.23	8.01	3.66	50.60
10	538.2	49.98	50.02	58.66	41.34	1.822	169	421	34.02	18.67	8.22	3.99	54.79
12	551.7	46.27	53.73	56.36	43.64	1.889	65	469	32.69	17.31	8.30	4.44	60.20
16	580.1	45.84	54.16	52.28	47.78	2.057	48	529	30.32	14.74	8.39	4.76	70.90
Pile mix 3													
0	340.2	56.25	43.75	74.48	25.52	1.438	405	69	43.2	30.13	8.29	2.60	38.70
1	361.0	59.15	40.85	73.23	26.77	1.443	817	116	42.47	29.43	8.02	2.95	40.14
2	410.5	56.00	44.00	71.33	28.67	1.451	871	141	41.37	28.51	7.70	3.11	42.30
3	435.0	55.10	44.90	67.95	32.05	1.490	604	162	39.41	26.45	7.53	3.32	45.61
4	468.0	58.95	41.05	65.65	34.35	1.514	415	199	38.08	25.15	7.60	3.30	48.10
6	502.9	52.48	47.52	61.93	38.07	1.591	334	238	35.92	22.58	7.84	3.65	53.30
8	526.5	52.37	47.63	58.24	41.76	1.695	206	272	33.78	19.93	7.90	3.96	59.40
10	549.1	51.27	48.73	55.49	44.51	1.777	131	321	32.18	12.11	8.17	4.34	62.63
12	561.0	46.95	53.05	53.36	46.64	1.855	74	400	30.95	16.68	8.21	4.97	68.60
16	583.3	46.15	53.85	49.69	50.31	2.005	44	486	28.82	14.37	8.28	5.14	77.10

Table (8b): Some analytical parameters of 5 different compost piles over 16 weeks of composting.

Periods (week)	Bulk Density (kg/m^3)	Moist. Content %	Dry Matter %	Organic Matter %	Ash %	Total N %	Soluble N (mg/kg)		Organic Carbon %	C/N Ratio	PH (1:5)	EC (1:5) dSm^{-1}	C.E.C meq/100g
							NH_4^+	NO_3^-					
Pile mix 4													
0	342.5	56.45	43.55	74.71	25.29	1.446	473	58	43.33	29.97	8.25	2.07	33.6
1	363.2	59.05	40.95	73.32	26.68	1.451	729	121	42.53	29.31	8.07	2.59	35.16
2	415.9	55.03	44.97	71.32	28.68	1.459	813	161	41.37	22.36	7.72	2.34	37.41
3	439.0	58.34	41.66	68.06	31.94	1.497	614	148	39.47	26.37	7.77	2.54	41.07
4	464.5	59.25	40.75	65.72	34.28	1.541	391	191	38.12	24.74	7.45	2.79	43.70
6	519.8	53.00	47.00	60.81	39.19	1.744	336	265	35.27	20.22	7.77	3.00	49.72
8	537.4	52.64	47.36	56.57	43.43	1.765	220	280	32.81	18.60	7.89	3.39	56.70
10	556.7	48.15	51.85	52.94	47.06	1.862	122	327	30.70	16.49	8.08	3.96	61.36
12	567.2	50.85	49.10	50.23	49.77	1.949	74	366	29.13	14.15	8.19	4.66	67.60
16	584.5	44.53	55.47	45.34	54.66	2.133	39	450	26.30	12.33	8.20	4.91	78.20
Pile mix 5													
0	333.5	54.60	45.40	78.60	21.40	1.530	371	71	45.59	29.80	8.20	2.20	36.80
1	359.8	56.67	43.33	77.24	22.76	1.528	864	159	44.80	29.32	8.00	2.38	37.90
2	401.9	59.95	40.05	75.21	24.79	1.527	928	124	43.62	28.57	7.75	2.69	39.55
3	428.5	55.92	44.08	71.80	28.20	1.528	640	142	41.64	27.25	7.63	2.73	42.31
4	472.6	58.25	41.75	69.10	30.90	1.570	429	182	40.08	25.53	7.87	2.84	44.50
6	508.7	53.13	46.87	65.57	34.43	1.645	345	276	38.03	23.12	7.95	2.91	49.48
8	523.1	51.06	48.94	62.33	37.67	1.713	228	280	36.25	21.16	7.98	3.40	54.90
10	543.2	48.02	51.98	58.66	41.34	1.836	126	382	34.02	18.53	8.00	3.95	58.19
12	559.9	46.25	53.75	56.51	43.49	1.919	57	477	32.78	17.08	8.04	4.35	63.80
16	580.1	45.94	54.06	52.91	47.09	2.086	31	538	30.69	14.71	8.32	4.66	75.60

attributed to the physical characteristics and weights of the organic wastes and to the additive conditioners used for making the composting mixtures at initial time before heaping. Particle sizes of the wastes and there capacities for holding water and porosity percentages may have an important influence on the bulk densities throughout the composting period. **Raviv *et al.* (1987)** mentioned that as the composting process lengths, the general particle size shifted from larger to smaller particles. 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.

4.1.1.3. Changes in the pH during composting:

Like temperature, pH may be a good parameter of the bio-oxidative phase evolution and microbial development **(Jimenez and Garcia, 1991).** All compost piles showed similar pH behaviour (Fig. 3a, b). At the initial time of composting the pH values of all compost piles were ranged between 8.17 and 8.31 units. The alkaline values of pH could be refer to the poultry litter, which is used as a source for nitrogen contained high amount of ammoniacal-nitrogen and/or use of any alkaline chemical compound for cleaning the poultry fatting house before collecting the poultry litter. During the first three weeks of composting, the pH values of all compost piles showed little decreases but still in the alkaline range, then the pH gradually increased towards the last week of the composting process. The pH values for compost piles mix. 1, 2, 3, 4 and 5 were 8.42, 8.39, 8.28, 8.20 and 8.32, respectively.

The decrease in the pH could be a consequence of degradation of easily decomposable polysaccharides and the productions of organic acids during bio-oxidative 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 behaviour curves were observed in the previous works conducted by **Godden and Penninckx (1986); Hanafy-Ehsan et al. (1990), Shehata and Ali (1990) and Jimenez and Garcia (1991).**

4.1.1.4. Changes in the electrical conductivity:

The effects of 16 weeks of composting on the electrical conductivity (EC) of piles mix 1, 2, 3, 4 and 5 are presented in Table (8a, b) and shown in Fig. (3a, b). The initial values of EC for all compost piles ranged between 2.02 and 2.60 dS/m. This may be due to the original characteristics and the amounts of the materials used for making the composting heaps under this study. The composting piles showed gradual increases in EC during the composting period. The composting material's conductivity values at end of the composting period were 4.32, 4.76 and 4.81 dS/m for piles mix 1, 2 and 5, respectively, while piles mix 3 and 4 showed slightly higher EC values, which were 5.14 and 5.61 dS/m, respectively. The increase in the conductivity of all compost materials could be referred to the high concentration of ammonia and other nutrient ions released during the mineralization of organic matter. The relative fluctuation observed at 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 had been reported by **Raviv *et al.* (1987).**

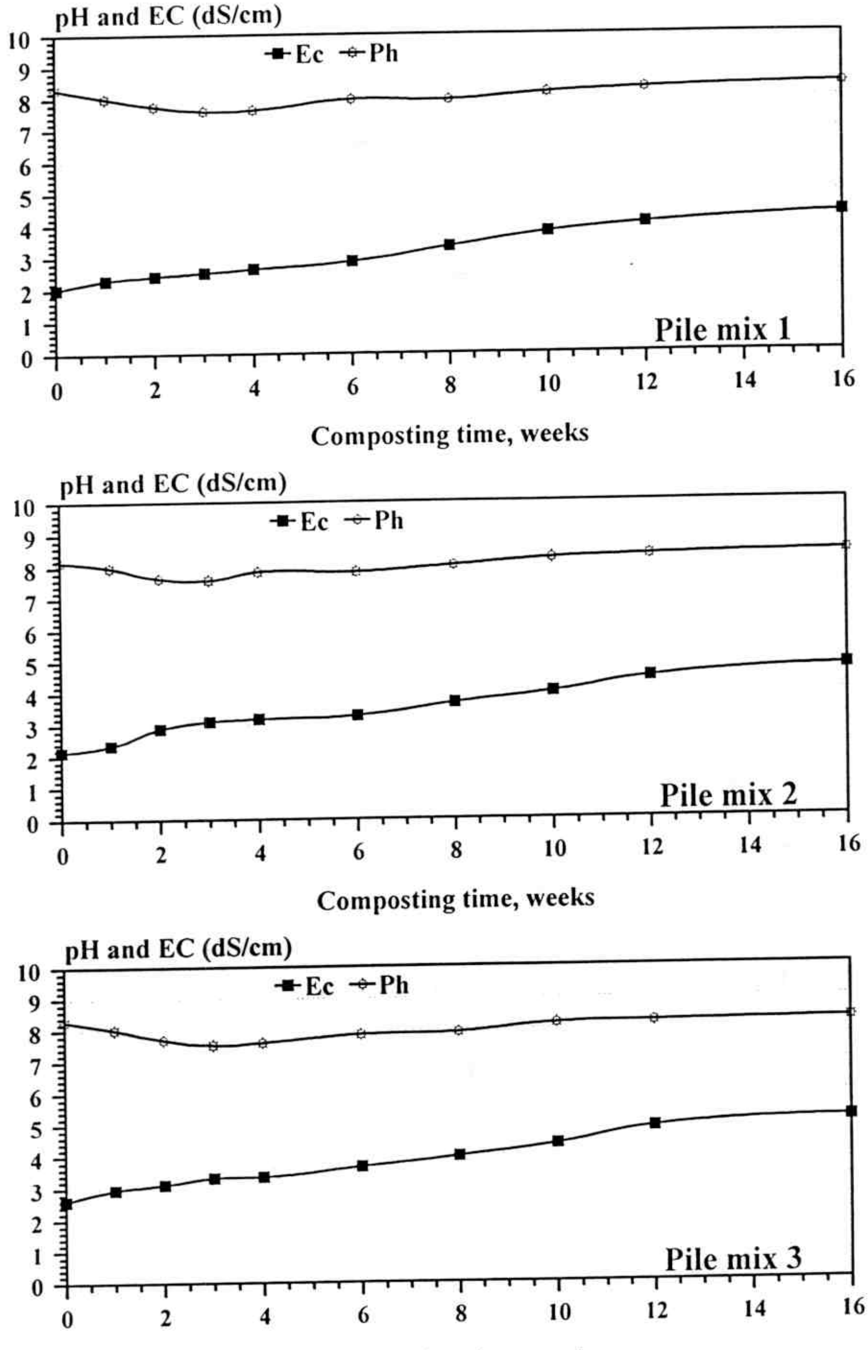


Fig. (3a): Changes in pH and electric conductivity (Ec) during composting a mixture composed of rice straw, banana residues and poultry litter under different additive materials for 16 weeks (piles mix 1, 2 and 3).

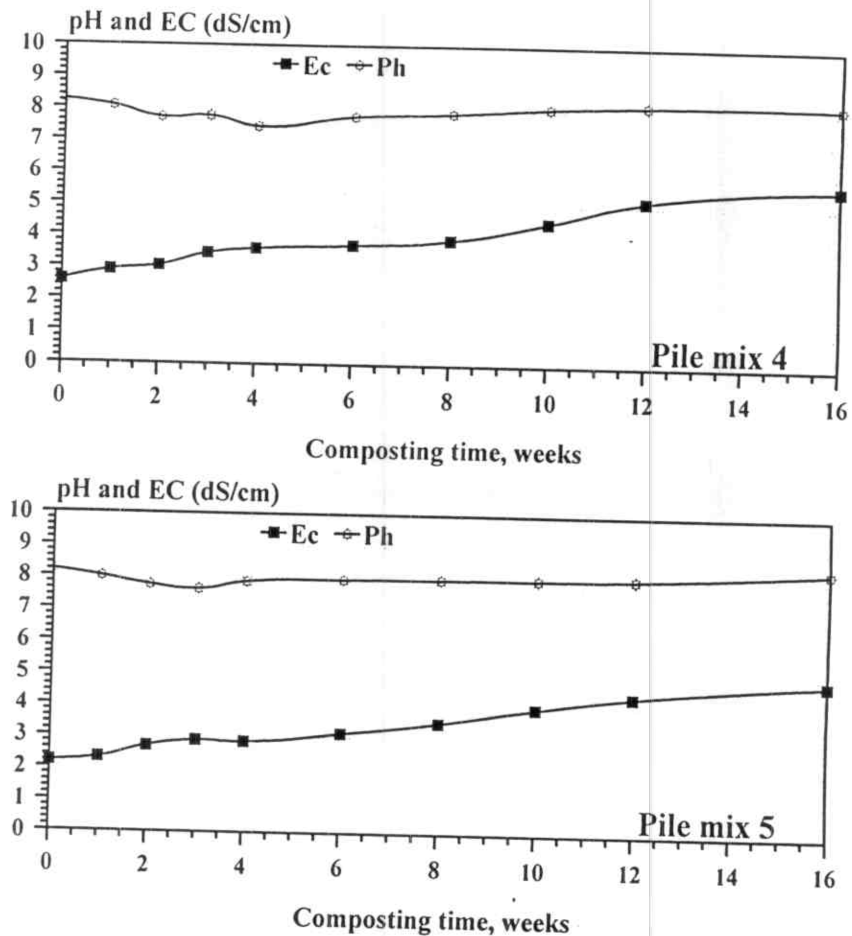


Fig. (3b): Changes in pH and electric conductivity (Ec) during composting a mixture composed of rice straw, banana residues and poultry litter under different additive materials for 16 weeks (piles mix 4 and 5).

4.1.2. Mineralization of organic matter and nitrogen transformation during composting process:

Some of NH_4^+ generated during the high rate metabolic activities (45-65 °C) will be lost through volatilization in the for of NH_3 if the pH of the compost piles is above 7. Nitrifying bacteria will nitrify the remaining NH_4^+ to produce NO_3^- during the maturation or curing phase **(Haug, 1980).**

Changes in the analytical data of the percentages of OM, ash and total nitrogen throughout the composting course are presented in Table (8a, b). These data are used for making calculations to estimate the changes in compost dry weight, organic matter, nitrogen contents and their losses during composting process as well as to estimate the decomposition rates of organic matter in relation to compost total and organic solids. These results are presented in Table (9a, b) and illustrated in Fig. (4a, b). Changes in ammoniacal and nitrate nitrogen were also determined and presented in Table (8).

The decomposition rate of the organic matter was slow during the first week of the composting period, and then rapidly increased to show maximum value at the third week for all piles. Thereafter, it decreased with different degrees towards end of the composting period. In respect to pile mix. 1 that did not receive microbial inoculants or additives (control treatment), the decomposition rates in relation to compost volatile solids (VS) and total solids (TS) increased from 8.58 g/kg VS/day and 6.75 g/kg TS /day at the first week to 20.01 g/kg VS/day and 15.19 g/kg TS/day at the third week, but rapidly decreased to 4.05 g/kg VS/day and 2.49 g/kg TS/day by end of the composting period (16 weeks).

The decomposition rate estimated for pile mix 2 was higher especially after addition of the microbial inoculants at the 22nd day towards the end of the composting process in comparison with those of compost pile mix. 2. The maximum decomposition rates in relation to compost VS and TS weights were 18.4 g/kg VS/day and 13.98 g/kg

Table (9a): Decomposition of rate organic matter and nitrogen loss of five different mixtures for 16 week.

Composting Period (week)	Dry matter			Organic matter			Nitrogen	
	Weight (Kg)	Loss %	Decomp. Rate g/Kg/day	Weight (Kg)	Loss %	Decomp. Rate g/Kg/day	Weight (Kg)	Loss %
Pile mix 1								
0	200.00	--	--	157.32	--	--	3.042	--
1	190.55	4.73	6.75	147.87	6.01	8.58	2.927	3.78
2	177.19	11.41	10.02	134.51	14.50	12.91	2.715	10.75
3	158.35	20.83	15.19	115.67	26.47	20.01	2.430	20.12
4	147.90	26.05	9.43	105.22	33.12	13.25	2.316	23.87
6	135.33	32.33	6.07	92.65	41.10	8.53	2.191	27.98
8	125.86	37.07	5.00	83.18	47.13	7.31	2.102	30.90
10	116.91	41.55	5.08	74.23	52.82	7.69	2.034	33.14
12	111.07	44.47	3.57	68.39	56.53	5.62	1.994	34.45
16	103.32	48.34	2.49	60.64	61.45	4.05	1.983	34.81
Pile mix 2								
0	200.00	--	--	157.66	--	--	3.032	--
1	189.87	5.07	7.24	147.53	6.43	9.19	2.877	5.11
2	176.44	11.38	10.10	134.10	14.94	12.99	2.667	12.04
3	159.17	20.41	13.98	116.83	25.90	18.40	2.425	20.02
4	148.29	25.86	9.76	105.93	32.80	13.30	2.301	24.11
6	127.67	36.17	9.93	85.33	45.88	13.90	2.059	30.90
8	114.17	42.92	7.55	71.83	54.44	11.30	1.962	35.29
10	102.43	48.79	7.34	60.09	61.89	11.67	1.866	38.46
12	97.01	51.50	3.78	54.67	65.32	6.44	1.832	39.58
16	88.72	55.64	3.05	46.38	70.58	5.42	1.825	39.81
Pile mix 3								
0	210	--	--	156.41	--	--	3.020	--
1	200.21	4.66	6.66	146.62	6.26	8.94	2.890	4.30
2	186.95	10.98	9.46	133.36	14.74	12.92	2.712	10.20
3	167.20	20.38	15.09	113.61	27.36	21.16	2.492	17.48
4	156.01	25.71	9.56	102.42	34.52	14.07	2.362	21.79
6	141.56	32.97	6.62	87.17	44.27	10.64	2.239	25.86
8	128.32	38.89	6.72	74.73	52.22	10.19	2.175	27.98
10	120.41	42.66	4.40	66.82	57.28	7.56	2.140	29.14
12	114.90	45.29	3.27	61.31	60.80	5.89	2.131	29.44
16	106.52	49.28	2.61	52.93	66.16	4.88	2.136	29.27

Table (9b): Decomposition of rate organic matter and nitrogen loss of five different mixtures for 16 week.

Composting Period (week)	Dry matter			Organic matter			Nitrogen	
	Dry weight (Kg)	Loss %	Decomp. Rate g/Kg/day	Dry weight (Kg)	Loss %	Decomp. rate g/Kg/day	Dry weight (Kg)	Loss %
Pile mix 4								
0	210	--	--	156.89	--	--	3.037	--
1	199.04	5.22	7.55	145.93	6.99	9.98	2.888	4.91
2	.185.19	11.81	19.94	132.08	15.81	13.56	2.702	11.03
3	166.26	20.83	14.60	113.15	27.88	20.47	2.489	18.04
4	154.91	26.23	9.75	101.80	35.11	14.33	2.387	21.40
6	135.53	35.46	8.94	82.42	47.47	13.6	2.228	26.64
8	122.28	41.77	6.98	69.17	55.91	11.48	2.158	28.94
10	112.86	46.26	5.50	59.75	61.92	9.73	2.102	30.79
12	106.71	49.19	3.89	53.60	65.84	7.35	2.080	31.51
16	97.16	53.73	3.20	44.05	71.92	6.36	2.072	31.78
Pile mix 5								
0	200.00	--	--	157.2	--	--	3.060	--
1	188.05	5.98	8.54	145.25	7.60	10.89	2.874	6.08
2	172.68	13.66	11.68	129.88	17.38	15.12	2.637	13.82
3	151.77	24.12	17.30	108.97	30.68	23.00	2.319	24.22
4	138.50	30.55	12.49	95.70	39.12	17.40	2.174	28.95
6	124.32	37.84	7.31	81.52	48.14	10.58	2.045	33.17
8	113.61	43.20	6.15	70.81	54.96	9.38	1.946	36.41
10	103.53	48.24	6.34	60.73	61.37	10.17	1.901	37.88
12	98.42	50.79	3.53	55.62	64.62	6.01	1.889	38.27
16	90.89	54.56	2.73	48.09	69.41	4.84	1.896	38.04

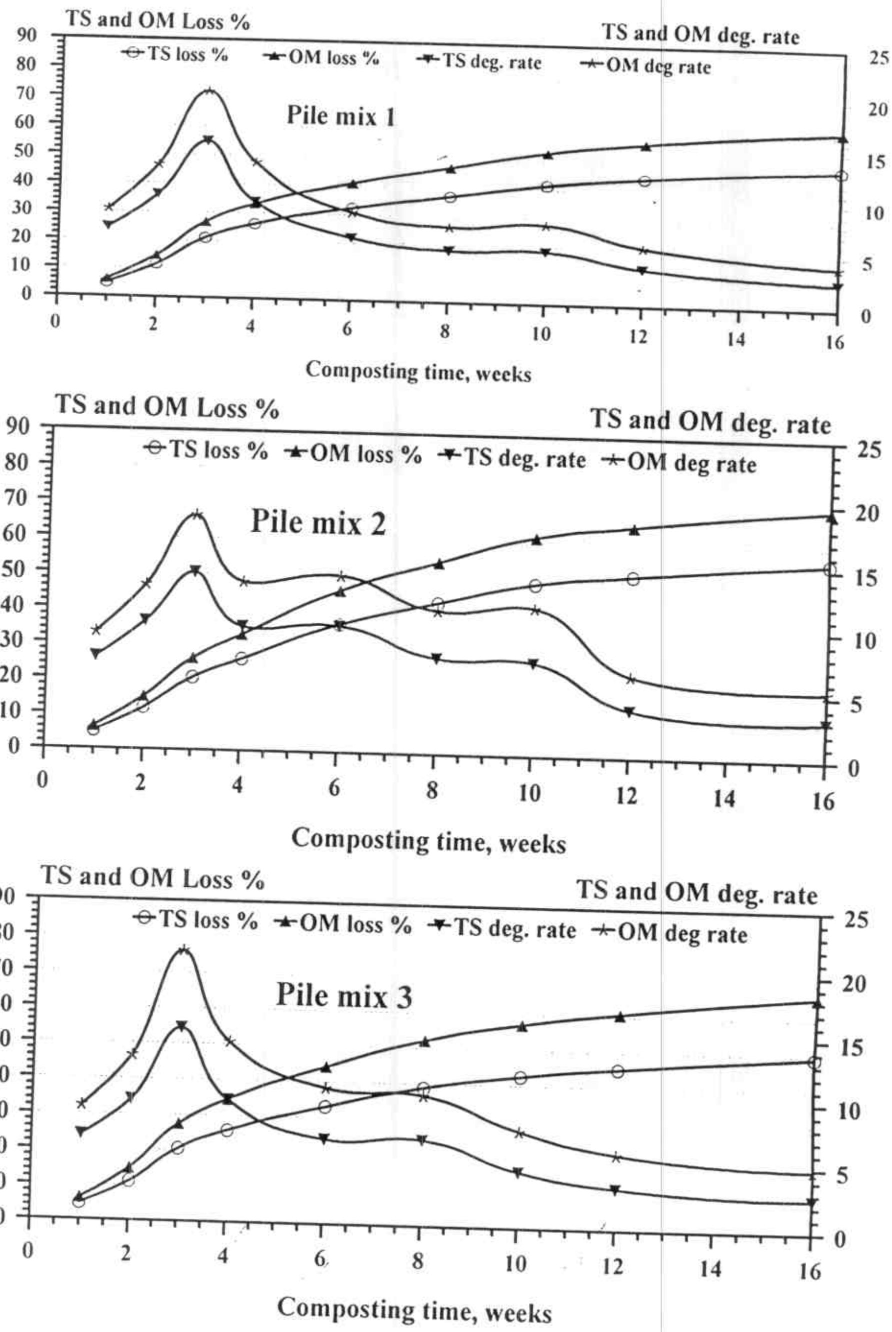


Fig. (4a): Degradation rates and loss percentages related to compost total and organic solids during composting a mixture composed of rice straw, banana residues and poultry litter under different additive materials for 16 weeks (piles mix 1, 2 and 3).

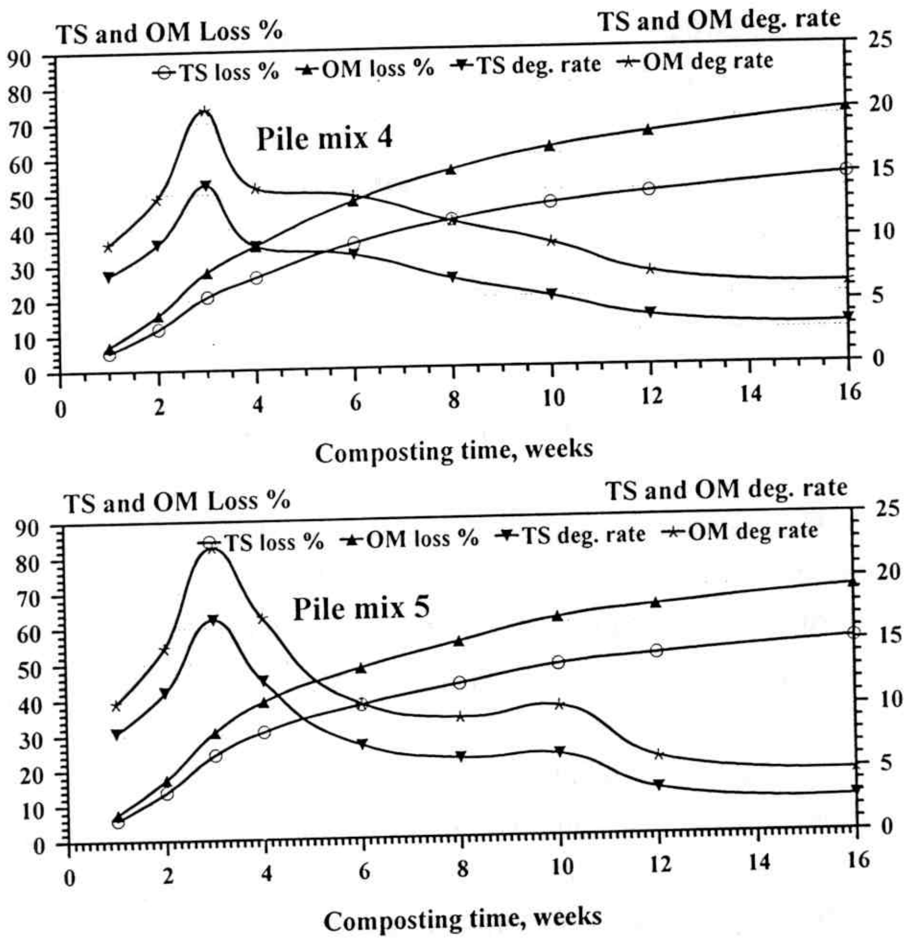


Fig. (4b): Degradation rates and loss percentages related to compost total and organic solids during composting a mixture composed of rice straw, banana residues and poultry litter under different additive materials for 16 weeks (piles mix 4 and 5).

TS/day at the third week, respectively. These rates decreased to be somewhat at constant values ranged between 13.90-11.30 g/kg VS/day and 9.93-7.34 g/kg TS/day during the period from 4th to 10th week of composting. Thereafter, the decomposition rate decreased to 5.42 g/kg VS/day and 3.05 g/kg TS/day at end of the composting period.

Addition of natural rocks such as rock phosphate (for phosphorus) and feldspar (for potassium) to compost pile mix. 3 enhanced the decomposition rate throughout the composting course, when values of decomposition rate of pile mix. 3 were compared with the corresponding values of compost pile mix.1 (control treatment). The maximum decomposition rates in relation to compost VS and TS weights were 21.16 g/kg VS/day and 15.09 g/kg TS/day at end of the third week of composting, then these values gradually decreased to 4.88 g/kg VS/day and 2.61 g/kg TS/day at end of the composting period, respectively.

