Journal of Pharmaceutical and Scientific Innovation

www.jpsionline.com

Research Article

SUCCESSFUL BIODEGRADATION OF COIR PITH WASTE USING NOVCOM COMPOSTING METHOD: A CASE STUDY FROM VANIAMPARA RUBBER ESTATE, INDIA

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DOI: 10.7897/2277-4572.04117

Received on: 23/12/14 Revised on: 09/02/15 Accepted on: 19/02/15

ABSTRACT

Dumping of coir pith, the by product of coir-industry is posing serious environmental problems in the southern states of India, especially Kerala, Tamil Nadu, Andhra Pradesh and Karnataka, India. A study was conducted at Vaniampara Rubber Estate (Kerala, India) to demonstrate the potential of Novcom composting method towards production of quality compost using coir-pith as raw material. Novcom coir pith compost was produced within a period of 21 days with one turning of the compost heap on 10th day. Physicochemical and fertility status of compost resembled the standard set by different international composting councils, while its total nitrogen (1.48 percent) content was much higher than coir pith compost produced using other composting processes. The high value of nitrogen might be due to intense biodegradation process, which lowered the potential for N loss and favorably influenced atmospheric- N fixation through naturally generated autotrophic micro flora within compost heap. The finding was corroborated by the high population of microbes (10^{14} to 10^{16} c. f. u. per g moist compost) within compost, which were generated naturally during the composting process. Maturity and phytotoxicity bioassay tests confirmed that Novcom coir pith compost was mature and free from phytotoxic effect. The study concluded that Novcom composting method could be an effective and economical process for speedy conversion of coir pith into a valuable input for organic soil management.

Keywords: Atmospheric N fixation, Coir pith waste, Novcom composting method.

INTRODUCTION

Coir pith is a biomass residue generated during the extraction of coir fiber from coconut husk and is a byproduct of the coir manufacturing industry. It is lingo-cellulosic material forming about 70 % of the coconut husk. Normally, coir pith is dumped as agricultural waste and become accumulated as a waste product in the form of heaps of coarse and fine dusts. These agricultural wastes have traditionally been disposed of by burning, which resulted in various environmental problems, including carbon deposits as well as the warming of the atmosphere. During the rainy season, the tannins and phenols of the coir pith leached out into the soil and into the irrigation canals, thereby making agricultural lands unproductive. Moreover, the water pollution caused by such leaching is harmful to the aquatic and soil biological life[1]. High salt content in some coir dust following curing of coconut husks in lagoons[2], along with its very slow degradability offers little scope for its direct application in agricultural soil. Exploitation of coir pith in other industrial uses haves faced several hurdles viz. lack of proper and eco-friendly technology[3] as well as higher transport[4] and technological set-up cost. Moreover, the bulk of the plant (not just the fibers) needs to be used for a number of different purposes, so as to minimize the quantity of waste produced and increase the value of the crop[5]. Coir pith is a fluffy, light, spongy and extremely compressive material with increased water-holding capacity and sizable percentage of combustible matter along with low ash content. It decomposes very slowly in soil, because its pentosan / lignin ratio is 1: 0.30; the minimum required for moderately fast decomposition in the soil is 1: 0.50[6]. About 7.5 - 10^5 tons of coir pith is produced annually in India[7]. Due to its very high lignin content, its use as a composting material is very limited in existing composting methods. In this context, Novcom composting method was used for compost production at Vaniampara Rubber Estate (Kerala, India) to study the effectivity of the method in terms of effective biodegradation of coir pith.

MATERIALS AND METHODS

Method of Compost Preparation

Raw materials used

Coir pith and cow dung in 80 : 20 ratio was used for making compost.

Novcom Solution

It is the biologically activated and potentized extract of Doob grass (*Cynodon dactylon*), Bel (*Sida cordifolia* L) and common Basil (*Ocimum bascilicum*). Details of the solution is given by[8] working on biodegradation pathway of Novcom composting method.

