

Maturity Indices as an Index to Evaluate the Quality of Compost of Coffee Waste Blended with Other Organic Wastes

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ABSTRACT

Coffee pulp, husk and effluent are the main byproducts generated by the coffee processing units and are disposed into arable land and surface water. The presence of phytotoxic substances, organic acids in these byproducts is affecting the soil, water quality and restricts the crop growth. However, these wastes contain high concentrations of biodegradable organic and minerals of plant origin which can be better utilized by composting with other organic materials. Since the maturity indices of compost evaluate the quality of the compost, this study ascertains the change in maturity indices of coffee wastes composts. Aerobic composting was taken with coffee pulp, husk as main raw materials and it is enriched with other additives. Fortification of compost with Zinc and Boron during the termination of compost as nutrient supplement was carried out. The results revealed that there was a slow reduction in pH (7.41) and narrowing of C: N ratio (7.25), greater reduction in lignin content (37.54% to 28.46%), cellulose content (25.95 to 16.75%) and total phenol content (76.75 mg /100g to 38.8 mg /100g) with the increase in humic substances (40.65%) during the composting period when compared to the composition of original raw materials. And also there was gradual increase in major nutrients, secondary nutrients and micronutrients during the period of composting. However, the stabilization of compost was achieved at 150th day of composting.

Keywords: *Maturity Indices, Aerobic composting, fortification.*

1.0 INTRODUCTION

Coffee is a commercial plantation crop, grown in ecologically vulnerable ecosystem like Western Ghats. Coffee processing industries, are posing environmental hazards due to large-scale disposal of coffee pulp, husk, and effluents from these units. This practice poses a greater threat to water and land quality around the coffee processing units. Presence of toxic compounds like phenols in these byproducts restricts their direct use in agriculture. In addition, the indiscriminate use of fresh coffee pulp also affects crop through acid formation and local heat generation in the process of its fermentation. In order to restrain from the possibility of adverse effect of the disposal of coffee wastes, there need a healthier and productive way of utilizing these wastes.

Scientific method of preparing enriched compost using decomposition technique and fortification technique can render this waste fit for agricultural use. Enrichment of compost is conventionally done using inorganic nitrogen source and rock phosphate. But the use of organic sources of nitrogen such

as green weeds, forest litter and fortification of micronutrients to enhance the quality of compost is less explored so far. It is also possible to use microorganisms to solubilize the rock phosphate and to digest the resistant fraction of coffee waste by making use of the locally available organic materials such as cowdung. Treatment of coffee wastes by composting lessen the severe damage that the application of immature compost to the soil would cause and allows a more complete conservation of the residual energy stored in the organic material. Since the maturity indices of compost evaluate the quality of the compost, this study ascertains the change in maturity indices of coffee wastes composts. Therefore, one should ideally know the degree of maturity of compost before they are applied. Various parameters have been proposed to establish the degree of stability and quality of composts. The true maturity of compost can be assessed by measuring the maturity indices such as: C: N ratio, lignin, cellulose, humus composition, phenol contents and quality by major nutrients, secondary nutrients and micronutrients during the period of composting.

2.0 MATERIALS AND METHODS

The basic organic raw materials used for composting were coffee pulp (CP), coffee husk (CH) and the other additive like forest litter, weeds; coffee effluents, cowdung, rock phosphate, microbial inoculum etc. were used for enrichment of compost.

Coffee pulp, coffee husk, Forest litter, weeds were added at the rate of 33.3% on dry weight basis. Water was used to maintain 60% moisture in the compost and 33.3% of the moisture was met by coffee effluent. For enrichment, 12kg cow dung (20%), 2.5kg rock phosphate and 300ml of bacterial culture consisting of the P-solubilising bacteria (*Bacillus megatherium*) was added to solubilise rock phosphate. These substrates were piled into a cement cistern of dimension 70 cm height and 55 cm diameter. The compost materials were turned at an interval of 30 days up to 120 days. The compost was fortified with Zn and B at 30 days before the termination of composting (Micronutrients Zn and B in the form of $ZnSO_4 \cdot 7H_2O$ and H_3BO_3 were added at the rate of 400ppm Zn, 200ppm B on dry weight basis) and representative samples for analysis were taken periodically at the time of each turning. All the samples were dried under shade, then it was crushed and screened thorough 1 mm sieve.

The samples collected were analyzed for maturity indices and manurial value of coffee waste and parameters such as pH, organic carbon, total N, lignin, cellulose, total phenol and humic fractions. Other parameters major, secondary, micronutrients were determined by standard procedure. The pH was determined potentiometrically in 1:10 suspension while organic carbon by wet oxidation method (Walkley and Black's, 1934), total nitrogen by Kjeldahl procedure (Piper, 1966), lignin, cellulose and total phenol content were determined by the procedure given by Sadasivam and Manickam (1996). On the other hand humic substances were extracted by 0.1 N NaOH + $Na_4P_2O_7$ (ratio sample solution 1:10) and then separated into humic (HA) and fulvic (FA) acid by acidifying the suspension to pH 2 with HCl, precipitation and centrifugation were repeated to attain partial purification of HA fractions and further purification was done as described by Schnitzer (1982). Nutrient viz. P, K, Ca, Mg, S and micronutrients viz. Zn, Cu, Fe, Mn and B were determined in the sample by diacid digestion method (Piper, 1966) and analysed by the standard methods.

