Research article

The Change of Phosphorus Form in Vermicompost Using Cassava Pulp

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Abstract The aim of this study was to investigate the change of phosphorus form in vermicompost using cassava pulp. The ratio of cassava pulps: soil mix (sandy soil and cow manure) were applied at 75%:25% (W/W) in compost (CP: without earthworm) and vermicompost (VCP: with earthworm). The qualities of vermicompost and the form of phosphorus after 60 days incubation were analyzed. The results showed that the pH and EC (Electrical conductivity) were increased in CP and VCP. The water-soluble P in VCP was increased by 21.55% from initial and higher than CP 16.07%. The exchangeable P in VCP was increased by 39.57% from initial and higher than CP 24.25%. Total P in VCP was increased by 21.55% from initial and higher than CP 16.07%. The total N in VCP was increased by 87.61% from initial and higher than CP 85.14%. Moreover, the decrease of %OC (organic carbon), C/N ratio, C/P ratio were found in VCP more than CP, the percentage of decreasing from initial was 76.93%, 97.27%, 82.15%, respectively. The humic acid (%) content in VCP was higher than CP and the percentage of changing after 60 days of VCP was 56.41% and of CP was 32.83%. The growth and reproduction of earthworm showed that the growth rates of earthworm were 10.75 $worm^{-1}day^{-1}$ (mg) and the numbers of cocoons produced in vermicompost were 6.8 $earthworm^{-1}$. Therefore, the activity of earthworm and microbial was helpful to phosphorus available form and nutrient fertilizer content in vermicomposting. These data suggest that vermicompost helps to enhance phosphorus availability in compost.

Keywords phosphorus, cassava pulps industrial wastes, vermicompost, earthworm

INTRODUCTION

There are many cassava agro-industrial factories in Thailand, large and growing industries. When they finish the manufacture process with about 10 million tons of fresh cassava roots used for the production of starch, generates at least 1 million tons of pulp annually (Sriroth, 1994). Cassava pulps wastes can be used as nutrient fertilizer cycling and managing which is sustainable in agricultural systems. However, if cassava wastes were not be controlled and managed the environmental problem with disposal would happen. Therefore, the easy and fast management of wastes is using earthworm to breakdown wastes and enhance nutrients fertilizer for compost. Vermicomposting is normally more capable than composting because earthworms were feed on organic and create conditions that favor the degradation of decomposed and fragmented organic material by aerobic microorganisms (Edwards, 2004). The interactions between earthworms and microorganisms were the non-thermophilic biodegradation of organic wastes. (Arancon et al., 2004). Vermicomposting increases P bioavailability, microorganisms, and earthworms; including organic acid production, which solubilizes inorganic P (Scervino, et al., 2010). Saha et al. (2008) showed that phosphatases was helpful on faster transformation of organic P by using of earthworm casts in soil. Organic matter modifies supplement soil phosphatase activity. Phosphorus available forms are important for plant production. Earthworm and microorganisms were helpful, changed mineralization P of organic forms that transform P from non-available, organically bound forms, into bioavailable phosphate ions (Eivazi and Tabatabai, 1977). In the study of Jader et al. (2012) showed that vermicompost was an alternative technology for increasing P availability for plant nutrition. Accordingly, the degradation of organic wastes by earthworm and microorganism were helpful on the amount and quality of the humic acid. For example, this fraction in composts and vermicomposts are respected as important indicators of their biological perfection and successful performance and insurance for a safe impact and chemical consistency in soil (Senesi et al., 2007; Benítez et al., 2000; Atiyeh et al. 2000).

OBJECTIVE

The objective of this study was to investigate the change of phosphorus form as using cassava pulp and relationship of nutrient cycle in vermicompost process.

