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Physical, Physico-Chemcial and Enzymes Activities of Vermiash Compost

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Abstract: In view of the environmental problems generated by large-scale production of fly ash, increasing attention is now being paid to the recycling of fly ash as a good source of nutrients. Because availability of many nutrients is very low in fly ash, available ranges of such nutrients must be improved to increase the effectiveness of fly ash as a soil amendment and possibility of increasing total nutrient content in fly ash through vermicomposting. Fly ash was mixed with different organic residues in 1: 0, 1:1, 1:1.5, 1:2.0 and 1:3 ratios and incubated with *Eudrilus eugeniae* for 75 days. The concentration of above said macro and micronutrient was found to increase in the earthworm-treated series of fly ash and organic residue combinations compared with the fly ash alone. This helped to transform considerable amounts of total nitrogen, phosphorus, potassium and micronutrients from fly ash into more soluble forms and thus resulted in increased bioavailability of the nutrients in the VERMIASH compost. Among different combinations *o*f *organic* residues and fly ash, nutrient availability was significantly higher in the 1:1 and 1:1.5 ratio treatment compared with the other treatments. The dehydrogenese, urease and phosphate activity of VERMIASH compost increased significantly due to earthworm activity .The source of organic residues also had significant influence on the soil enzyme activity.

Key words : Fly ash, organic residue, vermiash, compost, nutrient recovery, enzyme activity, fly ash.

Introduction

Fly ash is the fine residue captured from flue exhausts when coal is burnt in power stations. With the consistently increasing number *o*f coal-fired plants, the large-scale generation of fly ash is creating acute waste disposal problems in different parts of the world. The amount of ash produced annually in India was around 100 million tons during 2005 and is likely to exceed 150 million tons in 2020. There are few uses for the tonnages produced and the disposal of fly ash has become a significant problem. The common practice is to dispose these residues to the dumping sites of the power plants, which cover huge areas of otherwise agriculturally productive land. Fly ash is used as landfill depending on its pH, for reclaiming acid or sodic soil (Gene Stevens and David Dunn, *2004)* and to alter the texture and water holding capacity of the sandy soils (Pathan *et al*., 2003). Co- composting of sewage sludge and coal fly ash has been an effective way *to* transform the fly ash into nutrient rich product (Fang *et al*., 1999). However, these procedures do not utilize a major portion of the ash and thus thermal power stations have to manage its storage, while keeping the levels of air and water pollution associated with it to a minimum. T*o* overcome this, various possible methods for the safe disposal and reuse of fly ash have been envisaged by different researchers, of which the composting process has received a particular interest (Bhattacharya and Chattopadhyay, *2004).*

Composting is one of the most promising ways *to* recycle the wastes generated from power plants, as the process reduces the volume, and stabilizes the waste. The high organic matter content in the compost product also preserves soil fertility. Composting is a widely acceptable alternative for converting waste into a more useful eco-friendly fertilizer to improve soil fertility (Fang *et al.,* 1998). Vermicomposting is a suitable technology for decomposition of different types of organic waste (domestic as well as industrial) into value added material.

Keeping this in view the present study was conducted to assess the potential of *Eudrilus eugeniae* in composting *o*f different organic residues blended with fly ash and its effect on recovery of nutrients and soil enzyme activity.

