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Recycling of Coir Pith Using Vermitechnology

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Abstract

The menace of solid wastes and their disposal is a huge concern. One such solid waste is coir pith which is released from coir industries during coir extraction. This waste creates air, water, and land pollution to a greater extent. The disposal of coir pith was tried in the present work by means of vermicomposting through the earth worm species Eudrilus eugeniae. The characteristics of raw coir pith and vermicomposted coir pith were analyzed and compared.

Key words: disposal, extraction, pollution, vermicomposting.

INTRODUCTION

Solid Waste Management is the thirsty area that is prevailing among the environmentalists now-a-days. One among the important industrial wastes created all over India is coir pith from coir making industries. The disposal of coir pith is of widespread national concern. The coir pith is generally a mixture of dusts, bits and fibres of lesser length. It is usually dumped on the roadside near the coir factories in huge mounds. These mounds occupy a lot of space in the vicinity of the factories.

The coir pith is considered as a reject and no value addition to it is so far known. The accumulation of the rejected coir pith around coir fibre processing centres year by year is creating disposal problems. Being a light weight dust, it is easily blown by wind causing air pollution. If the coir pith is fired, the bulk does not reduce considerably due to high level of ash. Moreover the burning causes continuous smoke for several days emitting fugitive gases. The leaching from the dumping yards during monsoon is also considered to create environmental pollution. The coir pith due to its high moisture content cannot be used as a fuel. Ultimately it poses fire hazard, space problem and health problem if an appropriate solution is not found.

Similarly, trials are being carried out to evaluate the amenability of coir pith for microbial degradation in composting, its effect on soil nutrient availability, nutrient uptake and yield of the cultivated crop. The resistance of coir pith to microbial degradation will be reduced only if the C: N ratio is narrowed down. Composting is one of the several methods to bring down the C:N ratio.

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But in all the above methods, the coir pith degradation is not complete due to the rich content of lignin, tannin, phenol and cellulose. Coir pith will not degrade by itself and will remain over the soil years together, thus polluting the environment.

Vermicomposting is the only method to degrade coir pith completely. It is the method of implanting earthworms for the process of composting. The aim of composting is to convert a major proportion of solid wastes into a marketable or value added product. Earthworms are very apt for this process of composting. Earthworms are defined as invertebrates, belonging to the phylum Annelida, Order Oligocheata, Class Clitellate, which live in soil. They range in size from a fraction of a centimetre to two or more metres long. There are about 1800 species of earthworms which make a large contribution to the total weight or biomass of invertebrates in soil particularly in temperate regions.

REVIEW OF LITERATURE

The coir pith is a by-product obtained after the extraction of coir fibre from the coconut husk in coir making industries. The coir extraction leaves a dusty, nonfibrous spongy material called coir pith or coco peat or coir dust. It is a pure natural organic biodegradable matter. Coir pith accounts for about 50-60 percent of the coconut husk mass [1]. Extraction of 1 kg of coir fibre generates 2 kgs of coir pith. This problematic waste can be considered as a valuable biomass [2] if used in some specialized works.

Because of its high C: N ratio (about 100:1), high content of lignin and cellulose (about 40% each) and high polyphenol content (about 100mg/100g coir pith), under natural conditions its degradation and mineralization rates are very slow, preventing its direct use as an organic manure. The application of raw coir pith with wide C:N ratio can result in immobilization of plant nutrients. In addition, polyphenols and phenolic acids can be phytotoxic and inhibit plant growth.

The reviewed literature reveals the structural and chemical characteristics of coir pith and the various techniques adopted for the degradation purpose. Though several methods of degradation techniques followed, like incorporation of microbes like bacteria, fungi and actinomycetes, traditional method of composting, Chinese method of composting, etc., the degradation purpose is either incomplete or takes a long period of 1-2 years or it may be more costlier to adopt. To rectify all these drawbacks, vermicomposting can be suggested which balances all the necessities like complete degradation, reduction of C: N ratio, short processing period (30-45 days), detoxification, addition of antibiotics and growth hormones, presence of all macro and micro nutrients, etc.