METHODOLOGY

Cassava industrial wastes: cassava pulps located Kalasin province northeast of Thailand. Earthworm: the earthworms (*Eudrillus eugeniae*) were carefully brought to the laboratory along with the moist soil and culture in laboratory and acclimatized for 1 month under laboratory conditions in polyethylene buckets (culture pot) containing soil. Sandy soil (Nampong Soil) and the fresh manure amendment, which material was collected form a local cattle farm were used in the experiment.

Experiment design: The vermicompost (VCP) cassava pulp waste material in process was used. Experiment plan was CRD (Completely Randomized Design), 3 replication, the experiment repetitions were mixed in the rate of 75%:25% (cassava industrial wastes: soil mixture) for the experiments compost (CP: without earthworm) and vermicompost (VCP: with earthworm). The 25% in compost process is Soil mix. It was featured Nampong soil, cow manure. VCP and CP were decomposed cassava pulp waste; soil mix (soil and cow manure). The mixture was composted for 15 day before earthworm addition at incubation. The fermentation processes have a high temperature because of earthworm breakdown. The mixture of moisture content was adjusted to 70-80% of WHC (Water Holding Capacity) by water and it keeps content in plastic black block 2 L by adding 10 earthworm(*Eudrillus eugeniae*)/1 kg (mix waste), which was covered with a net to prevent direct exposure to sunlight(Maity et al, 2008). The times incubation of study were VCP and CP at 0, 30 and 60 days. The temperature was 30±2 ℃ in laboratory.

Chemical analysis: The compost (CP) and vermicompost (VCP) were measured for pH using a digital pH meter in 1/ 2.5 (w/v) by deionizered water. Total Organic carbon was determined by the partially-oxidation method (Walkley and Black, 1934). Total N (Total nitrogen) was measured by micro Kjeldahl method (Jackson, 1973; Bremner and Mulvaney, 1982). Total P (TP) was digested with acid (HNO_3: H_2SO_4:$HClO_4$ (5:2:1)). The sample used 1 g / 10 ml (mix acid) (w/v). Water soluble P (WSP) was measured in DI water extraction ratio VCP and CP 1 g/ 25 ml (W/V) and shaken for 2 hour (150 rpm). Exchangeable phosphorous (Exch. P) was determined by following Bray II extraction method (Schroth et.al, 2003). The total form P solutions were determined the ascorbic acid molybdenum blue method by UV spectrophotometer (Murphy and Riley, 1962). C:N ratio was calculated from the measured value of C and N. C:P ratio was calculated from the measured value of C and P. TOC in the VC was estimated using the dichromate oxidation method (Nelson and Sommers, 1982; Walkley and Black, 1934). Humic acid extracted soil and vermicompost caste derived humic acids (HA) were extracted with a slightly HA modified procedure recommended and used by the IHSS to isolate standards of humic acid (Chen, et al., 1977).

RESULTS AND DISCUSSIONS

The characteristic of cassava pulp wastes: the pH was 3.823±0.586, EC (mS/cm) was 0.867± 0.029, Total P (%) was 0.063±0.001, Total N (%) was 0.206±0.016, Total K (%) was 0.322±0.004, and C: N ratio 94.63±6.73. The characteristic of soil: the pH was 4.500 ±0.557, EC (mS/cm) was 0.357± 0.051, Total P (%) was 0.008±0.000, Total N (%) was 0.021±0.003, Total K (%) was 0.121±0.000, and C: N ratio 9.432 ±0.165. The characteristic of cow manure: the pH was 9.233 ±0.029, EC (mS/cm) was 3.577± 0.025, Total P (%) was 0.664±0.178, Total N (%) was 1.350± 0.050, Total K (%) was 0.495±0.010, and C: N ratio 17.970± 1.251.