Material and Methods

The study was conducted in yards with cement pots (15 L volume) at College of Agriculture, Raichur during 2006-2007.Fly ash for this study was collected from RSTPS Shaktinagar, Raichur. A bulk sample of fresh fly ash was taken from the hopper of power plant. Three different types of organic sources were used for the production of VERMIASH compost viz., paddy straw, cattle shed waste and mixed sources, in combination with fly ash. The fly ash used as complementary substrate and cow dung slurry as stimulator for earthworm feeding activity. Organic residues sources were collected locally available at Regional Agricultural Research Station farm, Raichur and placed in cement pots of size 0.45 x 0.35 x 0.35m. Cow dung slurry was prepared by dissolving equal proportions of water and cow dung. This slurry was mixed thoroughly with organic residues in proper proportion and left for partial decomposition for twenty days. Optimum moisture at field capacity was maintained through out the period of experiment. Later partially decomposed substrates were taken out and mixed with different proportions of organic residues and fly ash and transferred cement pots. Earthworms *Eudrilus eugeniae* and *Eisinia foetidia* were introduced to feed on the partially decomposed organic residues with different proportions of fly ash. The cement pots were kept under shade using moist gunny bags as covers on pots to maintain optimum temperature. For completion of VERMIASH compost production earthworms took 44 to 75 days. After completion of composting, earthworms were separated from VERMIASH compost. VERMIASH was dried, sieved and preserved in polythene bags for further physico- chemical analysis. The physico-chemical properties of fly ash, soil and different organic residues used in the incubation studies are presented in Table 1 & 2. Particle fractions and WHC was determined by Piper (1966), Bulk density described by Barauh and Bhakhawar (1999), pH by electrometric and EC by conductivity bridge in 1:2.5 soil water ratio and organic carbon by Walkely and Black wet oxidation method were determined as per procedure given by Jackson (1973). The initial soil properties were analyzed for pH, EC (Jackson, 1973), OC (Nelson and Sommer, 1982), available nitrogen (Subbaiah and Asija, 1956), P (Olson *et al.,* 1954), K (Knudsen *et al.,* 1982), exchangeable Ca and Mg and S (Jackson, 1973) and DTPA extractable micronutrients (Lindsay and Norwell, 1978). The total elemental composition of vermiash compost was determined by acid digestion following procedure suggested by Jackson (1973) and micronutrients by Atomic absorption spectrophotometer.

Prior to the main experiment filler study was conducted to know the survival rate of earthworms with graded level of fly ash mixing (1:0, 1:1, 1:1.5, 1:2 and 1:3). Results indicated that organic residues and fly ash mixing up to 1:1.5 ratio was optimum for survival of earthworm and activity can be observed at field capacity moisture levels.

A pot culture study was conducted to know the enzyme activities due to application of VERMIASH compost. Enzyme assays were on moist samples preserved in refrigerator. Dehydrogenase and phosphatase activity of soil sample was determined by following the procedure as described by Casida *et al.* (1964) and Eivazi and Tabatabai (1979) respectively. The procedure adopted to determine the urease activity of soil was essentially same as adopted by Pancholy and Rice (1973), except that the ammonia liberated due to hydrolysis of urea in the reaction mixture was determined by nesslerisation as described by Jackson (1973).

Table 1.Characterization of fly ash and soil

Parameters	Fly ash	Soil
Sand (%)	26.40	76.52
Silt (%)	47.60	5.40
Clay (%)	24.12	18.00
Texture	SiCL	SCL
BD (Mg/m^{-3})	0.97	1.58
WHC (%)	58	45.25
pH (1:2)	9.30	7.80
EC (dS/m)	0.85	0.10
OC (%)	0.12	0.34
Total N (mg/kg)	23.40	Av. N : 288 (kg/ha)
Total P (mg/kg)	13.12	Av. P : 36.58 (kg/ha)
Total K (mg/kg)	127	Av. K : 125 (kg/ha)
Total S (mg/kg)	87.10	Av. S : 3.09 (ppma)
Total Ca (mg/kg)	15.28	Ex. Ca: 5.26 (c mol/kg)
Total Mg (mg/kg)	10.97	Ex. Ca: 1.46 (c mol/kg)
Total Iron (mg/kg)	970	Av. Fe : 1..30 (mg/kg)
Total Manganese (mg/kg)	273	Av. Mn : 11.60 (mg/kg)
Total Copper (mg/kg)	24	Av. Cu : 0.73 (mg/kg)
Total Zinc (mg/kg)	0.83	Av. Cu : 7.83 (mg/kg)