Similarly, addition of natural rocks and microbial inoculants (after 4 weeks of composting) to compost pile mix. 4 enhanced the decomposition rate throughout the composting course, when values of decomposition rates of compost pile mix. 4 were compared with the corresponding ones of compost pile mix 2, which was supplemented with the same microbial inoculants. The maximum decomposition rate in relation to compost VS and TS weights was 20.47 g/kg VS/day and 14.6 g/kg TS/day at end of the third week of composting, then these rates decreased gradually to 6.36 g/kg VS/day and 3.20 g/kg TS/day at the end of the composting period, respectively.

Application of compost tea to compost pile mix. 5 at initial time of composting greatly increased the decomposition rates during the first four weeks of composting in comparison with all compost piles, then rapidly decreased till end of the composting period. The maximum decomposition rate in relation to compost VS and TS weights were 23.0 g/kg VS/day and 17.3 g/kg TS/day at the end of the third week of composting, then these rates decreased to 4.84 g/kg

VS/day and 2.73 g/kg TS/day at end of the composting period, respectively.

The lower decomposition rates observed at the first week of composting may be resulted from the change in compost microflora (transition between the mesophilic and thermophilic stages) and/or the thermal inhibition of the microbiological activities during the period characterized by high temperature range (60-71 °C) above the optimum thermophilic range (45-60°C).

Maurice *et al.* (1987) observed a reduction in the metabolic activity (Oxygen consumption) as the temperature rose to above 65 °C. Several investigators have shown that the thermophilic microorganisms degrade organic materials most efficiently below 60 °C **(Hoitink et al.1984; Fernando et al.1988 and Hogan, 1998).**

As a result of these microbial activities on the composting materials, the losses in the compost materials in relation to the initial organic matter and dry solids weights after 16 weeks of composting reached 61.45 and 48.34 % for pile mix. 1 (control), 70.58 and 55.64 % for pile mix. 2, 66.16 and 49.28 % for pile mix. 3, 71.92 and 53.73 % for pile mix. 4, and 69.41 and 54.56 % for pile mix. 5. Similar loss percentages were reported to be 33.6% for dry weight and 56.1% for organic matter when a mixture of city refuse and sewage sludge was co-composted for 16 weeks **(Hanafy-Ehsan *et al.*, 1990)**, while **Jimenez and Garcia (1991)** reported organic matter loss percentages of 74.8 and 73.7% when domestic refuse and domestic refuse-sewage sludge were composted using window technology for 165 days. Also, **Fahmy-Soheir *et al.* (1997)** stacked the sand bed dried sludge for a period of 180 days and reported a loss of 62.2% in the organic matter weight of the stacked sewage sludge.

As a result of the high rates of the ammonification process on nitrogenous organic materials during the bio-oxidative phase, ammoniacal-nitrogen showed gradual increases and reached maximal concentrations of 943, 975, 871, 813 and 928 mg/kg fresh weight at the 2nd week of composting for pile mixtures 1, 2, 3, 4 and 5, respectively (Fig 5a, b). Thereafter, the concentration of ammonia decreased rapidly until the end of the composting period to reach minimal values of 55, 48, 44, 39 and 31mg/kg fresh weight for the piles mixtures 1, 2, 3, 4 and 5 respectively. In contrary, nitrate showed gradual increases during composting as a result of converting ammonia to nitrate by nitrifying bacteria **(Buchanan, 1974)**. It was reported that the nitrifying bacteria have a relatively slow growth rate and are inactive at temperatures greater than 40 °C **(Alexander, 1977)**, hence they will become more active normally after the reactions of organic waste decomposition are complete during the growth and thermophilic phases. As nitrate (NO_3^-) is the form of nitrogen, which is readily available for crop uptake, the maturation phase thus becomes an essential step in composting to produce good compost quality for use as fertilizer and soil conditioner **(Polprasert, 1996)**. In this study maximal levels of nitrate were recorded at the last week of composting, where they were 460, 529, 486, 450 and 538 mg kg^{-1} for piles mix 1, 2, 3, 4 and 5, respectively.

As a result of the higher bio-oxidation of the easily decomposable carbonaceous substrates, the initial percentage of total nitrogen increased gradually throughout the composting period from 1.521 to 1.919 % for pile mix 1, 1.516 to 2.057 % for pile mix 2, 1.438 to 2.005 % for pile mix 3, 1.446 to 2.133 % for pile mix 4 and 1.530 to 2.086 % for pile mix 5 (Table 8a, b). In spite of these increases in nitrogen percentages, its content showed maximal losses of 34.81 and 39.81 % for piles mix 1 and mix 2 after 16 weeks of composting, while nitrogen losses for piles mix 3 and mix 4 were lesser than those estimated for piles mix 1 and 2. The maximal losses were 29.44 % and 31.78 % after 12 and 16weeks of composting for piles mix 3 and mix 4, respectively Table 9 a, b) and Fig. (6 a, b). Nitrogen loss from pile mix 5 was 38.04 % after 12 weeks of composting. Nitrogen contents for piles mix 3 and 5 exhibited little increases towards the end of the composting process. These increases amounted 0.17 and 0.23 % for piles mix 3 and mix 5, respectively.

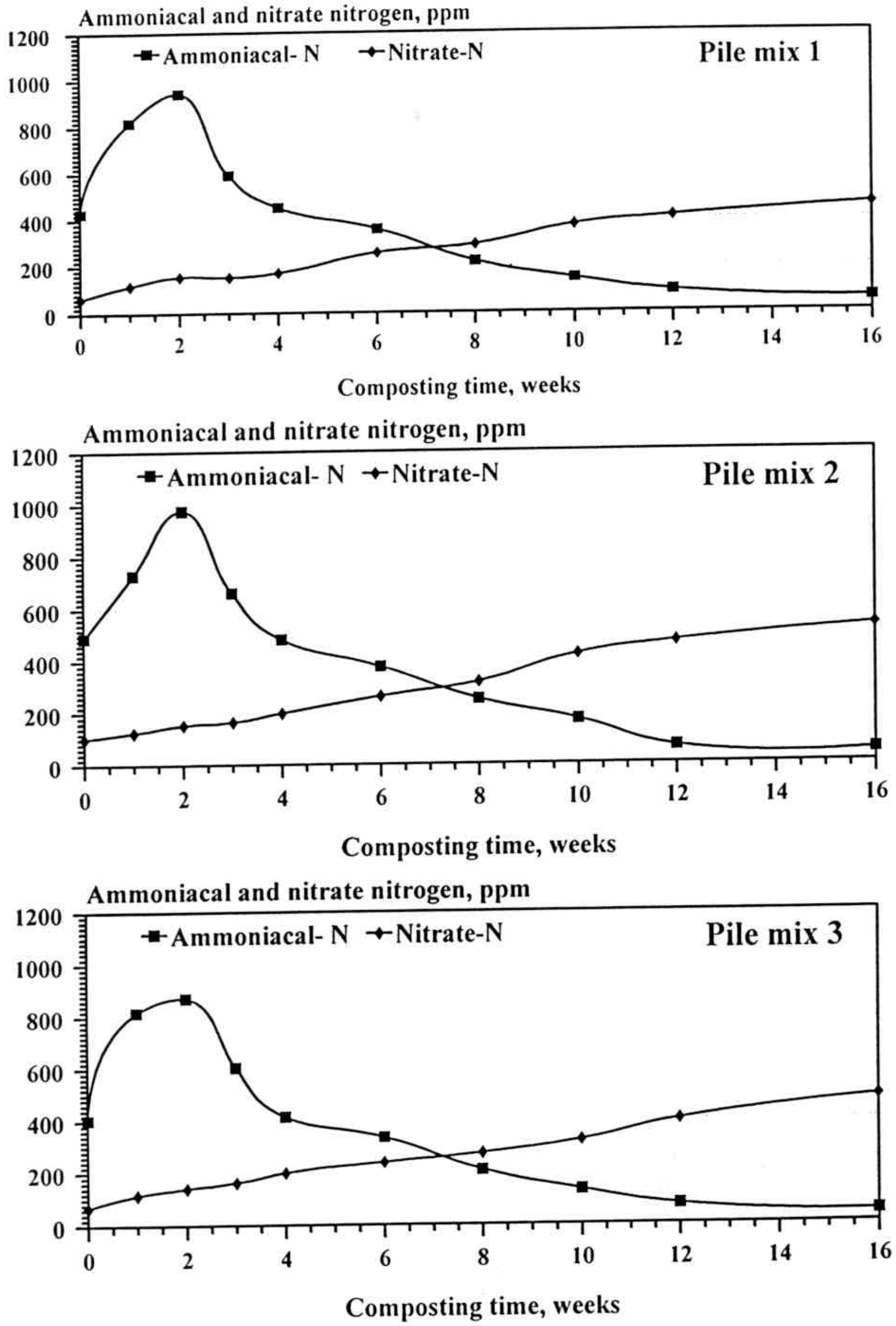


Fig. (5a): Changes in ammoniacal- and nitrate-nitrogen during composting a mixture composed of rice straw, banana residues and poultry litter under different additive materials for 16 weeks (piles mix 1, 2 and 3).

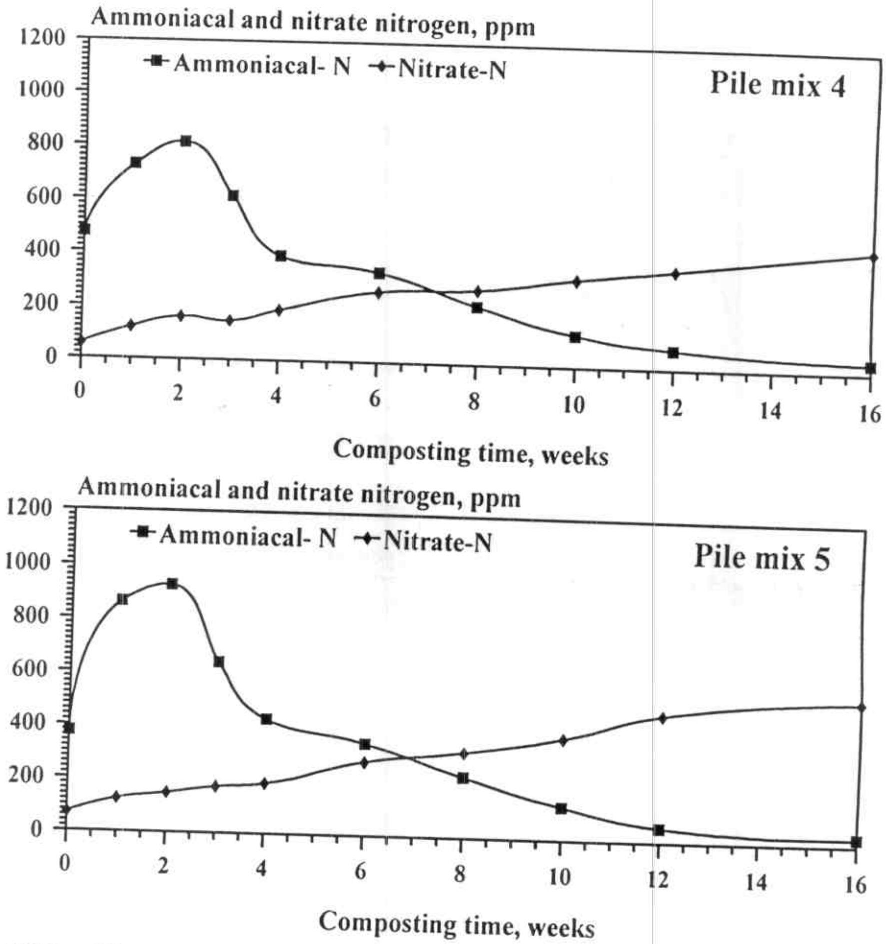


Fig. (5b): Changes in ammoniacal- and nitrate-nitrogen during composting a mixture composed of rice straw, banana residues and poultry litter under different additive materials for 16 weeks (piles mix 4 and 5).

The continuous decrease in total nitrogen content during the bio-oxidative period could be attributed to its volatilization as ammonia or/and by leaching as nitrate after moistening the piles **(Biddlestone *et al.* 1987).** The little increases in nitrogen during the later stage (cooling and maturation phase) may be referred to the non-symbiotic nitrogen fixation activities **(Poincelot, 1972)** dictated by Azotobacter and N_2-fixing Clostridia. **De Bertoldi *et al.* (1980)** found a strong nitrogenase activity during the second mesophilic phase of the composting process. Many species of N_2-fixing bacteria were isolated during city refuse composting, mostly in association with the mesophilic phases, fundamentally *Azomonas, Klebisella* and *Entrobacter* **(De Bertoldi *et al.*1983).**

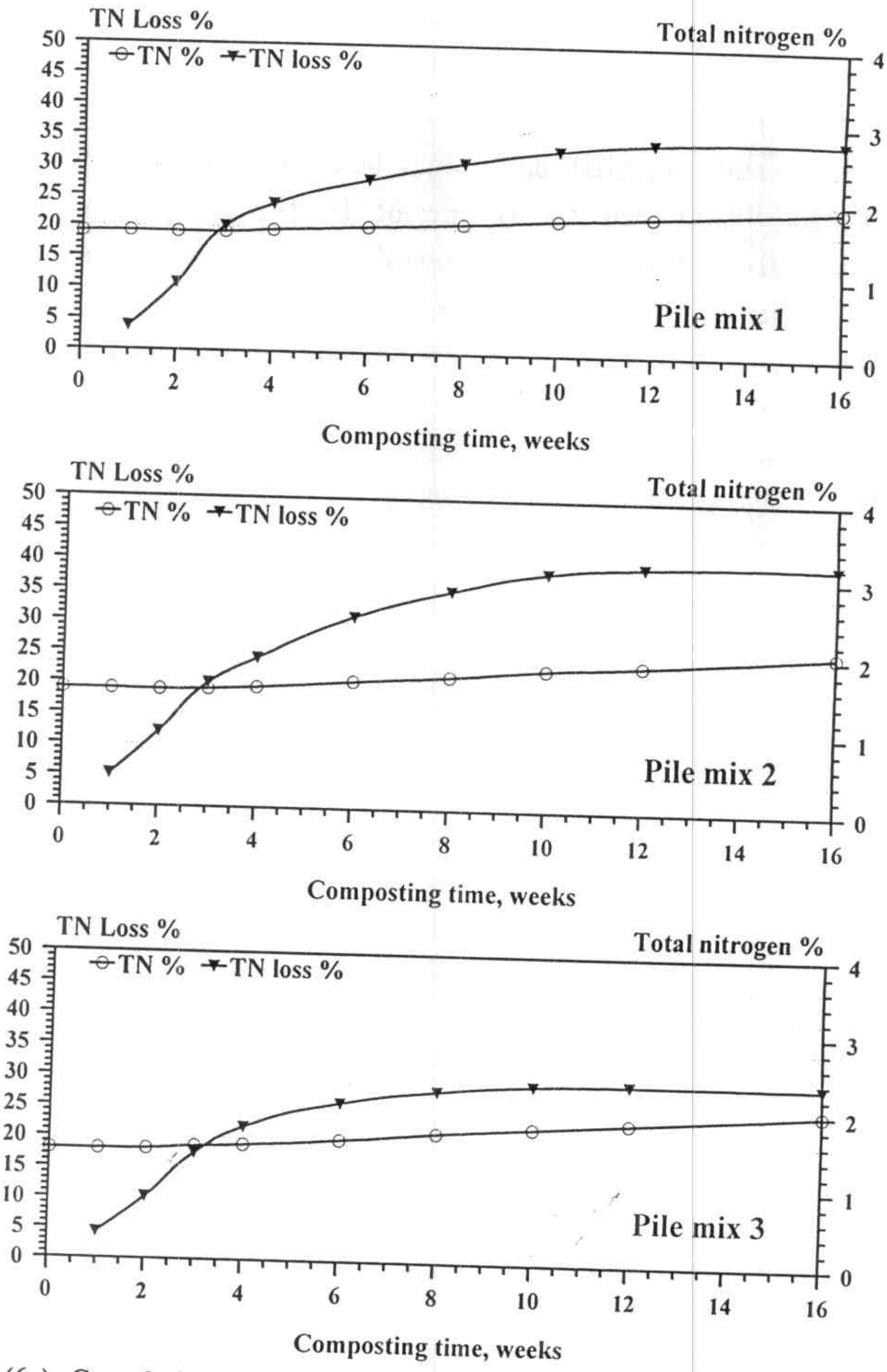
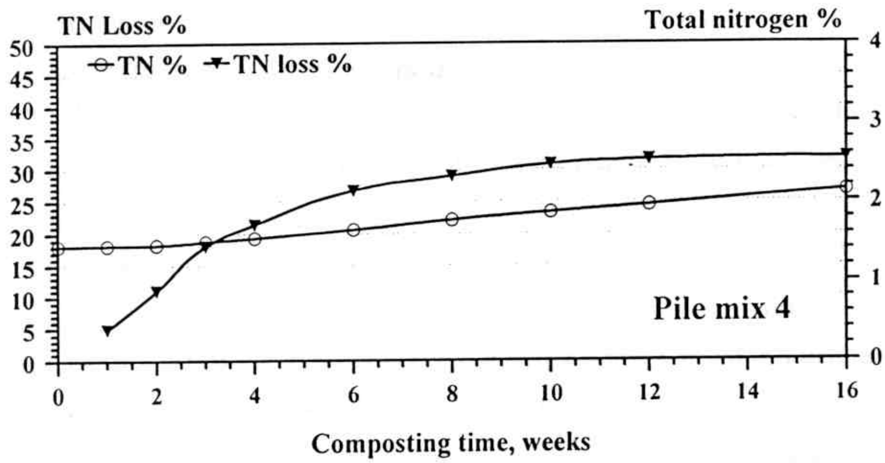


Fig. (6a): Cumulative curve of nitrogen loss (%) and behaviour of TN percentages during composting a mixture composed of rice straw, banana residues and poultry litter under different additive materials for 16 weeks (piles mix 1,2 and 3).



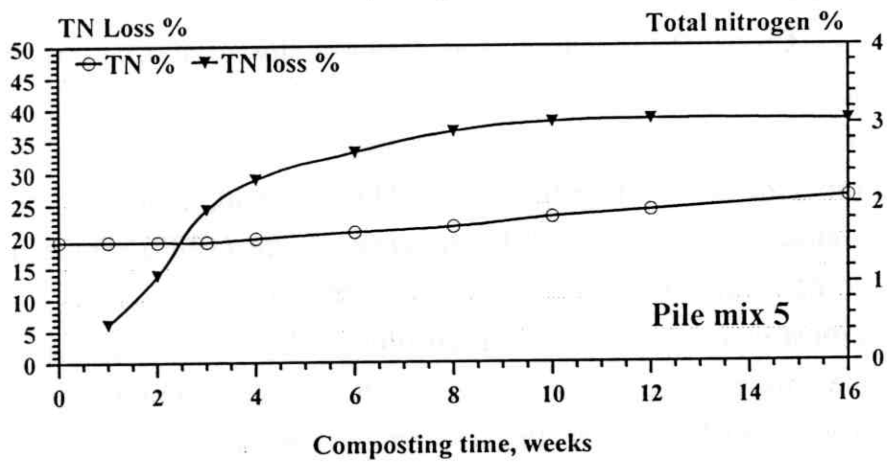


Fig. (6b): Cumulative curve of nitrogen loss (%) and behaviour of TN percentages during composting a mixture composed of rice straw, banana residues and poultry litter under different additive materials for 16 weeks (piles mix 4 and 5).

4.1.3. C/N ratio:

The changes in C/N ratio during composting period are shown in Table (8a, b). The C/N ratio values were calculated from the data of OM and TN percentages that were determined throughout the composting period. Carbon content is considered as 58% of the volatile solids **(Black *et al.*1965).** The values of C/N ratios showed higher reduction during the first eight weeks of composting process, and little decreases towards end of the composting period were observed. This was true for all tested piles, where the C/N ratios narrowed from initial values of 29.99; 30.16, 30.04, 29.97 and 29.80 to final values of 17.74, 14.74, 14.37, 12.33 and 14.71 for the compost piles mix 1, 2, 3, 4 and 5, respectively.

Carbon/Nitrogen ratio is traditionally used to determine the degree of compost maturity and its quality. Many authors reported that a C/N ratio below 20 is indicative of an acceptable maturity **(Poincelot, 1972; Cardenas and Wang, 1980, Golueke 1981 and Jimenez and Garcia, 1991), whereas Juste (1980)** reported that a ratio of 15 or even less is being preferable. However, The C/N ratio of compost cannot be used as an absolute index of compost maturation, since this parameter varies greatly in the well-composted materials **(Hirai *et al.*1983).** For this reason it is possible to find immature composts with a C/N ratio lower than 20 when the relative N- content in raw material is high. This is frequently occurring when the agricultural wastes are composted with sewage sludges. Because of this fact, **Morel *et al.* (1985)** noted that it was necessary to carry out a periodic monitoring for the C/N ratio during composting until stability is reached and proposed the following ratio:

(Final C/N) /(Initial C/N ratio).

The values of this parameter in our study are 0.592, 0.489, 0.478, 0.411 and 0.494 for piles mix 1, 2, 3, 4 and 5, respectively, after 16 weeks of composting. **Jimenez and Garcia (1989)** proposed that a reasonable estimation for this criterion could be less than 0.75 in composts fermented for more than 120 days, preferably order of 0.6 (compost of about 180 days). From the above-mentioned data, it may be suggested that this criterion should be taken only as indicative parameter.

4.1.4. Cation exchange capacity (CEC):

Cation exchange capacity (CEC) is an important horticultural standard characterizing material's ability to act as a regulator for nutrient supply for plant growth **(Raviv *et al*, 1987).** It was also mentioned that decomposition of organic matter, plant residues and manures is closely correlated to the CEC. Consequently, measurements of CEC are considered useful for estimating the degree of compost maturity. Data of CEC for the tested pile mixtures are presented in Table (8a, b). The CEC profiles of all piles showed a gradual increase throughout composting period. The CEC values of pile mixs 1, 2, 3, 4 and 5 increased from 37.1, 38.7, 31.3, 33.60 and 36.8meq/100g dry weight at initial time to 69.3, 77.10, 70.90, 78.2 and 75.60meq/100g dry weight, respectively after 16 weeks of the composting process. **Harada *et al.* (1981)** reported that the CEC of city refuse rose from 40 to 80 meq/100g TS during 12 weeks of composting and thereafter the CEC showed approximately constant value. **Galler and Davey (1971)** composted poultry manure with sawdust and showed that CEC increased from 35 to 65 meq/100 g TS in 8 weeks, and this also displayed a constant value at the 20^{th} week. Similar trend of results was determined by **Jimenez and Garcia (1991).** 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/100g on an ash-free material basis **(Harada *et al.*1981 and Roig *et al.*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 products, but also by increases of carboxyl, phenol and hydroxyl groups in the material **(Lax *et al.*, 1986**).

The relationship between the values of CEC and C/N ratio is statistically calculated and illustrated in Fig. (7).

There was a highly significant negative correlation between values of the CEC and the values of C/N ratio of all pile mixtures during composting

$$\ln CEC = 6.235 - 0.710 \ln C/N$$

$$(r= -0.954^{**}\ r^2= 0.909)$$

Harada *et al.* (1981) studied the evolution of CEC during a controlled trial of composting. They also found a negative correlation as follow:

$$\ln CEC= 4.90 - (0.0436 \ln C/N) \quad (r=- 0.9488)$$

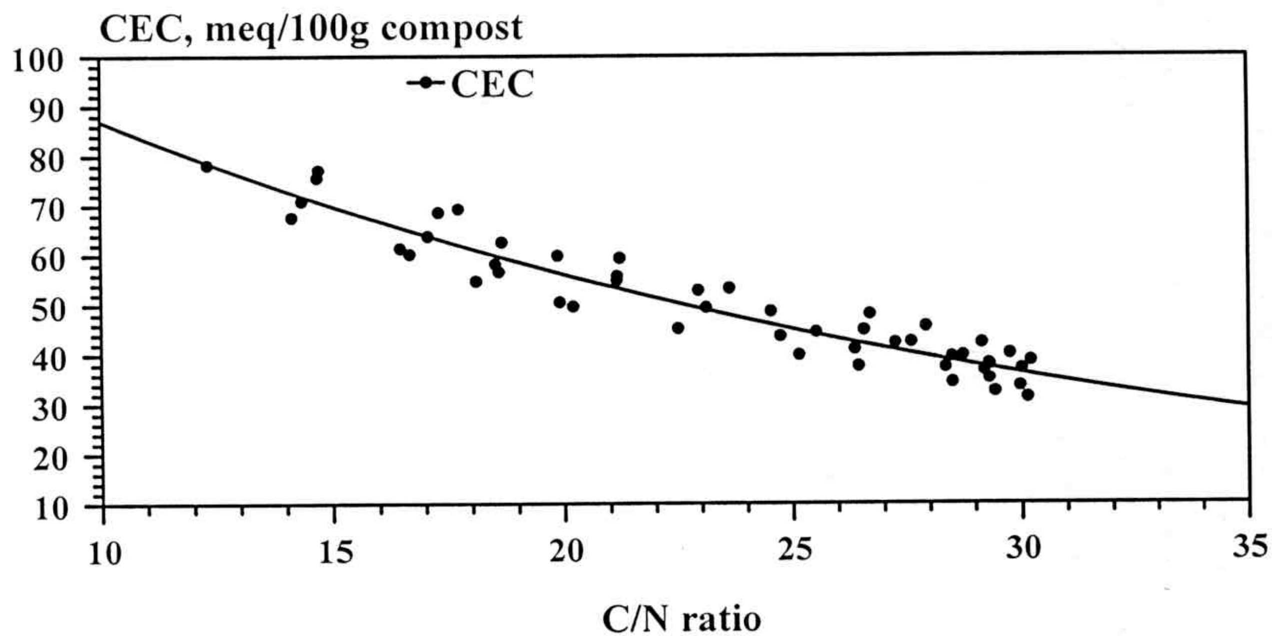


Fig. (7): Relationship between C/N ratio (carbon /nitrogen ratio) and CEC (cation exchange capacity).

4.1.5. Degradation of Biomacromolecules during Composting

Percentages of biomacromolecules (protein, hemicellulose, cellulose and lignin) are presented in Table (10). These data are used for making calculations to estimate the changes in biomacromolecules dry weight, and their losses during composting process.

Values of protein for all compost piles showed gradual increases during the composting course. Protein percentages increased from 9.20 to 11.68%, 9.21 to 12.54%, 8.69 to 12.30%, 8.71 to 12.98% and from 9.28 to 12.68% for compost piles mix 1, 2, 3, 4 and 5, respectively. All compost piles exhibited high reduction in protein dry weight during the first month of composting, then little reductions in protein dry weights were observed. The loss percentages of protein after 4 weeks of composting were 24.46, 24.81, 22.36, 21.49 and 29.63% for compost pile mix 1, 2, 3, 4 and 5, respectively.

Addition of natural rocks (such as rock phosphate and feldspar) to compost piles mix. 3 and 4 decreased the loss percentage of protein throughout the composting course, when values of protein loss percentage of piles mix. 3 and 4 were compared with the corresponding once of compost pile mix.1 (control treatment). The maximum loss % were 28.77 and 31.06 %, respectively at the end of composting period in comparison with loss % of 34.40 for compost pile mix1

On contrary, addition of microbial inoculants and compost tea to compost piles mix 2 and 5 increase the loss percentage of protein throughout the composting course, when values of protein loss % of piles mix. 2 and 5 were compared with the corresponding values of compost pile mix.1 (control treatment). The maximum losses % were 39.59 and 37.88 % for compost piles mix 2 and 5, respectively at the end of composting period.

Values of hemicellulose percentages for all compost piles showed gradual decreases during the composting course. These percentages decreased from 26.67 to 17.47%, 26.49 to 15.42%, 25.79 to 10.23%, 24.93 to 11.87% and from 26.94 to 15.40% for compost piles mix 1, 2, 3, 4 and 5, respectively. All compost piles exhibited high reduction in hemicellulose dry weight during the first 8 weeks of composting, and then little reductions were observed. The loss percentages of hemicellulose after eight weeks of composting were 55.79,63.74, 59.53, 66.70 and 74.02% for compost pile mix 1, 2, 3, 4 and 5, respectively.