Mechanism of Novcom Solution under Element Energy Activation Principle

Taking inspiration from Vedic literature the Element Energy Activation Principle, the system of energy management in agriculture is developed by Dr. P. Das Biswas, an Indian scientist, who is also pioneer in the revolution of Indian Organic Tea cultivation. He developed Inhana Rational Farming (IRF) Technology, which is perhaps the only organic farming technology which provides a complete scientific solution from seed showing to crop harvesting[9-14]. Presently more than 40 % of total organic tea produced in India was directly guided by this technology. Novcom composting method is part of this technology, which facilitates an easy and effective biodegradation of any raw materials within very short period. There are specific steps for any proper bio-degradation process, mesophillic- thermiophillic – mesophillic, where one stage only comes when the previous one is completed. Novcom solution along with the method of heap construction just speeds up the steps in a very organized and synchronized manner. This method provides the necessary environment in each major step and once the process start it gets completed in the desire manner. Here also no specific input, agent known to have influence in the breaking down of the organic material is added because these singly or in combination have their own limitation. Apana Prana along with Udana Prana, the Life Force for elimination works on the earth element primarily the organic matter. Since all the matter is also composed of five elements, these are broken into their individual identity. Udana Prana activates fire element to rise the temperature in intense manner up to minimum 60 to 65^{0}C in these stage pathogenic bacteria or the seeds of the unwanted plants are destroyed and thermophillic bacteria starts growing up. After this actinomycetes group of microorganism come to break the degraded material into further finer material. The process continues at various levels with the help of fire element, air element and space element and finally the degradation of cellulose and hemicelluloses part occurs. The specific Life Forces such as Udana, Vhana and Prana are providing through Novcom Solution on the various days of operation as per the requirement and specificity of particular organic material.

Preparation of Compost

At a selected upland and flat area a pit was dug out measuring 2 ft. in depth, 6 ft. in length and 4 ft. in width. A layer of cow dung was put at the bottom of the pit and along its four sides. Coir pith was mixed with cow dung at 80:20 ratio and spread in the pit layer wise (each layer being approximately 0.5 ft. thick.) till it reached the top surface, Diluted Novcom solution (25 ml in 5 liter water) was sprayed on each layer. Hence, total 100 ml of Novcom solution was required for 4 layers. The pith was covered with hay and left in this manner for 9 days. On 10th day, the composting material was removed from pit and mixed properly. The material was again put in the pit repeating the previous process. Once again 100 ml of Novcom solution was used. The compost was ready on 21st day.

Research Methodology

Analysis of compost samples

Physicochemical properties of compost, viz. moisture content, pH, electrical conductivity and organic carbon were analyzed according to the procedure of Trautmann and Krasny[15]. The total N, P and K in the compost were determined using the acid digestion method of Jackson[16]. Estimation of bacteria, fungi and actinomycetes was performed using Thornton's media, Martin's media and Jensen's media respectively, according to procedure outlined by Black[17]. Stability tests for the compost (CO_2 evolution rate, phytotoxicity bioassay test/ germination index) were performed according to the procedure suggested by Trautmann and Krasny[15]. Cress (*Lepidiun sativum* L.) seeds were used for the phytotoxicity bioassay test. Statistical Analysis in terms of standard error was performed with SPSS software (version 7.2).

RESULTS AND DISCUSSION

Analysis of Compost Quality

To evaluate the composting process and the end product quality under Novcom composting method, raw coir pith and final Novcom coir pith compost samples were evaluated for 16 different quality parameters as per National and International standards. The samples were analyzed for physicochemical properties, microbial population and maturity and phytotoxicity parameters (Table 1).

Physico-Chemical Parameters of Compost Samples

All the compost samples appeared dark brown in color with an earthy smell, deemed necessary for mature compost[18]. Average moisture in the compost samples varied from 62.54 - 74.36 which is lower than the raw materials but higher than the standard reference range (40 to 50 percent) as suggested by Evanylo[19]. Such high moisture content was primarily due to the porous nature of coir pith, which causes very high retention of water molecules as compared to other organic materials. The predominant use of compost is to mix it with soil to form a good growing medium for plants, for which pH forms an important criteria of consideration[20]. pH values of the Novcom coir pith compost samples was varied from 6.65 -6.89, which indicated that they were within the neutral range as suggested for good quality and mature compost[21]. High electrical conductivity (EC) of raw coir pith is one of the concern points for its agricultural use. However mean EC value in final Novcom coir pith compost was 2.04 dSm^{-1}, which was not only lower than its initial value but also at safely below (< 4.0 dSm^{-1}) the stipulated range suggested for saline toxicity as per USCC[19,22]. Organic carbon content in the compost samples varied from 26.87 – 34.21 percent, qualifying not only the criteria for field application (16 to 38) as per the range suggested by USCC[22] but also the standard suggested value of > 19.4 percent[23] for nursery application. The rate of the decomposition of organic matter over time indicates the speed of biodegradation during composting[24,25]. The organic carbon content of mature compost; which generally depend on the types of raw material used, varied from 16 to 38 %[19]. Hence, change in organic carbon content from 52.59 percent in raw material to 28.12 in the final compost (i.e. on day 21 of composting) indicated faster biodegradation and simultaneously pointed towards compost maturity within a short time frame. Compost mineralization index (CMI) expressed as ash content/ oxidizable carbon indicated the ready nutrient supplying potential of compost for plant uptake. The mean CMI values of the compost samples (1.51) were well within the standard range (0.79 to 4.38) as suggested by Rekha *et al*[26].

