Original Research Article

Monitoring of Composting Practices in Selected Rural Areas Near Pucallpa City, Peru

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Abstract

Soils in surroundings of Pucallpa are in general of a low quality for agriculture. One of the promising strategies how to improve soil fertility in this location is implementation of composting technology. This was therefore the aim of our study. Selected farmers have received composting bins within a frame of Czech project “Sustainable Management of Natural Resources in the Peruvian Amazon”. We evaluated the suitability of this low-technology and low-cost composting method in the area under study. The research activities were based on field work with local farmers from villages near Pucallpa city with the intent to analyse organic waste generation and composition, its recycling and reuse, and the overall willingness to manage the composting process. The field operations were carried out along with laboratory analyses. Generally this composting method was well adopted and can be considered as an appropriate instrument for improving soil management in the studied area.

Keywords: Organic waste management; composting; farmers; Pucallpa.

INTRODUCTION

Farmers in surroundings of Pucallpa traditionally practise slash-and-burn agriculture to produce annual crops. Due to increasing population, intensive deforestation and intensive annual plant cultivation without fertilizer applications, the soils become degraded, exhausted and of low quality for agriculture. Soils near Pucallpa are mainly acidic (Kobayashi et al., 2001) and use of capital inputs such as fertilizers, pesticides, ploughs, etc. is extremely limited (Yanggen and Reardon, 1999). To prevent this location from further devastation, the relation to the natural resources has to be changed. As the local farmers are highly dependent on plant production, more attention should be paid to sustainability of soil fertility. Agroforestry and application of fertilizers can be considered as the strategies how to improve land management in the location studied. Chemical fertilizers have an immediate effect on the production while the soil structure does not improve due to its application (HDRA, 1998). On the other hand, compost has been considered as a rich source of organic matter playing an important role in maintaining soil fertility. It is of value in agriculture for improving the physico-chemical and biological properties of the soil and for supplying plant nutrients as the compost finally breaks down to mineral matter (Misra et al., 2003).

Therefore within the frame of Czech project “Sustainable Management of Natural Resources in the Peruvian Amazon”, we analysed the use of easily manageable composting bins by selected families with

the aim to introduce a low-technology and low-cost treatment option for organic waste recycling in the studied area.

MATERIALS AND METHODS

Study area

Pucallpa is the capital of Ucayali department characterized by humid tropical forest cover (Fujisaka et al., 1999), is located 860 km from the capital Lima, the average elevation is 150 meters above the sea level and the climate is warm and humid with only slight variation throughout the year (Lojka et al., 2007). According to MINAG (2002), the rainfall ranges from 1 500 to 2 100 mm, the mean annual temperature is 25.78 °C, and mean annual relative humidity reaches 80 per cent.

The research activities were based on field work with local farmers from four villages located in Campo Verde near Pucallpa city with the aim to analyse various segments, from organic waste generation and composition to its recycling and reuse. Those villages are: Antonio Raimondi, Nueva Belén, Pimental and Túpac Amaru.

Field survey and data collection

In total, 21 families already owning the composting bin were visited. The survey was conducted on the basis of data collection through semi-structured questionnaires and interviews with those responsible for composting process.

Questionnaires were structured to gain information on the potential organic waste material available for composting and potential usage of final compost in studied location.

Monitoring the composting process

Twenty-one implemented compost bins were regularly monitored, depending upon the current climate conditions and farmers presence, in each of village mentioned above the main goal of monitoring was to determine the degree of stabilization of the compost. Monitoring was mainly focused on the temperature, moisture content, change in colour and homogeneity of material.

Temperature plays a major role in the composting process when heat is generated as a result of microbial activity in the pile (Rothenberger et al., 2006). The temperature was measured manually in two different sites using a special rustproof bimetallic thermometer, which enables to monitor the temperature inside the composting bin, with the range from -10 to $+90 \pm 0.5$ °C.

As micro-organisms can only take up nutrients for their growth from the liquid phase of the material, it is important that adequate moisture content is maintained in the pile (Rothenberger et al., 2006). Moisture level in compost piles was estimated using the “hand-squeeze” method.

Changes in the colour of the compost materials during the composting process can be used to gauge the maturity stage of the compost by mere visual examination. The colour of mature composts turns to dark brown or black (Mbuligwe et al., 2002).