Addition of natural rocks, microbial inoculants and compost tea to compost piles mix. increased the loss percentage of hemicellulose throughout the composting course, when values of hemicellulose loss %. Were compared with the corresponding one of compost pile mix.1 (control treatment). The maximum loss % were 74.18, 70.05, 77.98 and 77.98 %, respectively at the end of composting period in comparison with loss % of 66.16 for compost pile mix1. It was observed that addition of natural rocks and microbial inoculants together to compost pile mix 4 maximized the loss % of hemicellulose.

Data of cellulose percentages for all compost piles showed little decreases or increase during the month of composting, and then gradual decreases were recorded. These percentages of cellulose decreased from 33.19 to 29.56%, 33.42 to 23.72%, 31.43 to 22.51%, 31.11 to 19.43 and from 26.32.95 to 25.21% for compost piles mix 1, 2, 3, 4 and 5, respectively. All compost piles exhibited high reduction in cellulose dry weight during the first 8 weeks of composting, and then little reductions were determined. The loss percentages of cellulose after eight weeks of composting were 36.19,47.32, 45.559, 49.50 and 46.47% for compost pile mix 1, 2, 3, 4 and 5, respectively.

Addition of natural rocks, microbial inoculants and compost tea to compost piles mix. increased the loss percentage of cellulose throughout the composting course, when values of cellulose loss % were compared with the corresponding one of compost pile mix.1.

The maximum loss % were 68.55, 63.67, 71.10 and 65.21 %, respectively at end of composting period in comparison with loss % of 53.99 for compost pile mix1. The addition of natural rocks and microbial inoculants together to compost pile mix 4 maximize the loss % of cellulose. The loss percentages of cellulose in general, were lower than those of hemicellulose during the composting course for all compost piles

Values of lignin for all compost types showed gradual increases during the 12 weeks of composting course. Lignign percentages increased from 11.71 to 14.41%, 11.56 to 14.56%, 11.09 to 13.59%, 11.40 to 12.99% and from 12.08 to 12.6815.55% for compost piles mix 1, 2, 3, 4 and 5, respectively. Very little decreases in lignin percentages after 16 weeks of composting for all compost piles. The compost piles exhibited high reduction in lignin dry weight during the first 4 weeks of composting, then little reductions in lignin dry weights were observed. The loss percentages of lignin after 4 weeks of composting were 20.96,16.18, 17.65, 19.79 and 22.94% for compost pile mix 1, 2, 3, 4 and 5, respectively.

Addition of natural rocks, microbial inoculants and compost tea to compost piles mix. Increased the loss percentage of lignin throughout the composting course, when values of lignin loss %. Were compared with the corresponding one of compost pile mix.1. The maximum loss % were 45.22, 38.47, 71.10, 47.31 and 42.36 %, respectively at the end of composting period in comparison with loss % of 36.70 for compost pile mix1. The addition of natural rocks and microbial inoculants together to compost pile mix 4 maximize the loss % of lignin. The loss percentages of lignin is in general was lower the those of hemicellulose and cellulose during the composting course for all compost piles. The degradation order of biomacromolecules is protein > hemicellulose > cellulose > lignin.

Table (10): Changes in the percentages of Biomacromolecules (hemi-cellulose, cellulose, lignin and protein) during composting for 16 weeks.

Comp. Period (week)	Protein			Hemicellulose			Cellulose			Lignin		
	Dry weight (Kg)	Prot. %	Loss %	Dry weight (Kg	Hemi. %	Loss %	Dry weight (Kg	Cellul. %	Loss %	Dry weight (Kg	Lignin %	Loss %
Pile mix 1												
0	18.40	9.20	--	53.34	26.67	--	66.38	33.19	--	23.42	11.71	--
4	13.90	9.40	24.46	35.51	21.98	39.05	50.93	34.44	23.28	18.51	12.52	20.96
8	12.74	10.12	30.76	23.58	18.74	55.79	42.36	33.66	36.19	17.30	13.75	26.13
12	12.11	10.91	34.18	19.78	17.81	62.92	34.43	31.00	48.13	16.01	14.41	31.64
16	12.07	11.68	34.40	18.05	17.47	66.16	30.54	29.56	53.99	14.76	14.29	36..70
Pile mix 2												
0	18.42	9.21	--	52.98	26.49	--	66.84	33.42	--	23.11	11.56	--
4	13.85	9.34	.24.81	30.75	20.74	41.96	49.82	33.60	25.46	19.37	13.06	16.18
8	11.86	10.39	35.61	19.21	16.83	63.74	35.21	30.84	47.32	15.88	13.91	31.29
12	11.14	11.48	39.52	15.36	15.83	71.01	25.43	26.21	61.95	14.12	14.56	38.90
16	11.13	12.54	39.58	13.68	15.42	74.18	21.04	23.72	68.58	12.66	14.27	45.22

Table (10): continueous.

Comp. Period (week)	Protein			Hemicellulose			Cellulose			Lignin		
	Dry weight (Kg)	Prot. %	Loss %	Dry weight (Kg	Hemi. %	Loss %	Dry weight (Kg	Cellul. %	Loss %	Dry weight (Kg	Lignin %	Loss %
Pile mix 3												
0	18.25	8.69	--	54.16	25.79	--	66.00	31.43	--	23.29	11.09	--
4	14.17	9.08	22.36	32.55	20.86	39.90	47.52	30.46	28.00	19.18	12.29	17.65
8	13.20	10.29	27.67	21.92	17.08	59.53	35.91	27.98	45.59	16.77	13.07	27.99
12	12.98	11.30	28.88	18.38	16.00	66.06	28.34	24.66	57.06	15.62	13.59	32.93
16	13.00	12.20	28.77	16.22	10.23	70.05	23.98	22.51	63.67	14.33	13.45	38.47
Pile mix 4												
0	18.29	8.71	--	52.35	24.93	--	65.33	31.11	--	23.95	11.40	--
4	14.36	9.27	21.49	29.34	18.94	43.95	46.17	29.80	29.33	19.21	.12.40	19.79
8	13.11	10.72	28.32	17.43	14.25	66.70	32.99	26.98	49.50	15.74	12.87	34.28
12	12.66	11.86	30.78	.13.69	12.83	73.85	23.94	22.43	63.36	14.22	13.33	40.63
16	12.61	12.98	31.06	11.53	11.87	77.98	18.88	19.43	71.10	12.62	12.99	47.31
Pile mix 5												
0	18.56	9.28	--	53.88	26.94	--	65.89	32.95	--	24.15	12.08	--
4	13.06	9.43	29.63	27.45	19.82	49.05	46.96	33.91	28.73	18.61	13.44	22.94
8	11.80	10.39	36.42	20.07	17.67	62.75	35.27	31.04	46.47	16.55	14.57	31.47
12	11.48	11.66	38.15	15.84	16.09	70.60	27.24	27.68	58.66	15.30	15.55	36.65
16	11.53	12.68	37.88	14.00	15.40	74.02	22.92	25.21	65.21	13.92	15.32	42.36

The major component of lignocellulose materials is cellulose, along with lignin and hemicellulose. Cellulose and hemicellulose are macromolecules from different sugars, whereas lignin is an aromatic polymer synthesized from phenylpropanoid precursors. The composition and percentages of these polymers vary from one plant species to another. Moreover, the composition within a single plant varies with age, stage of growth, and other conditions **(Jeffries, 1994).**

Most of the cellulolytic microorganisms belong to bacteria and fungi, even though some anaerobic protozoa and slime molds able to degrade cellulose. Cellulolytic and ligninolytic microorganisms can establish Synergistic relationships with non-cellulolytic species in cellulosic wastes. The interactions between these Populations lead to enhance the degradation of cellulose and lignin, releasing carbon dioxide and water under aerobic conditions, and carbon dioxide, methane and water under anaerobic conditions **(Be´ guin, 1994 and Leschine,19950)**

There is some debate and perhaps significant variability in the rate of lignin decomposition in aerobic systems. **Lynch and Wood (1985)** stated that "little, if any, lignin degradation occurs during composting", and **Iiyama *et al* (1995)** assume constant lignin as the basis of their calculations of polysaccharide degradation. However, **Hammouda and Adams (1989)** reported lignin degradation ranging from 17% to 53% in grass, hay and straw during 100 days of composting, Interestingly, after this initially high decomposition rate under thermophilic conditions, In contrast, in a laboratory incubation study, **Horwath *et al* (1995)** measured 25% lignin degradation during mesophilic composting and 39% during thermophilic composting of grass straw during 45day experiments.

4.1.6 Changes in trace elements during composting.

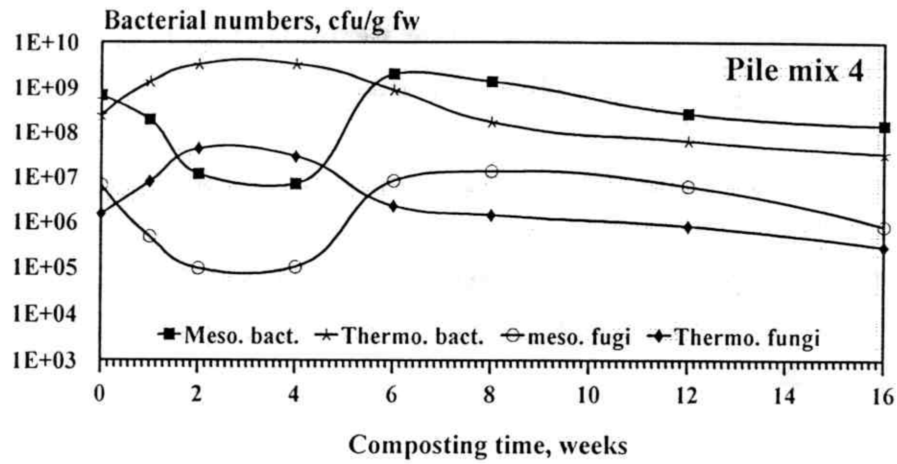
Values of some trace elements determined in this study are presented in Table (11). For example, Concentrations of Iron at initial time of composting were 1690, 1667, 1632, 1625 and 1648mg Fe/kg dry weight for piles mix 1, 2, 3, 4 and 5, respectively while their levels after 16 weeks composting time were greatly increased (about double values) to be 3171, 3205, 2992, 3085 and 3252 mg Fe/kg dry finished compost following the same order of the pile mix. Similar results were obtained for Zn, Cu and Mn.

Table (11): Concentrations of cationic micronutrient in 5 different compost piles at starting time and after 16 weeks of composting.

Compost Pile mix	Fe		Mn		Zn		Cu	
	At Initial time	After 16 weeks	At Initial time	After 16 weeks	At Initial time	After 16 weeks	At Initial time	After 16 weeks
1	1690	3171	220	379	199	365	58	99
2	1667	3205	212	408	218	392	67	121
3	1632	2992	224	420	224	401	55	104
4	1235	3085	237	441	210	415	62	117
5	1648	3252	209	415	206	389	71	125

Trace elements and heavy metals are not directly part of the organic chemicals but they have a very strong tendency to be adsorbed on the organic matter. They are further not transformed during the aerobic composting process and they will therefore not be lost to the surrounding environment in any significant manner. This means that the metals found in the incoming material will also be found in the finished compost. The mass of the compost is reduced during composting and the concentrations of the heavy metals (mg metal/Kg dry matter compost) will therefore increase and reach their highest levels in the final product **(Tjalfe *et al* 2oo3).**

under different additive materials for 16 weeks (piles mix 1, 2 and 3).



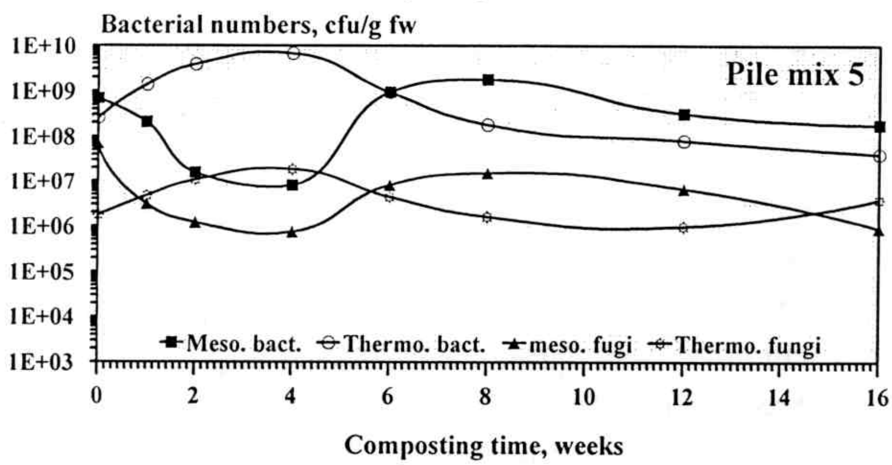


Fig. (8b): Changes in the numbers of mesophilic and thermophilic of total viable bacteria and fungi during composting a mixture composed of rice straw, banana residues and poultry litter under different additive materials for 16 weeks (piles mix 4 and 5).

temperatures exceed 70 °C for a long period. Only few species of thermophilic sporiugenous bacteria show metabolic activity above 70 °C: *Bacillus subtilis, B. stearothermophilus* and none-spore forming, *G-, aerobic genus thermus* **(De Bertoldi *et al.* (1983).** This could be true in the pile center. In this study, the maximal temperatures were between 68 and 71 °C only for one to two days. Therefore, the microbial inactivation was not appearing in all pile under study. In the curing and maturation phase, the thermophilic-TVB numbers decreased gradually towards the end of the composting process to be in numbers ranged between 1.5 x 10^7 and 4 x 10^7 cfu/g fw. These results are in agreement with those reported by **Falcon *et al* (1987) and Strom (1985).**

4.1.7.2. Fungi:

Changes in the numbers of mesophilic and thermophilic fungi throughout the composting course of five different mixtures or agricultural wastes are illustrated in Fig. (8a,b). Initially the numbers of mesophilic fungi were higher than those of thermophilic species. They were determined in numbers ranged between 5.7 x 10^6 and 7.1 x 10^7 cfu /g fw. Subsequently, with the rise in temperature, there was a rapid reduction in the counts of mesophilic fungi to reach to the lowest number, which ranged between 1.15 x 10^5 and 7.5 x 10^5 cfu/g fw at the fourth week of composting for all piles under this study. After 4 weeks, as the temperature start to drop towards the maturation phase, the mesophilic fungi counts began to increase and reached maximum at the 8^{th} week of composting in all piles. Their numbers were ranged between 1.17 x 10^7 and 1.5 x 10^7 cfu/g fw. Thermophilic fungi at initial time was found in numbers lower than those of mesophilic fungi, where their numbers ranged between 1.35 x10^6 to 1.75 x 10^6 cfu/g fw. During the first 4 weeks of composting in which the temperature degree was higher than 45 °C, the thermophilic fungi proliferated rapidly and showed maximum peak at the fourth week of composting for all piles under study. These beaks of thermophilic fungi were 1.52 x 10^7, 1.68 x 10^7, 1.59 x 10^7, and 1.84 x 10^7 cfu/g fw for piles mix 1, 2, 3, 4 and 5, respectively. In the curing and maturation phase, the thermophilic-TVB numbers decreased gradually towards the end of the composting process to be in numbers ranged between 2 x 10^5 and 9.8x 10^5 cfu/g fw.

Fungi, particularly the thermophilic species are known to be active in compost heaps and other self-heating organic material **(Chang and Hudson, 1967; Gomez and Park 1983 and Thambirajah and Kuthubutheen, 1989).** They also reported that the ratio of thermophilic to mesophilic fungi rapidly increased, especially during the optimum temperature range (45-55°C) of the thermophilic phase, and even after the compost had cooled down the thermophilic fungal counts were quite high.

They suggested that the fungal spores presets in the compost for some time. **Strom (1985)** reported that Aspergillus is the common fungus species in composting materials. **De Bertoldi *et al.* (1983)** found the importance of the second mesophilic phase because of the spectacular development of mesophilic eumycetes which were very active in the degradation of cellulose and lignin.

4.1.7.3 Survival of pathogenic indicators and Salmonella and Shigella:

Total and fecal coliform bacteria (pathogenic indicators) and Salmonella & Shigella (pathogenic microorganisms) were monitored during the composting period for the five pile mixtures. Their counts are illustrated in Fig. (9a,b). The numbers of total coliform bacteria rapidly decreased during the composting period and their numbers ranged between 200 and 300 cfu/g fresh weight after 16 weeks of composting in all composting piles, Similar results were observed for the survival fecal coliform bacteria and Salmonella & Shigella but the fecal coliform bacteria were found to be more persistent, their numbers ranged from 390 to 600 cfu/g fresh weight at $16^{\underline{th}}$ week of composting. Salmonella & Shigella were non-detectable after 12

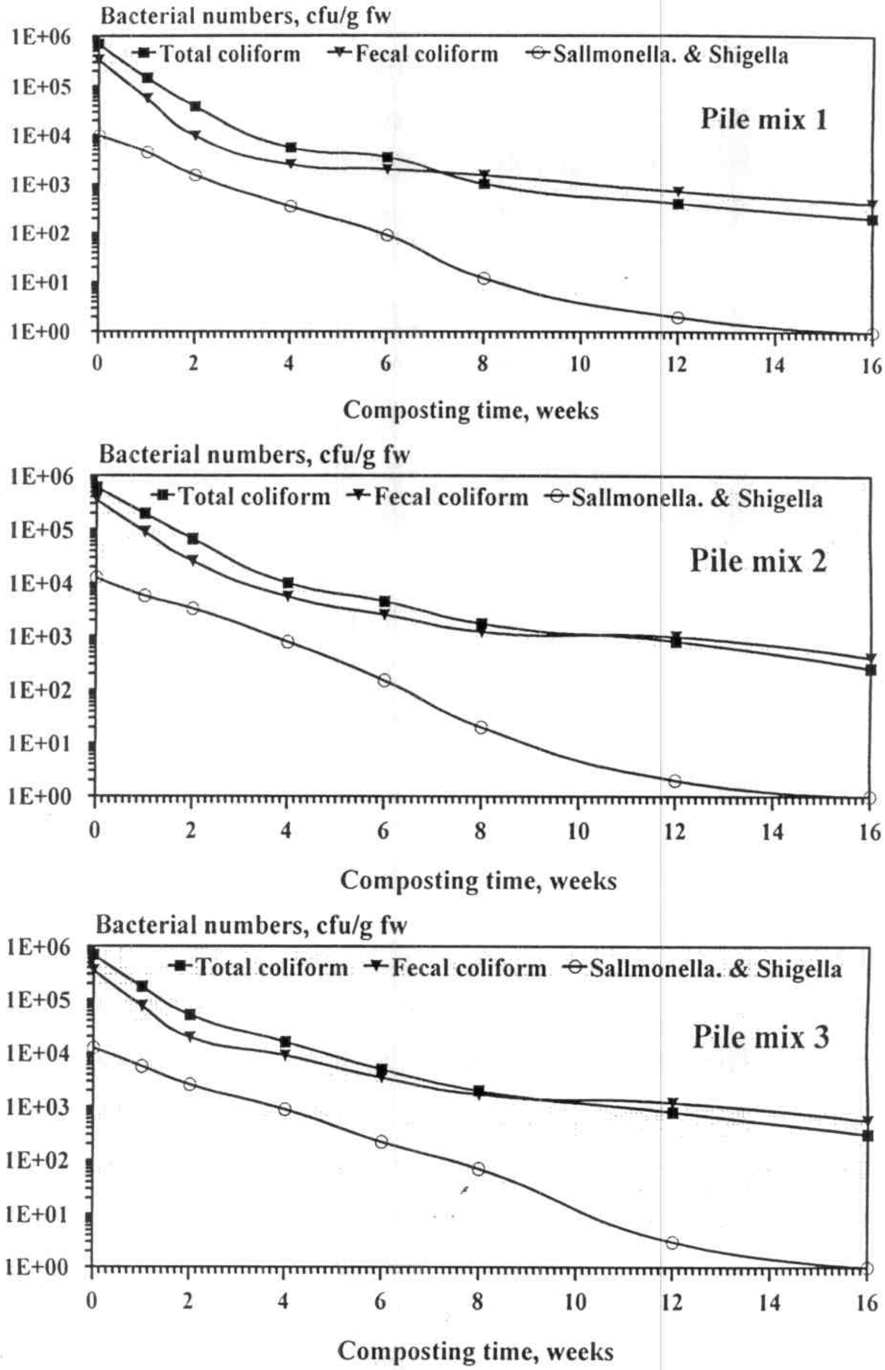
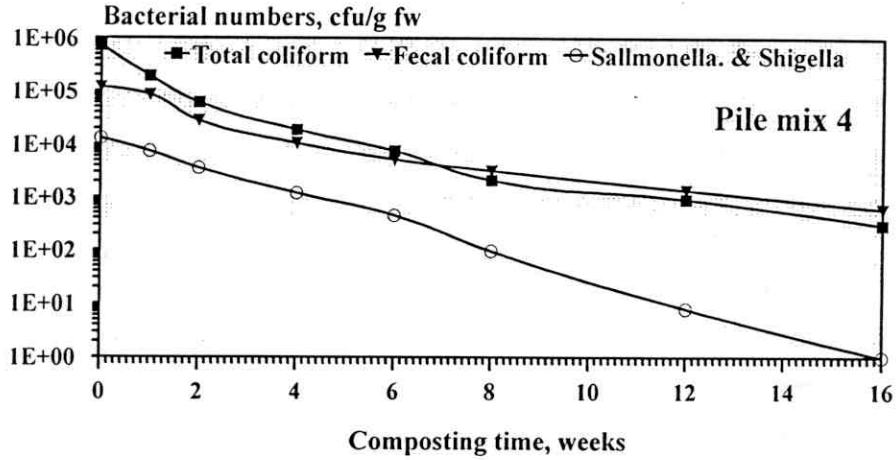


Fig. (9a): Changes in the numbers of total and fecal coliforms bacteria (pathogenic indicators) and Salmonella & Shigella (pathogenic bacteria) during composting a mixture composed of rice straw, banana residues and poultry litter under different additive materials for 16 weeks (piles mix 1, 2 and 3).



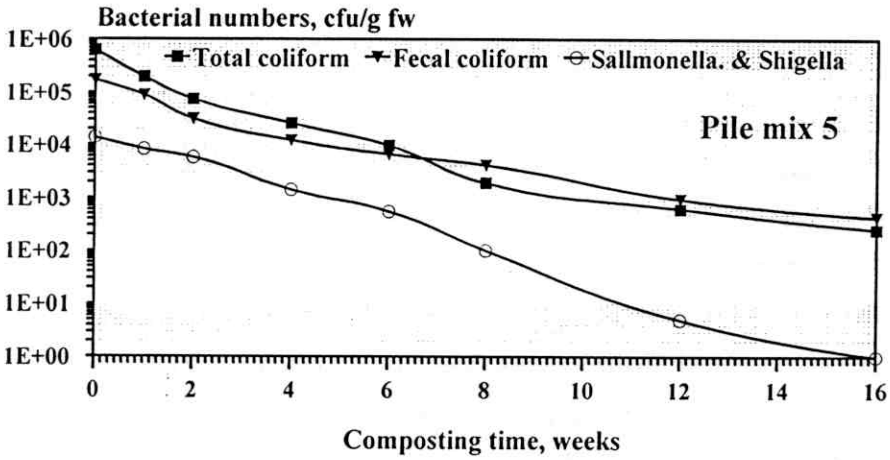


Fig. (9b): Changes in the numbers of total and fecal coliforms bacteria (pathogenic indicators) and Salmonella & Shigella (pathogenic bacteria) during composting a mixture composed of rice straw, banana residues and poultry litter under different additive materials for 16 weeks (piles mix 4 and 5).

weeks of composting in all studied piles. The average removal percentages of total and fecal coliform bacteria were 99.96 and 99.82 % while Salmonella & Shigella were reduced by 100%

Time and temperature are the most important parameters responsible for pathogen die-off during composting. It should be noted that a complete inactivation of pathogens in compost pile is rarely achieved. This is due to many reasons, such as 1) the heterogeneous character of the compost materials, which may form clumps with the pathogens and protect them from being fully exposed to thermophilic temperatures. 2) The uneven temperature distribution in the compost piles. Unless completely mixed continuously, the outer surfaces of a compost heap normally have a lower temperature than the inside, causing a lower efficiency of pathogen kill, and 3) many pathogens (not determined in this study) such as spore forming bacteria, cysts and helminthes ova are only partially inactivated **(Cooper and Golueke 1979)** during competing. They can re-grow and become infective again if exposed to a favorable environment such as under moistened conditions in crop fields (**US. EPA, 1981).** A number of workers **(Kawata,** ***et al.*****1977; Cooper and Golueke 1979**) have reported several orders of magnitude reduction of bacteria (total and fecal coliforms; fecal streptococci, Salmonella & Shigella) and viruses (poliovirus and Coliphages) during composting. The reduction in the coliform group bacteria and probably most of the pathogenic microorganisms may be due to the high temperature during the thermophilic stage **(Nell** ***et al.*****1983)** and/or to the antagonistic effects of other microorganisms found in compost materials. **Stentiford** ***et al*** **(1984)** mentioned that the production of antibiotics within the pile is probably involved in the inactivation of the pathogens.

Similarly, it has been suggested that temperatures exceeding 55 °C for at least 3 days throughout the composting material should be sufficient to produce a pathogenically harmless material (**Golueke 1982 and El-housseini** ***et al.*** **2002),** while other investigators concurred that the thermophilic phase has to be maintained for at least

10 days and the optimum level should be between 60 and 70 °C to destroy thermosensible pathogens **(Gray *et al.*1971; De Bertoldi *et al.*1983).**

4.2 Characterization of humic substances isolated from composted organic wastes.

Humic substances are major components of OM, they often constituting 60 to 75% of the total organic matter **(Schnitzer and Khan, 1972)**. Different fractions of humic substances are operationally defined by extraction procedures that rely on differences in solubility in base and acid **(Swift, 1996)**

The humic substances could be defined as organic constituents formed due to the chemical and biological degradations of plant and animal residues (**Schnitzer, 1986**). Humic and fulvic acids differ in their molecular weights and contents of functional groups.

4.2.1. Total humus (Hs), humic acid (HA) and fulvic acid (FA) contents and HA/FA ratio.

Humus and its content of humic and fulvic acids as percentages of the corresponding total organic matter are illustrated in Table (12).

Percentages of humus, HA and FA acids increased with increasing composting period. Also, data showed that the percentages of humic acids were lower than the corresponding ones of fulvic acids at all periods of composting. Different values of humic and fulvic acids in all the used compost materials may be attributed to the variations in the microorganisms activity which can utilize different decomposable organic residues along with newly formed humus substances, (**El-Sirafy, 1978).**

The percentage of humus isolated from the different composted materials increased with increasing decomposition period. This was true with all compost types. The results obtained agree with those of **Soliman(1982)** who found that the percentage of humus isolated from composted materials i.e. Egyptian clover and wheat straw ranged from 19.74 to 39.7% and 24.18 to 37.19%, respectively.

Table (12): Percentage of humic substances (humus, humic(HA) and fulvic(FA) acids) isolated from composted organic wastes and HA/FA ratio.