3.0 RESULTS AND DISCUSSION

Chemical composition of the major organic materials used for the composting is presented in Table 1. The analysis data revealed that the pH of the coffee pulp and coffee husk were low in reaction (pH 6.8

and 5.3 respectively) when compared to cowdung (pH 7.8). The low pH of coffee wastes may be due to the presence of acids in these materials. The EC of coffee wastes samples ranged from 2.5 to 3.2 dSm⁻¹ in CP and CH respectively, indicating the presence of higher soluble salt content in these wastes.

Table 1. Chemical Composition of the Major Organic Materials used for Composting

<i>Parameters</i>	<i>Coffee pulp</i>	<i>Coffee husk</i>	<i>Cow dung</i>
pH (1:10)	6.80	5.30	7.80
EC (dSm ⁻¹)	3.20	2.51	0.85
Organic carbon (%)	38.2	35.0	43.0
Nitrogen (%)	2.05	2.25	1.87
C:N ratio	18.5	15.6	23.0
Lignin (%)	38.6	39.4	19.0
Cellulose (%)	29.4	28.9	12.3
Phenol (mg 100g ⁻¹)	111	95.0	59.0

The organic carbon content was higher in cowdung (43.0%) followed by coffee pulp (38.2%) and coffee husk (35.0%). The coffee pulp and husk contained high amount of nitrogen (2.05 and 2.25% respectively) with C: N ratio of 18.5 and 15.6 respectively. Presence of high lignin (38.6 in CP and 39.4% CH), cellulose (29.4% in CP and 28.9% in CH) and total phenol (110.5 mg100g⁻¹ in CP and 95.01 mg100⁻¹g in CH) contents are the some of the problems associated with the direct application of these wastes to crops. Fermentation of fresh pulp in the soil may also damage crops through acid formation and by heat generation. However, higher amount of phenols, lignin and cellulose may hasten the humification process which is one of the parameter to confirm the good quality of compost.

The pH of the compost was 8.95 on 30 days of composting which slightly decreased with the increase in the composting periods finally reached pH value of 7.41 at 150th day of composting (Table 2 and Figure 1). The decrease in pH of decomposing organic material after 15 days might be due to production of organic acids, phenolic compounds and further increase in pH due to the formation of ammonia during decomposition. However, the pH was stabilized due to the buffering nature of humic substances. The findings in the present study confirmed the results reported by Poincelot (1974) and Verdonck (1988).

The compost treatment show a reducing trend in organic carbon content from 41.88% on 30th day to 21.69% on 150th day However the differences were insignificant. There was a slight increase in the total nitrogen content of the compost as decomposition proceeded. Total N content of the compost has significantly increased from 2.38 to 2.99%. In spite of higher N content of coffee pulp, forest litter, weeds and effluent, the reduction in the total weight of the initial compost materials during composting yield to increasing the N content..This change in organic carbon and nitrogen is reflected in the C: N ratio.The C:N ratio of the compost materials has decreased with advancement of the period of decomposition from 17.6 to 7.25 (Figure 1).

The inoculation of microorganisms combined with rock phosphate application during composting showed significant increase in the CO₂ evolution and also increase in N concentration by loss in initial weight of composting materials. This resulted in narrowing the C: N ratio of the compost materials (Bangar and Patil, 1980).

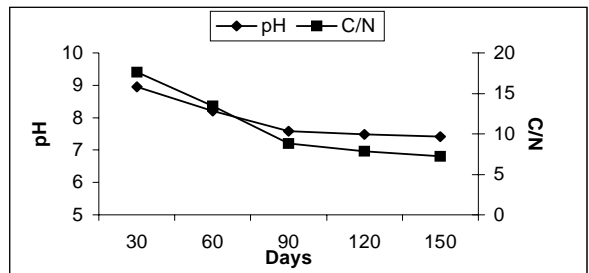


Figure 1 Changes in pH and C:N Ratio of Compost Samples Collected

The changes in the content of lignin, cellulose and phenols during composting are indicated in Figure 2. It depicts that the lignin, cellulose and phenol content of composting materials decreased with composting (Table 2). This may be due to positive effect of these additives on decomposition by way of increased availability of N, P and essential nutrients for microorganisms involved during the decomposition process. Microbial succession ensures the breaking down of such compounds over a period of time. The results have clearly show that microbial inoculation enhanced the degradation of cellulose, lignin and phenols over a period of time.

