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Original Article

Utilization of waste from concentrated rubber latex industry for composting with addition of natural activators

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Abstract

The utilization of wastes from concentrated rubber latex industry for composting is promising as a sustainable and environmentally friendly method.The aim of this study was to utilize wastes including skim latex serum (SS) and concentrated latex sludge (CS) as a raw composting ingredient after being combined with para rubber wood sawdust (SD) at a ratio of SS, CS, and SD of 1:1:1.Effective microorganisms, pig manure and chicken manure were used as natural activator sand were added to the composted materials at ratios of 10, 20, and 30 wt%.The best activator for composting was found to be PM added at a ratio of 10 wt% after a composting time of 25 days.The growth of Chinese kale after application of this compost to which chitosan had been added produced a much higher yield of fresh weight than those was achieved using commercial compost. Thus, compost from waste materials produced from the rubber latex industry could be employed in conjunction with chitosan to promote better agricultural growth, and logically should contribute to cost saving in the latex industry as well as aiding its waste disposal.

Keywords: chicken manure, composting, pig manure, rubber industry waste, waste disposal

1. Introduction

Currently, waste management is a major concern around the world, and composting has been especially promoted as a sustainable method frecycling or adding value to waste material. A survey of the cooperative concentrated rubber latex industry in southern Thailand has shown that most cooperatives do not use adequate methods to avoid increasing the cost of latex production. There are major problems with air pollution caused by the release of ammonia, sulfur, and nitrogen compounds. and there are also major problems with water pollution, as the particularly from the chemicals and solid materials associated with the spinning of latex in hydro cyclones, washing latex in storage tanks and skimming latex which produces materials considered as wastes such as skim latex serum and concentrated latex sludge (Pollution Control Department, 2005).

Most natural rubber sheet and latex industries simply discharge these materials into the environment without sufficient treatment and this causes environmental problems. Mohammadi *et al.* (2010) reported that about 80 million liters of untreated wastewater are discharged into streams and rivers in Malaysia daily. Skim latex serum (SS) which is one of the main waste products generated from the rubber industry,

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contains a high amount of ammonia and the main solid waste produced, concentrated latex sludge (CS) has a high phosphorus content. SS usually contains about 4% total solids, including nitrogen in the form of ammonium sulphate (0.26%), protein (0.09%) and potassium (0.2%) (Sharifuddin & Zaharah, 2009). Sakornrat (2002) reported that SS can be used as rice fertilizer for rice seedling sand is in fact more effective than Hoagland solution. Meanwhile, Ubon *et al.* (2007) analyzed the nutrient contents in CS which included nitrogen (1.02-2.53%), phosphorus (22.15-48.19%),and potassium (0.39-0.60%)ona dry weight basis. Uttraporn *et al.* (2012) reported that blending CS with pig manure was feasible for para rubber seedlings because the combined nutrients can enhance plant growth.The nutrients in SS and CS would have a direct impact on plant growth, even with a low amount of organic matter, and this was one of the main factors encouraging the investigation of its use as compost.The addition of organic matter such as sawdust (SD) for composting would also help to optimize the properties of CS and SS as effective compost.The addition of organic matter plays an essential role in controlling the decomposition rate and promoting nitrogen retention within the compost (Bernal *et al.*,2009).

Normally, the organic content of composting materials will take a long time to break down and will require the addition of useful microorganisms to speed up the process (Vargas-Garcia *et al.*,2007).In our previous work it was found that for compost made from SS, CS, and SD a ratio of 1:1:1 was the optimal mixing ratio with a composting time of 50 days (Taenkaew *et al.*,2014).However, this composting time is considered to be too long, and the use of suitable activators to reduce the composting time is an interesting option.Effective microorganisms (EM), pig manure and chicken manure have all been suggested as suitable compost activators that could reduce the composting time. Jusoh *et al.* (2013) reported that the application of EM to compost increased the macro and micro nutrient content to a much higher value than without EM.The application of manures for composting have also provided other opportunities for livestock producers, including the reduction of greenhouse gas emissions (nitrous oxide and methane) and fly problems as well as the production of a more uniform and easily transportable fertilizer product (Petric *et al.*, 2009).Chicken manure in particular can be used as a soil conditioner because it can hold the soil's moisture and increase its nutrient-holding capacity(McCall, 1980).