Vermicompost is able to retain more soil moisture and also protects crops from pests and diseases thus reducing the demand of water for irrigation by nearly 30-40% and pest and disease control by almost 75%. This significantly cut down on the cost of production. As it also helps the crops to attain maturity and reproduce faster, it shortens the harvesting time. This further cuts on the cost of production and also adds to the economy of farmers as they can grow more crops every year in the same farm plot.

Researches show that vermicompost further stimulates plant growth even when plants are already receiving optimal nutrition. Vermicompost has consistently improved seed germination, enhanced seedling growth and development and increased plant productivity much more than would be possible from the mere conversion of mineral nutrients into plant-available forms.

Taking into consideration of the previous works carried out, the present work was thus initiated with a broad objective of solving the disposal problem of coir pith by vermicomposting and it is sure that use of vermicompost would significantly reduce or even replace the use of dangerous agrochemical, reduce the demand of water for irrigation thus benefiting the farmers and the economy and ecology of the nation in every way.

MATERIALS AND METHODS

Collection of Coir Pith

The coir pith required for the present study was collected from the coir pith mount near the coir factory located at Pettai, Tirunelveli (Fig. 1).

The fibre and the pith are then separated by a crude breaking machine. The separated pith are considered as a reject and mounted outside the factory. The coir pith required for the present study was collected from these fresh mounds. While collecting coir pith from the mounds, the surface layer of the mound to a depth of 15cms was scrapped and discarded. The fresh coir pith was collected in gunny bags and brought to the laboratory immediately.

Fig. 1: Coir pith dumped as huge mounds outside the coir producing factory

Pre-processing of Coir Pith

The coir pith collected was washed with potable water for several times (5 times) to leach out the excess potassium, calcium, sodium and chloride salts. This process of washing coir pith several times is represented as pre-processing. The excess soluble salts present in the soil amendments could be easily and effectively leached out from the medium under normal irrigation regimes in the fields.

PHYSICAL CHARACTERISTICS OF COIR PITH AND COIR PITH VERMICOMPOST AND SOIL

Physical properties of coir pith play a major role during degradation studies. The soil to be analysed was air dried and sieved to pass through a 2 mm screen and later analyzed in the laboratory. The following physical properties were determined by standard methods for both pre-processed and vermicomposted coir pith.

Moisture Content (MC)

The moisture content of the samples was determined as described by [3].

Water Holding Capacity (WHC)

The maximum water holding capacity of the samples was determined as described in Annex C of the ISO DIS 11268-2 [1].

CHEMICAL CHARACTERISTICS OF COIR PITH AND COIR PITH VERMICOMPOST

Sundried and sieved samples were subjected to the chemical analysis by preparing an aqueous extract as described by Ross [3]. It was also used for the analysis of various chemical parameters.

pH

The pH was recorded in all the samples using (HI 2215) digital pH meter (HANNA instruments).

Electrical Conductivity (EC)

The EC was recorded using (304) digital conductivity meter in all the samples.

Total Organic Carbon (TOC)

TOC was estimated by Walkley and Black (1984) method that uses ferrous ammonium sulphate and diphenylamine as an indicator for all the samples.

Lignin

The lignin content was estimated by the method adopted by Zadrazil and Brunnert (1980) method for all the samples.

Cellulose

The cellulose content was estimated by the method described by Updegroff (1969) in all the samples.

Sodium

Sodium content was determined in a digital flame photometer (Model Systronics 130) for the samples.

Calcium

The calcium content was estimated by EDTA titration method described in APHA [4] for the samples.

Magnesium

The magnesium content was estimated by EDTA titration method described in APHA [4] for the samples.

NUTRIENT STATUS IN COIR PITH AND COIR PITH VERMICOMPOST

Nutrients such as total nitrogen, total phosphorus, total potassium and C/N ratio were determined in the samples.