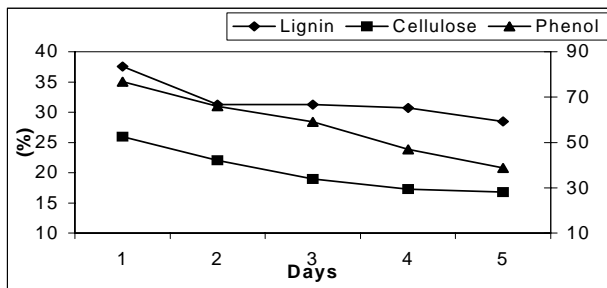


Figure 2 Changes in Lignin, Cellulose and Phenol of Compost Samples Collected

The humic substances (HA and FA) recorded was in higher amount to the tune of 40.63%. Presence of all the required essential conditions might have hastened the humification process. Bamick and Ziechmann (1991) opined that a direct relation exists between the microbial decomposition of organic matter and formation of humic acids. There may be higher degradation of lignin, which serve as starting material for synthesis of humic substances. According to polyphenolic theory of formation of HA, phenols are precursor for synthesis of humic substances (Stevenson, 1981).

Addition of rock phosphate, inoculation with microorganisms might have increased the P content during decomposition from 1.97 to 2.45%. The organic acid such as carbonic acid and chelating substances which are produced during decomposition helps in solubilising P from rock phosphate. According to Radhakrishna et al. (1995) enrichment of compost with nutrients results in high value compost with high degree of decomposition. Due to the K rich raw materials like coffee pulp and coffee husk, composts recorded higher K content (2.94%) Also, there was a significant increase in the calcium and magnesium content of enriched composts due to the addition of microbial inoculants and

rock phosphate (Table 3 and Figure 3). The content of Ca, Mg and S in the compost could be attributed to the presence of these elements in the raw materials used as additives.

The micronutrients in compost depending upon the raw material used (Table 3 and Figure 3). The content of the micronutrients 922.11, 269, 247 14.2 and 26.65 ppm of Fe, Mn, Zn Cu and B respectively were recorded in the matured compost. Fortification through Zn and B showed significant increase in the available Zn and B content of the compost due to the chelating effect of organic materials (Gupta et al.,1986).

Table 3. Changes in Nutrients Content of Compost Samples Collected during Different Periods of Composting

Parameters		Days				
		30	60	90	120	150
P	%	1.97	2.15	2.18	2.42	2.45
K		2.28	2.48	2.9	2.91	2.94
Ca		2.64	3.92	4.54	4.6	4.68
Mg		1.15	1.21	1.81	1.88	1.92
S		0.2	0.43	0.53	0.63	0.63
Fe	ppm	922	987	998	1005	1012
Mn		153	197	234	250	269
Zn		121	153	159	168	247
Cu		9	12	13.5	13.9	14.2
B		8	14	16	18	27

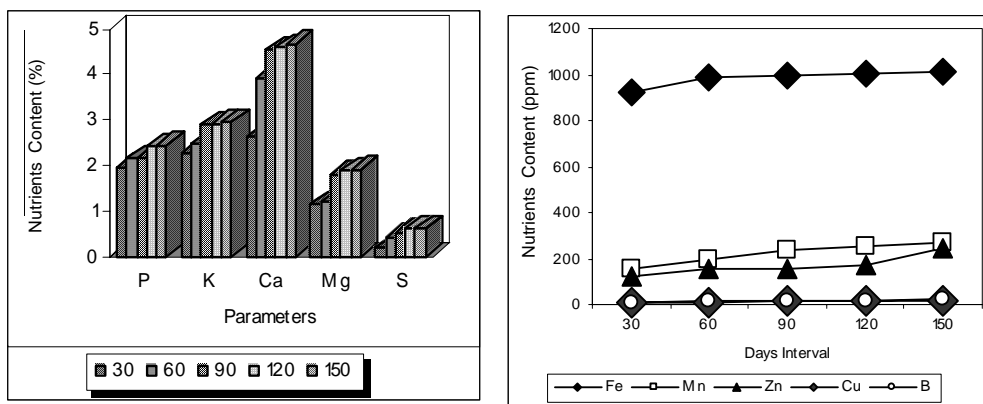


Figure 3 Changes in Macro and Micro Nutrients Content of Compost Samples Collected during Different Periods of Composting

4.0 CONCLUSION

Direct land disposal of coffee wastes such as coffee pulp, coffee husk and effluent causes problems associated with crop and soil quality due to presence of toxic phenolic compounds in these materials

in higher amounts. However, these wastes can be made into good utilization for land application by composting them by enriching with other additives. It is found that phenolic compounds, lignin, cellulose present in coffee wastes decreased and nutrients content were increased in the process of composting. However, the biostability was achieved at 150th day of composting.

The feasibility of ideally knowing the degree of maturity compost would forbid the application of immature compost on soil and allow complete conservation of nutrient stored in organic materials.

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