Treatment / Period (month)	Compost mix (1)	Compost mix (2)	Compost mix (3)	Compost mix (4)	Compost mix (5)
Humus % (HS)					
0	16.03	13.22	14.90	13.88	17.35
3	22.28	34.35	31.82	26.48	26.85
6	26.97	40.70	39.55	35.57	33.02
9	29.80	42.62	40.86	41.48	36.49
12	34.24	43.02	42.72	44.70	39.41
Humic acid % (HA)					
0	6.56	7.09	6.62	6.89	6.15
3	8.64	10.79	9.90	10.93	9.70
6	11.46	14.16	12.64	14.41	12.69
9	12.86	16.61	16.06	17.60	15.07
12	14.32	19.80	18.32	20.29	17.78
Fulvic acid % (FA)					
0	9.47	6.13	8.28	6.99	11.20
3	13.64	23.56	21.92	15.55	17.15
6	15.51	26.54	26.91	21.16	20.33
9	16.94	26.01	24.80	23.88	21.42
12	19.92	23.22	24.40	24.41	21.63
HA/FA Ratio					
0	0.69	1.16	0.80	0.99	0.55
3	0.63	0.46	0.45	0.70	0.56
6	0.74	0.53	0.47	0.68	0.62
9	0.76	0.64	0.65	0.74	0.70
12	0.72	0.85	0.75	0.83	0.82

The results also show that humus (Hs) as percentages of total organic matter after 12 months of composting ranged from 34.24 to 44.70%, the lowest value was recorded for compost mix.No.1 while the highest one was recorded for the compost mix.No.4. the results obtained herein agrees well with those of **Badawi, (1997)** who stated that humic substances contents increased with incubation time. The percentages of humus contents isolated from composted rice straw, corn stalks, banana trees and sawdust were 21.72, 25.24, 24.82 and 16.34 %, respectively.

Humic acids contents as percentages of the corresponding total organic matter after 12 months of composting ranged from 14.32 to 20.59 %. The lowest value characterized the compost mix. No.1 while the highest one characterized the compost mix. No.4

Likewise, the percentage of fulvic acids content after 12 months of composting ranged from 19.92 to 24.40 %. The lowest value was recorded for compost mix. No.4 while the highest one was recorded for the compost mix. No.3.

Generally, the percentage of the fulvic acids was higher than that of humic acids throughout all periods of composting. The results obtained herein agree with those of **Ali (2001)** who found that the percentages of HA and FA isolated from composted materials ranged from 4.17 to 28.52 and 11.23 to 15.97%, respectively while **Soliman (1982)** found that the percentages of HA and FA isolated from composted materials ranged from 10.72 to 16.97% and 13.46 to 21.22%, respectively.

The presence of high cellulose content in rice straw in the composted mixture used in this experiment might increased the rate of organic matter decomposition and consequently, increased values of humus, humic and fulvic acids.

4.2.2. Total macronutrients in humus, humic and fulvic acids derived from composted organic wastes.

Total nitrogen, phosphorus and potassium contents in humus, humic and fulvic acids extracted from composted materials are shown in Table (13).

4.2.2.1. Total nitrogen

Data presented in Table (13) show values of total N in humus (Hs) isolated from the different composted materials. These values increased with increasing decomposition periods. This was true with all compost types. The results also show that values of total N in humus after 12 months of composting ranged from 3.93 to 4.22%. The lowest value was recorded for compost mix No.1 while the highest one was recorded for compost mix No.5.

The corresponding total N values in humic acids after 12 months of composting ranged from 2.18 (for compost mix. No.1) to 2.39 % (for compost mix No.5). On the other hand, the values of N content in humic acids increased by increasing periods of composting up to 3 months then decreased by prolonging period of composting up to end of the experiment. The abovementioned trends were true for all the compost mixtures and at all periods of degradation. **Taha (1985)** and **El-Ghozoli (1994)** obtained similar results were they found that total nitrogen of humic acid samples derived from rice straw and cotton stalks composted to maturity ranged from 2.84 and 2.21%, respectively.

The N content of the fulvic acids after 12 months ranged from 1.27 to 1.35%, the lowest value was recorded for compost mix No.1 whereas the highest one was recorded for compost mix No.4.

Generally, it can be seen that the humic acids contained higher percentage of N than fulivic acids. This difference could be related to the nature and composition of the acids. The results obtained herein agree with those of **Abou El-Fadle (1993)** who found that nitrogen content ranged from 1.1 to 2.2% in some different fulvic acids and **Ali (2001)** who found that the total N in HA and FA isolated from

Table (13): Macronutrients concentration (%) in the Humus, Humic and Fulvic acids isolated from different composted treatment during decomposition period.

Treatment / Period Per month	Compost Mix No.(1)			Compost Mix No.(2)			Compost Mix No.(3)			Compost Mix No.(4)			Compost Mix No.(5)		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
Total Humus (TH)															
0	3.46	0.272	1.46	3.09	0.258	1.42	3.70	0.231	1.35	3.75	0.287	1.37	3.81	0.246	1.18
3	3.65	0.285	1.64	3.78	0.267	1.71	3.90	0.283	1.42	3.89	0.294	1.54	3.98	0.265	1.24
6	3.73	0.322	1.76	3.84	0.310	1.89	3.98	0.322	1.57	3.96	0.331	1.65	4.10	0.296	1.36
9	3.86	0.351	1.78	3.92	0.346	1.91	4.08	0.388	1.66	4.05	0.391	1.86	4.13	0.338	1.64
12	3.93	0.394	1.81	4.02	0.398	1.89	4.14	0.415	1.85	4.17	0.435	1.91	4.22	0.381	1.76
Humic acid (HA)															
0	2.31	0.105	0.345	2.41	0.092	0.337	2.48	0.089	0.310	2.42	0.119	0.362	2.50	0.096	0.318
3	2.42	0.112	0.442	2.51	0.108	0.410	2.63	0.115	0.360	2.52	0.128	0.390	2.61	0.119	0.385
6	2.25	0.126	0.498	2.38	0.121	0.483	2.42	0.131	0.395	2.41	0.142	0.434	2.52	0.130	0.462
9	2.11	0.141	0.516	2.25	0.128	0.522	2.37	0.147	0.446	2.32	0.155	0.475	2.42	0.141	0.508
12	2.18	0.148	0.552	2.30	0.141	0.587	2.29	0.163	0.495	2.26	0.172	0.531	2.36	0.152	0.544
Fulvic acid (FA)															
0	0.98	0.157	0.81	1.05	0.135	0.96	1.12	0.115	0.98	1.15	0.137	0.89	1.19	0.127	0.92
3	1.13	0.161	0.87	1.14	0.142	1.08	1.21	0.142	1.02	1.32	0.159	0.94	1.26	0.136	0.96
6	1.24	0.175	0.89	1.26	0.169	1.09	1.44	0.171	1.03	1.48	0.171	0.98	1.41	0.155	0.99
9	1.37	0.191	0.94	1.45	0.176	1.10	1.31	0.195	1.08	1.51	0.202	1.04	1.34	0.172	1.08
12	1.27	0.217	1.02	1.32	0.201	1.18	1.29	0.231	1.19	1.35	0.241	1.13	1.31	0.214	1.03

different composted materials ranged from 2.21 to 3.95% and 1.85 to 2.01%, respectively.

4.2.2.2. Total phosphorus

Table (13) shows that the amounts of total P in the isolated humus Hs. HA and FA are much lower than the corresponding ones of nitrogen.

Total P content of Hs, HA and FA increased with increasing the decomposition periods.

The results also show that values of total P in Hs, HA and FA after 12 months of composting ranged from 0.381 to 435, 0.141 to 0.172 and 0.201 to o.241%, respectively. The highest values were recorded for compost mix No.4 for all the HS, HA and FA, while the lowest corresponding values were recorded for compost mix No.5 (for Hs) and compost mix No.3 (for HA and FA).

Generally, it can be seen that the fulvic acids contain a higher percentage of P than humic acids. This was true for all the compost mixtures and at all periods of degradation. Similar results were attained by **Singh *et al.*, (1990)** they found that the percentage of phosphorus in the humic and fulvic acids isolated from straw compost with Rock phosphate ranged between 0.177 to 0.286% and 0.197 to 0.498%, respectively.

4.2.2.3. Total potassium

Data presented in Table (13), show that the total K content of Hs, HA and FA derived from composted organic wastes followed a pattern differed due to period of composting where the K values increased with increasing the decomposition periods of the Hs, HA and FA.

Results show that the K content values in humus ranged from 1.76% (for compost mix No.5) to 1.91% (for compost mix No.4) after 12 months, the corresponding total K content values of humic acids after 12 months ranged from 0.495% (for compost mix No.3) to

0.587% (for compost mix No.2) while the total K content values of fulvic acids after 12 months ranged from 1.02% (for compost mix No.1) to 1.19% (for compost mix No.3). Also, data show that total K content was lower in humic acids than in fulvic acids.

From these results, it can be concluded that values of total N, P and K in Hs, HA and FA derived from composted materials, followed the descending order: N> K>P with relatively higher amounts of those elements in fulvic acids than in humic acids.

4.2.3. Total micronutrients in humus, humic and fulvic acids isolated from the composted organic wastes.

Humic substances are effective in binding the micronutrients such as Fe, Mn, Zn and Cu **(Tan, 1993)**. The metal-organic matter interaction was suggested to be in two different ways. The first was an exchange one thereby the organic matter affects the solubility of the metal cations. The second way of interaction of metals with humic substances occurs when metals are non-exchangeable. **(Sequi *et al.*, 1975).**

4.2.3.1. Total iron

Data presented in Table (14) show values of total iron in humus (Hs) isolated from the different composted materials. These values increased with increasing decomposition periods. This was true with all compost types. The results also show that values of total Fe in Hs after 12 months of composting ranged from 634 to 712 mg kg^{-1}. The lowest value was recorded for compost mix .No.1 while the highest one was recorded for the compost mix. No.4

The corresponding total Fe values in the humic acids after 12 months of composting ranged from 342 to 416 mg kg^{-1} . The lowest value characterized the compost mix. No.1 while the highest one characterized the compost mix.No.4.

All the studied humic acid contents of total Fe increased with increasing decomposition period. The increase percentages after 12 months of composting were 67.6, 69.1, 96, 96.2 and 84.3% for compost mix. Nos. 1, 2, 3, 4 and 5, respectively as compared with the values of total Fe at zero times.

The values of total iron content of fulvic acids were higher in the early periods of decomposition of the used composted materials then tended to decrease gradually with increasing period of decomposition up to 12 months. This was true for all the composted organic wastes. Values of the Fe content in fulvic acids after 12 months of composting ranged from 214 to 2334 mg kg^{-1}. The lowest value was that of the compost mix. No.3 while the highest corresponding one was that of the compost mix.No.2

Generally, the total Fe content in fulvic acids was higher than that of the humic acids in first periods of composting. **Elgala *et al.*(1976)** found that, fulvic acids are characterized by higher amounts of COOH and phenolic-OH groups as compared with HA. This means that fulvic acids might contain metal cations in an exchangeable from that can be easily released from the fulvic acids-metal complexes. Noteworthy, the Fe content in HA and FA isolated from different compost materials are compatible with those obtained by **Ali(2001)** who found that they ranged from 217 to 408 and 290 to 392 mg kg^{-1}. for compost rice straw and ranged from 200 to 356 and 240 to 280 mg kg^{-1} for compost of cotton stalk, respectively. Also, **El-Ghozoli, (1994)** found that the total iron contents of humic acid isolated from rice straw and cotton stalks composted at maturation stage were 300 and 660μg g^{-1} ,respectively.

4.2.3.2. Total manganese

Table (14) shows that the amounts of total Mn in the isolated Hs, HA and FA are much lower than the corresponding ones of Fe. Total Mn content of humus and humic acids increased with increasing the decomposition period up to 12 months.

On the other hand, the values of total Mn content in fulvic acids increased with increasing period of composting up to 6 months;

thereafter they decreased up to end of the composting period i.e.12 months. The above-mentioned trends were true for all compost mixtures and at all periods of degradation.

Generally, the total Mn content of humus and humic acids isolated from compost mix. No.3 after 12 months of composting was the highest as compared with the other used compost types. The Mn content values of the humic acids after 12 months ranged from 52 to 62mg kg^{-1}. The lowest value was recorded for compost mix. N0.5 whereas the highest Mn content after 12 months was recorded for the compost mix. No.3.

Values of total Mn are generally higher in the fulvic acids than those of the humic acids. Results of Mn associated with HA and FA indicate that the extracted Mn amount is probably a function of the composted organic waste and types of the functional groups of both humic and fulvic acids. On the other hand, increasing humfication was associated with a drastic lowering in humic acids **(Schnitzer *et al.*, 1967). Schnitzer and Khan (1972)** reported that the action of HA with Mn is a matter of trap within the polymer structure of the molecule which is characterized by the presence of holes, beside a minor attachment with the functional group. The results obtained herein agree with those of **Ali (2001)** who found that the Mn contents of HA and FA isolated from composted materials of rice straw and cotton stalks ranged from 27 to 46 and 40 to 49 μg g^{-1} , and 20 to 36 and 36 to 44 mg kg^{-1} respectively. On the other hand, **Al-Ghozoli, (1994)** who found that the total manganese content of humic acid isolated from rice straw and cotton stalks composted at maturation stage was 75 and 69 mg kg^{-1} respectively.

4.2.3.3. Total Zinc

Data presented in Table (14). show that the total Zn contents of humus and HA derived from the used composted organic materials are almost of the same contents as Mn. Likewise, Zn content increased with increasing the composting period where the increase percentages reached 20.3, 18.0, 27.6, 20.0 and 23.6% in the humus (Hs) corresponding to 54.5, 56.5, 57.1, 63.2 and 64.7% in the humic acids for compost mix. Nos 1, 2, 3, 4 and 5, respectively after 12 months of composting as compared with its values at zero time. Results show that Zn content values in humus (Hs) ranged from 136 (for comp. mix. No.5) to 148 mg kg^{-1}. (for comp. mix. No.3) after 12 months. The corresponding total Zn content values of HA after 12 months ranged from 56 (for comp.mix.No.5) to 72 mg kg^{-1}. (for compost mix. No.2). the lowest and highest values were recorded for the compost mix. No.5 and 2, respectively.

Total Zn content of fulvic acids derived from the composted organic wastes followed a pattern differed due to period of composting in a way similar to those followed by both Fe and Mn. Moreover, values of total Zn content of FA are very close to its Mn ones i.e. no wide difference could be observed between FA contents of Mn and Zn.

Zn values associated with FA are relatively higher than those of HA. This finding could be ascribed to the increase in adsorption strength of HA for Zn by increasing the degree of humfication as reported by **Matsuda and Lto (1970)**. Theses results are in accordance with the finding of **Montasser (1987)** and **Ali (2001)** who found that Zn content in HA and FA isolated from composted materials of rice straw and cotton stalk ranged from 32 to 30 and 41 to 46 mg kg^{-1} and 21 to 38 and 13 to 38 mg kg^{-1} , respectively. Also, **Al-Ghozoli, (1994)** found that the total zinc contents of humic acid isolated from rice straw and cotton stalks composted at maturation stage was 77 and 68 mg kg^{-1} respectively.

4.2.3.4. Total copper

Values of total Cu content associated with Hs, HA acids and FA acids seemed generally to be lower than the corresponding ones of Fe, Mn and Zn. However, the increase in period of composting resulted in obvious increases in Cu contents of both the humus (Hs) and humic acids. The total Cu content of fulvic acids isolated from the composted materials slightly increased with prolonging period of composting up to 3 or 6 months beyond which they tended to decrease. This occurred with all the studied composted materials.

The estimated increases in Cu content of Hs as related to its content at zero time, are 27.3, 18.5, 37.5, 25.9 and 28% while the corresponding increases in HA are 85.7, 66.6, 112.5, 77.7 and 112.5% for compost mix. Nos. 1, 2, 3, 4 and 5, respectively after 12 months of composting. The highest value of total Cu content in humus (Hs) was recorded for compost mix. No.4 (68 mg kg^{-1}. after 12 months) while the lowest value was recorded for compost Mix.No.1 (56 mg kg^{-1}. after 12 months).

Total Cu content in humic acids isolated from composted materials after 12 months ranged from 26(for compost mix. No.1) to 34 mg kg^{-1}. (for compost mix. No.3 and 4). Theses results agree with these of **Ali (2001)** who found that the Cu content in HA and FA isolated from compost rice straw and cotton stalks ranged from 15 to 26 and 16 to 19 mg kg^{-1} and 14 to 23 and 13 to 18 mg kg^{-1} , respectively. On the other hand, **Al-Ghozoli, (1994)** found that the total copper content of humic acid isolated from rice straw and cotton stalks composted at maturation stage was 27.2 and 25.0 mg kg^{-1} respectively.

Values of total Cu content of FA are slightly higher than the corresponding values of HA at the early stage of composting.

From these results, it can be concluded that values of total Fe, Mn, Zn and Cu in humus (Hs), HA and FA derived from composted materials, followed the descending order: Fe>Zn>Mn>Cu with relatively higher amounts of those elements in fulvic acids than in humic acids.

Table (14): Micronutrients concentration (mg kg^{-1}) in the humus, humic and fulvic acids isolated from the different composted treatment during the decomposition period.

Treatment / Period Per month	Compost Mix No.(1)				Compost Mix No.(2)				Compost Mix No.(3)				Compost Mix No.(4)				Compost Mix No.(5)			
	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
Total Humus (TH)																				
0	484	92	118	44	497	88	122	54	454	96	116	48	488	94	120	54	464	86	110	50
3	512	98	122	48	522	94	128	56	510	108	126	52	528	102	126	58	524	98	114	52
6	546	112	128	50	566	102	132	60	556	120	134	58	592	110	134	62	582	106	120	58
9	572	122	134	52	618	114	138	62	648	128	142	62	666	118	138	64	610	114	128	62
12	634	128	142	56	688	126	144	64	702	134	148	66	712	124	144	68	672	126	136	64
Humic acid (HA)																				
0	204	32	44	14	214	34	46	18	200	36	42	16	212	30	38	18	204	32	34	16
3	232	36	48	16	236	38	54	20	234	42	46	22	244	34	44	22	232	36	40	22
6	290	48	56	20	288	44	60	24	296	48	52	26	310	42	52	24	286	42	44	26
9	324	54	64	22	328	52	64	26	346	54	58	32	382	48	56	28	324	48	50	30
12	342	62	68	26	362	58	72	30	392	62	66	34	416	56	62	32	376	52	56	34
Fulvic acid (FA)																				
0	248	48	56	20	262	50	58	26	236	56	50	24	246	46	48	30	234	52	62	32
3	266	54	62	22	280	54	66	32	272	62	58	28	272	54	56	32	282	56	66	38
6	250	56	58	24	272	56	62	30	256	66	54	26	264	50	54	28	278	58	64	34
9	234	50	54	22	248	52	58	24	242	60	48	22	252	44	48	24	246	50	60	30
12	222	44	50	18	234	46	54	22	214	52	44	20	224	40	42	20	228	42	54	26

4.2.4. Values of total acidity, functional groups and cation exchange capacity of the humic and fulvic acids isolated from composted organic wastes.

4.2.4.1. Total cidity.

Data presented in Table (15&16) indicate that values of total acidity which is the sum of the dissociable hydrogen of the COOH and the phenolic-OH groups in humic or fulvic acid samples of both aromatic and aliphatic origin, **(Schnitzer and Gupt, 1965)** for the all composting treatments increased with increasing decomposition period. This may be due to the maturity of humic and fulvic acids. Also, this is because under arid conditions, oxidation processes are predominated and reaction shifts to the formation of more complicated humic and fulvic acids and more aromatic compounds (**Stevansin, 1994**).

Generally, the values of total acidity of the fulvic acids were higher than the corresponding ones of the humic acids. These results agree with **Abd El-Latif (1973)** who found that values of the total acidity (carboxylic and phenolic groups) in the fulvic acids where higher than the corresponding was of the humic acid derived from organic residues which averaged 1049 to 1258 m mol c/100g FA and 972 to 1008 m mol c/100g HA. Also similar results were found by **Soliman (1988)** who reported that total acidity of HA and FA isolated from composted materials ranged from 335.16 to 982.35 m mol c/100g, 198.21 to 701.11 m mol c/100g HA and 687.15 to 1035 m mol c/100g, 715.34 to 1387.21 m mol c/100g FA for composted Egyptian clover and wheat straw, respectively.

Data show also that values of total acidity of the humic acids after 6 months of composting ranged from 598 to 673 m mol.c /100g. The lowest value was that of the compost mix No.(3), while the highest one was that of the compost mix. No.(5). Values of total acidity of the humic acids after 12 months of composting seemed, as mentioned before, higher than the corresponding ones attained after 6 months where they ranged from 675 to 782 m mol c/100g. It is worthy to indicate that the compost mix No.(3) and the compost mix No (5) which recorded the lowest and highest values of total acidity, respectively after six months of composting were also the composts that recorded the lowest and highest values of total acidity after 12 months. These values of total acidity are relatively smaller than those attained by **Abd El-Latif (1973)** who found that the total acidity of humic acids derived from different organic residues (wheat residues) ranged from 934 to 1090 m mol c /100g. On the other hand, the values of total acidity obtained were relatively higher than the corresponding ones reported by **Kopisch-Obuck(1970) and Khan (1971)** who found that the maximum value of total acidity was 573 m mol c /100g of humic acids while, **El-Ghozoli, (1998)** showed that the total acidity of the humic acids isolated from organic residues (chicken manure, town refuse, biogas manure and poudratte) ranged from 908 to 1103 m mol c/100g acid. **Sweed (2005)** found that the total acidity of humic acid isolated from farm yard manure was 720 m mol c/100g HA

The values of total acidity of fulvic acids after 6 months ranged from 785(for compost No.3) to 841 m mol c/100g (for compost No.5). The corresponding total acidity values after 12 months ranged from 912 (for compost mix No.1) to 989 m mol c/100g (for compost N0.4).

Higher value for total acidity of fulvic acids (FA) was reported by **Schnitzer (1970)** who found that it was 1240 m mol c /100g of fulvic acid.

According to values of total acidity of the humic acids, the different composted materials can be arranged in the following descending order:

Comp mix 5 > Comp. mix.2 > C. mix.4 > C. mix.1 > C. mix. 3.

while in case of the fulvic acid the following descending order was attained :

C. mix 4 > C. mix.2 > C. mix.5 > C. mix.3 > C. mix.1.

Table(15): Functional groups contents, CEC and total acidity of the humic acid isolated from the different composted materials during the decomposition periods.

Treatments	Period per month	Total acidity m mol c /100g H.A	Functional groups m mol c /100g H.A		COOH / Phenolic-OH ratio	CEC m mol c /100g acid	CEC / total acidity of %
			Carboxyl COOH	Phenolic-OH			
Comp.Mix No.(1)	6	645	307	338	0.91	321.15	50
	12	717	354	363	0.97	380.39	53
Comp.Mix No.(2)	6	657	312	345	0.90	331.22	50
	12	763	371	392	0.95	396.75	52
Comp.Mix No.(3)	6	598	286	312	0.92	316.90	53
	12	675	330	345	0.96	377.16	56
Comp.Mix No.(4)	6	651	317	334	0.95	341.18	52
	12	743	368	375	0.98	403.60	54
Comp.Mix No.(5)	6	673	321	352	0.91	338.72	50
	12	782	384	398	0.96	416.55	53

Table(16): Functional groups contents, CEC and total acidity of the fulvic acid isolated from the different composted materials during the decomposition periods.

Treatments	Period per month	Total acidity m mol c /100g H.A	Functional groups m mol c /100g F.A		COOH / Phenolic-OH ratio	CEC m mol c /100g acid	CEC / total acidity of %
			Carboxyl COOH	Phenolic-OH			
Comp.Mix No.(1)	6	795	344	451	0.76	362.24	46
	12	912	404	508	0.80	425.20	45
Comp.Mix No.(2)	6	820	352	468	0.75	371.15	45
	12	977	433	544	0.80	462.30	47
Comp.Mix No.(3)	6	785	341	444	0.77	364.25	46
	12	932	419	513	0.82	454.60	49
Comp.Mix No.(4)	6	841	363	478	0.76	383.39	46
	12	989	441	548	0.82	477.26	48
Comp.Mix No.(5)	6	806	359	447	0.80	390.10	48
	12	967	435	532	0.82	491.18	51

4.2.4.2. Values of carboxyl (COOH) and phenolic-OH groups in humic and fulvic acids.

Humic substances contain a variety of reactive functional groups such as carboxylic acids, phenolic acids, amine and thiol(sulfhdryl) groups that can complex heavy metals **(Stevenson, 1994)**

The values of COOH and phenolic-OH groups are recorded in Tables (15&16) Values of the phenolic-OH groups were higher than those of the COOH groups in both of humic and fulvic acids. This was true for all the studied composted materials. Similar results were found by **Abd El-Latif (1973)** who stated that the carboxyl-COOH and phenolic-OH groups of humic and fulvic acids isolated from organic residues ranged from 237 to 277, 698 to 771 m mol c/100g HA and from 403 to 577, 647 to 681 m mol c /100g FA, respectively. These results agree with those of **El-Ghozoli (1998)** who found that the COOH groups of humic acid isolated from organic residues ranged from 243 to 320 m mol c /100g HA while the phenolic-OH groups of humic acid ranged from 662 to 783 m mol c /100g HA.

The results also show that the values of COOH groups in humic acids after 6 months ranged from 286 (for compost mix No.3) to 321 m mol c /100g (for compost mix No.5). The corresponding values after 12 months ranged from 330 to 384 m mol c /100g HA. The lowest and highest values were recorded also for the compost mix No.3 and 5, respectively. Also, **Soliman (1982)** who found that the COOH and phenolic groups of HA and FA extracted from composted materials and wheat straw ranged from 112.13 to 361.41 m mol c /100g, 157.81 to 494.34 m mol c /100 g HA and 214.17 to 533.59 m mol c /100g, 501.17 to 853.62 m mol c/100g FA, respectively.

Values of COOH groups in fulvic acids after 6 months of composting ranged from 341 to 363 mmalc/100g FA. The corresponding COOH values after 12 months ranged from 404 to 441 m mol c /100g FA. The lowest values were recorded for the compost mix No.3 after 6 months and the compost mix.No.1 after 12 months.

The compost mix. No.4 recorded the highest COOH values after 6 as well as after 12 months of composting. Values of the phenolic-OH groups in humic acids after 6 months of composting ranged from 312 to 352 m mol c /100g. The corresponding phenolic-oH values after 12 months ranged from 345 to 398 m mol c /100g. The lowest values were recorded for the compost mix No.3 whereas the highest phenolic-OH groups were recorded for compost mix.No.5. Higher values of phenolic-OH groups of the humic acids were recorded by **Inbar *et al.*(1990)** who found that the phenolic-OH groups of humic acids ranged from 676 to 800 m mol c /100g. HA.

Values of phenolic-OH groups in fulvic acids ranged from 444 to 478 m mol c /100g FA after 6 months of composting. The lowest value was recorded for the compost mix.No.3 whereas the highest one was recorded for compost mix No.2. The corresponding phenolic-OH groups values after 12 months ranged from 508 to 548 m mol c /100g, the lowest value was recorded for the compost mix No.1 while the highest one was recorded for the compost mix.No.4. **Sweed (2005)** reported that the COOH and phenolic-OH groups of humic acid isolated from farmyard manure were 402 and 365 m mol c /100g HA, respectively.

It is worthy to indicate that the COOH and phenolic-OH groups of both the humic and fulvic acids increased with increasing the decomposition period.

The abovementioned results and discussion reveal that values of the functional groups depend on the characteristics of the extracted humic and fulvic acids.

These findings stand in well agreement with those of **Kononova (1966), Schnitzer (1978), Kuwatsaka *et al.*(1978), Saiz-Jimenez *et al.* (1978)** who found that the analytical characteristics and the chemical structure of humic substances, humic and fulvic acids affect their contents of total acidity, COOH and phenolic-OH groups.

Generally, the difference in the content of COOH and total-OH groups is related to the chemical composition of organic residues as well as the effect of humification processes **(Stevenson, 1982 and 1994, Abo-El-Fadl, *et al.*, 1992, Abo El-Fadl, 1993 and Rivero, *et al.*, 1998)**

4.2.4.3. Cation exchange capacity of humic and fulvic acids.

The results presented in Tables (15 &16) indicate that values of the cation exchange capacity of humic and fulvic acids increased with increasing decomposition period .

Generally, the CEC values of the fulvic acids were higher than the corresponding ones of the humic acids. This was true for all the composted mixtures of the organic wastes and at all periods of degredation. Such results are in agreement with those reported by **Kononova (1966), El-Damaty *et al.* (1975) and Soliman (1982) who** studied effect of organic residues on the chemical characteristics of humic and fulvic acids and found that the CEC of humic acids was lower than that of the fulvic acids, they were about 385 and 475 m mol c /100g acids, respectively.