Changing of Phosphorus in CP and VCP: the result showed that changing of phosphorus form comparing with CP and VCP in cassava pulps agro-industrial wastes in vermicomposting at time incubation 0 day, 30 days and 60 days (Table 1). The total P in content initial wastes mixtures at 0 day CP and VCP were 0.54%, after that the end 60 day TP value was increased 16.07-21.55% in both, but when the compare with CP and VCP that VCP was minimum increased than CP. Similarly, there was about water soluble P (WSP) increase in VCP better than CP. Initial at 0 day CP and VCP was value 0.037%, after that at 30 days and 60 days had increased water soluble P (WSP) in both. In VCP and CP, percentage of changing was increased 74.72% and 61.73%, respectively. The study showed that vermicomposting helped to increase water soluble P (WSP) higher than general tradition compost. Exchangeable P is important for growing plant, because it is available P form as plant was direct absorbed. The table 1 showed that exchangeable P content in VCP was better than CP. Initial at 0 day CP and VCP was value 0.227%, after that at 60 day, it had increased water soluble P (WSP) in both. In VCP and CP, percentage of changing was increased 39.57% and 24.25%. The C:P ratio (Table 1) showed that value content in VCP was decreased which better than CP. Initial at 0 day CP and VCP was value 26, after that at 60 days, it had decreased C:P ratio in both. In VCP and CP, percentage of changing was increased 82 % and 73%. After earthworm and microorganism activity, Vermicomposting can be proficient technology for transformation of unavailable forms of phosphorus to easily available forms for plants. Lee (1985) the organic wastes passing thought the gut of worm was produced phosphatase and it was released of P may be microorganisms in casts. Ghosh et al. (1999) have reported that vermicomposting can be an efficient technology for the transformation of unavailable forms of phosphorus to easily available forms for plants and it can help to enhance the transformation of organic P into mineral forms, it also to release P into in soluble inorganic forms and to increase the availability of P (Exchangeable P and WSP).

The result showed that the pH and EC in incubation at 60 day were increased in CP and VCP (Fig. 1). The pH of CP 0day value was 7.4. The pH of CP and VCP at 60 day value was 8.6 and 8.2, respectively. Percentage of increased was 13.59% and 9.98% .The increase of pH may be attributed to the decomposition of nitrogenous substrates resulting in the production of ammonia. Ammonia which forms a large proportion of the nitrogenous matter was excreted by earthworms (Cohen and Lewis, 1949). The total organic carbon (TOC) in VCP all time declined drastically compared to their initial at o day; the maximum organic C loss was observed in VCP. The comparison with CP and VCP were also calculated by using vermicomposting coefficient (VCP) that organic C loss better than CP by percentage of loss CP:25% and VCP: 76.93%. Causing of the organic C loss was vermicomposting process in organic C budget of the waste decomposition system and accelerates the waste degradation process (Garg et al, 2005). The vermicomposting cause increased total N. The comparison between CP and VCP, VCP was increased total N than CP. By percentage of increasing in VCP was 87.61%. Earthworms and microbial have an abundant impact on nitrogen transformation, by increasing nitrogen mineralization, therefore, mineral nitrogen was maintained in the nitrate form (Atiyeh et al., 2000). However, the report of Viel et al., (1987) in the substrates might be responsible for nitrogen addition stated, results to decrease in organic carbon. The nitrogen through excretory products, enzymes, mucous and even by decaying worm tissue (Tripathi and Bhardwaj, 2004). So that the value C:N ratio was decreased in VCP and CP (Fig. 1). C:N ratio was important used indices for maturity of organic wastes, decreased with time for all the VCP and CP. Initial C:N ratio was 128. Vermicompost can be attributed to initially lower content of nitrogen in these feeds. Final C:N ratios were 3.51 by percentage of decreasing was 97.27, whereas the final C:N ratio of VCP was higher than CP feed.