Sheikha (2011) and Toan and Hanh (2013) found that chitosan is a natural polymer derived from the deactylation of chitin which has a positive effect on the growth of plant. It can substantially increase the microbial population, and transform organic nutrients into inorganic nutrients, which can be easily absorbed by a plant's roots (Somashekar and Richard, 1996). It is interesting to study the use of chitosan as a constituent of compost products since this may lead to the promotion of better agricultural production.

The main objective of the research reported in this paper was to utilize the waste produced by the concentrated rubber latex industry to make compost. EM, pig manure, and chicken manure were used as activators for compostingat10, 20, and 30 wt% of the composted materials to determine the optimum ratio. In making the compost, the SS, CS and SD were mixed at a ratio of 1:1:1. The resulting compost as well as compost with chitosan added was tested as treatments for the cultivation of Chinese kale because it is a fast growing vegetable requiring a high amount of nitrogen as a nutrient. The compost parameters were analyzed according to the Thai Agriculture Standards for compost, including temperature, pH, electrical conductivity, organic matter, total nitrogen, total phosphorus (as P_2O_5), total potassium (as K_2O), and the carbon nitrogen ratio (C:N).

2. Materials and Methods

2.1 Composting materials and composting activators

Composting materials: SS, CS, and para rubber SD were used to make compost. The SS and CS were obtained from a concentrated rubber latex factory (Chalong Latex Industry Co., Ltd.), Hat Yai, Songkhla, Thailand. The SD was obtained from Rattaphum parawood industry Co.,Ltd., Rattaphum, Songkhla, Thailand.Both the CS and SD were dried in sunlight until constant weights were achieved. Then the SD was milled and sieved to a size of 3-5 mm while the CS was separated from the rubber particles remaining before being milled and sieved to a size of 3-5 mm. Reside of rubber particles would probably cause soil problems after prolonged usage if left in the compost (Uttraporn *et al.*, 2012).

Composting activators: Commercial effective microorganisms (EM) were used in this study in the form of EM solution. The EM solution was prepared by suspending one part commercial EM in a mixture made from one part molasses with 20 parts of chlorine-free water (Jusoh *et al.*, 2013). Meanwhile, pig and chicken manures were obtained from the Faculty of Natural Resources**,** Prince of Songkla University.

2.2 Composting procedure

Amounts of SS, CS and SD were mixed together at a ratio of 1:1:1 by weight, following the recommendations of a previous experiment (Taenkaew *et al.* 2014), to make up approximately 5 kg of composting material. This ratio was based on the optimum mixing ratio that gave the highest nutrients.

EM solution and pig and chicken manures were applied to samples of the composting mixture at various adding ratios as shown in Table 1. All the experiments we rerun at the same time in composting vessels with three replicates. The composting vessels used were of a conventional design made from a truncated conical plastic bucket with a volume of 15L (302 mm in height, 300 mm top diameter and 200 mm bottom diameter). Twenty-eight holes with a diameter of 5 mm were drilled at regular spacing on the side of the vessel for ventilation, and four holes were drilled in the bottom for drainage (Figure 1). The top of the vessel was covered with a plastic cap. The moisture content of the composting material was controlled at 50-60% wet basis as suggested by Tiquia*et al.* (1996) either by adding water or providing aeration using a spatula to turn and mix the compost twice daily. This range of moisture content is suitable to allow the microorganisms in the compost to absorb nutrients during microbial metabolism. Ten experiments on different ratios of activator to compost were conducted simultaneously, and hence 30 such vessels were used for three replicates.

Table 1. Composting experiments with adding natural activators.

Experiments	Composting activators (wt % of composting materials)		
	EM (liquid)	Pig manure (solid)	Chicken manure (solid)
1	10	-	-
2	20	-	-
3	30	-	-
4	-	10	-
5	-	20	-
6	-	30	-
7	-	-	10
8	-	-	20
9	-	-	30
10 (Control)	-	-	-

Note: EM is effective microorganisms; control experiment is composting without addition of activator.