Fertility Parameters of Compost Samples

Although 36 different nutrients are required for plant growth, but the macronutrient (N, P, and K) contribution of compost is usually of major interest[27]. Among the different macronutrients, availability of nitrogen to the plants is most complex. The total nitrogen content in the compost samples ranged between 1.34 and 1.64 percent, which was well above the Indian standard[28] of 0.5 percent and the range of 1 – 2 as suggested by Watson, Alexander[20,29]. The value obtained for Novcom coir pith compost was much higher than that of coir pith compost produced by other composting methods[1,30]. The total nitrogen content in compost sample increased from 0.90 to 1.48 percent during the biodegradation period, which might be due to fixation of atmospheric N within the compost heap by autotrophic micro organisms generated naturally during the composting process. According to de Bertoldi[31,32], an increase in the population of N-fixing bacteria in the later phase of composting, can be attributed towards increase in the value of total N in compost, despite volatilization (primarily) losses from compost heap during biodegradation. Similar findings were obtained in case of Novcom compost produced from garden weeds at Maud T.E. (Assam, India) under FAO-CFC-TBI Project, where there was up to 95 percent appreciation in total- N value as compared to raw material[33]. Total phosphorus (0.38 – 0.55 percent) was higher than the suggested standard of 0.22 percent[28], whereas the values obtained for total potassium (0.43 – 0.68 percent) were higher than the range (0.2–0.5 percent) suggested by Watson, Alexander[20,29] on dry matter basis. Hence, the analytical values obtained in case of Novcom compost might indicate intense biodegradation process resulting in minimum loss of nutrients and moreover appreciation of N content from initial value, which contributed towards the comparatively higher nutritional status of the final compost samples. The ideal C/N ratio of any mature compost should be about 10, as in humus; but it can be hardly achieved in composting[34]. However, of greater importance is its critical value (C/N ratio 20), below which further decomposition of compost in soil did not require soil nitrogen, but release mineral nitrogen into the soil[35]. C/N ratio varied from 17 : 1 to 20 : 1, which was within the reference range of ≤ 20[28] as suggested for well-matured compost indicating that all the compost samples were mature and suitable for soil application. The change in C:N ratio of the composting material was also considered in terms of stability, because as the readily available C in the organic matter is oxidized and released as carbon dioxide, there is a general reduction in carbon content over time[37]. Novcom coirpith compost also met the additional criteria for compost stability, i.e. C:N ratio of > 20 and $C:N_{final}$ / $C:N_{initial}$ ratio > 0.75[21], confirming that it attained maturity within 21 days.

Microbial, Maturity and Phytotoxicity Status of Compost Samples

Microbial Status of compost is one of the most important parameter for judging compost quality because microbes are the driving force behind soil rejuvenation as well as crop sustenance, through maintenance of soil – plant – nutrient dynamics[37]. The microbial population, their biomass and activity, are key parameters that can also be used to elucidate the composting process[38]. Scientists Lynch and Wood[39] observed that the microbial flora built up rapidly with composting initiation[45] and, in the case of the Novcom composting process, the population of total bacteria, fungi and actinomycetes built up in an exponential manner. It has been established that the diversity of micro organisms contributing to organic matter decomposition changes with composting. The total count for bacteria, fungi and actinomycetes in c. f. u. g^{-1} moist compost sample increased from 21 x 10^3, 12 x 10^3 and 9 x 10^3 on day 0 to 39 x 10^{16}, 16 x 10^{14} and 13 x 10^{14} respectively, on day 7. Such high generation of microbial population could be possible only due to presence of an ideal micro-atmosphere within the compost heap influenced by application of Novcom solution[8]. Stability of compost sample indicated the status of organic matter decomposition and is a function of biological activity. Hence, microbial respiration formed an important parameter for determination of compost stability[41]. Mean respiration or CO_2 evolution rate of all compost samples (1.87 to 3.21 mgCO_2–C/g OM/day) was more or less within the stipulated range (2.0 - 5.0 mgCO_2–C/g OM/day) for stable compost as proposed by Trautmann and Krasny[15,42]. Direct assessment of phytotoxicity can be made by growing plants in compost media and calculating per cent seed germination and root elongation over control. Test results of compost samples using garden cress (*Lepidium sativum* L.) as test seed revealed that per cent seed germination and root elongation over control ranged from 87 to 98 percent and 90 to 102 percent respectively, being well above (in most cases) the standard value (> 90 % seed germination), which indicated 'very mature compost with no phytotoxic effect'[22]. The phytotoxicity bioassay test, as represented by germination index provided a means of measuring the combined toxicity of whatever contaminants may be present[44]. The mean test value (0.88) indicated total absence of any phytotoxic effect in Novcom coir pith compost as per the standard value of 0.8 to 1.0 as suggested by Trautmann and Krasny[15].