Compost quality analysis

A 200 g sample of mature compost was taken for the final compost quality evaluation. From the total number of composts ($n = 21$), ten acceptable samples were taken, sifted and sent to the laboratory of National Agrarian University, La Molina, Peru. Values measured by the laboratory include: pH, organic matter (OM), organic carbon (C), nitrate ($\text{NO}_3\text{-N}$) and ammonium nitrogen ($\text{NH}_4\text{-N}$).

RESULTS AND DISCUSSION

General characteristics of the surveyed households

Sixty seven per cent of those who are responsible for the composting process are women; this is in agreement with the fact that the management of household waste is usually the responsibility of women. The disposal of household waste is just one of the routine duties of housewives (Lardinois and Klundert 1993). However, Somda et al. (2002) in a

study area in Burkina Faso found that men are likely to be more willing to adopt composting than women and that women might be unwilling to invest in such a technology, if they are not sure of profiting from it. Men generally have more physical strength, thus are more powerful to carry or manage heavy and voluminous inputs such as compost (Folefack, 2008). According to our research results, compost user's mean age is 47 years. Young people from rural areas usually move to the city, thus the general mean age of the farmers in this location is quite high. The average size of cultivated land is 3 hectares. The rest of land serves usually for pasture, reforestation or is lying fallow. All of the selected farmers have access to the organic waste such as manure, crop residues, kitchen waste, dead leaves, wood fire ash, fruit and vegetable peelings, and so on. Most of fruit and vegetable peelings and kitchen residues are used to feed animals. However, there are still enough leftovers that can be used for composting process.

Composting practices

All of the respondents have been using the plastic composting bins for composting purposes. This is stressed due to previous experiences, when local people used constructed wooden composters for different purposes such as pig breeding. During our observation the composting process was interrupted in only two cases. Among the interviewed farmers, 90.5% were satisfied with this method and 9.5% responded that it depends on the results. The owners were asked if they would change something on the composting bins; 9.5% mentioned that the composting bin could be more capacious.

Previous composting experience

The question whether the respondents used to compost before project intervention was asked in order to learn whether the composting is an absolutely new method for the farmers in this locality or the farmers already have had an experience with the decomposition of the organic material before implementing these composting bins. Three of the interviewed stated that they already have experience with composting. They used the wooden composters implemented in previous experiment done by Czech experts. Although the previous method had not found a wider use, two farmers are still using them. One of the users is so satisfied with the results of compost usage (in relation to the better plant production) that he is recommending composting to the other farmers, and he even sometimes sells the final compost product (about 2 kg / 0.6 USD) to the neighbour farmers. Other respondents (about 14.3%) use the organic waste material in the following ways: (1) poultry manure is stored in holes for a

few months with occasional watering; thereafter the final material is used to plant seedlings; (2) chopped kudzu (*Pueraria phaseoloides*) is left on the field and used as a convenient source of nitrogen; (3) cow manure mixed with sawdust is used as fertilizer; and (4) of fire wood ash is applied directly to the plants. Most of the respondents with no previous composting experience generally burnt all of the household organic waste together with whatever solid waste.

Materials used for composting

Composting process is always better when a diversity of organic wastes is being processed, rather than just a single material (Dalzell et al., 1987). Apparently among the most used material belong fruit and vegetable peelings such as peelings of bananas, cassava, pineapple, papaya, citrus fruits, cherimoya, etc. and kitchen residues which are not fed to domestic animals. Farmers are also using dead leaves, wood fire ash, egg shells, sawdust and manure (generally dung of guinea pigs and poultry manure). Egg shells decompose slowly, however, they can be considered as a source of calcium. Crop residues such as stems, husks and leaves are usually chopped up and left on the field.

Final compost use

The majority of respondents will use final compost for sowing the vegetable such as cucumbers, tomatoes, onion, chilli, cilantro etc. They may also apply mature compost directly mainly to the fruit trees such as: banana trees, orange trees, lemon trees, cocoa trees, coconut trees etc. to increase their production. All participants stated that they consider the composting method being beneficial and would recommend it to the other farmers.

Monitoring the composting process

To determine the degree of stabilization of the compost, factors such as temperature, moisture content, change in colour, homogeneity of material and other factors were monitored. At first it should be mentioned that the average age of the initially established composts while monitoring was 135 days (4.5 months). This means that the initial composting process monitoring and evaluation could not be realized.