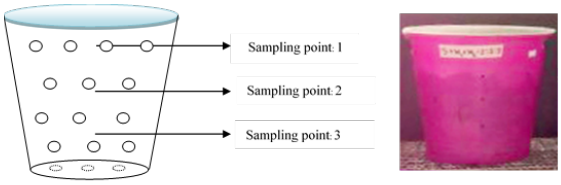

Figure 1. Schematic diagram and photograph of the composting vessel.

conducted by using a sliding microtome at a thickness between 10-15 μm to investigate the anatomical characteristics and to obtain the marked cells of annual-ring boundaries.

To explain the effect of climate variability on growth of *M. azedarach*, monthly climate data of rainfall, temperature, relative humidity and soil moisture contents with the multi-collinearity removal by using the technique of principle component analysis (PCA) (Hu & Bentler, 1999; O'Brien, 2007) were hierarchically related to leaf phenological characteristics and monthly wood increments of IBD and OBD by using the application of multiple linear regression, namely path analysis (PA), which illustrated both of the direct and indirect effects of the climate data on tree growth in terms of leaf phenologies and monthly wood increments.

2.3 Compost sampling and physico-chemical analysis

Each day 20 g samples, of compost were taken from each vessel at its three sampling points, as shown in Figure 1, to be analyzed for moisture content, pH, and electrical conductivity. Analysis of the organic matter, total nitrogen, total phosphorus (as P_2O_5), total potassium (as K_2O) and the C:N ratio was conducted every five days until the C:N ratio was found to be less than 20:1. This value of the C:N ratio implies that the composting materials have completely decayed (Lokman*et al.*, 2013).Temperature was measured using a thermometer at the sampling points.

2.4 Effect of the finished compost on Chinese kale cultivation

As mentioned earlier, Chinese kale was selected as the plant to test the effect of the compost that obtained from previous experiment. This plant was selected because of its quick growth and nitrogen needs. Six Chinese kale seeds were sown in plastic bags with a size of 30 cm x 40 cm x 10 cm and filled with 2 kg of soil and 0.3 kg of compost as described in Table 2. 200 ml of chitosan solution (0.5wt %) was also added in experiments 2 and 3. The concentration of chitosan solution used was selected based on Sheikha (2011) which found that chitosan was a positive factor supporting plant growth. All the growing bags received 500 ml of tap water every morning and evening for 30 days. The diameter and height of the leaves and the height of the trunk of the Chinese kale plants were measured at 7, 15 and 30 days. The process of harvesting the Chinese kale plants was carried out by cutting them at ground level to calculate their fresh weight (oven dried at 65°C for 3 days). Each experiment was run three times.

Table 2. Testing of the finished compost for Chinese kale plantation.

Experiments	Description
1	Commercial compost (control)
2	Commercial compost + Chitosan 0.5wt%, 200 ml
3	Finished compost+ Chitosan 0.5wt%, 200 ml
4	Finished compost

Note: Finished compost is compost that was obtained from a previous experiment.

3. Results and Discussion

3.1 Raw composting material characteristics

The physico-chemical properties of the raw composting material are shown in Table 3. Not all the physio-chemical properties of each raw material passed the Thai Agricultural Standards for compost (TAS 9503, 2005). It was noted that the SS had a total nitrogen content of 39.96 %w/wand total potassium content(as K_2O)of 10.80%w/w, both of which passed the TAS for compost. However, its total phosphorus content (as P_2O_5) was 0.25 %w/w which did not meet the standard. The CS had a phosphorus content (as P_2O_5) of 0.71 %w/wand a total potassium content as (K_2O) of0.77 %w/w which passed the TAS for compost while its total nitrogen content of 0.76 %w/w did not pass the standard. These results showed that the compost obtained from mixing SS and CS together would not pass all the TAS for compost in terms of their N-P-K contents and would therefore not be suitable to be used for composting due to the low total organic matter content (i.e. the carbon content was insufficient for the microorganisms used in the digestion step). Moreover, when considering the moisture content of the SS and CS shown in Table 3, it can be observed that the moisture content was excessive (over 60 % wet basis) which maybe a barrier to oxygen transfer by microorganisms (Gajalakshmi *etal.*, 2008). For these reasons, Bhamidimarri and Pandey (1996) recommended that SD should be used as a bulking agent to absorb the excessive moisture since its structure provides adequate porosity in the compost. Consequently, SD which had total organic matter content (OM) of 65.96 %w/w was added to the SS and CS to reduce the moisture content and to provide a source of carbon. The blended raw materials together provided good compost which had physio-chemical properties passed the TAS for compost.