Table 1: Analysis of raw coir pith and compost samples under Novcom composting method at Vaniampara Rubber Estate, Kerala, India

S. No.	Parameter	Analytical Value			
		Raw coir pith sample	Novcom compost from coir pith		
			Range value	Mean	± S.E.
1.	Moisture percent (%)	80.51	62.54 - 74.36	70.07	± 2.12
2.	pH_{water} (1 : 5)	6.13	6.65 -6.89	6.62	± 0.32
3.	EC (1 :5) dS/m	2.65	1.89 – 2.14	2.04	± 0.28
4.	Organic carbon (%)	52.59	28.87 – 34.21	30.21	± 1.68
5.	CMI[1]	0.101	1.42 – 1.61	1.51	± 0.29
6.	Total nitrogen (%)	0.90	1.34 – 1.64	1.48	± 0.08
7.	Total phosphorus (%)	0.40	0.38 – 0.55	0.42	± 0.06
8.	Total potassium (%)	2.99	0.43 – 0.68	0.53	± 0.06
9.	C/N ratio	58:1	17 :1 – 22:1	20 :1	± 0.82
10.	Total bacterial count[2]	21 x 10^3	(11 -46) x 10^{16}	39 x 10^{16}	± 11 x 10^{16}
11.	Total fungal count[2]	12 x 10^3	(10 – 23) x 10^{14}	16 x 10^{14}	± 4.2 x 10^{14}
12.	Total actinomycetes count[2]	9 x 10^3	(8 -21) x 10^{14}	13 x 10^{14}	± 2.5 x 10^{14}
13.	CO_2 evolution rate (mgCO_2–C/g OM/day)	-	1.87 - 3.21	2.04	± 0.18
14.	Seedling emergence (% of control)	-	87 - 98	92	± 3.21
15.	Root elongation (% of control)	-	90 – 102	94	± 03.52
16.	Germination index (phytotoxicity bioassay)	-	0.82 – 0.96	0.88	± 0.05

[1]CMI: Compost mineralization index; [2] per g moist soil

Figure 1: Mixing of coir pith and fresh cow dung (80: 20 ratio) on 1st day

Figure 2: Pasting cow dung slurry at the base and four sides of the pit

Figure 3: Stacking of coir-pith layer (0.5 ft.) within the pit (size: 6 x 4 x 2 ft.)

Figure 4: Spraying Novcom solution (25 ml in 5 ltr. water) over each layer of coir pith

Figure 5: Completed pit on 1st day

Figure 6: Raw coir pith before initiation of Novcom composting process

Figure 7: Mature Novcom coir pith compost after 21 days of composting

CONCLUSION

The results indicated that, Novcom composting method could be a suitable option for not only eco-friendly disposal of coir pith waste, but also for generation quality input for organic soil management. The high quality compost generated through this composting method within a short time period indicates potential as an effective technological tool towards driving the 'Waste to Wealth' programme in a successful manner. Large scale adoption of this technology can restrict pollution caused by coir pith industry; at the same time generate additional mandays and options for income generation.

ACKNOWLEDGMENT

The authors are thankful to M/s Vaniampara Rubber Company Limited for providing necessary documentation regarding Novcom composting programme using coir pith as raw material, at their rubber estate.

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Source of support: Nil, Conflict of interest: None Declared

QUICK RESPONSE CODE	ISSN (Online) : 2277 –4572
	Website http://www.jpsionline.com

How to cite this article:
Antara Seal, Ranjan Bera, Anupam Datta, Susmita Saha, Ashis Kumar Chatterjee, Arun Kumar Barik, Debashis Mazumdar. Successful biodegradation of coir pith waste using Novcom composting method: A case study from Vaniampara rubber estate, India. J Pharm Sci Innov. 2015;4(1):72-77 http://dx.doi.org/10.7897/2277-4572.04117