Results and Discussion

Physico-chemical properties of Vermiash composts : The changes in soil reaction , electric conductivity, moisture content and bulk density of VERMIASH compost are presented in Table 3 were significantly differed due to treatment effect. The results suggest that earthworms play significant role in processing fly ash in to organic manure. The earthworm activity accelerated the process of decomposition of organic residue and fly ash mixture and stabilizing the waste. The VERMIASH compost was much darker in color and had been processed in to much more homogenous mass after 75 days of earthworm activity, where as the material without earth worms remain in compact clumps. The pH value in the no fly ash treatment was 6.59 which increased to 7.08 due to increase in level of fly ash from 1:1 to 1:3 ratios with paddy straw as the organic source. Similar trend was noticed with the other two organic sources. However, the pH of the compost was stabilized to neutral value, irrespective of the organic sources. The bulk density of the compost varied from 0.65 to 0.90 Mg m^{-3} due to incorporation of organic residues and fly ash. Irrespective of the organic sources, the MWHC of the compost improved significantly due to incorporation of fly ash in different ratios with organic sources. This was mainly attributed to the light weight and porous size particles in the fly ash with enormous surface area. These results are similar with earlier findings by Senapati (1993) who observed increase in pH values with an increase in incubation time due to addition of FYM and Fly ash. Further, it reduced the metal stability and decreased the bulk density of the composted materials.

Chemical properties : The changes in total carbon, nitrogen, phosphorus and micronutrients in different combination of organic residues and fly ash are presented in Table 4. The organic carbon decreased with time in all the treatments. The organic carbon is lost as carbon dioxide and total nitrogen is increased as a result of carbon loss (Croford, 1983). Microorganisms that use the carbon as a source of energy and nitrogen for building structure bring about decomposition of organic matter. But the reduction was greater in vermicomposting compared to the ordinary composting. This may be due to the fact that earth worms having higher assimilating capacity.

Earth worms had a great impact on nitrogen transformation in the VERMIASH compost. The total nitrogen content gradually decreases at the end of the total period incorporation. Total phosphorous was also increased with time in all the treatments processes and gradually decreased at the end of the experiment. Highest amount of total P (0.27 %) was recorded in mixed organic residues and fly ash in 1:1 ratio. Normally P is bound in unavailable from with calcium phosphate. Vermicomposting with fly ash proved to be an efficient method for providing better P nutrition from organic waste in accordance with Ghosh (1999). In all these treatments the value of micronutrients in increased due to rapid treatment effect.

The organic carbon content of vermiwash compost was not influenced due to earthworm activity but was significantly influenced by the different organic sources. The organic carbon content values were found to be significantly lower in paddy straw as compared to cattle shed waste and mixed organic residues. The results are in agreement with the earlier reports of (Garcia *et al.,* 1997)who reported improvement of organic carbon content of soil due to addition of different green manure along with fly ash @ 7.5 per cent and fertilizer in soybean crop. The C: N ratio is one of the most important parameter that determines the extent of composting and degree of compost maturity. Wide C/N ratio was recorded in the VERMIASH compost obtained from mixed organic residues followed by cattle shed waste and paddy straw. The pre treatment of the substrate significantly reduced the C/N ratio of paddy straw, cattle shed waste and mixed organic residues after 48, 55 and 60 days of composting to 13.93, 17.85 and 21.78 respectively due to incorporation of fly ash in different proportions. These observations corroborate with the findings of Jadrijevic *et al.* (1991). It was also observed that the total nitrogen content in paddy straw source was significantly higher than that of cattle shed waste and mixed organic residues with graded level of fly ash incorporation. The phosphorus content of VERMIASH compost ranged from 0.11 – 0.27 per cent and were higher in cattle shed waste and mixed organic residues. Mansell *et al.* (1981) suggested that earthworms increased the available phosphorus derived from plant litter by 2-3 folds. Improvement in the amount of easily extractable P during the course of vermicomposting has been reported by Ghosh *et al.* (1999). This was mainly attributed to the greater phosphatase activity in earthworm casts as reported by Satchell *et al.* (1984). To increase the acceptability as a source of plant nutrients, it is necessary to increase its bioavailability through recycling fly ash with different organic residues(Chattopadhaya and Bhattacharya ,2000).