Table 3. Composting materials'characteristics.

Parameters	Raw materials			Criteria of Thai Agriculture Standard for compost (TAS 9503, 2005)	Testing method
	SS	CS	SD		
1. pH	4.50	8.38	7.59	5.50-8.50	AOAC 973.04 (2000)
2. M	100	63.00	20.59	≤ 35.0	AOAC 950.01 (2000)
3. EC	0.270	0.018	0.019	≤ 3.500	BS EN 13038 (2000)
4. TS	176	-	-	-	Glass Fiber Filter Disc
5.BOD	9,000	-	-	-	Azide Modification
6. OM	25.73	15.21	65.96	≥ 35.00	AOAC 967.05 (2000)
7. N	39.96	0.76	0.22	≥ 1.00	AOAC 955.04 (2000)
8 .Total P_2O_5	0.25	0.71	0.27	≤0.50	AOAC 958.01 (2000)
9. Total K_2O	10.80	0.77	0.23	≥ 0.50	AOAC 983.02 (2000)
10.C:N ratio	0.37:1	11.63:1	174.31:1	≤ 20.00:1	BS 7755 (1995)

Note: SS is skim latex serum; CS is concentrated latex sludge; SD is sawdust; M is the moisture content on a % wet basis; EC is the electrical conductivity, in dS/m; TS is the total solids, in mg/l; BOD is the biochemical oxygen demand, in mg/l; COD is the chemical oxygen demand, in mg/l; OM is the organic matter, as %w/w; N is the total nitrogen, as %w/w; Total P_2O_5 is the total phosphorus in the form of P_2O_5, %w/w; Total K_2O is the total potassium in form of K_2O, %w/w; C:N ratio is the ratio of total carbon to nitrogen; AOAC is the Association of Official Analytical Chemists; BS is British standards and BS EN are British European standards

3.2 Physical changes of composting materials during composting

The composts to which had pig manure and chicken manure had been added had screwworms and a dense malodor on the 3rd day but that disappeared on the 7th day and they had a light odor on the 10th day. The color of the finished composts to which activators had been added turned brown to brownish black and the texture became similar to wet coffee grounds (soft-fine grain) by the 15th day. The high level of the finished composts in the composting vessels with the addition of EM, PM and CM decreased by approximately 50% over the 25 days of composting, compared with their initial level. Since both SD and CS have an initially high bulk which gradually reduces during composting. Meanwhile, the color of the control compost turned brown to brownish black and the texture became similar to wet coffee grounds by the 30th day and the level of control compost in the composting vessels also decreased by approximately 50% over the50 days of composting.

3.3 Effect of composting activators on C:N ratio of finished compost

The C:N ratio is normally, used as one of the main parameters to assess the rate of decomposition in the composting process (Jusoh *et al.*, 2013) and t he composting process will be considered as successful when the final value of the C:N ratio of the compost reaches a range of between 20 and 40 (Fong *et al.*, 1999).However, in this research a C:N ratio of 20:1 or lower was selected as the standard to be reached in accordance with the relevant TAS(TAS 9503, 2005). The values of the C:N ratios obtained from all the experiments are shown in Table 4.It is noteworthy that all the C:N ratios were less than 20:1 in the experiments to which activators had been added and that this level was achieved more quickly than in the experiments to which activators were not added. C:N ratios of less than 20:1 were achieved in the experiments to which pig and chicken manure were added after the composting times of 25 and 30 days, respectively, while for the experiments without activators a 20:1 ratio was achieved only after a composting time of 50 days. These results clearly show that the addition of activator scan reduce the composting time.

When considering the effect of the type of activator on composting, it was notable that the C:N ratios tended to decrease to lower level safter the 20th day in the experiments to which PM had been added, than in the other experiments. This may be due to the microorganisms in EM requiring a longer time in the lag phase than PM after being placed in the compost material. In addition, Mupondi *et al.* (2006) reported that composting with the inoculation of EM alone did not significantly influence the composting of pine bark mixed with goat manure. Additionally, Nasir *et al.* (2012) reported that chicken manure had low biodegradability and its action was inhibited by the release of ammonia during degradation . Thus, PM was selected as the optimum activator to produce compost from rubber industry waste.

