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RESEARCH ARTICLE

EFFECT OF DIFFERENT BIO-COMPOSTING TECHNIQUES ON PHYSICO - CHEMICAL AND BIOLOGICAL CHANGES IN COIR PITH

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ABSTRACT

Coir pith is an agro industrial by product, which is considered as a waste in the coir factory of India. Pollution created by the improper management and due to polyphenol leaching and its resistance for natural degradation has become an important social and environmental issue. Naturally coir pith is rich in potash but low in nitrogen and phosphorus. It has very high lignin, cellulose, hemicelluloses and C:N ratio which makes composting process difficult and slow. Hence, an attempt was made for the effective conversion by biological treatments using different techniques and decomposing agents and enriched by natural additives. The various macro (NPK) and micronutrients (Zn, Cu, Fe) were enriched in coir pith composted by basidiomycete fungus *Pleurotus sajor caju* and in vermicomposting by *Eudrilus eugeniae* and *Eisenia fetida. Phanerochaete chrysosporium* and *Pleurotus sajor caju* showed highest reduction of lignin, cellulose, hemicelluloses and C:N ratio. Vermicomposting technique proved to be able decomposer of coir pith when amended with 20 % of cow dung. Coir pith composting by white rot fungus *P. chrysosporium* and *Pleurotus* sp. were found to be able decomposer of lignin and cellulose. Biocomposted product can be used efficiently in hydroponic systems and organic manure for agriculture fields like growing roses, medicinal plants, vegetables, etc.

INTRODUCTION

Limitations in the availability of conventional manures like farmyard manure (FYM), poultry litter, cow dung etc., can be overcome through the exploitation of new sources of organic matter like coir pith. Coir pith, an agro waste by-product is collected during the process of coir fibre extraction from coconut husk of the coir industry, constitutes about 70% of the coconut husk and 7.5 million tonnes of coir pith are produced per annum in India (Kamaraj, 1994). In Tamil Nadu, nearly 0.2 million tonnes of coir pith are available annually (Parasuraman *et al.*, 2002). More than 98% of this waste is used for land filling, for want of a viable technology for its economic utilization. Present forms of management or utilization, such as land filling, hydroponics, manuring, etc., are not sufficient enough to totally consume the waste generated and it continues to be a perennial problem to the nearby aquatic and terrestrial environments. If the coir pith is not removed from the site of production, rainwater may percolate through it and leaches out polyphenols contaminating both surface and ground waters. This leads to leaching out of organic matter, and consequent increase of BOD and COD resulting in depletion of oxygen, which adversely affects the fish growth even in the nearby water zones. Secondly, components leaching out from coir pith and coconut husk negatively affect quality of soil, making the area not suitable for aquaculture. As a result of dumping coir pith in these water bodies, anaerobic condition sets in. In addition to hydrogen sulphide, methane and carbon dioxide are also released into the atmosphere. Methane is a green house gas having longer atmospheric residence time compared to carbon dioxide, which is another environmental issue. The issue of improper management of retted coir pith is creating a pessimistic impact on the coir fiber extraction industry. So what is needed is an interdisciplinary research to manage the traditional occupation so that external measures can be taken to maintain the environmental quality preserving this green industry. The husks are now being utilized as a raw material for the production of coir fibre. Extraction of one kilo of coir generates two kilos of coir pith. During the extraction of coir fibre from the husk, a light weight spongy material is released. This spongy material is referred to as coir pith which accounts for 50-60 percent of the total weight of the husk (Mathew *et al.*, 2000). The moisture absorption by coir dust is significantly high and practically takes lot of time for drying in the sun due its spongy in nature. Hence it has excellent moisture retaining capacity and high water holding capacity. Coir pith will not degrade by itself and will remain over the soil years together, thus polluting the environment. The quantity of coir waste produced is so enormous and accumulated in the coir industry, making its disposal difficult because of its high lignocellulose and slow degradation in natural environment. Consequently the coir dust is neither subjected to burning nor any productive application without composting. Coir pith in its natural form is not a conducive medium for the cultivation of any crop plants. Coir pith is comparatively rich in potash, but low in nitrogen and phosphorus besides higher proportion of lignin, cellulose and hemicelluloses (Abad *et al.*, 2002). It also contains appreciable