Available Nitrogen

The available nitrogen was determined after digesting the sample with concentrated H_2SO_4 (1:20, w/v) followed by Kjeldahl method [3].

Available Phosphorus

Available Phosphorus content of the aqueous extract of raw coir pith was determined by Stannous chloride method as described in Section 4500- PD of Standard Methods for the Examination of Water and Waste Water (APHA / AWWA / WEF, 1998). The values were reported as phosphate phosphorus.

Available Potassium

Available potassium (TK) was determined using digital flame photometer (Systronics 130) after digesting the sample.

C/N ratio

C/N ratio was calculated from the measured values of C and N.

VERMICOMPOSTING OF COIR PITH

Collection of Exotic Earthworms

The exotic worms, *Eudrilus eugeniae* (Fig. 2) were procured from the stock culture of Annamalai University laboratory.

Fig. 2: Eudrilus eugeniae

Experimental Setup for Vermicomposting

The process of vermicomposting was done in rectangular, plastic tubs of 30 cm breadth, 20 cm height and 45 cm length (Fig. 3).

Fig. 3: A single plastic tub used for vermicomposting

About four replicates were taken for each ratio and for each experiment with the worms. The pre-processed coir pith and cow dung were dried and weighed for different ratios and used as medium for earthworms. In all the composting tubs, the medium (i.e. coir pith and cow dung) was kept in equal amount i.e. 1kg. The control tubs had been filled with 1 kg of coir pith alone. The other ratio tubs (1:1, 2:1 and 3:1) contained 500:500, 666.5:333.5 and 750:250gms of coir pith and dried cow dung respectively for the experiments to make up the whole content to 1 kg. This setup was kept undisturbed for 1 day to make the composting material soft and edible for worms to consume. The next day, earthworms were introduced.

Introduction of Earthworms

Usually 15 numbers of worms were implied for composting 1 kg of waste in every replicate. The worms at pre-clitellate stage were selected and introduced into the experimental tubs except the control tubs. The worms entered into the media immediately after the inoculation. The tubs were kept closed with a steel mesh cover to keep other animals away from damaging the set up and to prevent the escaping of worms. These tubs were kept undisturbed in a shady place. Regular watering was done to keep the right amount of moisture in the tubs. The composting pile was kept moist but not wet and soggy. As the weather was very dry it was dampened periodically.

The compost was turned occasionally since this allows better aeration. In 45 to 60 days the compost was ready as indicated by the presence of earthworm castings (vermicompost) on the top of the bed. Vermicompost was harvested from the tubs and placed in a heap in the sun so that most of the worms move down to the cool base of the heap. The worms were separated and the compost was sieved and packed (about 50gms from each tub) for physico-chemical analysis.

RESULTS AND DISCUSSION

Physico-Chemical Properties of Raw Coir Pith and Pre-Processed Coir Pith

The physico-chemical properties of raw coir pith, pre-processed coir pith are presented in Table. The pH and electrical conductivity of raw coir pith collected was 5.43 and 3.49 mS/cm. Mak and Yeh (2001) studied that higher EC of a coir pith based medium caused high physiological stress to *Spathiphyllum* when grown under sub-irrigation conditions. Too low an EC (0.14 and 0.19 mS/cm) may lead to nutrient deficiency in plants.

High salinity (>3.5 dS/m) had adverse effects on the rate of seed germination and on the growth and development of seedlings (Bernstein, 1975). The raw coir pith showed decreasing trend in electrical conductivity on sequential washings.

Rich availability of potassium was known to inhibit the uptake of nitrogen, calcium and magnesium in plants (6). The potassium and sodium salts were found to be higher in amount than the phosphorus and calcium in raw coir pith collected for this study (Table 1).