3.4 Characteristics of the composting materials with pig manure added

Increasing the ratio of PM had no effect on the physio-chemical properties of the composting materials during composting. The temperature profiles of the composting process are shown in Figure 2. The temperatures were in the mesophilic range (15°C to 40°C) and not in the thermophilic range (35°C to 65°C) which was similar to the experiments in which EM and chicken manure had been added. However, this does not imply that decomposition was not observed, as the visual observation of the finished composts indicated a clear difference between the physio-chemical characteristics of the raw materials and the final materials which corresponds to the findings of Paradelo *et al.* (2013). The color of the finished composting materials turned brown to brownish black and the texture became heterogeneous to homogeneous similar to wet coffee grounds in accordance with the results reported by Hagerty *et al.* (1973).The mesophilic temperature range noted could have resulted from the porosities of the composting materials (Simujide *et al.*, 2013), ventilation and agitation.The composting process in the experiments to which pig manure had been added reached a maximum temperature of 35°C

Table 4. Adding ratios of natural activators and mean C:N ratios of the compost.

Experiment	Activator adding content (by weight)	C:N ratio, mean ± S.D.							
		Composting time (days)							
		0	5	10	15	20	25	30	50
1	EM, 10 %	60.03 ±0.39	51.56 ±0.22	32.75 ±0.05	32.75 ±0.39	29.74 ±0.20	23.54 ±0.10	20.01 ±0.38	-
2	EM, 20 %	62.61 ±0.21	49.52 ±0.12	29.97 ±0.59	29.97 ±0.39	34.31 ±0.39	24.41 ±0.44	19.17 ±0.28	-
3	EM, 30 %	65.43 ±0.22	51.34 ±0.39	34.63 ±0.69	34.63 ±0.39	37.83 ±0.39	22.43 ±0.39	20.01 ±0.48	-
4	PM, 10 %	64.90 ±0.09	56.75 ±0.19	33.21 ±0.79	33.21 ±0.39	25.38 ±0.39	19.18 ±0.67	-	-
5	PM, 20 %	67.47 ±0.31	51.18 ±0.09	26.24 ±0.59	26.24 ±0.39	29.75 ±0.67	21.25 ±0.39	-	-
6	PM, 30 %	67.07 ±0.30	58.53 ±0.30	33.04 ±0.29	33.04 ±0.39	25.27 ±0.27	20.17 ±0.38	-	-
7	CM, 10 %	64.99 ±0.19	58.06 ±0.09	27.05 ±0.59	27.05 ±0.66	46.55 ±0.59	25.15 ±0.12	21.00 ±0.38	-
8	CM, 20 %	64.05 ±0.44	57.78 ±0.19	34.27 ±0.39	34.27 ±0.45	32.79 ±0.76	22.19 ±0.56	20.07 ±0.28	-
9	CM, 30 %	64.09 ±0.02	51.42 ±0.14	27.60 ±0.13	27.6 ±0.35	30.10 ±0.37	24.50 ±0.22	20.22 ±0.18	-
10	Control	63.97 ±0.12	72.13 ±0.30	64.48 ±0.09	64.48 ±0.42	58.44 ±0.08	48.13 ±0.67	42.50 ±1.60	20.50±0.60

Notes: EM denotes effective microorganisms; PM, pig manure; CM, chicken manure, and each C:N value recorded is a mean value from three samples ±standard deviation (S.D).

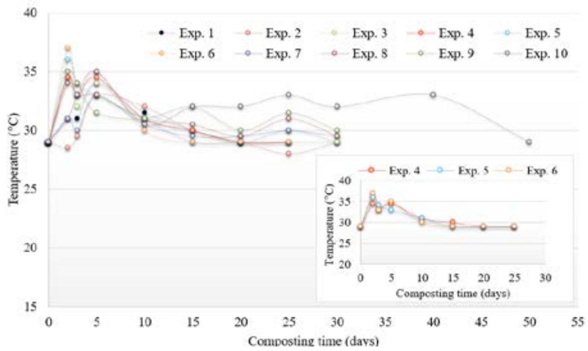

Figure 2. Changes in temperatures in all the experiments during the composting process

after two days. This temperature was maintained for a short time only then fell to the environmental temperature (29±1°C) on the 6th day. Meanwhile the composting process in the experiments to which EM and CM had been added reached a maximum temperature of 35°C after two days and fell to the environmental temperature on the 7th day. The temperature increases were a result of the microbial activity which biodegraded the organic compounds whereas the decreases in temperature were the result of the depletion of organic matter (Zhu, 2007).