Table 2. Chemical composition of different organic materials used for vermiash compost production

Organic materials	OC	N	C:N ratio	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn
	—%—		—%—						---mg/kg---			
Paddy straw	42.30	0.97	43.62	0.03	0.67	0.96	0.38	0.08	48.0	72.0	8.0	27.0
Cattle shed waste	45.2	1.12	45.35	0.10	0.63	2.32	0.77	0.20	108.0	39.0	10.0	34.0
Mixed organic residues	47.06	1.42	33.14	0.17	0.75	1.28	0.38	0.32	192.0	52.0	13.0	43.0

Table 3. Physical and Physico-chemical properties of vermiash composts obtained from different organic sources

Type of vermiash composts	pH (1:2.5)	EC (dSm^{-1})	Bulk density (Mg m^{-3})	WHC (%)
Paddy straw				
PS: FA (1:0)	6.59	1.82	0.66	34.00
PS: FA (1:1)	6.97	0.80	0.71	41.33
PS: FA (1:1.5)	7.01	0.74	0.90	46.42
PS: FA (1:2)	7.05	0.69	0.86	49.10
PS: FA (1:3)	7.08	0.57	0.88	54.28
Cattle shed waste				
CSW:FA (1:0)	6.81	1.13	0.68	31.10
CSW:FA (1:1)	7.00	0.80	0.84	38.23
CSW:FA(1:1.5)	7.01	0.60	0.77	44.42
CSW:FA (1:2)	7.01	0.62	0.89	51.15
CSW:FA (1:3)	7.20	0.70	0.87	55.52
Mixed organic residues				
MOR: FA (1:0)	6.86	1.17	0.65	32.34
MOR: FA (1:1)	6.90	0.86	0.88	38.10
MOR:FA(1:1.5)	6.91	0.80	0.83	43.20
MOR: FA (1:2)	7.01	0.72	0.79	49.00
MOR: FA (1:3)	7.06	0.65	0.90	53.10
F-TEST	*	NS	*	*
S.Em±	0.048	0.187	0.007	0.086
CD (0.01)	0.19	NS	0.03	0.34

FA: Fly Ash; PS: Paddy Straw; CSW: Cattle shed Waste; MOR: Mixed Organic Residues; WHC: Water Holding Capacity.

Irrespective of different organic sources used for composting with fly ash there was significant increase in the K, Ca, Mg and S content in the VERMIASH compost with increasing levels of fly ash this was mainly attributed, due to native source of these elements in fly ash. The potassium content of the VERMIASH compost varied from 0.53 to 0.83, calcium from 0.60 to 2.68, magnesium from 0.32 to 1.76 and Sulphur from 0.09 to 0.53 due to different organic sources with graded level of fly ash ratios. Increase in potassium content in the vermicompost obtained from different sources of organic material has been reported by (Vadiraj *et al.,* 1992 and Ushakumari *et al.,* 1996). Similar increase in content of calcium, magnesium, sulphur in the vermicompost prepared from different sources and organic material has been reported by Vadiraj *et al.* (1992). Micronutrients *viz.,* Fe, Mn, Cu and Zn were higher in VERMIASH composts irrespective of the organic sources used in the composting with graded levels of fly ash. Extracts of ash revealed that fly ash had higher total concentrations of K, Ca and Fe and intermediate contents of P, Mg, Cu and Zn (Adriano *et al.,* 1980). Similar increase in concentration of micronutrients in the vermicompost prepared from different sources of organic material has been reported by Vadiraj *et al.* (1992).