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amounts of micro nutrients. The low amount of nitrogen which results in high C/N ratio makes the material refractory (Joshi *et al.*, 1982). The waste material consists of Lignin 20-40%, Cellulose 40-50%, Hemicellulose 15-35 % and wider C:N ratio of 60 to 112:1 and the presence of soluble tannin related phenolics compounds and hence not favoring proper plant growth (Thampan, 2000). Lignins constitute the second most abundant group of biopolymers in the biosphere. These complex polymers need effective microorganisms for their degradation and can be converted into organic manure making it ideal for gardening and horticulture.

Composting is the natural microbial process of decomposition of organic matter by microorganisms such as Bacteria, Fungi and Actinomycetes. Biocomposting process is a viable means of converting various organic generated from the industry and the agricultural sectors into beneficial products such as biofertilizer and as a soil conditioner. Microbial degradation of coir pith is considered to be a safe, effective and environmentally friendly process. Vermicomposting has been recognized as an eco-friendly technology for converting organic wastes into high value organic manure (Kale *et al.*, 1982; Senapathi, 1994). The potentiality of vermiculture technology in the disposal of organic wastes is vast and differs from other methods of composting (Gandhi *et al*., 1997). White rot fungi, which have lignocelluloses degrading enzymes, play an important roles in carbon recycling in nature, because lignin, next to cellulose is the second most abundant organic compound on earth (Kanmani *et al*., 2009).

The alarming trend in environmental pollution emphasizes the need to use organic manures to sustain soil productivity. The prevention of environmental pollution and the increasing cost of chemical fertilizers warrant an integrated nutrient management approach in agriculture. The aim of the present work was carried on to find out the usefulness of coir pith composting by different methods and enriched with organic manure in examining the physico-chemical and biological properties.

MATERIALS AND METHOD

Sample collection

The coir pith collected from Coir industries, Pollachi, Tamil Nadu, India. It was sun dried and sieved (5 mm mesh) to remove long fibres, stored in gunny bags and used within one month after procurement.

Procurement and selection of microorganisms

For composting, various microbes namely bacteria (*Pseudomonas* sp.), fungi (*Trichoderma viride*) and earthworm (*Eudrilus eugeniae* and *Eudrilus foetida*) were obtained respectively from the Department of Microbiology and Department of Zoology of Annamalai University. *Phanerochaete chrysosporium* (MTCC 787) was procured from the Microbial Type Culture Collection, Chandigarh, India. The bacteria and fungi cell concentration were adjusted with 0.5 McFarland standard and cultures were maintained on NA and RBA slants respectively and stored at 4°C. The mushroom *Pleurotus sajor caju* and various organic amendments *viz.,* panchagavya, poultry manure, cow urine and cow dung were procured from the CIKS (Centre for Indian Knowledge Systems), Sirkazhi.

Composting process

The coir pith was subjected to decomposition by various ways and means to achieve the good quality compost. A pilot study of composting was carried out in plastic tub during which the moisture content was maintained at 50-60 % and kept for 60 days in shade place. To accelerate the decomposition process turning was manually done every week during composting. In case of vermicomposting using *Eudrilus eugeniae* and *Eudrilus foetida*, initially coir pith was allowed to partial decomposition along with cow dung and then after 20 days the earthworms were inoculated to it and kept it for further 40 days to obtain complete compost.