The pH profiles of the composts to which pig manure had been added ranged from 7.37 to 7.95as shown in Figure 3 corresponding with optimum value for bacterial growth (Polprasert, 1996). The electrical conductivity in experiment 4 to which pig manure had been added to a proportion of 10%wt of the composted materials was higher than for the other experiments as shown in Figure 4.The increase in electrical conductivity with increasing composting time resulted from the release of mineral salts during decomposition of the organic matter (Abid & Saydi, 2006).

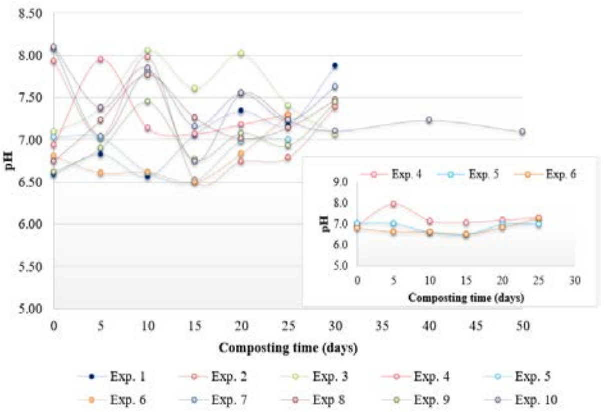

Figure 3. Changes in pH in all experiments during the composting process.

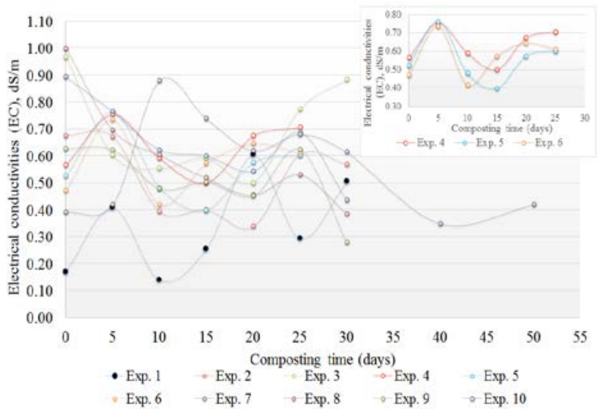

Figure 4. Changes in electrical conductivities (EC) in all experiments during the composting process.

In addition, when considering the other characteristics of the finished compost as shown in Table 5, the results showed that all the characteristics of the finished composts which were produced using PM activators passed the c Criteria of the TAS for compost (TAS 9503, 2005). The N, P and K nutrient contents of the finished compost obtained from experiment 4 (PM, 10wt%) were 1.81, 0.49 and 2.83, respectively, whereas those of experiment 5 (PM, 20wt%) were 1.12, 0.62 and 2.12 respectively. The N, P and K nutrient contents, of experiment 6 (PM,30wt%) were 1.32, 0.47 and 2.43, respectively. Thus, experiment 4 was selected as providing the optimum conditions for composting due to the higher nitrogen nutrient content achieved than those in the other experiments. Nitrogen is an important indicator of good compost and most of this nitrogen is available for plant growth (Radovich *et al.*,2015).

Table 5. Physio-chemical characteristics of the initial mixed compostingmaterials and the finished composts.