Table 1 The result showed that changing of Phosphorus form compares with between CP and VCP in Cassava pulps agro-industrial wastes vermicompost at time incubation 0 day, 30day, 60 day

Total P (%)	TP(%)0d	TP(%)30d	TP(%)60d	% changing
Compost	0.540±0.009	0.513±0.002	0.643±0.043	16.07
Vermicompost	0.540±0.009	0.545±0.016	0.688±0.067	21.55
Water Soluble P (%)	**WSP(%)0d**	**WSP(%)30d**	**WSP(%)60d**	**% changing**
Compost	0.037±0.001	0.076±0.006	0.097±0.002	61.73
Vermicompost	0.037±0.001	0.091±0.006	0.146±0.028	74.72
Exchangeble P (%)	**Exch.P(%)0d**	**Exch.P (%)30d**	**Exch.P(%)60d**	**% changing**
Compost	0.227±0.010	0.239±0.008	0.300±0.004	24.25
Vermicompost	0.227±0.010	0.377±0.016	0.376±0.024	39.57
C/P ratio	**C/P(%)0d**	**C/P(%)30d**	**C/P(%)60d**	**% changing**
Compost	26.07±0.319	19.75±2.997	7.01±0.349	73.09
Vermicompost	26.07±0.319	20.22±4.978	4.65±0.432	82.15

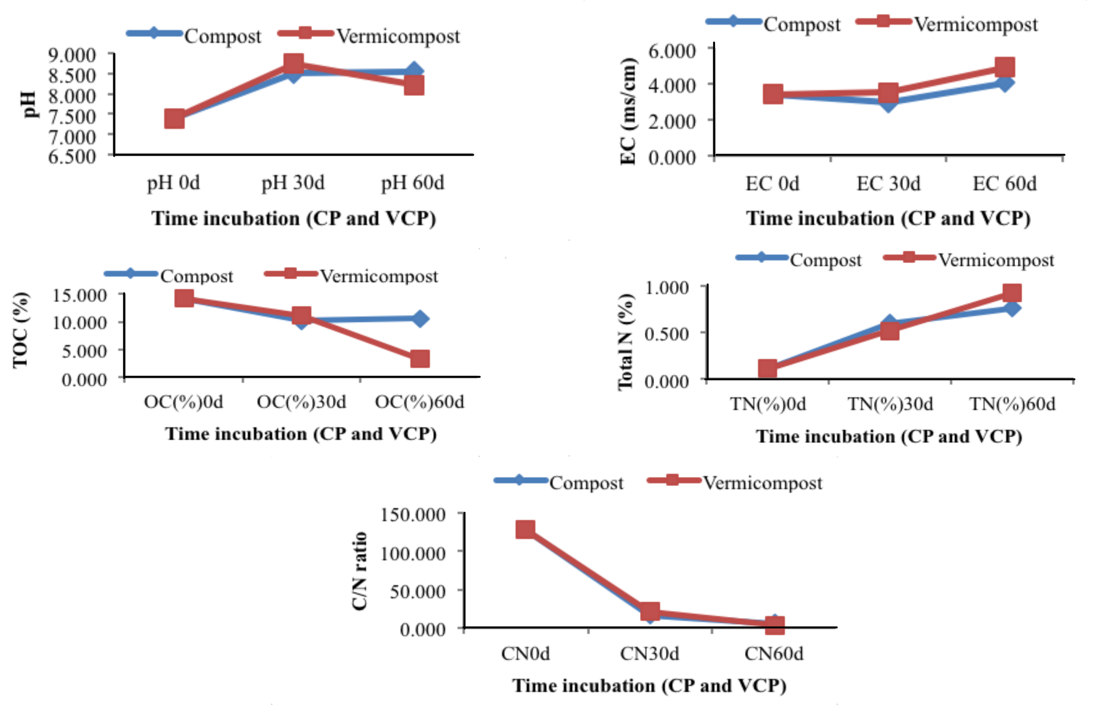
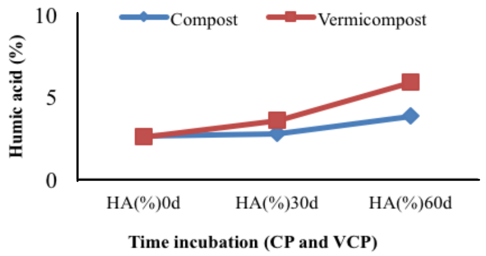