Data presented in Table (15 &16) show that the CEC values of the humic acids after 6 months ranged from 316.9 to 341.18 m mol c /100g HA. The corresponding CEC values after 12 months of decomposition ranged from 380.39 to 416.55 m mol c /100g. The lowest values were recorded for compost mix No.3 after 6 months and compost mix. No.1 after 12 months. On the other hand, the highest CEC value after 6 months was recorded for the compost mix No.4 whereas the mix No.5 recorded the highest CEC value after 12 months. These results are in accordance with the finding of **El-Ghozoli (1998) who** found that the CEC of HA and FA isolated from different organic residues ranged from 354 to 412 m mol c /100g HA and 425 to 496 m mol c /100g FA, respectively. Likewise, the **Soliman (1982)** found that the CEC of HA and FA isolated from composts of Egyptian clover and wheat straw ranged from 496.15 to 491.18, 101.12 to 346.20 m mol c /100g HA and ranged from 301.47 to 542.11, 381.11 to 573.31 m mol c/100 FA, respectively. Data also, show that the CEC values of the fulvic acids after 6 months ranged from 362.24 to 390.10 m mol c /100g FA. The corresponding CEC values after 12 months of decomposition ranged from 425.20 to 491.18 m mol c /100g.FA. The lowest values were recorded for compost mix No.1 after 6 and 12 months. On the other hand, the highest CEC values after 6 and 12 months were recorded for the compost mix No.5. **Kononova (1966)** reported that the exchange cation capacity of humic and fulvic acid ranged from about 200 to 600 m mol c/100g acid.

The increase in values of CEC of the humic and fulvic acids produced due to composting the different organic wastes is likely to be due to the increase in the functional groups and humification of the organic substances. This finding agrees with **Alexandrova (1970)** who reported that the increase in carboxylic groups during humification increased cation exchange capacity. Moreover, the results found by **Keppel (1966) and Raik (1969)** declared that the CEC of humic substances depends on the presence of COOH and phenolic-OH groups and is expected to depend on pH. The COOH groups occur in the low pH while the phenolic-OH groups being at pH below 7 and extends to pH values 10 to 11.

Data also show the values of the CEC of humic and fulvic acid as percentages of values of the total acidity. These percentages ranged between 50 to 56% for HA and 45 to 51% for FA. This means that values of the CEC as percentage of the total acidity were only about half or less of the total acidity of humic and fulvic acids. **(Abd El-Latif, 1973 and El-Damaty *et al.*, 1975)**

4.2.5. Elementary composition and atomic ratios of the humic and fulvic acids isolated from composted organic wastes:

4.2.5.1. Elemental composition

Results presented in Tables (17 and 18) reveal that the elemental composition of the humic and fulvic acids isolated from the composted materials under study differed due to period of composting as well as type of the isolated acids.

1- Total carbon percentage:

Carbon is the major element in organic structures, it is metabolized initially in the form of carbon dioxide and it is converted to organic carbon mainly through the photosynthetic activities of the higher plants and to a lesser extent by microorganisms. About 90% of the dry matter of plant is composed of carbohydrate levels of varying complexities **(Stevnson, 1994)**

Total carbon of the humic acids ranged from 46.2-48.9% while the corresponding total carbon percentage of the fulvic acids ranged from 37.4 to 39.33% after six months of composting. Meanwhile, total carbon percentage of the humic acids ranged from 40.3-43% while the corresponding values of the fulvic acids ranged from 32.8-35.2% after 12 months of composting. Theses results mean that total carbon percentage of the humic acids was generally higher than the corresponding total carbon content of fulvic acids within each period of composting due to the high molecular weight of humic acid. This finding agrees with those of **El-Damaty *et al.* (1975) and Kuwatsaka *et al.* (1978)** who found significant correlation between many of the elemental constituents and the degree of humification. Also, results revealed a decreasing trend in carbon percentage of both the humic and fulvic acids by increasing period of incubation. Such a finding is expected due to the continuous break down of carbon. This finding stands in well agreement with those of **El-Ghozoli (1998)** who showed that the total organic carbon of humic acids derived from different organic residues ranged between 49.5 to 57.5%. Such results stand in accordance with the values reported by **Schnitzer (1977),**

preston and Rauthan (1982), Preston and Blackwell(1985), Taha (1985) and **El-Ghozoli (1994)**. These results revel that the carbon content of humic acids ranged from 41.3 to 60%. However, it seems likely acceptable such variations are mainly dependent on the initial composition of the decomposed organic waste and also on the level of decompositions and accumulation of the individual components of these manures.

El-Ghozoli (1998) showed that the total carbon of FA isolated from different organic residues ranged between 40.6% to 46.6% which stands in accordance with the results reported by **Abdel-Latif (1973)** and **Abou-Seeda (1988)** who found that the carbon content of some type composted materials of fulvic acids ranged from 41.02 to 46.9%. Also, **Soliman (1982)** found that the percentages of elementary composition C, N, H and O+S of humic acids isolated from composted Egyptian clover and wheat straw were 44.0%, 3.90%, 6.31% and 45.79% and 47.13%, 1.45%, 6.48% and 44.94% for HA and 38.30%, 2.48%, 6.15% and 52.9% and 41.13%, 1.20, 6.60, and 51.07% for FA, respectively. Also, **Sweed (2005)** found that, the percentages of elemental composition C, H, N, O and C/N ratio of humic acids isolated from farmyard manure and poudrette were 50.75, 4.35, 2.95, 19.20 and 46.40, 5.40, 3.76, 44.44 and 8.59, respectively.

It is worthy to indicate that compost mix.No.5 resulted in the humic acids of highest carbon percentage as compared with the other studied composts. Likewise, compost mix.No.2 resulted in the fulvic acids of the highest carbon percentages as compared with the other studied composts

2-Total nitrogen percentage

Total N percentage in the humic and fulvic acids, generally, decreased slightly by increasing period of composting from 6 to 12 months. One exception was noticed with compost mix No.1 where the fulvic acids isolated from it were of a nitrogen percentage increasing very slightly with increasing period of composting i.e increasing the composting period was of a positive effect on N percentage. Nitrogen percentages in the humic acids, however, seemed to be generally higher than the corresponding N percentages of the fulvic acids. This was true for all the studied composted material over both the two periods of composting where N percentage ranged from 2.18 to 2.52 % in the humic acids whereas the corresponding N percentages of the fulvic acids ranged from 1.24 to 1.48% regardless of period of composting of the composted materials. Higher values were reported by **El-Ghozoloi (1998)** who found that the total N content of humic acids derived from organic residues ranged between 2.2 to 5.9% , the highest value of total N content was that of HA derived from biogas manure, whereas the lowest one was observed in HA originated from town refuse. However, the total N content of FA isolated from the different studied manures (chicken manure, town refuse, biogas manure and poudratte) ranged between 1.1 to 3.1%

In another study by **Abou Hussein (1991)**, it was found that, the percentage C. N. H. O. ash and C/N ratio for the humic acid extracted from the composted wheat straw were 51.50%, 2.30%, 5.57%, 40.63%, 2.81% and 9.24, respectively. Also, **Abo El-Fadl (1992)** and **Abo El-Fadl *et al.* (1994)** found that percentage C, O, H, N and C/N ratio for the humic acid extracted from corn straw, broad beans straw and clover hay ranged between 46.5 – 51.70, 5.21 – 5.62, 40.03- 46.08, 2.21-2.65% and 14.50 – 23.50, respectively.

3- Hydrogen percentage

Data in Tables (17 and 18) illustrate that period of composting of the composted materials was of no obvious effect on H percentages in the humic or fulvic acids isolated from the different composted materials. However, H percentage in the humic acids seemed to be lower than the corresponding percentage of H in the fulvic acids. . This was true for all the studied composted material over both the two periods of composting where H percentage ranged from 4.77 to 5.05

% in the humic acids whereas the corresponding H percentages of the fulvic acids ranged from 6.12 to 6.62 % regardless of period of composting of the composted materials. However, **El-Ghozoli (1998)** found that the values of hydrogen content in isolated HA from different organic residues were relatively smaller as these values ranged from 3.85 to 4.70%. these results are in accordance with those obtained by **Taha (1985)** and **Badran (1994)** who found the hydrogen content of some HA types ranged from 2.78 to 6.71 while the values of hydrogen content in FA ranged between2.3 to 4.9% Also, they agree with the findings of **Sposito *et al.* (1982) and Header (1987)** who found that the hydrogen content of FA ranged from 4.6 to 4.85%

4- Total sulfur percentage

Sulfur percentage in the humic acids ranged from 2.27 to 4.43% regardless of period of composting of the waste materials. The corresponding S percentages in fulvic acids ranged from 1.92 to 3.33%. This means that S percentages in the humic acids were generally higher than the corresponding values of the fulvic acids. **El-Ghozoli (1998)** show that the S content of HA and FA isolated from different organic residues ranged between 1.0 and 2.10% for HA, 2.20 and 3.80% for FA respectively. Also, **El-Ghozoli (1994)** found that the S contents of humic acids isolated from composted soybean straw, rice straw and cotton stalks were 3.30, 3.50 and 2.60% , respectively.

Regarding effect of the used composted materials on S percentages in both the humic and fulvic acids, it could be noticed that compost mix Nos.3 and 4 showed the highest S percentages. Such a finding is likely to be due to the presence of S-bearing impurities in the added rock phosphate or feldspars which are components of the mixtures used for preparing these compost mixtures.

Table (17): **Elemental composition and atomic ratios of humic acids isolated from different composted materials during decomposition periods.**

Treatment	Period per months	Elemental composition %					Atomic ratios				
		C	N	H	S	O	C /N	C/H	C/O	O/H	N/H
Comp.mix	6	47.7	2.25	4.88	2.74	42.43	21.2:1	9.77	1.12	8.69	0.46
No.(1)	12	40.3	2.18	4.91	2.51	50.10	18.5:1	8.21	0.80	10.20	0.44
Comp.mix	6	47.1	2.38	4.77	2.31	43.44	20.2:1	9.87	1.08	9.11	0.50
No.(2)	12	41.2	2.30	4.80	2.78	48.87	17.9:1	8.49	0.84	10.10	0.47
Comp.mix	6	47.3	2.42	4.92	3.49	41.87	19.5:1	9.61	1.13	8.51	0.49
No.(3)	12	43.0	2.29	4.98	3.91	45.82	18.8:1	8.63	0.94	9.20	0.46
Comp.mix	6	46.2	2.41	4.95	4.20	42.24	19.2:1	9.33	1.09	8.53	0.49
No.(4)	12	40.5	2.26	5.03	4.43	47.78	17.9:1	8.05	0.85	9.50	0.45
Comp.mix	6	48.9	2.52	4.99	2.27	41.32	19.4:1	9.80	1.18	8.28	0.51
No.(5)	12	42.2	2.39	5.05	2.42	47.94	17.7:1	8.36	0.88	9.49	0.47

Table (18): Elemental composition and atomic ratios of fulvic acids isolated from different composted materials during decomposition periods.

Treatment	Period per months	Elemental composition %					Atomic ratios				
		C	N	H	S	O	C /N	C/H	C/O	O/H	N/H
Comp.mix	6	37.95	1.24	6.23	2.47	52.11	30.6:1	6.09	0.73	8.36	0.20
No.(1)	12	34.40	1.27	6.44	2.04	55.84	27.1:1	5.34	0.62	8.67	0.20
Comp.mix	6	39.33	1.36	6.48	2.11	50.72	28.9:1	6.07	0.78	7.83	0.21
No.(2)	12	35.16	1.32	6.62	1.92	54.98	26.6:1	5.31	0.64	8.31	0.20
Comp.mix	6	39.17	1.44	6.12	3.33	49.94	27.2:1	6.40	0.73	8.16	0.24
No.(3)	12	33.12	1.29	6.31	2.75	56.53	25.7:1	5.25	0.59	8.96	0.21
Comp.mix	6	38.80	1.48	5.99	3.08	50.65	26.2:1	6.48	0.77	8.46	0.25
No.(4)	12	33.62	1.35	6.14	2.65	56.24	24.9:1	5.48	0.60	9.16	0.22
Comp.mix	6	37.42	1.41	6.25	2.08	52.84	26.5:1	5.99	0.71	8.45	0.23
No.(5)	12	32.81	1.31	6.47	1.99	57.42	25.1:1	5.07	0.57	8.87	0.20

5- Total oxygen percentages

Oxygen percentages of the fulvic acids seemed generally higher than the corresponding ones of the humic acids where oxygen percentage values ranged from 41.87 to 50.10% in the humic acids and from 49.94 to 57.42% in the fulvic acids regardless of period of composting. However, increasing period of composting of the wastes resulted in pronounced increase in oxygen percentage in both the humic and fulvic acids. This is probably attributed to the increase in the oxygenated functional group i.e. COOH, phenloic OH, alcoholic OH and methoxyl groups with time. Lower values for oxygen percentages were reported by **El-Ghozoli (1998)** who found that the total oxygen content of humic acids isolated from organic residues, generally fluctuated between 30.7 and 39.9%. However, similar values were reported by **Schnitzer (1977), Preson and Rauthan (1982) and El-Ghozoli, 1994** who found that the oxygen content of some types of humic acids isolated from composted materials ranged from 30 to 48% while the total oxygen content of fulvic acids ranged between 42.0 to 50.8%. These results are in accordance also with those obtained by **Header (1987), Abou-Seeda (1988) and Abo-El-Fadle (1993)** who found that the oxygen content of some FA types isolated from composted materials fluctuated between 43.01 and 61.83%

4.2.5.2. Atomic ratio

Increasing period of composting the used organic wastes from 6 to 12 months was associated always with decreases in C/N, C/H, C/O and N/H ratios. This finding is a direct result of the continuous break down of organic carbon with time due to its usage as a source of energy for microorganisms acting on the composted materials. However, it is of importance to indicate that the effect of period of composting of the organic materials on narrowing the above mentioned ratios seemed higher in the humic acid than in the fulvic ones.

Unlike what occurred with C/N, C/H, C/O and N/H ratios, increasing period of composting the organic materials was associated with an obvious increase in O/H ratio of the humic and fulvic acids which could be attributed, as mentioned before, to the prevalence of the oxygened functional groups.

Data in Table (17) reveal that values of atomic ratios C/N, C/H, C/O, O/H, N/H for humic acids after 6 months of composting varied from 19.2-21.2, 9.33-9.8, 1.08-1.18, 8.28-9.11 and 0.46-0.15. the corresponding atomic ratios for after 6 months for fulvic acids ranged from 26.2 to 30.6, 5.48-6.48, 0.71-0.78, 7.83-8.46 and 0.20-0.25, respectively. The respective values for HA after 12 months ranged from 24.9-27.1, 5.07-5.48, 0.57-0.64, 8.31-9.6 and 0.20-0.22 wheras the corresponding values for HA ranged from 17.7-18.8, 8.5-8.63, 0.80-0.94, 9.20-10.2 and 0.44-0.47, respectively.

The C/N ratios of the studied humic and fulvic acids differ according to the nature of the organic residues **(Abd-El-Latif, 1973, Taha 1985 and El-Ghozoli, 1994 and 1998).**

El-Ghozoli (1998) showed that the values of atomic ratios C/N, C/H, C/O, O/H and N/H obtained of humic acids isolated from different organic residues (chicken manure, town refuse, biogas manure and poudratte) ranged from 9.72 to 16.90, 11.3 to 14.8 and 1.24 to 1.86 and from 7.97 to 9.00 and 0.47 to 2.0. However, values of the corresponding atomic ratios for fulvic acid ranged from 13.2 to 19.5, 9.37 to 17.8, 0.80 to 1.16, 8.86 to 22.1 and 0.61 to 0.94, respectively. Whereas **Soliman (1982)** found that the C/N ratio of humic and fulvic acids extracted from composted materials ranged from 11.28 to 16.49, 32.50 to 52.38 and from 15.44 to 19.5, 34.28 to 44.45 for composted Egyptian clover and wheat straw, respectively.

Usually the C/H ratio is considered as a measure for the degree of condensation and humification of aromatic rings in the humic substances **(Kononva, 1966 and Abo El-Fadl, 1992)**

4.3. Tomato seedling production (Exp.II)

To evaluate the efficiency of some types of prepared compost as growing mediums for tomato seedling production, a green house trial was undertaken.

In this experiment four types out of five ones of compost (Table 2) prepared in Exp.(I) were investigated. The investigated four types of compost were represented by four compost piles, all which prepared by composting rice straw (RS), poultry manure (PM) and banana waste (BW) as a ground materials. The prepared growing media were derived by composting the above raw wastes pile compost mixture (Compo.Mix) No. 1 and other three piles with some additional materials i.e. microbial inoculation (pile 2), microbial inoculation +rock phosphate + feldspar (pile 4) and tea compost (pile 5). The four types of compost along with the peatmoss (control treatment, Po) were subjected to either pile washing or unwashing, to compost enriching (fertilization with nutrients or no and to compost mixing with either vermiculite or sand at volumetzie ratio of 1:1 for both materials (mixtures), comprising 54 treatments (Table 7). Tomato seeds (castal rock) were sown on those growing media for 40 days where the following data were obtained.

4.3.1. Growth parameters of tomato seedlings grown in different growing medians

4.3.1.1. Effect on seedling germination

4.3.1.1.1. Main effects:

(1) Effect of compost type (A factor)

Data in Table (19) and fig (10) reveal that, on a general scale, the germination% of tomato seeds after 15 days from sowing as related to growth media type (A) and aside from the other treatments averaged 57.10%.

The most effective type of growing media (63.04 %) was that derived from washed compost pile (2) treated with microorganism inoculants. However it is profitable to observe that the control media

Table (19): Effect of some different growing media with or without or/and enrichment pile washing on Germination (%) of tomato seedlings

A Compost \ Mixture treatment		Mixing components (B) 15 days: 100% No Enr.	100% Enr.	Vermiculite 50% No Enr.	Vermiculite 50% Enr.	Sand 50% No Enr.	Sand 50% Enr.	Mean	Mixing components (B) 30 days: 100% No Enr.	100% Enr.	Vermiculite 50% No Enr.	Vermiculite 50% Enr.	Sand 50% No Enr.	Sand 50% Enr.	Mean
		Germination (%) after 15 days							Germination (%) after 30days						
Peat moss(control		**64.2**	**63.06**	**85.79**	**88.64**	**67.68**	**77.29**	**74.65**	**74.43**	**77.27**	**92.18**	**93.18**	**76.70**	**84.09**	**81.85**
Compost (1)	unwashed	64.20	34.66	91.47	20.34	69.89	12.50	**48.89**	74.43	59.09	94.82	79.55	84.66	52.84	**74.23**
Compost (2)	unwashed	86.93	25.57	80.11	46.59	73.27	13.07	**54.25**	91.47	67.04	90.90	73.29	84.66	73.29	**80.08**
Compost (4)	unwashed	63.97	35.10	76.7	48.86	69.28	22.73	**52.77**	72.16	63.06	88.56	69.32	84.59	63.63	**73.55**
Compost (5)	unwashed	75.98	35.79	84.09	50.00	62.00	21.59	**54.91**	94.12	62.95	89.20	72.73	94.32	65.91	**79.87**
Mean		**72.77**	**32.78**	**83.09**	**41.45**	**68.61**	**17.47**	**52.70**	**83.05**	**63.04**	**90.87**	73.72	**87.06**	**63.92**	**76.94**
Compost (1)	washed	59.09	10.99	89.20	47.72	70.45	63.63	**56.85**	81.25	52.84	94.88	72.16	92.61	80.11	**78.97**
Compost (2)	washed	75.00	44.88	77.27	64.77	77.27	39.77	**63.04**	89.20	72.68	87.50	84.09	87.43	79.55	**83.41**
Compost (4)	washed	63.06	43.75	73.86	67.54	79.54	47.46	**62.53**	76.70	68.18	85.23	78.41	87.23	81.25	**79.72**
Compost (5)	washed	71.59	51.13	71.02	68.18	68.75	50.26	**62.48**	86.93	71.59	82.79	80.68	89.70	84.66	**82.71**
Mean		**67.16**	**37.69**	**77.84**	**62.05**	**74.00**	**50.28**	**61.50**	**83.52**	**66.32**	**87.6**	78.83	**89.24**	**81.39**	**81.20**
Grand mean		**79.97**	**35.24**	**80.48**	**51.75**	**71.31**	**33.88**	**57.10**	83.29	64.68	89.24	76.28	88.15	72.66	79.07
		Means of enrichment							**Means of enrichment**						
Unfertilized		67.04		82.24		70.09		**73.12**	80.33		90.22		84.33		**84.96**
Fertilized		44.51		64.05		48.35		**52.30**	68.88		81.91		76.47		**75.75**
Mean		**55.77**		**73.15**		**59.22**		**62.95**	**74.61**		**86.07**		**80.40**		**80.36**
LSDat 0.05		A= 1.916	B=2.347	C= 4.065	AxB= 4.30	AxC= 6.32	BxC=6.764	AxBxC= 8.428	A=0.977	B= 1.196	C= 2.073	AxB= 2.175	AxC= 3.10	BxC=3.329	AxBxC= 4.526

Comp. = Compost mixtiure [Rice straw (RS) + Banana wastes (BW) + Poultry manure (PM)]
Comp. Mix1 = (RS+BW+ PM)
Comp. Mix2 = (RS+BW+ PM) + add. microbial
Comp. Mix (4) = (RS +BW+PM) +add.microbial and natural mineral
Comp. Mix(5) = (RS+BW+PM) + compost tea

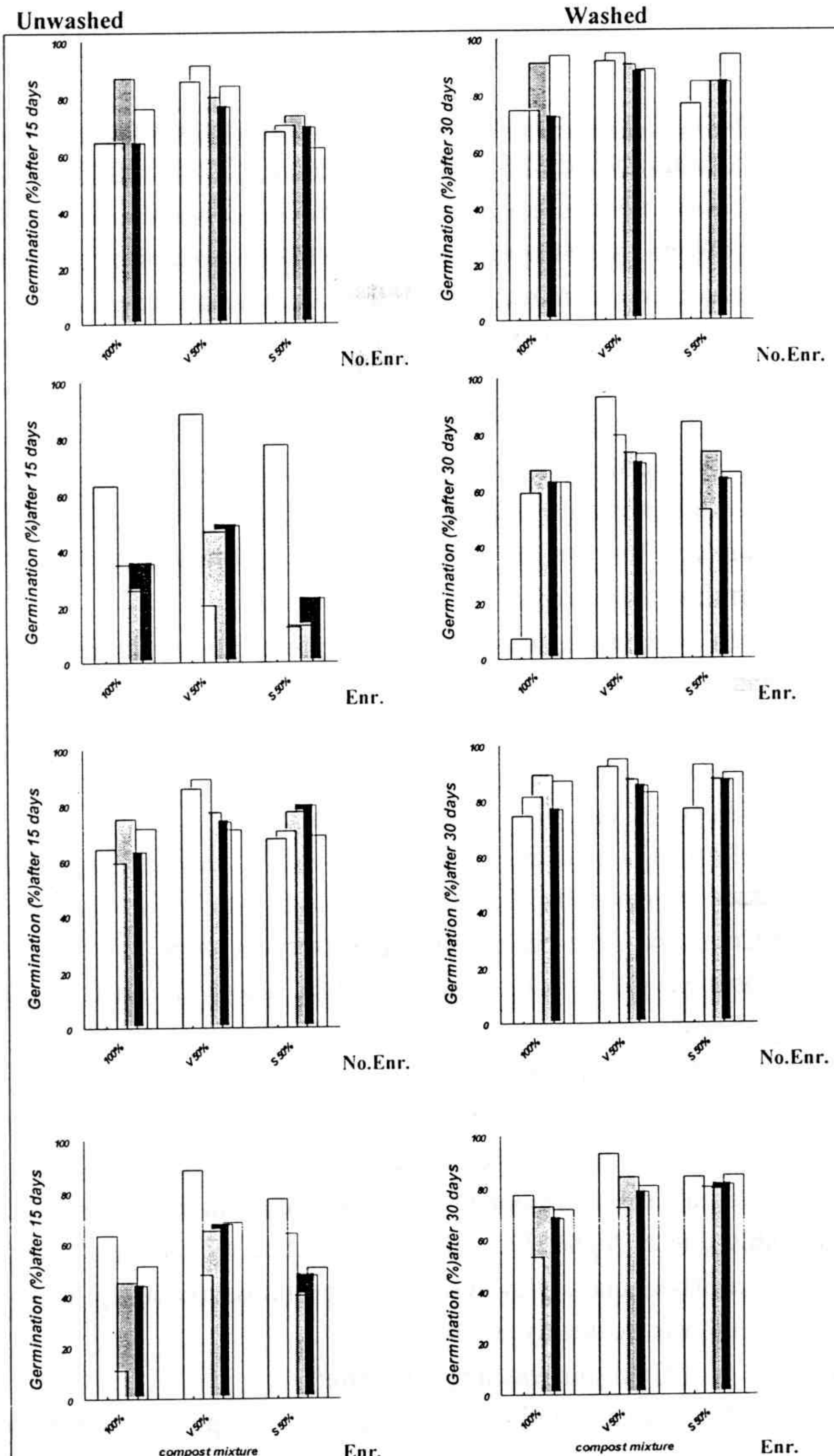


Fig (10): Effect of some different media with or without nutrients enrichment on germination (%) of tomato seedlings.

(Peatmoss, P0), surpassed all the other types of growing media either washed or unwashed with an overall average of 74.65% (G P)

Such trend seemed logic as the seed germination depends essentially on the biology of seed as well as the suitability of seed bad as a growing media rather than the fertility of the growing media.

As for the germination % (gp) after 30 days from seed sowing, also growing media of washed compost pile (2) showed the highest GP(83.41) of tomatos seeds, this average value, however, dose not differ significantly from neither the (GP) average value (82.71%) of the growing media derived from washed compost (5) treated with tea compost nor from the peatmoss control media(P0) was 81.85% where the germination % was 81.5%

In conclusion, the tested growing medians according to their inducing effect on germination % after 30 days from sowing, could be arranged descending in the order: Comp.Mix 2 (washed)> Comp. Mix. 4 (washed)> peatmoss> Com.Mix.2 (Unwashed).

(2) Effect of Com.Mix. components (B factor)

Results, on average, reveal that while the Verm-Comp.Mix surpassed dramatically the other two Comp.Mix's (No mixing and sand-Com.Mix.), the corresponding differences were so close at 30 days data especially with sand-Comp.Mix where the difference was insignificant.

(3) Effect Comp. Mix. enrichment

Result indicates that, on both an average and individual values scale, the germination % under uneriched Comp.Mix. sandly surpassed all the corresponding values under enriched Comp.Mixs, probably due to higher EC values of enriched medians compared to the unenriched ones. However under peatmoss (control) treatment such trend was frequently absent.

(4) Effect of Com.pils washing (D factor)

Mostly significantly but not entirely comp.pil washing induced the germin.% of tomato seeds in many acerage values but under many other cases the reverse was true.

4.3.1.1.2. Interaction effect

Results in Table (19) reveal that the highest values of germination percentage of tomato seeds under unwashed compost, after 15 days from seed sowing i.e. 91.47%, 89.20% and 88.64% accurred under not enriched vermin-Comp.Mix No.(1) that received no additions at all followed by the same type of washed, enriched Verm-Comp mix (No.1) and enrich Verm-Peatmoss (Po) Mix, respectively.

As for the germination % after 30 days from sowing, the highest values; 94.88, 94.82, 94.32, 94.12, 93.18, 92.61% and 92.18% G.P., occurred by using washed but not enriched Verm-Comp.Mix No.(1), not washed and not enriched sand-Com Mix(No.5), Neither washed nor enriched 100% Comp pile (No 5), enriched peatmoss (control)- sand Mix, No enriched Sand-Comp Mix (No.1) and non enriched Verm-Peatmoss (control) Mix, respectively.

Such results with such variations could be attributed to the different characteristics of growing media from one hand and to the biology of the germinated seeds from the other hand.