Enzyme Activities : Dehydrogenase activity : Dehydrogenase activity of Vermiash compost produced with incorporation of fly ash in different ratios showed significantly higher activity compared to control and fly ash alone (Table 5). The higher value of dehydrogenase activity in VERMIASH compost

Table 4. Chemical composition of Vermiash compost obtained from recycling of different organic sources and fly ash

Type of vermiash compost	OC (%)	Nitrogen (%)	C: N ratio	Phosphorus	Potassium	Calcium	Magnesium	Sulphur	Fe	Mn	Cu	Zn
					——%——				——mg kg^{-1}——			
Paddy straw												
PS: FA (1:0)	37.23	2.52	14.77	0.14	0.53	0.60	0.32	0.09	96	86	16.10	39.00
PS: FA (1:1)	33.21	2.54	13.07	0.16	0.63	0.83	0.42	0.11	1009	196	20.00	21.90
PS: FA (1:1.5)	30.19	2.53	11.93	0.19	0.64	1.33	0.53	0.18	1040	210	28.00	20.40
PS: FA (1:2)	27.70	2.20	12.50	0.17	0.70	1.41	0.68	0.20	1066	234	39.00	39.30
PS: FA (1:3)	26.90	1.93	13.93	0.11	0.69	1.46	0.71	0.23	1070	243	40.20	40.30
Cattle shed waste												
CSW: FA (1:0)	38.50	1.84	20.92	0.20	0.59	0.97	0.94	0.10	126	49	28.00	26.00
CSW: FA (1:1)	33.45	1.79	18.68	.0.24	0.60	1.32	1.63	0.14	1023	214	31.00	31.00
CSW: FA (1:1.5)	31.60	1.77	17.85	0.25	0.68	2.60	1.76	0.29	1028	269	43.00	43.00
CSW: FA (1:2)	29.81	1.50	19.87	0.22	0.71	2.65	1.56	0.31	1078	318	52.00	43.20
CSW: FA (1:3)	28.10	1.30	21.61	0.18	0.73	2.68	1.43	0.33	1126	322	58.00	43.80
Mixed organic residues												
MOR:FA (1:0)	44.04	1.80	24.46	0.26	0.60	0.79	0.43	0.16	215	64	30.20	30.30
MOR:FA (1:1)	38.28	1.74	22.00	0.27	0.63	0.92	0.53	0.18	1110	271	39.00	40.20
MOR:FA (1:1.5)	36.81	1.69	21.78	0.25	0.79	1.29	0.89	0.49	1123	284	53.00	58.00
MOR:FA (1:2)	31.80	1.40	22.71	0.23	0.81	1.38	1.01	0.51	1169	324	69.00	58.50
MOR:FA (1:3)	29.90	1.24	24.11	0.21	0.83	1.49	0.97	0.53	1185	336	77.00	59.90
F-TEST	NS	*	*	*	*	*	*	*	NS	*	NS	*
S.Em±	4.32	0.02	0.08	0.017	0.004	0.03	0.03	0.009	252.03	0.05	23.15	0.27
CD (0.01)	NS	0.06	0.32	0.066	0.015	0.11	0.12	0.04	NS	0.12	NS	1.08

Table 5. Mean effect of vermiash composts obtained from different organic sources with graded level of fly ash on enzyme activity.