Exp.	Activator content added (by weight)		Physio-chemical parameter						
			pH	EC	OM	N	P_2O_5	K_2O	C:N ratio
1	EM, 10 %	Initial	6.59	0.1709	239.79	2.3169	0.9968	2.05	60.03
		Finished	7.40	0.1947	40.24	1.1693	0.5073	2.14	20.01
2	EM, 20 %	Initial	7.93	0.6770	115.59	1.0708	1.4338	2.05	62.61
		Finished	6.64	0.3160	34.24	1.0385	0.6046	2.56	19.17
3	EM, 30 %	Initial	7.09	0.9680	159.59	1.4147	1.2307	2.06	65.43
		Finished	6.60	0.4870	32.38	0.9409	0.5943	3.45	20.01
4	PM, 10 %	Initial	6.94	0.5800	124.57	1.1133	1.5519	2.10	64.90
		Finished	6.76	0.1640	59.79	1.8126	0.5930	2.83	19.18
5	PM, 20 %	Initial	7.03	0.3260	157.43	1.3534	1.6183	2.07	67.47
		Finished	6.86	0.3070	41.11	1.1249	0.6232	2.12	21.25
6	PM, 30 %	Initial	6.81	0.2750	165.88	1.4345	1.2630	2.23	67.07
		Finished	6.63	0.3340	45.94	1.3244	0.4718	2.43	20.17
7	CM, 10 %	Initial	8.08	0.8960	177.77	1.5865	1.5260	2.41	64.99
		Finished	7.04	0.1638	34.38	0.7519	0.5567	3.67	21.00
8	CM, 20 %	Initial	6.74	0.9960	124.65	1.1288	1.3841	2.35	64.05
		Finished	6.97	0.1453	34.74	1.0066	0.5080	2.75	20.07
9	CM, 30 %	Initial	6.62	0.6290	172.82	1.5640	1.5213	2.65	64.09
		Finished	7.11	0.2360	36.89	1.0608	0.6713	3.23	20.22
10	Control	Initial	7.22	0.2057	191.04	1.7322	1.9974	3.01	63.97
		Finished	6.85	0.3080	35.59	1.0085	0.5073	3.12	20.50
Criteria of TAS for compost (TAS 9503, 2005)			5.50-8.50	≤ 3.50	≥ 35.00	≥ 1.00	≥ 0.50	≥0.50	≤ 20.00

Note: Exp denotes experiment number; Initial, mixed composting materials; Finished, finished compost**;** EM, effective microorganisms; PM, pig manure; CM, chicken manure; EC is the electrical conductivity, in dS/m; OM is the organic matter, as %w/w; N is the total nitrogen, as %w/w; P_2O_5 is the total phosphorus in the form of P_2O_5, %w/w; K_2O is the total potassium in the form of K_2O, %w/w; C:N ratio is the ratio of total carbon to nitrogen.Each value recorded is the mean value from three samples.

3.5 Testing the results of the compost on the cultivation of Chinese kale

The physical characteristics of Chinese kale cultivated in the four experiments are shown in Table 6. The Chinese kale plants treated with only commercial compost had the lowest values for fresh weight, plant height, and leaf height of the Chinese kale among all the experiments. The growth and weight yield of the Chinese kale treated with the finished compost combined with 200 ml of chitosan solution (0.5wt%), after cultivation for 30 days was higher than those of the other experiments. This was due to the nitrogen content of the finished compost (N:P:K; 1.81:0.49:2.83) being higher than the values in the commercial compost (N:P:K;0.48:7.71:0.016). The compost with higher nitrogen contents promoted better growth of the Chinese kale. In addition, after soaking the compost pellets in water for one hour, it was observed that the compost which had not been mixed with chitosan gave a better distribution in water than the compost to which chitosan had been added. This was because the chitosan has the property of a binder that is able to reduce the decomposition rate of the compost in the soil and soak up large amounts of water to allow the compost to be leached out slowly.

4. Conclusions

The composting of SS, CS and SD at a ratio of 1:1:1 was achieved after 50 days of composting. The combination of these wastes together with the addition of PM, CM and EM as activators was able to reduce the composting time to 25, 30 and 30 days, respectively. The addition of PM at a ratio of 10%wt of the composted materials produced the most effective compost based on its N, P and K nutrient contents, (1.81, 0.49, and 2.83%w/w) respectively. The use of this compost together with chitosan gave the best outcome based on the cultivation of Chinese kale plants; the chitosan seems to have further stimulated the effectiveness of the finished compost. The compost produced in this research could be an economically viable means of managing wastes from rubber factories and represents an environmental closed loop approach to recycling nutrients from the wastes back into the agriculture system.

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