4.3.1.2. Effects on tomato seedling dimensions

4.3.1.2.1.Main effects

Data in Table (20) shown in Fig (11) reveal that the obtained results for seeding length and seedling stem in general, are very close together in most cases. However the main findings could be summarized in the following:

(1) The most efficient growing medians are the Peatmoss (Po), unwashed Comp Mix (No. 4) and washed Comp Mix.(No.5) showing stem diameter values of 3.99, 3.99 and 3.97 mm, respectively.

(2) The Verm-Comp Mix effect surpassed significant those due Sand Com Mix. and the no mixing treatment with mean values of 4.16, 375 and 371 mm, respectively.

Table (20): Effect of some different growing media with or without or/and enrichment pile washing on seedling length and stem diameter of tomato seedlings(Shoot + Root)

(A) Compost \ Mixture treatment		Mixing components (B): 100% No Enr.	100% Enr.	Vermiculite 50% No Enr.	Vermiculite 50% Enr.	Sand 50% No Enr.	Sand 50% Enr.	Mean
		Seedling length (cm)						
Peat moss(control)		24.82	25.22	33.55	25.85	26.93	26.02	27.06
Compost (1)	unwashed	22.8	15.43	35.30	29.10	31.53	16.25	25.45
Compost (2)	unwashed	25.63	17.33	28.93	21.95	24.68	16.18	22.41
Compost (4)	unwashed	25.15	18.55	29.75	25.38	30.78	28.40	26.34
Compost (5)	unwashed	32.35	18.72	28.30	23.90	32.23	18.43	25.24
Mean		26.48	17.50	30.57	25.08	29.81	19.82	24.86
Compost (1)	washed	23.33	12.78	37.28	21.23	29.18	28.95	25.45
Compost (2)	washed	25.83	26.75	29.58	26.43	26.00	25.93	26.75
Compost (4)	washed	27.35	26.93	35.20	25.28	25.60	25.93	27.71
Compost (5)	washed	27.25	24.70	34.78	24.08	26.68	25.95	27.24
Mean		25.94	22.79	34.21	24.26	26.87	26.69	26.79
Grand mean		26.21	20.15	32.39	24.67	28.33	28.26	26.67

Means of enrichment

	100%	Vermiculite 50%	Sand 50%	Mean
Unfertilized	26.25	32.78	27.87	28.97
Fertilized	21.84	25.06	24.18	23.69
Mean	24.05	28.92	26.03	26.33
LSDat 0.05	A= 0.455 B=0.557 C= 0.965 AxB= 1.11	AxC= 1.44 BxC=1.55 AxBxC= 2.01		

Mixing components (B): 100% No Enr.	100% Enr.	Vermiculite 50% No Enr.	Vermiculite 50% Enr.	Sand 50% No Enr.	Sand 50% Enr.	Mean
Stem diameter (mm)						
3.3	4.0	3.8	4.0	4.0	4.9	3.99
3.5	3.2	4.5	3.8	4.0	3.1	3.81
3.7	3.7	4.1	3.7	3.7	3.9	3.90
4.1	4.0	4.1	3.9	3.6	3.6	3.99
3.9	4.0	4.2	4.1	3.8	3.9	3.76
3.8	3.73	4.23	3.87	3.78	3.63	3.84
3.2	3.2	4.8	4.0	3.6	3.8	3.90
4.1	3.7	4.2	4.0	3.7	3.8	3.91
3.8	3.5	4.3	4.1	3.8	4.0	3.88
4.2	3.4	4.7	4.0	3.9	3.7	3.97
3.83	3.45	4.5	4.03	3.75	3.83	3.90
3.82	3.59	4.37	3.95	3.77	3.73	3.87

Means of enrichment

100%	Vermiculite 50%	Sand 50%	Mean
3.64	4.18	3.84	3.89
3.73	3.97	4.12	3.94
3.69	4.08	3.98	3.91

A=0.061 B= 0.074 C= 0.129 AxB= 0.145
AxC= 0.21 BxC=0.23 AxBxC= 2.66

Comp. = Compost mixtiure [Rice straw (RS) + Banana wastes (BW) + Poultry manure (PM)]
Comp. Mix1 = (RS+BW+ PM)
Comp. Mix2 = (RS+BW+ PM) + add. microbial
Comp. Mix (4) = (RS +BW+PM) +add.microbial and natural mineral
Comp. Mix(5) = (RS+BW+PM) + compost tea

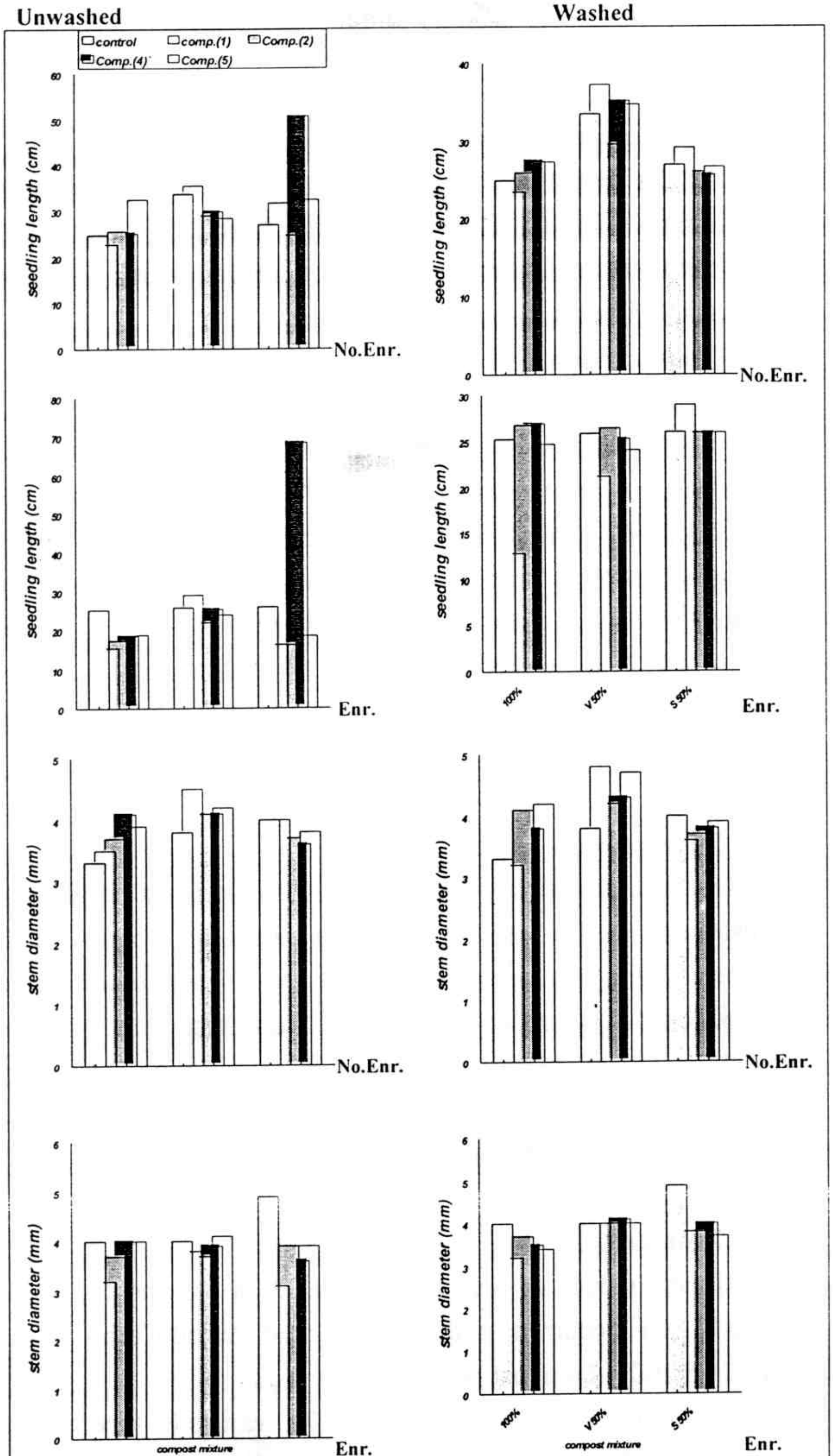


Fig (11): Effect of some different media with or without nutrients enrichment on seedling length and stem diameter of tomato seedlings.

Effect of compost washing

Results reveal that washing the compost pile tended to induce the tomato seedling length, an average, from 24.86 cm to 26.79 cm and stem ø from 3.84 mm to 3.97 mm/seedling stem.

4.3.1.2.2. Interaction effects

A x B interaction

Results of the interaction between the type of growing media (A) with Comp Mix components (B) indicate that the highest value of seedling length average 30.73 cm /seedling accured under Verm-Comp Mix. No.1 while the lowest value (18.82 cm) occurred under Comp Mix No.1 without mixing neither with Vermic nor without. On the other hand, while the least stem ø (3.28 mm/S) occurred with Comp Mix No. 5 like the seedling length, the highest stem ø value (4.45 mm) was produced under the Sand-Comp Mix.

A x C interaction

The interaction of Comp Mix with compost enrichment is illustrated in the highest value of seedling length 31.75 cm occurred with enriched Comp Mix. No. 4 while the least one (20.62 cm) occurred under enriched Com-Mix No. 1. As for the seedling stem ø, the highest value 4.3 cm and the lowest one 3.25 cm occurred under enriched peatmoss (control Po) and enriched Comp Mix No. 4, respectively.

B x C Interaction

Highest values of seedling length 32.78 cm and the least one (21.84 cm) occurred under unenriched Verm-Comp Mix and enriched 100% compost respectively.

The highest (4.18cm) and least (3.73) values of seedling stem ø occurred under unriched Verm-Comp Mix. and enriched 100% Comp Mix., respectively.

A x B x C interaction

Two level of interaction may suggest that the most promising treatments of growing media for producing longer seedling (37.28 cm/S), and thickens stem (4.9 mm/S) of tomato seedling could be washed Ver-Comp Mix No.1 with out enrichment and sand-Petmoss (control) Mix (enriched), respectively.

The next promising treatments however, could be unwashed, No enriched Verm-Comp Mix No.1, washed no enriched Verm-Comp Mix.No. and Comp pile (5) under the same treatments but washed, they showed seedling length of about 35.30 and 35.20 cm, respectively. In other words all the best three treatments with respect to seedling length are no enriched Comp Mix either washed (Com No 1&5) or un washed (Comp Mix No 1).

4.3.1.3. Dry and fresh weights of seedling roots

Results in Table 21 and fig. 12 indicate the following for roots dry weight of tomato seedling under the tested treatments.

4.3.1.3.1. Main effects:

(1) Peatmoss (control) was the most effective growing media yield roots having average dry weights of 151 mg followed by Comp pile (No) which received no additive at all with weight average of 93.88 mg/S. The other types of compost were of lower effect with seedling weight varying from 76.77 with Comp 1 (washed) up to 93.81 with Comp unwashed.

(2) The most effective growth media components Mix , was that containing Vermiculite either with peatmoss or with any prepared comp. showing average dry weight values 117.54 mg with Vermiculite Mix. 69.15 for Sand-comp.Mix and 61.76 mg for no mix compost media activity.

(3) The uneriched treatment yield an average dry weight value of root seedling of about 132.28mg/S compared to 84.08 mg with enrichment compost.

Table (21): Effect of some different growing media with or without or/and enrichment pile washing on fresh and dry weight of tomato seedlings root

Mixture treatment / A Compost		Mixing components (B) 100% No Enr.	100% Enr.	Vermiculite 50% No Enr.	Vermiculite 50% Enr.	Sand 50% No Enr.	Sand 50% Enr.	Mean	Mixing components (B) 100% No Enr.	100% Enr.	Vermiculite 50% No Enr.	Vermiculite 50% Enr.	Sand 50% No Enr.	Sand 50% Enr.	Mean
		(Root) Fresh weight (g/seedling)							(Root) Dry weight (mg/seedling)						
Peat moss(control)		**0.257**	**0.345**	**0.233**	**0.267**	**0.395**	**0.355**	**0.31**	69.26	**74.75**	**265.75**	**123.75**	**183.75**	**191.75**	**151.41**
Compost (1)	unwashed	0.177	0.185	1.045	0.298	0.357	0.150	**0.37**	44.25	50.00	252.75	62.25	103.75	50.250	**93.88**
Compost (2)	unwashed	0.402	0.103	0.425	0.215	0.355	0.143	**0.27**	91.00	35.00	148.75	67.25	116.25	31.00	**81.46**
Compost (4)	unwashed	0.283	0.192	0.357	0.310	0.315	0.183	**0.27**	82.75	49.75	123.00	65.00	109.50	45.25	**79.21**
Compost (5)	unwashed	0.295	0.225	0.453	0.300	0.390	0.180	**0.31**	85.25	57.50	128.50	66.00	128.50	35.00	**83.46**
Mean		**0.289**	**0.176**	**0.570**	**0.281**	**0.354**	**0.164**	**0.306**	**75.81**	**48.06**	**163.25**	**65.13**	**114.5**	**40.38**	**84.50**
Compost (1)	washed	0.165	0.110	0.437	0.137	0.315	0.245	**0.23**	59.00	35.00	123.75	44.50	109.50	84.75	**76.37**
Compost (2)	washed	0.213	0.287	0.305	0.290	0.235	0.173	**0.25**	53.75	74.75	167.25	134.00	52.00	63.00	**90.79**
Compost (4)	washed	0.257	0.357	0.440	0.408	0.135	0.170	**0.30**	69.50	45.50	151.00	124.50	28.00	39.75	**76.38**
Compost (5)	washed	0.275	0.297	0.502	0.330	0.250	0.212	**0.31**	80.00	65.50	132.25	97.75	67.00	42.75	**80.87**
Mean		**0.228**	**0.263**	**0.421**	**0.291**	**0.234**	**0.200**	**0.273**	**65.56**	**55.19**	**143.56**	**100.19**	**64.13**	**57.56**	**81.10**
Grand mean		0.259	0.220	0.496	0.286	0.294	0.182	0.290	70.69	51.13	153.41	82.66	89.32	48.97	82.80
		Means of enrichment							**Means of enrichment**						
Unfertilized		**0.258**		**0.408**		**0.327**		**0.331**	**70.21**		**205.85**		**120.79**		**132.28**
Fertilized		**0.261**		**0.279**		**0.239**		**0.259**	**59.33**		**96.35**		**96.56**		**84.08**
Mean		**0.260**		**0.344**		**0.283**		**0.296**	**64.77**		**151.10**		**108.68**		**108.18**
LSDat 0.05		A= 0.005 AxC= 0.022	B=0.059 BxC=0.11	C= 0.103 AxBxC= 0.18	AxB= 0.0.06				A=1.262 AxC= 3.87	B= 1.546 BxC=4.156	C= 2.60 AxBxC= 5.422	AxB= 2.83			

Comp. = Compost mixtiure [Rice straw (RS) + Banana wastes (BW) + Poultry manure (PM)]
Comp. Mix1 = (RS+BW+ PM)
Comp. Mix2 = (RS+BW+ PM) + add. microbial
Comp. Mix (4) = (RS +BW+PM) +add.microbial and natural mineral
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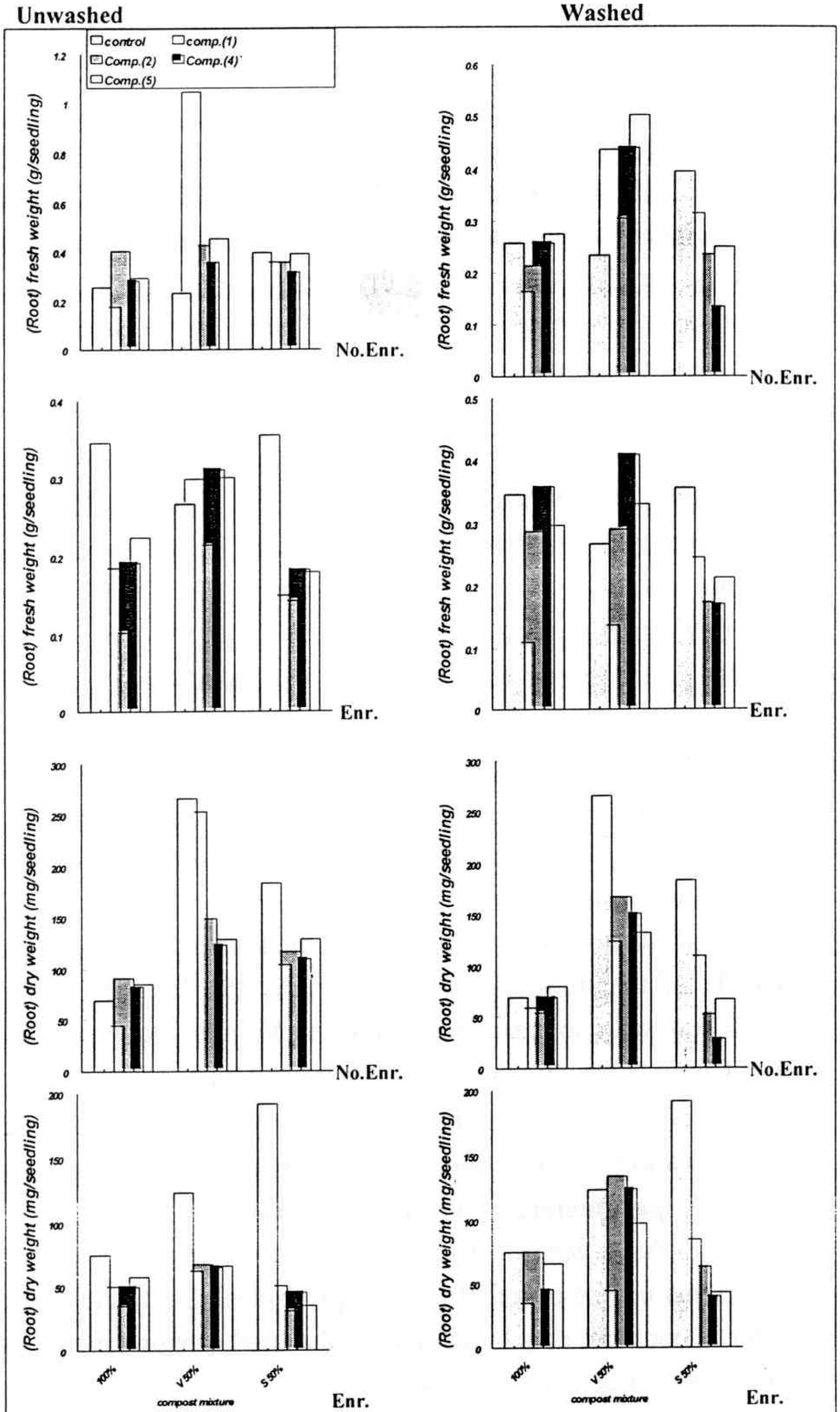


Fig (12): Effect of some different media with or without nutrients enrichment on root fresh and dry weight of tomato seedlings.

4.3.1.3.2.Interactions

The AB interaction reveal that growth media containing Vermiculite either control (Peatmoss) or compost was of the most synergistic effect on seedling dry weight with highest values with Peatmoss (194.75) and 129.32 with Comp 2. The Sand-Peatmoss and Sand-Comp mixtures showed maximum values of 187.75 and 87.07, respectively.

The AC interaction showed the superiority of the combined treatments of Peatmoss with unenrichment. The second and third effective treatments were enriched Peatmoss and the unenriched Comp (No. 1) with average values of 172.92, 130.08 and 115.0 mg D.W/seedling root.

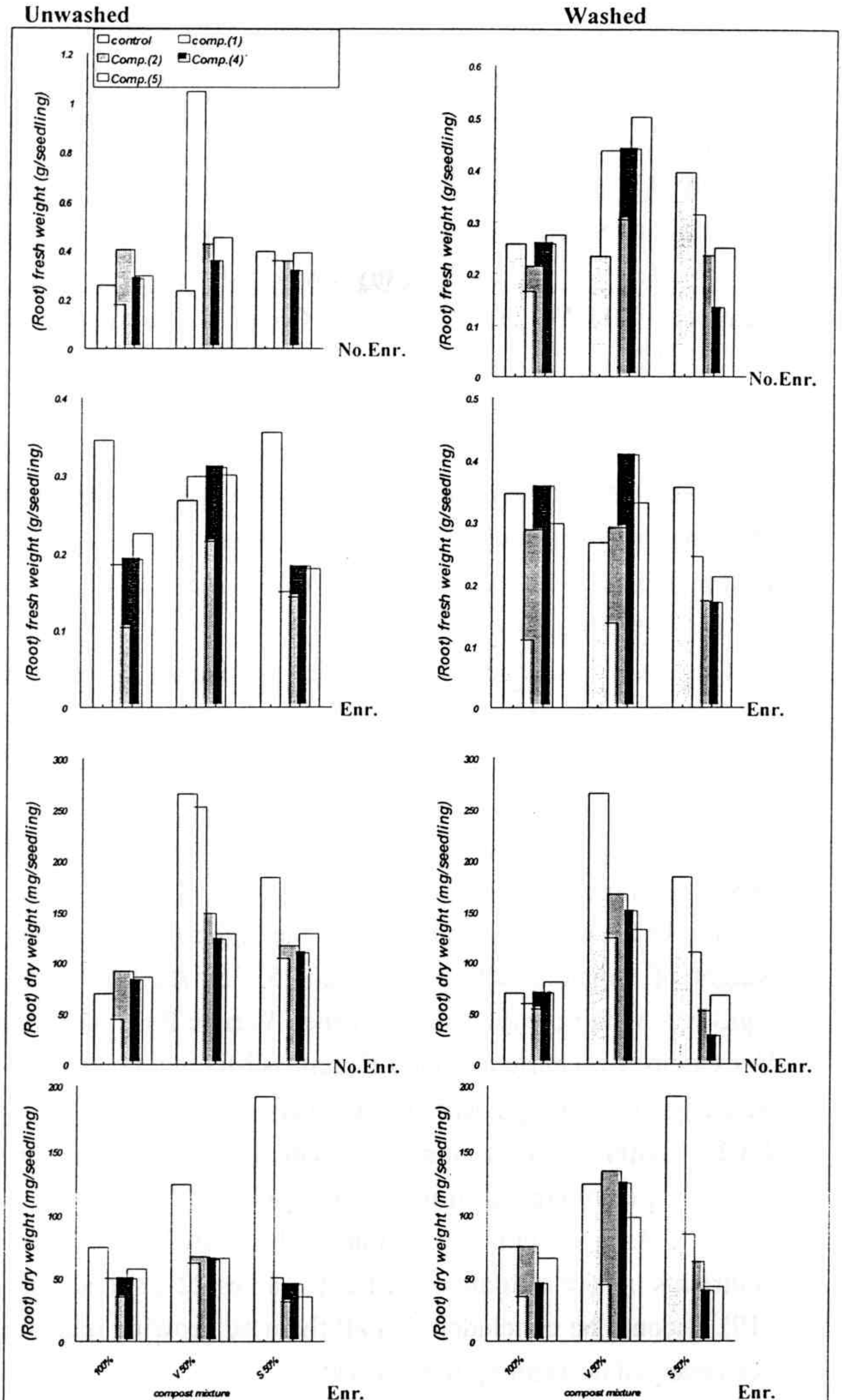
The BC interaction showed in particular a very sound synergistic effect with unenriched Vermi-CompMix followed by Sand-Comp Mix with average values of seedling root D.W. of 205.85 and 120.79 respectively either compared with corresponding enrich ones 96.35 and 96.56, respectively with no mixed compost (70.21).

The ABC interaction indicate that the highest values of root dry weight of tomato seedling were 265.75, 252.75, 18375 and 167 mg/S root with no enriched, no washed Vermic-Peatmoss Mix and Ver Comp. 1 no enriched Sand-Peatmoss Mix and no enriched but washed Vermi-Comp 2 Mix, respectively.