Table 1 Analysis of physico-chemical and biological properties

Parameters	Methods	References
pH	1:10 solid waste: distilled water using pH meter	Falcon *et al.* (1987)
EC (dSm^{-1})	1:10 solid waste: distilled water using conductivity fridge	Falcon *et al.* (1987)
BD g/cm^3	Specific gravity bottle method	Kanwar and Chopra (1980)
Porosity (%)	Specific gravity bottle method	Kanwar and Chopra (1980)
WHC (%)		Muthuvel and Udayasoorian (1999)
Chemical Properties		
N (%)	Using Sani automatic kjedahl apparatus.	Bremer (1965)
P (%)	Vanadomolybdic colorimetric method	Jackson (1973)
K (%)	Neutralization of triacid with ammonia method and reading in an ELICO CL-360 flame photometer	Jackson (1973)
Ca (%)	EDTA titrimetric method	AOAC, (2005)
Mg (%)	EDTA titrimetric method	AOAC, (2005)
OC (%)	Chromic acid wet digestion method	Walkely and Black (1934)
Lignin (%)	Acid detergent lignin method	Dutta (1981)
Cellulose (%)	Neutral detergent fiber method	Dutta (1981)
Zn, Fe & Cu (ppm)	Using atomic absorption spectrophotometer	Lindsay and Norvell (1978)
C:N ratio		
Organic matter	Chromic acid wet digestion method	Walkey and Black (1934)
Biological properties		
Bacteria	Serial dilution and plating method	Johnson *et al*. (1956)
Fungi	Serial dilution and plating method	Johnson *et al*. (1956)
Actinomycetes	Serial dilution and plating method	Johnson *et al*. (1956)

Treatment details

T_1 - Raw coir pith alone (1 kg) control
T_2 - Coir pith (1 kg) + *Pleurotus sajor caju* (12 g) + poultry manure (5 %)
T_3 - Coir pith (1 kg) + *Pleurotus sajor caju* (12 g) + panchagavya (5 %)
T_4 - Coir pith (1 kg) + *Pleurotus sajor caju* (12 g) + cow urine (5 %)
T_5 - Coir pith (1 kg) + *Trichoderma viride* (5 ml) + cow dung (5 %) + panchagavya (5 %)
T_6 - Coir pith (1 kg) + *Phanerochaete chrysosporium* (5 ml) + cow dung (5 %) + panchagavya (5 %)
T_7 - Coir pith (1 kg) composting by anaerobic digestion (biogas) method using cow dung (20 %)
T_8 - Coir pith (1 kg) + *Pseudomonas* sp. (5 ml) + panchagavya (5 %)
T_9 -Vermicomposting of coir pith (1 kg) + cow dung (20 %) + panchagavya (5 %)

Analysis of physico-chemical and biological characteristics of coir pith compost

After the composting period is over they were subjected to physico-chemical and biological analysis as per the following standard methods, the details are given in Table 1.

Statistical analysis

The results were subjected to the analysis of variance (ANOVA) as per the method suggested by Gomez *et al*. (1976). The experimental data processed statistically by applying the SPSS software technique for analysis of variance in RBD (Panse and Sukhatine, 1978). The critical difference was worked out at five per cent probability level for significant results (p=0.05).

RESULTS AND DISCUSSION

Composting is the most suitable technique for transforming organic waste into usable agricultural amendments (Vargas *et al*., 2007). Although the waste composition is very diverse, lignocellulose is the most abundant component which is responsible for limiting degradation (Dixon and Langer, 2006). The physico – chemical and biological characteristics of coir pith compost were analyzed and the results were discussed below. During composting the microorganisms altered the properties like pH, EC, N, P, K, organic carbon contents and C: N ratio towards desired levels over natural decomposition process. They stabilize the pH, EC and effectively mineralize N, P, K and carbon then the natural process.

Physical properties of coir pith compost

The physical properties of the compost were analyzed and the results were given in Table 2. The values of control coir pith prior to composting and after composting were almost similar in various properties. Hence, it needed biological treatments for the effective decomposition. The pH of the control was acidic in nature and looks brown color where as the composted coir pith showed the increased pH was slightly acidic to neutral. The pH was moderately increased in all the treatments over the control. The coir pith composted with mushroom *Pleurotus sajor caju* (T_3) showed the superior results of pH (6.91) and EC (1.25) where as higher values of BD (0.13), porosity (91.02) and WHC (681) obtained in vermicomposted coir pith (T_9) and their values were closely parallel to the values of above treatment and *vice versa.* In addition to this, fungi can also be efficiently composted the raw coir pith. The values of EC and BD of composted coir pith were reduced from the values of the control. Similarly, the values of porosity and WHC were increased from the control. The well composted coir pith looks black color. It was found that there won't be any change even after several years when the coir pith dumped. In the vermicomposted coir, the pH value was found increasing towards the maturation of the compost. The trend was increasing from slightly acidic to neutral. Lunt and Jacobson (1944) described that casts are usually found to have a higher pH and the slight increase in pH of vermicomposted coir pith may be attributed to the presence of calciferous glands.