Table - 1: Physico-chemical parameters of Raw coir pith, Pre-processed coir pith

Physico-Chemical Parameters	Raw Coir pith	Pre-processed Coir pith
MC in %	84.54±0.04	59.73±0.02
WHC in %	577.62±3.15	464.31±3.01
pH	5.43±0.11	7.45±0.12
EC in mS/cm	3.49±0.39	0.21±0.041
Lignin in %	47.32±0.2	46.26±0.3
Cellulose in %	31.68±0.3	31.07±0.2
Nitrogen in %	0.74±0.01	0.68±0.02
Phosphorus in %	0.036±0.04	0.024±0.05
Potassium in %	0.778±0.03	0.752±0.04
Calcium in %	0.75±0.05	0.7±0.07
Magnesium in %	0.38±0.02	0.32±0.01
Sodium in ppm	0.26±0.04	0.22±0.02
C:N ratio	47.43	51.17

The mean values show that there is not much variation in the overall moisture content (MC) in the coir pith particles but it was reduced to 84 to 59% in the pre-processed coir pith. The water holding capacity (WHC) has significantly decreased to 19.61% in pre-processed coir pith from the raw coir pith.

The smaller particle may have been retaining the moisture highly and larger particle may have the lowest capacity of moisture rententivity. The calcium, magnesium and sodium level was recorded in a decreasing trend in the pre-processed coir pith after washing for several times than the raw coir pith. Traditionally, the sequential washing has important role upon the toxification of animals or human beings. The same trend was used in this study and analyzed that the level of soluble salts like calcium, magnesium and sodium was decreased.

Thus in the present study, the pH, electrical conductivity, MC, WHC and other soluble salts were optimized by pre-processing of coir pith with potable water making it suitable for both vermicomposting and for plant growth.

Physico-Chemical Properties of Coir Pith Vermicomposts

In the present study coir pith degradation was carried out by earthworm with 60 days composting process and the obtained product was used as vermicompost. Microflora in the intestine of earthworm is involved in the decomposition [7]. Cow dung was used as a supplementary source to improve the efficiency and quality of vermicompost. Vermicomposting of coir pith was done with the earthworm species, *Eudrilus eugeniae* which showed higher casting activity. The composting process was completed in 60 days by *Eudrilus eugeniae*

The castings of *Eudrilus eugeniae* were cylindrical in shape measuring 3mm in length and 1mm in thickness. The physical properties such as MC and WHC were increased in vermicomposted coir pith (1:1 ratio) than the pre-processed coir pith. The values of MC in various vermicomposts differed slightly between one another. But the value of WHC in control was found to be decreased double the times from that of the 1:1 vermicompost.

The chemical analysis of control and worms worked coir pith (vermicomposts) showed changes in all the parameters analyzed. The various macro nutrients such as NPK, Ca, Mg and Na were found enriched in coir pith vermicomposted by *Eudrilus eugeniae* than the raw coir pith. The values of control coir pith prior to composting and after composting were almost similar or slightly increased in various chemical properties like N, P, K and other macro nutrients.

Table - 2 Physico-chemical properties of Eudrilus eugeniae vermicompost

Physico-Chemical Properties	Treatment ratio (coir pith : cow dung)			
	Control	1:1	2:1	3:1
MC in %	74.20±0.02	84.20±0.02	83.40±0.01	83.20±0.02
WHC in %	262.95±4.05	573.50±2.31	559.75±1.52	387.15±9.59
pH	7.41±0.11	7.24±2.65	7.25±0.01	7.46±0.02
EC in mS/cm	0.17±0.028	0.10±0.063	0.11±0.085	0.12±0.014
Lignin	1.06±0.3	0.62±0.1	0.71±0.2	0.64±0.7
Cellulose	2.17±0.2	2.14±0.4	2.15±0.6	2.16±0.8
Nitrogen in %	0.623±0.02	1.023±0.05	0.995±0.01	0.974±0.01
Phosphorus in %	0.024±0.05	0.052±0.09	0.044±0.08	0.036±0.04
Potassium in %	0.783±0.04	0.992±0.04	0.852±0.05	0.794±0.05
Calcium in %	0.81±0.01	0.92±0.14	0.87±0.12	0.8±0.13
Magnesium in %	0.48±0.05	0.51±0.01	0.46±0.02	0.41±0.02
Sodium in ppm	0.26±0.02	0.28±0.06	0.27±0.08	0.27±0.09
C:N ratio	37.07	20.92	22.81	23.40