4.3.2. General discussion and conclusion of the growth parameters and nutrients uptake.

As a general discussion of the growth parameters and nutrients uptake of tomato seedlings Tables(22-28) and Figs (13-19), it could be concluded that all the used growing media could be arranged descending in the order:

Verm. Peatmoss Mix > Peatmoss-Sand Mix. Peatmoss 100%(control and Comp-Sand Mix



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Verm. Peatmoss Mix > Peatmoss-Sand Mix. Peatmoss 100%(control and Comp-Sand Mix

Table (22): Effect of some different growing media with or without or/and enrichment pile washing on nitrogen uptake by tomato seedlings

(Shoot) N as uptake (mg/seedling)

Mixture treatment / A Compost		Mixing components (B)						Mean
		100%		Vermiculite 50%		Sand 50%		
		Enrichment (C)						
		No Enr.	Enr.	No Enr.	Enr.	No Enr.	Enr.	
Peat moss(control		**3.07**	**2.43**	**6.97**	**7.49**	**5.93**	**8.12**	**5.66**
Compost (1)	unwashed	4.31	2.34	9.35	4.79	6.43	2.58	**4.96**
Compost (2)	unwashed	6.87	2.59	6.58	3.25	6.86	2.69	**4.78**
Compost (4)	unwashed	6.23	4.18	7.91	3.91	5.29	2.38	**5.01**
Compost (5)	unwashed	12.91	3.38	7.12	5.13	9.12	2.71	**6.64**
Mean		**7.58**	**3.12**	**7.74**	**4.27**	**6.93**	**2.59**	**5.35**
Compost (1)	washed	3.68	2.05	12.81	3.79	6.39	6.49	**5.84**
Compost (2)	washed	7.07	5.51	11.39	5.03	6.66	2.99	**6.44**
Compost (4)	washed	5.52	4.94	15.67	5.56	9.00	4.78	**7.56**
Compost (5)	washed	6.59	5.50	13.10	6.35	5.89	3.68	**6.85**
Mean		**5.72**	**4.50**	**13.24**	**5.18**	**6.99**	**4.49**	**6.68**
Grand mean		**6.65**	**3.81**	**10.49**	**4.73**	**6.96**	**3.54**	6.02
Means of enrichment								
Unfertilized		5.46		9.32		6.62		**7.13**
Fertilized		3.35		5.65		5.07		**4.69**
Mean		**4.41**		**7.48**		**5.84**		**5.91**
LSDat 0.05		A= 0.093 B=0.116 C= 0.200 AxB= 0.211 AxC= 0.212 BxC=0.321 AxBxC= 0.421						

(Root) N as uptake (mg/seedling)

Mixture treatment / A Compost		Mixing components (B)						Mean
		100%		Vermiculite 50%		Sand 50%		
		Enrichment (C)						
		No Enr.	Enr.	No Enr.	Enr.	No Enr.	Enr.	
Peat moss(control		**1.32**	**1.44**	**3.87**	**2.23**	**2.54**	**2.37**	**2.3**
Compost (1)	unwashed	0.85	0.75	7.11	0.91	1.68	0.63	**1.98**
Compost (2)	unwashed	1.67	0.53	2.75	0.89	1.69	0.39	**1.31**
Compost (4)	unwashed	1.34	0.76	2.09	0.99	1.62	0.60	**1.23**
Compost (5)	unwashed	1.40	0.89	2.11	0.95	1.88	0.47	**1.28**
Mean		**1.32**	**0.73**	**3.52**	**0.94**	**1.72**	**0.52**	**1.46**
Compost (1)	washed	0.99	0.48	2.12	0.63	1.51	1.00	**1.12**
Compost (2)	washed	0.93	0.99	2.92	1.16	0.78	0.77	**1.25**
Compost (4)	washed	1.14	0.64	2.31	1.69	0.44	0.47	**1.11**
Compost (5)	washed	1.33	0.91	1.97	1.35	1.00	0.52	**1.17**
Mean		**1.10**	**0.76**	**2.33**	**1.21**	**0.93**	**0.69**	**1.17**
Grand mean		**1.21**	**0.75**	**2.93**	**1.08**	**1.33**	**0.61**	1.32
Means of enrichment								
Unfertilized		1.25		3.24		1.73		**2.07**
Fertilized		0.98		1.46		1.19		**1.21**
Mean		**1.12**		**2.35**		**1.46**		**1.94**
LSDat 0.05		A=0.033 B= 0.041 C= 0.071 AxB= 0.075 AxC= 0.105 BxC=0.113 AxBxC= 0.154						

Comp. = Compost mixtiure |Rice straw (RS) + Banana wastes (BW) + Poultry manure (PM)|
Comp. Mix1 = (RS+BW+ PM) Comp. Mix (4) = (RS +BW+PM) +add.microbial and natural mineral
Comp. Mix2 = (RS+BW+ PM) + add. microbial Comp. Mix(5) = (RS+BW+PM) + compost tea

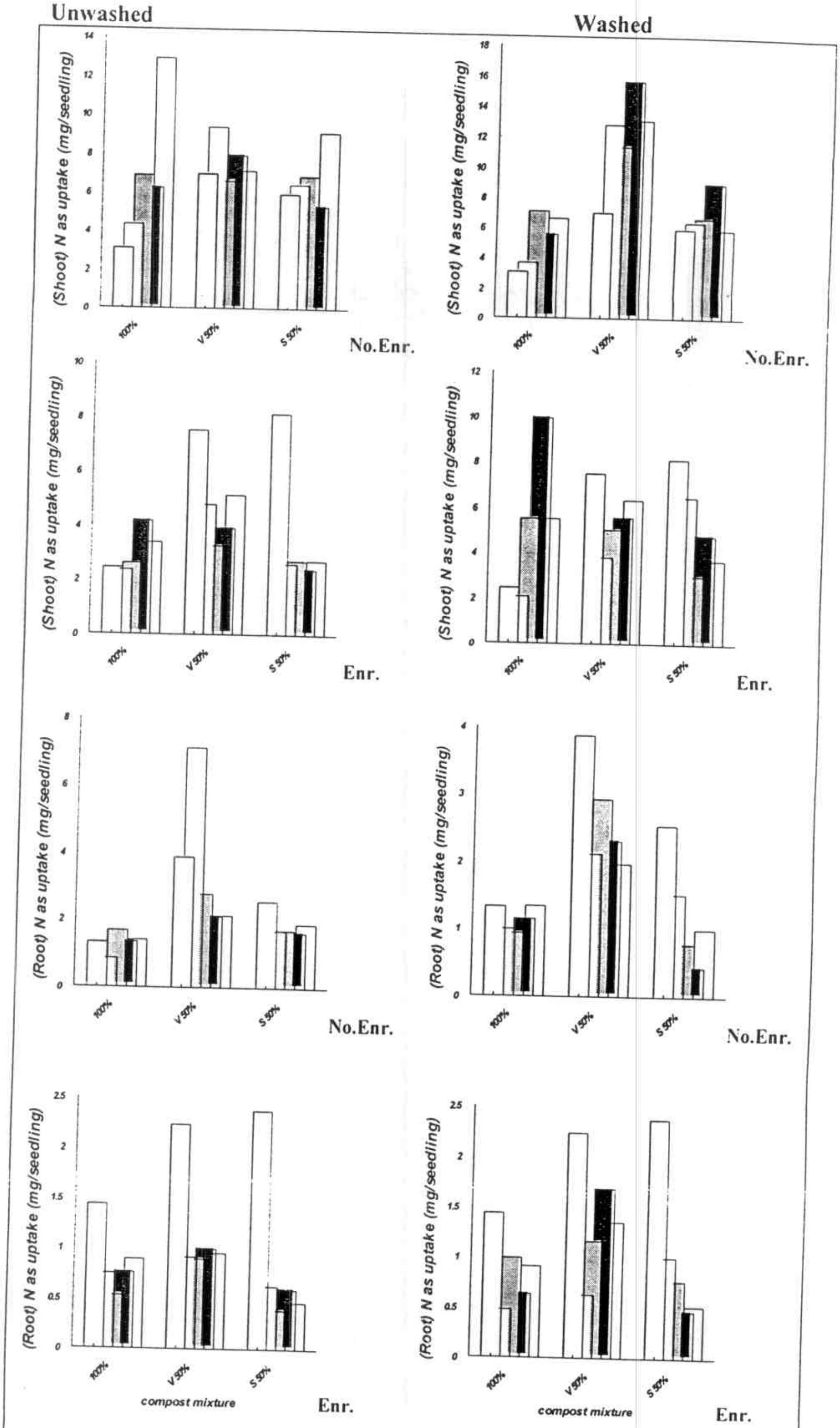

Fig (13): Effect of some different media with or without nutrients enrichment on nitrogen uptake of tomato seedlings.

Table (23): Effect of some different growing media with or without nutrient enrichment on Phosphorus uptake by tomato seedlings

Mixture treatment / A Compost		Mixing components (B)						Mean
		100%		Vermiculite 50%		Sand 50%		
		Enrichment (C)						
		No Enr.	Enr.	No Enr.	Enr.	No Enr.	Enr.	
		(Shoot) P as uptake (mg/seedling)						
Peat moss(control		**0.68**	**1.19**	**0.98**	**2.01**	**1.00**	**1.36**	**1.22**
Compost (1)	unwashed	0.96	0.42	2.08	1.11	1.13	0.41	**1.01**
Compost (2)	unwashed	1.33	0.56	1.44	0.67	0.96	0.49	**0.91**
Compost (4)	unwashed	1.05	0.84	1.52	0.83	0.99	0.45	**0.94**
Compost (5)	unwashed	2.42	0.56	1.76	1.02	1.21	0.46	**1.24**
Mean		**1.44**	**0.60**	**1.70**	**0.91**	**1.07**	**0.45**	**1.03**
Compost (1)	washed	0.74	0.45	2.69	0.80	0.68	1.16	**1.09**
Compost (2)	washed	1.44	1.04	1.85	1.13	0.95	0.54	**1.16**
Compost (4)	washed	1.30	0.88	2.94	1.29	1.35	0.84	**1.43**
Compost (5)	washed	1.33	1.02	1.97	1.41	0.92	0.74	**1.22**
Mean		**1.20**	**0.85**	**2.36**	**1.16**	**0.98**	**0.82**	**1.23**
Grand mean		**1.32**	**0.73**	**2.03**	**1.04**	**1.02**	**0.64**	**1.13**
		Means of enrichment						
Unfertilized		1.11		1.68		1.02		**1.27**
Fertilized		0.88		1.36		0.88		**1.04**
Mean		**0.99**		**1.52**		**0.94**		**1.16**
LSDat 0.05		A= 0.019 B=0.023 C= 0.04 AxB= 0.042 AxC= 0.059 BxC=0.063 AxBxC= 0.092						

Mixture treatment / A Compost		Mixing components (B)						Mean
		100%		Vermiculite 50%		Sand 50%		
		Enrichment (C)						
		No Enr.	Enr.	No Enr.	Enr.	No Enr	Enr.	
		(Root) Pas uptake (mg/seedling)						
Peat moss(control		**0.39**	**0.58**	**1.69**	**0.98**	**0.93**	**1.03**	**0.98**
Compost (1)	unwashed	0.29	0.37	2.99	0.49	0.57	0.35	**0.85**
Compost (2)	unwashed	0.65	0.26	0.91	0.51	0.62	0.61	**0.52**
Compost (4)	unwashed	0.51	0.34	0.87	0.46	0.63	0.24	**0.51**
Compost (5)	unwashed	0.62	0.40	0.90	0.49	0.73	0.18	**0.55**
Mean		**0.52**	**0.34**	**1.42**	**0.49**	**0.64**	**0.35**	**0.62**
Compost (1)	washed	0.49	0.25	0.75	0.32	0.53	0.44	**0.46**
Compost (2)	washed	0.47	0.51	0.97	0.70	0.25	0.31	**0.54**
Compost (4)	washed	0.40	0.31	0.88	0.89	0.13	0.19	**0.49**
Compost (5)	washed	0.44	0.44	0.77	0.69	0.32	0.21	**0.48**
Mean		**0.45**	**0.38**	**0.84**	**0.64**	**0.31**	**0.29**	**0.49**
Grand mean		**0.49**	**0.36**	**1.13**	**0.57**	**0.48**	**0.32**	0.55
		Means of enrichment						
Unfertilized		0.45		1.32		0.63		**0.80**
Fertilized		0.43		0.71		0.56		**0.57**
Mean		**0.44**		**1.01**		**0.60**		**0.69**
LSDat 0.05		A=0.017 B= 0.021 C= 0.039 AxB= 0.041 AxC= 0.056 BxC=0.061 AxBxC= 0.081						

Comp. = Compost mixtiure [Rice straw (RS) + Banana wastes (BW) + Poultry manure (PM)]
Comp. Mix1 = (RS+BW+ PM)
Comp. Mix (4) = (RS +BW+PM) +add.microbial and natural mineral
Comp. Mix2 = (RS+BW+ PM) + add. microbial
Comp. Mix(5) = (RS+BW+PM) + compost tea

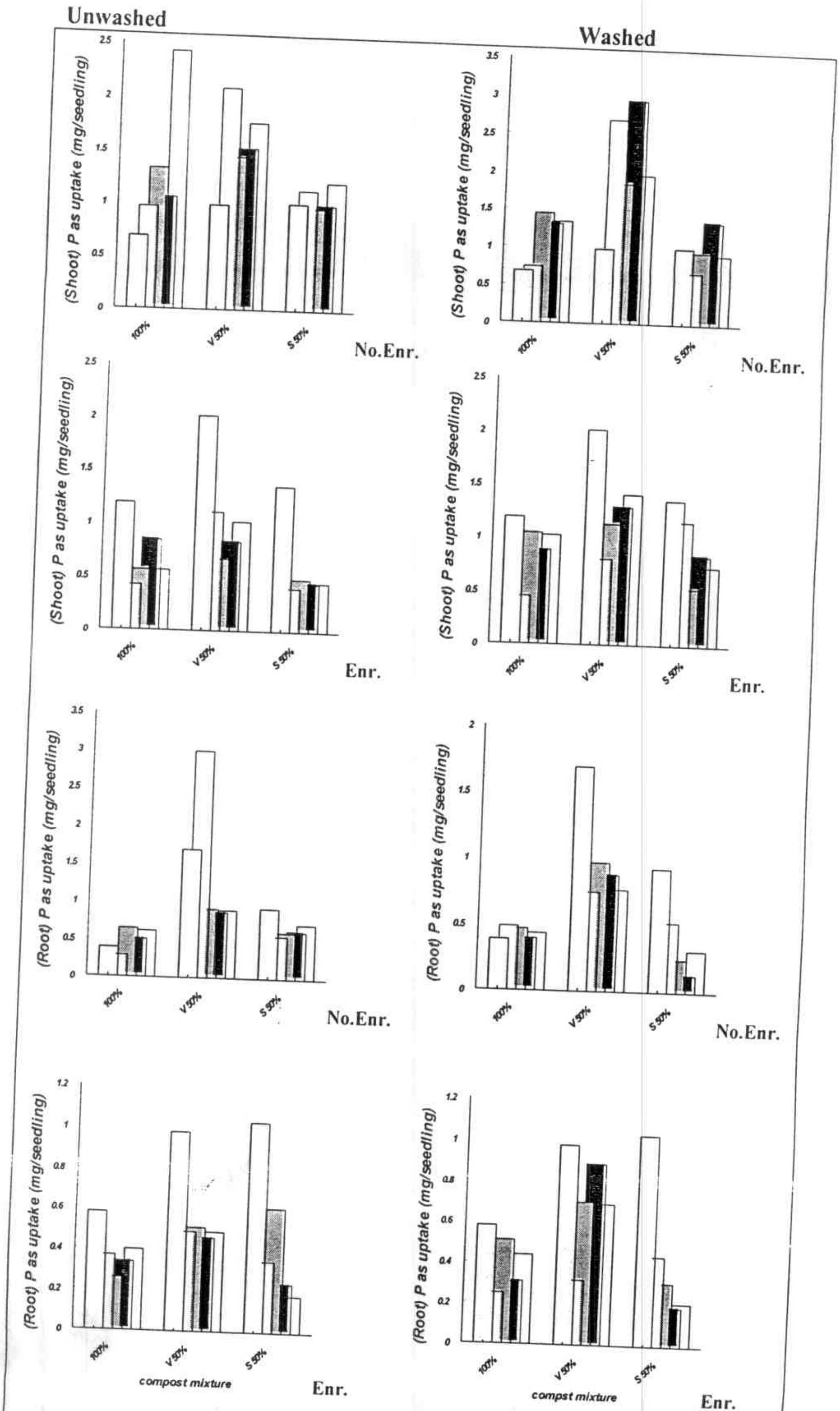

Fig (14): Effect of some different media with or without nutrients enrichment on phosphorus uptake of tomato seedlings.

Table (24): Effect of some different growing media with or without or/and enrichment pile washing on potassium uptake by tomato seedlings.

Mixture treatment / A Compost		Mixing components (B) 100%		Vermiculite 50%		Sand 50%		Mean
		Enrichment (C)						
		No Enr.	Enr.	No Enr.	Enr.	No Enr.	Enr.	
		(Shoot) K as uptake (mg/seedling)						
Peat moss(control		**3.33**	**4.13**	**4.10**	**6.58**	**4.84**	**4.09**	**4.51**
Compost (1)	unwashed	3.70	1.51	7.11	4.22	5.24	1.62	**3.90**
Compost (2)		5.63	2.06	5.75	2.72	4.58	2.12	**3.80**
Compost (4)		4.25	3.22	7.48	3.31	4.43	1.87	**4.09**
Compost (5)		9.07	2.21	6.34	4.07	5.99	1.91	**4.94**
Mean		**5.66**	**2.25**	**6.67**	**3.58**	**5.06**	**1.88**	**4.18**
Compost (1)	washed	3.27	1.63	11.16	3.15	4.29	4.64	**4.52**
Compost (2)		5.54	4.11	5.69	2.03	6.68	3.42	**4.58**
Compost (4)		5.79	3.40	10.93	4.79	6.64	3.20	**5.79**
Compost (5)		6.61	4.01	8.68	5.08	4.35	2.65	**5.24**
Mean		**5.30**	**3.29**	**9.12**	**3.76**	**5.49**	**3.48**	**5.03**
Grand mean		**5.48**	**2.77**	**7.90**	**3.67**	**5.28**	**2.65**	**4.62**
		Means of enrichment						
Unfertilized		4.76		6.63		5.13		**5.50**
Fertilized		3.22		4.64		3.15		**3.67**
Mean		**3.99**		**5.64**		**4.14**		**4.57**
LSDat 0.05		A= 0.083 B=0.102 C= 0.176 AxB= 0.191 AxC= 0.0.262 BxC=0.281 AxBxC= 0.363						

Mixture treatment / A Compost		Mixing components (B) 100%		Vermiculite 50%		Sand 50%		Mean
		Enrichment (C)						
		No Enr.	Enr.	No Enr.	Enr.	No Enr	Enr.	
		(Root) K as uptake (mg/seedling)						
Peat moss(control		**0.69**	**0.89**	**0.91**	**1.55**	**1.57**	**2.14**	**1.29**
Compost (1)	unwashed	0.48	0.67	3.73	0.60	1.44	0.72	**1.27**
Compost (2)		1.20	0.42	1.60	0.72	1.39	0.46	**0.96**
Compost (4)		0.93	0.59	1.22	0.69	1.15	0.61	**0.86**
Compost (5)		1.18	0.69	1.35	0.69	1.35	0.50	**0.96**
Mean		**0.95**	**0.59**	**1.98**	**0.68**	**1.33**	**0.57**	**1.02**
Compost (1)	washed	0.71	0.50	1.33	0.57	1.41	0.70	**0.92**
Compost (2)		0.77	1.12	1.68	1.07	0.73	0.99	**1.02**
Compost (4)		1.01	0.54	1.53	1.61	0.35	0.55	**0.93**
Compost (5)		1.19	0.83	1.36	1.16	0.83	0.56	**0.98**
Mean		**0.92**	**0.75**	**1.48**	**1.10**	**0.83**	**0.70**	**0.96**
Grand mean		**0.94**	**0.67**	**1.73**	**0.89**	**1.08**	**0.64**	**0.99**
		Means of enrichment						
Unfertilized		0.85		1.46		1.24		**1.18**
Fertilized		0.74		1.11		1.14		**1.00**
Mean		**0.80**		**1.29**		**1.19**		**1.09**
LSDat 0.05		A=0.023 B= 0.029 C= 0.050 AxB= 0.053 AxC= 0.074 BxC=0.081 AxBxC= 0:075						

Comp. = Compost mixtiure [Rice straw (RS) + Banana wastes (BW) + Poultry manure (PM)]
Comp. Mix1 = (RS+BW+ PM)
Comp. Mix (4) = (RS +BW+PM) +add.microbial and natural mineral
Comp. Mix2 = (RS+BW+ PM) + add. microbial
Comp. Mix(5) = (RS+BW+PM) + compost tea

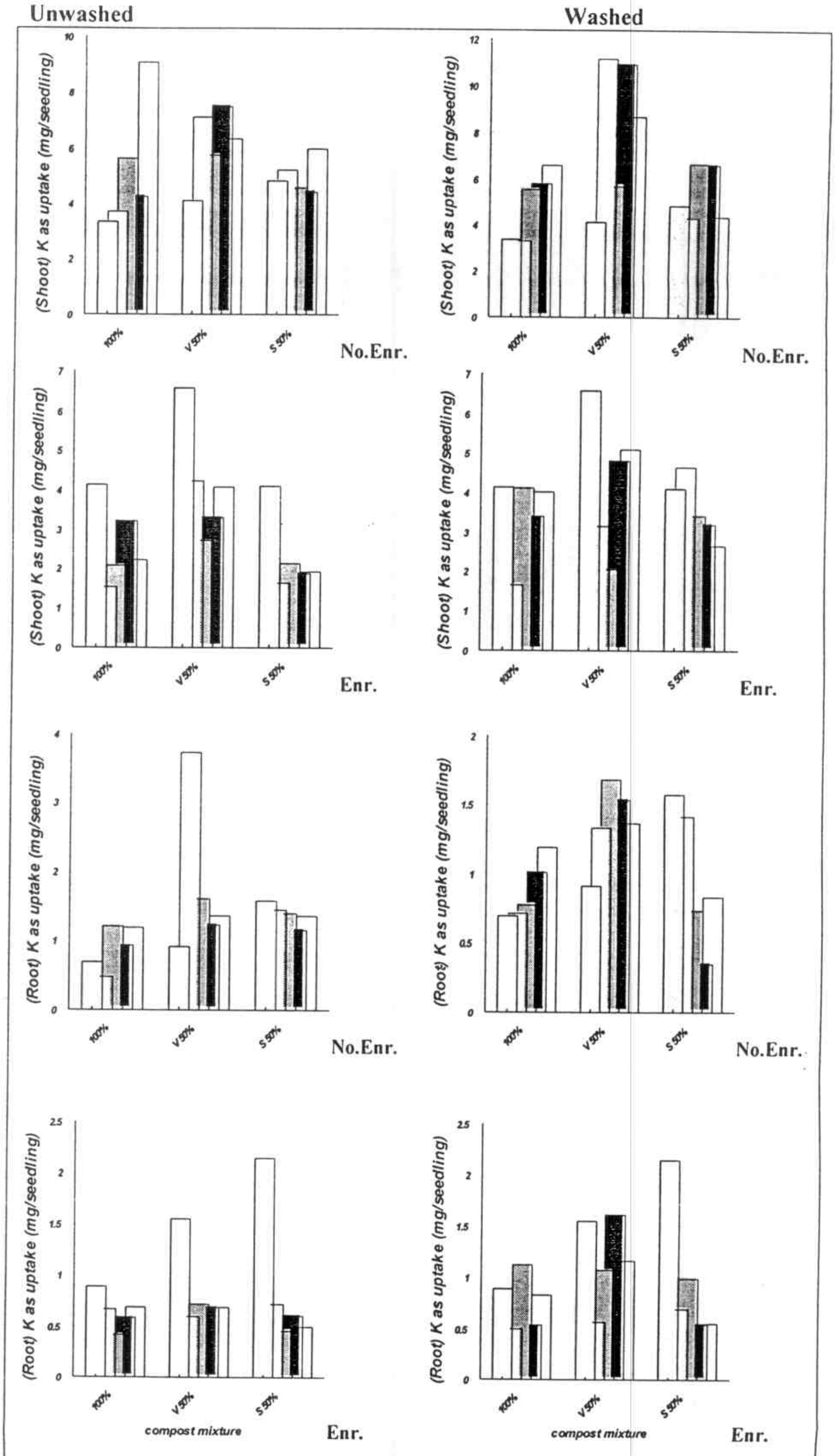

Fig (15): Effect of some different media with or without nutrients enrichment on potassium uptake of tomato seedlings.

Table (25): Effect of some different growing media with or without or/and enrichment pile washing on iron uptake by tomato seedlings.

Mixture treatment / A Compost		Mixing components (B) 100% No Enr.	100% Enr.	Vermiculite 50% No Enr.	Vermiculite 50% Enr.	Sand 50% No Enr.	Sand 50% Enr.	Mean
		(Shoot) Fe as uptake (µg/seedling)						
Peat moss(control)		**37.25**	**86.65**	**61.33**	**132.15**	**42.23**	**87.80**	**74.56**
Compost (1)	unwashed	66.80	33.80	153.05	90.68	56.28	32.93	**72.26**
Compost (2)	unwashed	94.50	43.53	104.03	58.23	53.15	42.00	**65.90**
Compost (4)	unwashed	76.88	66.18	137.47	73.63	48.05	36.50	**73.64**
Compost (5)	unwashed	156.55	45.68	130.55	88.05	68.38	37.88	**87.64**
Mean		**98.68**	**47.30**	**131.28**	**77.65**	**56.47**	**37.33**	**74.79**
Compost (1)	washed	43.30	31.18	177.55	61.90	37.05	90.03	**73.50**
Compost (2)	washed	84.70	80.55	132.60	80.30	41.05	40.18	**76.56**
Compost (4)	washed	74.85	70.60	174.67	97.40	61.63	62.93	**90.34**
Compost (5)	washed	81.05	78.98	127.40	102.95	38.70	53.80	**80.48**
Mean		**70.98**	**65.33**	**153.06**	**85.64**	**44.61**	**61.74**	**80.22**
Grand mean		**84.83**	**56.32**	**142.17**	**81.65**	**50.54**	**49.53**	**77.51**
		Means of enrichment						
Unfertilized		68.97		115.22		47.77		**77.32**
Fertilized		66.43		98.48		62.29		**75.73**
Mean		**67.70**		**106.85**		**55.03**		**76.52**
LSDat 0.05		A= 2.135 B=2.615 C= 4.529 AxB= 4.75 AxC= 6.75 BxC=7.15 AxBxC= 9.282						

Mixture treatment / A Compost		Mixing components (B) 100% No Enr.	100% Enr.	Vermiculite 50% No Enr.	Vermiculite 50% Enr.	Sand 50% No Enr.	Sand 50% Enr.	Mean
		(Root) Fe as uptake (µg/seedling)						
Peat moss(control)		**28.20**	**47.33**	**127.63**	**82.33**	**58.10**	**60.65**	**67.37**
Compost (1)	unwashed	25.95	38.40	247.33	42.20	39.13	32.48	**70.91**
Compost (2)	unwashed	53.90	25.28	86.38	48.58	42.43	20.03	**45.83**
Compost (4)	unwashed	44.28	37.95	72.38	46.75	40.35	28.55	**45.34**
Compost (5)	unwashed	49.35	43.48	75.08	45.90	50.00	22.25	**47.67**
Mean		**43.37**	**36.28**	**120.29**	**45.86**	**42.98**	**25.83**	**52.44**
Compost (1)	washed	29.48	24.43	60.18	29.73	35.73	52.20	**38.62**
Compost (2)	washed	27.73	49.65	80.40	60.15	17.68	36.68	**45.38**
Compost (4)	washed	34.77	32.15	62.13	86.52	10.00	23.03	**41.43**
Compost (5)	washed	40.38	45.05	62.87	65.20	22.70	25.83	**43.67**
Mean		**33.09**	**37.82**	**66.40**	**60.40**	**21.53**	**34.44**	42.28
Grand mean		**38.23**	**37.05**	**93.35**	**53.13**	**32.26**	**30.14**	47.36
		Means of enrichment						
Unfertilized		34.89		104.77		40.87		**60.18**
Fertilized		40.48		62.86		40.31		**47.88**
Mean		**37.69**		**83.82**		**40.59**		**54.03**
LSDat 0.05		A=5.48 B= 6.72 C= 11.63 AxB= 12.23 AxC= 17.12 BxC=18.42 AxBxC= 23.93						

Comp. = Compost mixtiure [Rice straw (RS) + Banana wastes (BW) + Poultry manure (PM)]
Comp. Mix1 = (RS+BW+ PM)
Comp. Mix2 = (RS+BW+ PM) + add. microbial
Comp. Mix (4) = (RS +BW+PM) +add.microbial and natural mineral
Comp. Mix(5) = (RS+BW+PM) + compost tea

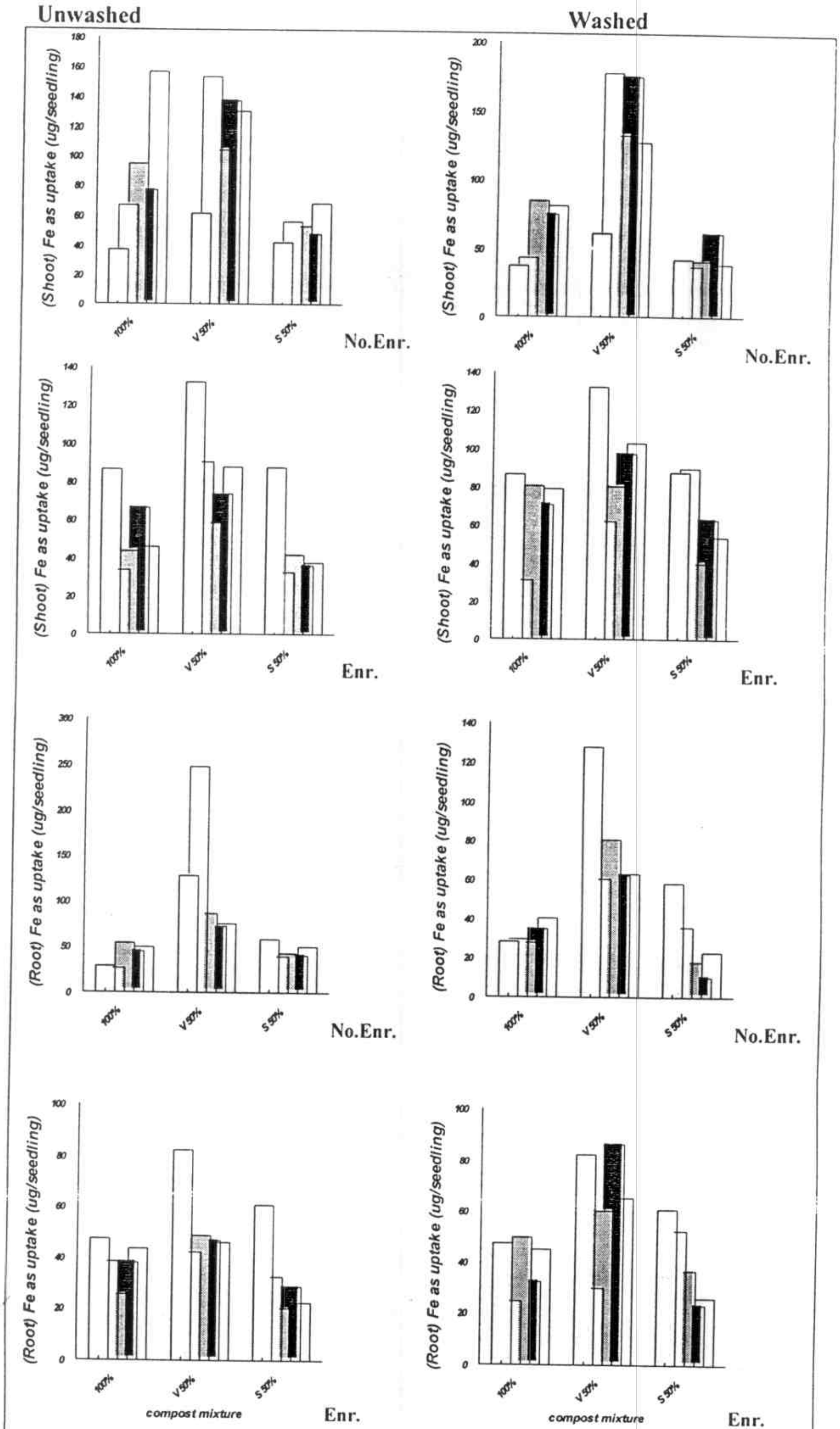

Fig (16): Effect of some different media with or without nutrients enrichment on iron uptake of tomato seedlings.