The compost temperature depends upon its age, ambient conditions, on the part of composting bin, where the temperature was measured, and other factors influencing the composting process. Average temperature measured was 25.9 °C, indicating a low microbial activity that was adequate to the compost age.

Moisture content of the compost feed materials was

monitored to ensure that it was within the optimum range for composting. It was determined by the “hand-squeeze test”, a non-quantitative method of estimating moisture. During the monitoring of the process, the majority of composts showed higher moisture content. The optimum moisture content was noted just in 20.3% of cases.

Mbuligwe et al. (2002) stated that changes in the colour of the compost materials during the composting process can be used to estimate the maturity stage of the compost by mere visual inspection. These changes in colour indicate the degree of stabilisation of the compost. Due to advanced age of composts the colour of material was usually brown, dark-brown or black.

The non-homogeneity is predominantly recorded in less aged composts where the types of fresh material such as peelings of different kind of fruits of vegetable could be well recognized. In some aged composts, the material was not homogeneous, and larger parts of material (mainly peelings of cassava, last in decomposing) were recognized. Just two composts could be considered as homogeneous.

Together with the above mentioned factors, the presence of unsuitable non-organic materials such as plastics, bottle tapes, cans etc. was monitored. In few cases such unsuitable material appeared repeatedly even though the farmers were previously informed that the presence of this indecomposable material is undesirable.

Compost Analysis

Values obtained from the laboratory of National Agrarian University, La Molina, Peru include: pH, organic matter (OM), organic carbon (C), nitrate (NO₃-N) and ammonium nitrogen (NH₄-N), see Table 1.

Table 1: The results of the composts analyses

No.	pH	OM %	Organic C %	NH ₄ -N %	NO ₃ -N %
1	8.70	18.42	10.51	0.004	0.042
2	9.07	12.30	4.71	0.005	0.035
3	8.37	7.22	3.45	0.006	0.168
4	9.11	20.90	8.16	0.004	0.070
5	9.13	11.58	3.14	0.004	0.042
6	8.05	14.18	6.59	0.006	0.056
7	9.69	10.42	3.76	0.021	0.007
8	8.06	12.86	5.33	0.035	0.035
9	8.84	8.42	2.51	0.005	0.006
10	4.32	1.74	0.31	0.005	0.007

Source: Laboratory of National Agrarian University, La Molina, Peru, 2008

The pH is a measure of active acidity in the feedstock of compost. Optimal values of final composts depend on compost use and range from 6.5 to 8.5. According to the Agricultural Analytical Services Laboratory of the

Pennsylvania State University, pH is not a measure of the total acidity or alkalinity and cannot be used to predict the compost effect on soil pH. However, the soil analyses carried out in the study location have proved that local soils are very strongly acidic ($\text{pH} < 5.5$) and the addition of compost to soil could be one of the possibilities how to modify the final pH. Values obtained from the analysis indicate that the majority of sample composts are alkaline (Table 1), which corresponds with previous experiments with composts in Pucallpa, when the higher pH was also measured. The reason of this alkalinity was not determined. Sullivan and Miller (2001) reported that the final pH of the compost is highly dependent on the feedstock, the compost process and the addition of any additions.

There is no ideal organic matter level for feedstock or finished compost. Organic matter content decreases during composting. However, organic matter content of the final compost should not decrease below 20%. According to the Agricultural Analytical Services Laboratory of the Pennsylvania State University the organic matter content of typical feedstock and starting mixes is greater than 60% while that of finished compost is in the range of 30-70% and that the organic matter content of 50-60% is desirable for most compost uses. Dalzell et al. (1987) recorded in the table of chemical composition ranges of matured composts made under tropical conditions that organic matter ranges from 25 to 80%. The results of our studied samples show that all sampled composts have organic matter content lower than 21% (Table 1). Bary et al. (2002) noted that low values ($< 30\%$) usually indicate that organic matter has been mixed with sand or soil. The other reason of this low organic matter content could be high age of sampled composts.

Total carbon (C) is a direct measurement of all organic and inorganic carbon in the compost sample. The value of the total carbon serves for determination of the ratio carbon to nitrogen. The results obtained from the laboratory indicate only the content of the organic carbon which ranges from 0.31 to 10.51%.