According to Richard (2006) bulk density and particle density is one of the factors determining the successful functioning of a growing medium, he also observed that bulk density and particle density decreased which the composting period is increased. The highest porosity was recorded in T_9 and T_3 over the other treatments and control. The conductivity value was found to be minimum with the techniques without cow urine addition and higher with cow urine addition. This is due to the presence of free ammonium ions. Talashilkar and Vimal (1999) were also obtained higher electrical conductivity values when they used urea and superphosphate for their decomposing purpose. The present work was also in line with the above finding.

Generally, during decomposition the bulk density is decreasing. Here, the decreasing of bulk density increases with the increase in decomposition period and also depends on the nature of enriching substance addition. The bulk density was found to be much reduced in vermicomposted coir pith. In the control, due to the lack of earthworm and absence of degrading bacteria and fungi along with organic supplements, its breaking activity was found to be very low whereas due to the earthworm inoculated treatments, the heavier particles are broken down into smaller particles due to the passage of coir pith through the gut of earthworm.

Table 2 Analysis of physical properties of compost

Treatments	Physical Properties of compost				
	pH (1:10 w/v)	EC (dSm^{-1})	BD g/cm^3	Porosity (%)	WHC (%)
Initial substrate*	5.78	2.90	0.25	57.00	499
T_1	5.86	2.80	0.22	60.00	502
T_2	6.84	1.28	0.16	89.90	676
T_3	6.91	1.25	0.14	90.34	680
T_4	6.87	1.27	0.15	89.20	675
T_5	6.79	1.39	0.17	87.12	670
T_6	6.81	1.37	0.16	88.51	672
T_7	6.24	1.43	0.16	84.62	525
T_8	6.26	1.97	0.18	85.34	628
T_9	6.89	1.29	0.13	91.02	681
SE_D	0.14	0.20	0.01	4.02	25.01
CD (P=0.05)	0.31	0.46	0.02	9.11	56.59

*coir pith analyzed prior to composting

Chemical properties of coir pith compost

The chemical properties of the compost were analyzed and the results were given in Table 3. The maximum values of various macro nutrients like NPK, Ca, Mg and micro nutrients such as Zn, Fe and Cu were found in mushroom (T_2, T_3, and T4) and vermicomposted coir pith (T_9) and closely followed by other treatments. The amount of lignin, cellulose, hemicellulose content and C:N ratio present in the coir pith were gradually reduced during composting. However, in particularly T_6 treatment showed superior values than other treatments. From this observation, the fungi *Phanerochaete chrysosporium* enriched with cow dung and panchagavya was identified as the potential lingo-cellulosic degrader of coir pith. Similarly, *Pleurotus* sp. composted coir pith also showed much reduction in their values. This is due to various degrading enzymes secreted by both of them and *Pleurotus* sp. is a slow decomposer of lingo-cellulosic compound than *Phanerochaete chrysosporium* and the results obtained in our study also according to it. Nagarajan *et al.* (1990) tried to enhance the decomposition of coir pith by amending with urea. In the present study, we have utilized poultry manure which is rich in uric acid and cow urine for enriching the nitrogenous status of the coir pith. Poincelot (1974) reported that the nitrogenous sources accelerated the process of breakdown of cellulose. Pramanik *et al.* (2007) reported that the available nitrogen content in composted cowdung manure and coirpith compost for enticing the nitrogenous sources accelerated the process of breakdown of cellulose. Kadalli and Suseela Nair (2000) enriched the coir pith using the organic additives like cow dung which enhanced the macro and micro nutrient content of compost. Similarly in our study various organic supplements were used and obtained same results. Nagarajan *et al.* (1985) reported that the C: N ratio of coir waste was narrowed down by *Pleurotus* sp. In the present study also the drastic reduction in C: N ratio was achieved by the activity of *Pleurotus* and other fungal strains.