Fig. 1 The picture showed that the comparing was pH, EC, TOC(%),Total N(%), C/N ratio between CP and VCP with as cassava waste (cassava pulps) in compost at 0 day, 30 day, 60 day

The humic acid (HA) (%) contents showed in Fig. 2 the comparison between VCP and CP that at 60 day after incubation, VCP was higher HA(%) than CP and ratio of humic acid (E4/E6) in VCP was higher than CP. Percentage of changing after 60 day VCP was 56.41% and at CP was 32.83%. The HAs were one of most active fractions of OM, they improved the absorption of nutrients by plants and soil microorganisms, there was a positive effect on the dynamic of N and P in soil, stimulate plant respiration and the photosynthesis process, and favor the formation of soil aggregates, etc (Hernandez et al., 2001). Chen et al., (1977) suggested and believes that the magnitude of E4/E6 was related to the degree of condensation of the aromatic C network, with a low ratio indicative of a relatively high degree of condensation of aromatic humic constituents. Conversely, a high E4/E6 ratio reflects a low degree of aromatic condensation and suggests the presence of relatively large portions of aliphatic structures. The values of E4/E6 ratio would depend on the average molecular weight or particle size (negative correlation) and low degree of aromatic C network content and low average molecular weight, probably due to a short period of humicfication that takes place in the composting process. This E4/E6 value suggested that during the composting process the HAs produced were similar to fulvic fraction and in this way they cloud undergoes more microbial degradation. It had been demonstrated that the fluorescent intensity of HAs and fulvic acid (FA) increase with decreasing molecular size (Edward et al., 1988; Aoyama, 2001).



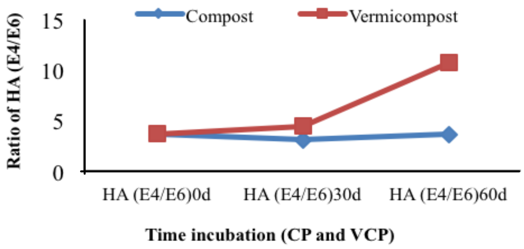


Fig. 2 The picture showed that humic acid (%) and ratio of humic acid (E4/E6) between CP and VCP with as cassava waste (cassava pulps) in compost at 0 day, 30 day, 60 day

Table 2 Growth of *Eudrillus eugeniae* cassava pulp waste industrial

Treatment	Mean initial weight earthworm^{-1} (mg)	Maximum weight achieved earthworm^{-1} (mg)	day	Net weight gain earthworm^{-1} (mg)	Growth rate worm^{-1}day^{-1} (mg)
Cassava pulp waste	323.43	645.96	60d	322.53	10.75

Table 3 Cocoon production by *Eudrillus eugeniae* in cassava pulp waste industrial

Treatment	Total no. of cocoons produced after 60 day	No. of cocoons produced earthworm^{-1}
Cassava pulp waste	68.0	6.8

CONCLUSIONS

In conclusion, the study observed the change of phosphorus form in vermicompost using cassava pulp. The transformations that resulted in phosphorus available form in vermicompost was generally more than efficient composting CP because of the activity of earthworm and microorganism that helped to change organic wastes and digestion wastes to phosphorus nutrient fertilizer. Increasing inorganic P was exchanged to P, water soluble P and total phosphorus. The vermicomposting process after 60 days was decomposing and changing, transforming by mineralization P into inorganic P nutrients form and was higher than general composting. Finally, The study observed the change of phosphorus availability form as with cassava waste (cassava pulps) in vermicompost on helping to change nutrient fertilizer: total N, C:N, total K, phosphorus available form, Humic acid for plant, growth and reproduction of earthworm. Vermicompost was encouraged as a disposal and management agro-industrial wastes which it decreases bio-wastes to change valuable nutrient to plants, and to reduce environment pollutions.

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