An increase in the values of nitrogen was observed and simultaneously all the C: N ratios recorded reached the optimum range (i.e. decreased from 51.17 in pre-processed coir pith to 20 to 37.9 in vermicomposts). Contrary to this, a marginal decrease in the values was observed in pH and Electrical Conductivity (Tables 4.1 and 4.2). This proves that effective mineralization process took place in composts with almost all the combinations with cow dung than the control. The coir pith composted with *Eudrilus eugeniae* showed the superior results of pH.

The values of pH and EC of vermicomposted coir pith were reduced from the values of the control. The values of lignin and cellulose were reduced by the earthworms. The compost of *Eudrilus eugeniae* showed highest reduction of lignin and cellulose. The physico-chemical nature of the coir pith before exposing to vermicomposting was analyzed and compared with the effect of the earthworm treatments on biodegradation of organic constituents in coir pith after 45 to 60 days. *Eudrilus eugeniae* is capable of over production of vermicompost within a short period.

The C: N ratio present in the pre-processed coir pith was gradually reduced during composting. However, particularly the 1:1 treatment with *Eudrilus eugeniae* showed superior values than other treatments. From this observation, the earthworm, *Eudrilus eugeniae* was identified as the potential lingo-cellulosic degrader of coir pith. [8] indicated that the employment of *E. eugeniae* reduced the C:N ratio in coir pith but increased the level of NPK and other micronutrients. They also observed that the composted coir pith had higher water holding capacity and microbial activity.

Composting is the biological process of decomposition of organic constituents of bio-waste materials under controlled conditions. During this process, carbon from organic molecules gets converted to carbon dioxide, resulting in the reduction of bulkiness of the organic forms, which can be absorbed directly by plants. Rates of decomposition and mineralization of organic residues differ among species having different plant chemistry [9]. Have observed that the ratio of C:N obtained in vermicomposted products of coir pith is also more favorable for the plant pathogen suppressive effect. Levels of exchangeable cations (K, Ca and Mg) were also significantly higher in the worm casts than in the raw coir pith.

In the control, due to the lack of cow dung 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 were broken down into smaller particles due to the passage of coir pith through the gut of earthworm.

In the present study, cow dung was utilized which is rich in nitrogen for enriching the nitrogenous status of the coir pith. In the present study also the drastic reduction in C:N ratio was achieved by the activity of earthworms. Earthworms play a major role in nitrogen transformations in manure, by enhancing nitrogen mineralization.

Initial C:N ratios were high in both test and control composts and then the C: N ratio drastically decreased in vermicompost than the control compost. Dash and Patra stated that C: N ratio decreasing process has been found to be enhanced by the addition of cow dung.

Naturally, coir pith degradation is very slow in the soil because of the chemical and structural complexity of its lignin–cellulose complex. In the present study coir pith degradation by earthworm was carried out with 60 days composting process and the obtained product was used as vermicompost. The biochemical composition of the used coir pith and cow dung materials suggested that the materials have potential as alternative nutrient sources. The low composition of lignin and cellulose in cow dung than the coir pith indicates that coir pith would be a more effective source. However, cow dung was used as a supplementary source to improve the efficiency and quality of vermicompost.

CONCLUSION

From the results it is inferred that vermicompost contained twice more nitrogen, phosphorus and potassium than the raw coir pith. These are the main minerals needed for plant growth and this was done by the large number of beneficial micro-organisms present in the earthworm gut which have at least as much to do with it. The casts are also rich in other macro and micro nutrients and also they have a perfect pH balance which is required for good condition of soil and contain plant growth promoting factors. The results of the growth parameters have confirmed this fact.

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