Table (26): Effect of some different growing media with or without or/and enrichment pile washing on manganese uptake by tomato seedlings

Mixture treatment / A Compost		Mixing components (B) 100%		Vermiculite 50%		Sand 50%		Mean
		Enrichment (C)						
		No Enr.	Enr.	No Enr.	Enr.	No Enr.	Enr.	
		(Shoot) Mn as uptake (µg/seedling)						
Peat moss(control)		**8.93**	**26.38**	**16.11**	**42.95**	**11.03**	**23.65**	**21.51**
Compost (1)	unwashed	19.15	10.93	49.70	31.58	20.03	10.25	**23.60**
Compost (2)	unwashed	27.98	13.75	33.70	20.00	17.55	12.48	**20.91**
Compost (4)	unwashed	25.67	22.18	42.77	23.35	20.50	11.68	**24.35**
Compost (5)	unwashed	53.13	15.58	39.13	31.35	23.90	12.38	**29.25**
Mean		**31.48**	**15.61**	**41.33**	**26.57**	**27.99**	**11.70**	**24.53**
Compost (1)	washed	14.43	10.17	53.38	19.88	12.40	26.20	**22.74**
Compost (2)	washed	26.03	26.98	41.73	27.25	13.45	11.04	**24.41**
Compost (4)	washed	23.78	23.00	56.38	31.78	10.75	19.05	**27.45**
Compost (5)	washed	31.35	25.55	42.45	32.60	13.10	14.73	**26.42**
Mean		**23.90**	**21.43**	**48.49**	**27.88**	**12.43**	**17.76**	**25.30**
Grand mean		**27.69**	**18.52**	**44.91**	**27.23**	**16.46**	**14.77**	24.92
Means of enrichment								
Unfertilized		21.44		35.31		14.65		**23.80**
Fertilized		21.14		32.47		17.70		**23.77**
Mean		**21.29**		**33.89**		**16.18**		**23.78**
LSDat 0.05		A= 0.379 B=0.464 C= 0.804 AxB= 0.844 AxC= 1.185 BxC=1.272 AxBxC= 1.651						

Mixture treatment / A Compost		Mixing components (B) 100%		Vermiculite 50%		Sand 50%		Mean
		Enrichment (C)						
		No Enr.	Enr.	No Enr.	Enr.	No Enr.	Enr.	
		(Root) Mn as uptake (µg/seedling)						
Peat moss(control)		**8.48**	**13.00**	**42.88**	**23.28**	**16.75**	**27.65**	**22.00**
Compost (1)	unwashed	8.33	11.45	89.93	15.45	13.33	9.58	**23.08**
Compost (2)	unwashed	17.85	8.18	29.88	15.45	15.43	9.58	**16.86**
Compost (4)	unwashed	15.43	10.73	24.15	15.88	14.68	5.68	**14.42**
Compost (5)	unwashed	16.40	13.55	26.23	15.90	17.73	8.30	**16.87**
Mean		**14.50**	**10.98**	**42.55**	**15.67**	**15.29**	**8.29**	**17.88**
Compost (1)	washed	9.05	6.95	22.65	9.65	12.05	14.45	**12.49**
Compost (2)	washed	8.35	15.58	28.08	19.70	6.28	10.33	**14.57**
Compost (4)	washed	11.15	9.50	26.08	28.03	3.13	6.53	**14.34**
Compost (5)	washed	11.50	13.65	24.40	20.73	6.90	7.00	**14.03**
Mean		**10.01**	**11.42**	**25.30**	**19.53**	**7.09**	**9.58**	**13.82**
Grand mean		**12.26**	**11.20**	**33.93**	**17.60**	**11.19**	**8.94**	**15.85**
Means of enrichment								
Unfertilized		11.0		36.91		13.04		**20.32**
Fertilized		11.80		19.49		15.17		**15.49**
Mean		**11.40**		**28.20**		**14.11**		**17.91**
LSDat 0.05		A=5.32 B= 6.515 C= n.s AxB= 11.92 AxC= 5.43 BxC=6.160 AxBxC= 12.10						

Comp. = Compost mixtiure [Rice straw (RS) + Banana wastes (BW) + Poultry manure (PM)]
Comp. Mix1 = (RS+BW+ PM)
Comp. Mix2 = (RS+BW+ PM) + add. microbial
Comp. Mix (4) = (RS +BW+PM) +add.microbial and natural mineral
Comp. Mix(5) = (RS+BW+PM) + compost tea

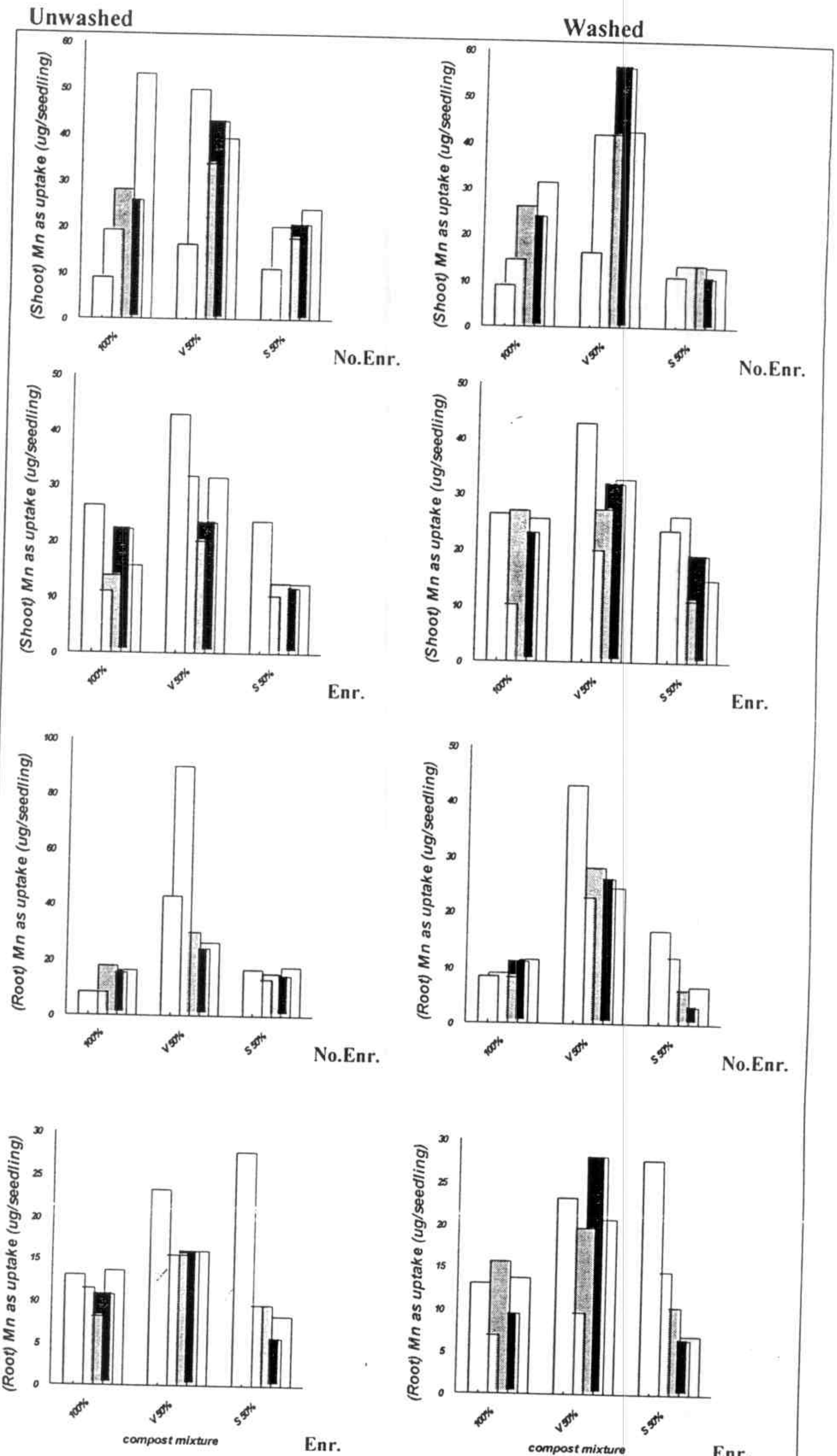

Fig (17): Effect of some different media with or without nutrients enrichment on manganese uptake of tomato seedlings.

Table (27): Effect of some different growing media with or without or/and enrichment pile washing on zinc uptake by tomato seedlings

Mixture treatment / A Compost		Mixing components (B)						Mean
		100%		Vermiculite 50%		Sand 50%		
		Enrichment (C)						
		No Enr.	Enr.	No Enr.	Enr.	No Enr.	Enr.	
		(Shoot) Zn as uptake (µg/seedling)						
Peat moss(control		**23.30**	**44.35**	**36.00**	**75.55**	**24.23**	**42.68**	**41.10**
Compost (1)	unwashed	33.70	17.63	83.20	49.13	35.08	16.35	**39.31**
Compost (2)	unwashed	49.55	23.53	57.58	32.60	31.20	22.08	**36.08**
Compost (4)	unwashed	41.13	36.75	70.38	42.18	32.28	19.10	**40.32**
Compost (5)	unwashed	83.65	25.70	70.60	50.13	46.43	19.75	**49.39**
Mean		**52.00**	**25.90**	**70.44**	**43.51**	**36.25**	**19.32**	**41.24**
Compost (1)	washed	25.73	17.48	91.65	35.63	24.93	47.80	**40.53**
Compost (2)	washed	43.63	45.75	75.78	45.40	24.77	20.90	**42.66**
Compost (4)	washed	44.73	38.35	105.40	51.80	39.53	35.78	**52.68**
Compost (5)	washed	49.57	43.48	80.35	56.18	24.83	27.95	**47.14**
Mean		**40.92**	**36.27**	**88.30**	**47.25**	**28.52**	**33.11**	**45.73**
Grand mean		**46.46**	**31.09**	**79.37**	**45.38**	**32.39**	**26.22**	**43.48**
Means of enrichment								
Unfertilized		38.74		64.91		29.67		**44.44**
Fertilized		35.51		55.44		31.70		**40.88**
Mean		**37.13**		**60.17**		**30.68**		**42.66**
LSDat 0.05		A= 0.559 B=0.685 C= 1.185 AxB= 1.245 AxC= 1.754 BxC=1.88 AxBxC= 2.450						

Mixture treatment / A Compost		Mixing components (B)						Mean
		100%		Vermiculite 50%		Sand 50%		
		Enrichment (C)						
		No Enr.	Enr.	No Enr.	Enr.	No Enr.	Enr.	
		(Root) Zn as uptake (µg/seedling)						
Peat moss(control		**17.00**	**26.73**	**20.88**	**45.90**	**36.28**	**55.33**	**33.68**
Compost (1)	unwashed	16.13	23.25	50.18	30.60	27.58	20.03	**27.96**
Compost (2)	unwashed	34.05	16.33	49.93	33.50	30.83	10.03	**29.11**
Compost (4)	unwashed	27.13	13.22	35.80	31.58	29.50	15.08	**25.55**
Compost (5)	unwashed	30.25	15.73	40.25	31.43	33.23	13.75	**28.06**
Mean		**26.89**	**17.13**	**44.04**	**31.78**	**30.29**	**14.72**	**27.67**
Compost (1)	washed	17.80	15.73	37.88	20.70	24.70	21.30	**23.04**
Compost (2)	washed	15.90	33.28	48.63	42.80	12.15	19.93	**28.77**
Compost (4)	washed	20.45	19.98	45.70	56.98	6.08	11.75	**26.82**
Compost (5)	washed	25.15	29.35	39.05	46.10	15.30	14.45	**28.23**
Mean		**19.83**	**24.59**	**42.82**	**41.65**	**14.56**	**16.86**	**27.19**
Grand mean		**23.36**	**20.86**	**55.93**	**36.72**	**22.43**	**15.79**	**27.43**
Means of enrichment								
Unfertilized		21.24		35.91		27.04		**28.06**
Fertilized		22.82		39.78		28.97		**30.52**
Mean		**22.03**		**37.85**		**28.00**		**29.29**
LSDat 0.05		A=0.706 B= 0.865 C= 1.498 AxB= 1.571 AxC= 2.354 BxC=2.633 AxBxC= 3.150						

Comp. = Compost mixtiure [Rice straw (RS) + Banana wastes (BW) + Poultry manure (PM)]
Comp. Mix1 = (RS+BW+ PM)   Comp. Mix (4) = (RS +BW+PM) +add.microbial and natural mineral
Comp. Mix2 = (RS+BW+ PM) + add. microbial   Comp. Mix(5) = (RS+BW+PM) + compost tea

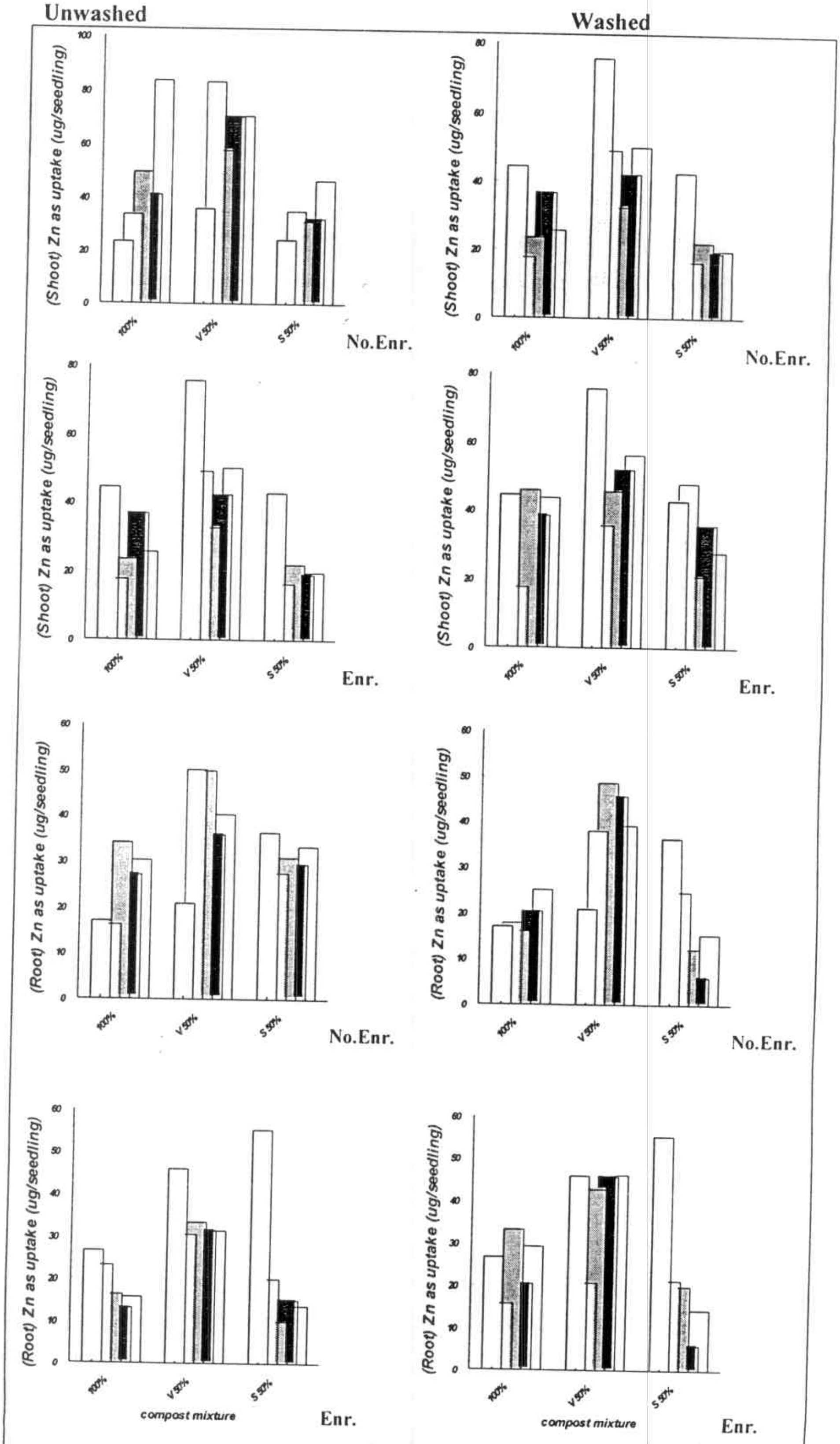

Fig (18): Effect of some different media with or without nutrients enrichment on zinc uptake of tomato seedlings.

Table (28): Effect of some different growing media with or without nutrient enrichment on cupper uptake by tomato seedlings

Mixture treatment / A Compost		(Shoot) Cu as uptake (µg/seedling) Mixing components (B) 100% Enrichment (C) No Enr.	100% Enr.	Vermiculite 50% No Enr.	Vermiculite 50% Enr.	Sand 50% No Enr.	Sand 50% Enr.	Mean	(Root) Cu as uptake (µg/seedling) Mixing components (B) 100% Enrichment (C) No Enr.	100% Enr.	Vermiculite 50% No Enr.	Vermiculite 50% Enr.	Sand 50% No Enr.	Sand 50% Enr.	Mean
Peat moss(control		**2.73**	**9.17**	**5.46**	**16.33**	**2.44**	**10.27**	**7.73**	**2.02**	**5.03**	**12.89**	**9.95**	**4.52**	**10.19**	**7.43**
Compost (1)	unwashed	9.46	4.10	17.14	12.08	8.56	3.63	**9.16**	4.04	5.05	39.36	6.64	5.67	6.64	**11.23**
Compost (2)	unwashed	12.08	4.81	13.59	7.93	7.93	5.23	**8.59**	6.96	3.66	11.75	6.91	6.36	6.91	**7.09**
Compost (4)	unwashed	8.54	8.18	15.74	9.96	7.79	4.05	**9.05**	6.99	5.15	9.96	6.48	5.57	6.48	**6.77**
Compost (5)	unwashed	20.92	5.80	15.41	11.92	9.49	4.79	**11.39**	7.06	6.05	10.76	7.12	6.57	7.13	**7.45**
Mean		**12.75**	**5.72**	**15.47**	**10.47**	**8.44**	**4.43**	**9.55**	**6.26**	**4.98**	**17.96**	**6.79**	**6.04**	**6.79**	**8.14**
Compost (1)	washed	4.25	3.63	18.39	8.11	5.17	9.96	**8.25**	3.59	2.99	6.59	4.00	4.49	5.48	**4.53**
Compost (2)	washed	8.21	10.40	16.13	10.59	4.79	4.04	**9.03**	3.47	6.68	3.84	8.25	1.92	4.44	**4.76**
Compost (4)	washed	8.07	8.55	19.98	11.83	5.87	7.26	**10.26**	3.52	4.14	9.50	11.83	1.14	2.52	**5.44**
Compost (5)	washed	8.07	9.18	13.30	13.16	4.46	5.34	**8.91**	4.56	5.72	9.12	8.99	2.65	2.72	**5.61**
Mean		**7.15**	**7.94**	**16.95**	**10.92**	**5.07**	**6.65**	**9.11**	**3.49**	**3.88**	**7.26**	**8.26**	**2.55**	**3.79**	**4.87**
Grand mean		**9.95**	**6.83**	**16.21**	**10.70**	**6.76**	**5.54**	**9.33**	**4.88**	**4.43**	**12.61**	**7.53**	**4.30**	**5.29**	6.51
Means of enrichment															
Unfertilized		7.54		12.63		5.32		**8.50**	4.02		12.70		4.37		**7.03**
Fertilized		7.61		12.57		7.12		**9.10**	4.63		8.33		6.92		**6.63**
Mean		**7.58**		**12.60**		**6.22**		**8.80**	**4.33**		**10.52**		**5.65**		6.83
LSDat 0.05		A= 0.281 B=0.344 C= 0.597 AxB= 0.652 AxC= 0.879 BxC=0.945 AxBxC= 1.232							A=0.131 B= 0.161 C= 0.79 AxB= 0.301 AxC= 0.932 BxC=0.952 AxBxC= 1.101						

Comp. = Compost mixtiure [Rice straw (RS) + Banana wastes (BW) + Poultry manure (PM)]
Comp. Mix1 = (RS+BW+ PM)
Comp. Mix2 = (RS+BW+ PM) + add. microbial
Comp. Mix (4) = (RS +BW+PM) +add.microbial and natural mineral
Comp. Mix(5) = (RS+BW+PM) + compost tea

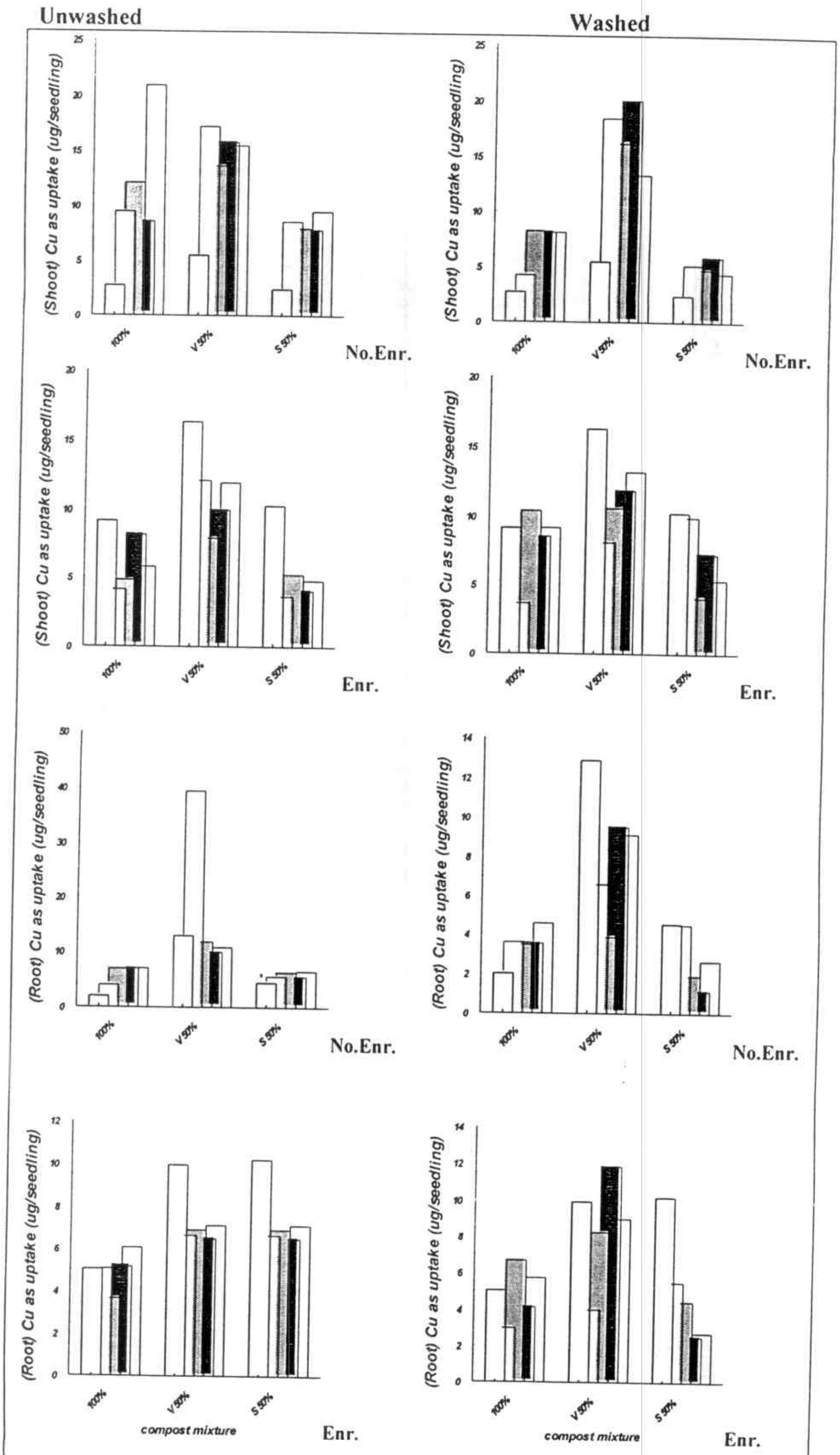

Fig (19): Effect of some different media with or without nutrients enrichment on cupper uptake of tomato seedlings.

Also, nutrients uptake by tomato seedling was very much induced at different rates by using the different types of the investigated growing medians.

However according to the aforementioned results of this part of study the following conclusion could be reached out

Although the peatmoss imported could act as suitable growth media for tomato (castal rock) transplants yet its reliability could be induced by using additive materials such as nutrients enrichments particularly through addition of natural materials like rock phosphate and feldspar as well as mixing with some type of clay minerals like vermiculite. The microbial inoculation as well as the tea compost over proved to be essential for inducing the general nutritive characteristics of peat moss as growing area for tomato transplants.

The prepared types of compost were used also as efficient growing media for tomato transplants such finding may lead to state that it is possible to use the prepared types or the local varieties of composts wastes and refuse as efficient substitutes for imported peat moss. Also, the efficiency of the produced types of compost was very much induced through mixing with vermiculite (Sand) at a volume ratio of 1:1 or through microbs inoculation or by adding what is so called compost tea to compost piles through its processing

Such finding may lead us to a final conclusion that suitable growth medians for production of vegetables and by using local materials. The different wastes of plants, town refuse, and sanitary wastes are important sources for compost processing and accordingly such type of compost could be used as safety substitutes for the imported peat moss growing media. Further more by using tea compost and some types of local clay and shales containing bentonite and montorlillonite that are of widespread occurrence in Egypt may lead to the entire replacement of local type of growing medians without any imparting of materials like peatmoss or vermiculite.

Such conclusions and statements were reported by **Abdalla** *et al.***(2000)** who tested bagasse, hyacinth composts substitutes for local used peatmoss in vegetable transplants production. They concluded that growing media containing 50% by volume of composted bagasse has been demonstrated physically and chemically to be safe for use in growing greenhouse tomato and cucumber transplants than hyacinth compost. The composting and use of bagasse in vegetable transplants production not only an effective means of recycling but it simultaneously decrease the dependency on imported peatmoss.

Abdallah, *et al.***(2000)** reported that the composted bagasse and hyacinth tested as substitutes for local used peatmoss in vegetable transplants production container media. The medium used contained vermiculite with 25%, 50% and 75% by volume from both bagasse and hyacinth composts in addition to congenital media of 50% peatmoss as check treatment. They found that tomato and cucumber transplants grown in 50% and 75% bagasse composted media were significantly of better growth parameters i.e. length, stem diameter, and shoot fresh and dry weight as well as root dry weight than those hyacinth composted media. They concluded that compost bagasse and hyacinth could be used substitutes for peatmoss in vegetable transplants production using the container media method. They found that the transplants produced in higher rate of bagasse compost contained similar N, P, K, Mn, Fe, Zn and Cu and growth measured characters as compared to plants grown in the check medium.

Several authors reported that compost application to growing media can improve the physical and chemical properties of soils. Also, increase the availability of macro and micronutrients needed for seedlings to be grown **(Chaney *et al.*; 1980, Falahi-Ardakani *et al.*; 1988a; Tripepi, 1996; Kalock, 1997; MohyEl-Dine, 1977 and Ozores-Hampton *et al.*;1998.)**