Treatments	Dehydrogenase (TPF µg g^{-1}hr^{-1})		Phosphatase (NH_4^+ µg g^{-1}hr^{-1})		Urease (PNPµg g^{-}hr^{1})	
	Days of incubation					
	0	30	0	30	0	30
T_1: Control	1.41	1.10	30.83	25.90	56.24	58.20
T_2: Fly ash @ 2.5 tha^{-1}	1.01	0.91	27.96	28.30	51.12	54.80
Paddy straw						
T_3: PS:FA (1:0)	2.96	3.32	47.17	52.28	81.42	89.92
T_4: PS:FA (1:1)	2.82	3.25	44.57	48.34	80.34	88.90
T_5: PS:FA (1:1.5)	2.71	3.10	42.25	47.20	79.20	86.33
T_6: PS:FA (1:2)	2.07	2.10	29.98	36.00	54.18	58.75
T_7: PS:FA (1:3)	2.00	2.09	24.30	31.20	42.00	45.46
Cattle shed waste						
T_8: CSW:FA (1:0)	2.88	3.45	51.12	60.20	79.20	87.83
T_9: CSW:FA (1:1)	2.83	3.47	49.20	58.18	77.89	84.90
T_{10}: CSW:FA (1:1.5)	2.80	3.23	50.50	57.20	70.10	76.23
T_{11}: CSW:FA (1:2)	2.36	2.42	39.20	43.28	62.28	66.34
T_{12}: CSW:FA (1:3)	2.02	2.20	35.28	38.10	57.10	59.95
Mixed organic residues						
T_{13}: MOR:FA (1:0)	2.98	3.40	48.52	58.24	77.02	86.12
T_{14}: MOR:FA (1:1)	2.87	3.37	46.00	54.00	74.12	81.00
T_{15}: MOR:FA (1:1.5)	2.82	3.32	44.28	50.20	71.20	77.83
T_{16}: MOR:FA (1:2)	2.48	2.53	35.14	40.10	59.14	64.10
T_{17}: MOR:FA (1:3)	2.33	2.37	32.00	34.23	52.10	56.20
F-TEST	*	*	*	*	*	*
S.Em±	0.006	0.004	0.467	0.468	1.114	0.402
CD (0.05)	0.017	0.012	1.378	1.387	3.276	1.185

FA: Fly ash; PS: Paddy straw; CSW: Cattle shed waste; MOR: Mixed organic residues

indicates the compost is still being decomposed and hence it exhibited higher microbial activity. In fully matured compost, decomposition was slow down and dehydrogenase activity is lower at fly ash incorporation in 1:2 and 1:3 ratios. Irrespective of different organic sources the dehydrogenase activity remained on par with each other. Similar results attributed by (Casida *et al.,* 1964) who reported increased dehydrogenase activity in wormcasts was the result of higher microorganisms present in warmcasts.

Phosphatase activity : The phosphatase enzyme activity is the indication of phosphorus mineralization power by the microorganisms involved in recycling. The higher values of phosphatase enzymatic activity in the paddy straw, cattle shed waste and mixed organic residues may be due to use of fly ash amendment in the composting process which accelerated the microorganism activity related to phosphorus mineralization (Table 5). This was mainly attributed to innate fly ash composition of essential nutrients and optimum moisture retention for the microbial activity. The average values for phosphatase activity in VERMIASH compost ranged from 48 to 52 µg g^{-1} h^{-1} . Tiwari *et al.* (1989) also found higher phosphatase activity in earthworm casts applied to red soil. Earthworms increased the phosphatase activity indicated by stimulating the micro flora (Sharpley and Syres, 1976). Increased phosphatase activity in vermicompost added soils was also recorded by Satchell *et al.* (1984).

Urease activity : Urease activity of mixed organic residues vermiash compost was lower as compare to cattle shed waste and paddy straw. This may be due to production of NH_4^+ in mixed organic sources due to narrow C:N ratio. Since NH_4 inhibits urease activity and syntheses. A release of NH_4 by urea hydrolysis may have been responsible for lower urease activity (Burgos *et al.,* 1993).The increase in urease activity due to earthworm inoculation may be due to increased biomass of earthworm and microbes which increases the enzyme activity. Also the presence of N fixers in vermicompost might have stimulated conversion of NH_4^+ to NO_3^-. The results suggest that earthworms play a significant role in processing of fly ash into quality organic manure. The earthworm activity accelerated the process of decomposition of fly ash and stabilizing the waste. The process reduced pH, EC and BD values of Vermiash compost and further improved the nutrient content of the manure.

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