Table 3 Analysis of chemical properties of compost

Chemical Properties of compost	Treatments									
	Initial substrate*	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
N (%)	0.35	0.36	1.1	1.2	1.1	0.92	0.94	0.86	0.85	0.99
P (%)	0.19	0.24	0.67	0.68	0.60	0.50	0.55	0.37	0.38	0.58
K (%)	0.85	0.92	4.14	4.15	4.18	3.15	3.18	3.11	2.91	4.04
Ca (%)	0.82	0.87	3.11	3.17	3.20	2.17	2.20	1.97	1.67	3.15
Mg (%)	0.24	0.38	2.25	2.35	2.41	1.85	1.91	1.45	1.65	2.34
Zn (ppm)	5.60	6.3	11.23	12.95	12.15	10.25	10.85	8.28	8.10	11.84
Cu (ppm)	3.21	3.8	12.92	13.15	12.55	10.94	11.15	7.90	7.67	12.23
Fe (ppm)	0.44	0.48	6.51	6.81	6.62	4.56	5.81	3.68	3.25	6.79
OC (%)	41	40	30	29.5	30.5	33	31.80	35	35.6	30.8
Lignin (%)	34.23	32.34	7.80	7.65	7.81	8.15	6.24	17.58	16.82	12.28
Cellulose (%)	27.28	25.23	6.85	6.67	6.95	7.15	5.65	10.25	10.32	9.25
Hemicelluloses (%)	19.76	17.89	6.75	6.97	6.80	7.25	5.12	7.89	10.65	7.15
C:N ratio	118.34	112.24	26.56	24.58	25.72	35.86	33.82	40.69	41.88	31.11
SE_D	9.17	8.69	2.55	2.45	2.54	3.19	3.05	3.60	3.69	2.79
CD (P = 0.05)	19.99	18.93	5.57	5.35	5.55	6.96	6.65	7.86	8.04	6.09

*coir pith analyzed prior to composting

The coir waste is found to be rich in potassium and micro nutrients such as Fe, Mn, Zn and Cu. Actually this forms the main reason for selecting the enormously available nutrient rich waste for decomposition. The highest amount of micronutrient content were recorded in vermicomposted coir next to the coir composted with *Pleurotus* sp. Ramesh and Gunathilagaraj (1996) obtained the similar results of higher amount of micronutrients in composted coir pith using *Perionyx excavatus.*

Biological properties of coir pith compost

The microbial population during composting was influenced by inoculated decomposing microflora during which bacteria and fungi were rapidly multiplied whereas actinomycetes exhibited gradual proliferation it might be due to the addition of organic supplements into coir pith. However, it was found that the inoculation of specific group of microorganism resulted in dominance of specific group i.e., bacterial inoculate treatment resulted in increased population of bacteria and vice-versa. The highest population of bacteria, fungi and actinomycetes were recorded in treatment T_8, T_6 and T_5 respectively. The lowest populations were observed in control.

According to Dash (1979) and Satchell (1983) the passage of soil or any organic waste through the digestion tract of the earthworm is accompanied by qualitative and quantitative changes of micro flora and fauna. Gaur and Mukherjee (1980) reported that the organic matter has an effect in increasing the microbial population. The same reason may be correlated in this study.

Table 4 Analysis of decomposing microflora on succession of total microbial population in compost

Treatments	Total microbial population (CFU/g)		
	Bacteria x 10^6	Fungi x 10^5	Actinomycetes x 10^4
Initial Substrate	6.5	5.12	2.27
T_1	7	5.43	2.35
T_2	24.33	12.78	9.57
T_3	25.24	13.12	10.13
T_4	25.11	12.94	9.72
T_5	26.14	19.12	12.42
T_6	26.72	20.56	12.15
T_7	25.11	11.13	7.12
T_8	28.34	12.34	6.45
T_9	24.67	18.45	10.96
SE_D	2.11	1.56	1.06
CD (P=0.05)	4.88	3.61	2.45

CONCLUSION

The present study concluded that the composted coir pith has optimum physical, chemical and biological properties besides rich nutrients. Thus, in organic farming the agro-industrial waste coir pith can be bioconverted into compost which will be definitely bring fruitful yield besides quality of produce.

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