Total nitrogen (N) includes all forms of nitrogen: organic N, ammonium N ($\text{NH}_4\text{-N}$), and nitrate N ($\text{NO}_3\text{-N}$). Total N normally ranges from less than 1 to around 5% in most feedstocks and from 0.5 to 2.5% in finished compost. While $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ are immediately available to plants, organic N is only slowly available. The laboratory of National Agrarian University, La Molina, Peru analysed only $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ levels, the value of total nitrogen fail in analyse, thus the final carbon to nitrogen ratio could not be identified.

Nitrate nitrogen ($\text{NO}_3\text{-N}$) is generally present in low concentrations in immature composts, although it may

increase as the compost matures. Nitrate-nitrogen is plant available and according to Bary et al. (2002) the ideal value of $\text{NO}_3\text{-N}$ in the compost ranges from 200 to 500 ppm (0.02-0.05%). The majority of the values of sampled composts correspond with this range (Table 1). Low values ($< 0.02\%$) such as in the samples No. 7, 9 and 10 indicate a lack of plant-available N.

Ammonium nitrogen ($\text{NH}_4\text{-N}$) levels may be high during initial stages of the composting process, but decreases with its maturation. According to Bary et al. (2002), ammonium nitrogen is plant-available N form, but high values injure plants. The ideal value is less than 500 ppm (0.05%). All of our samples ranged below 0.05% (see Table 1, 2).

The ratio of $\text{NO}_3\text{-N}$ and $\text{NH}_4\text{-N}$ is another chemical indicator of maturity. According to Brinton (2000) the nitrate-N levels in mature composts normally exceed the levels of ammonium-N by several factors. Therefore, determination of ammonium-N to nitrate-N ratios is a useful parameter to assess degree of maturity. However, if both levels of NH_4 or NO_3 are very low in compost (< 75 ppm, 0.0075%) this ratio has little value. According to maturity indices for Group B methods (Brinton, 2000) $\text{NH}_4/\text{NO}_3\text{-N}$ Ratio < 0.5 indicates very mature; 0.5-3.0 mature; and > 3 immature composts based on each of the Group B tests.

Table 2: The $\text{NO}_3\text{-N}/\text{NH}_4\text{-N}$ ratio and $\text{NH}_4\text{-N}/\text{NO}_3\text{-N}$ ratio

No.	$\text{NH}_4\text{-N}$ %	$\text{NO}_3\text{-N}$ %	$\text{NH}_4\text{-N}/\text{NO}_3\text{-N}$ ratio	$\text{NO}_3\text{-N}/\text{NH}_4\text{-N}$ ratio
1	0.004	0.042	0.10	10.50
2	0.005	0.035	0.14	7.00
3	0.006	0.168	0.04	28.00
4	0.004	0.070	0.06	17.50
5	0.004	0.042	0.10	10.50
6	0.006	0.056	0.11	9.33
7	0.021	0.007	3.00	0.33
8	0.035	0.035	1.00	1.00
9	0.005	0.006	0.83	1.20
10	0.005	0.007	0.71	1.40

Source: Laboratory of National Agrarian University, La Molina, Peru, 2008

According to $\text{NH}_4/\text{NO}_3\text{-N}$ ratio (Table 2) and the maturity indices for Group B methods (Brinton, 2000) is majority (60 percent from 10 samples) of sampled compost very mature (the value is less than 0.5, Table 2). And 40 percent indicates maturity (values range from 0.71 to 3.00). According to compost quality standards for compost use in agriculture in Switzerland (Rothenberger et al., 2006) the $\text{NO}_3\text{-N}/\text{NH}_4\text{-N}$ ratio should be more than 2, which is not fulfilled in the samples No. 7, 8, 9 and 10 (Table 2). It is thus possible that composts No. 7-10 were not mature enough.

CONCLUSION

The use of composting at household level in rural areas near Pucallpa provides an opportunity for the farmers how to profitably reuse organic waste and so contribute to better farm waste management. Compost as a final product of composting process is used as a soil conditioner and fertilizer improving soil structure which is in the studied area of low quality for agriculture. Although the results of laboratory analyses have not assessed the sampled composts as of high quality, none of the analysed values indicates these compost as to be unsuitable for further use. In general, all surveyed families have access to the organic waste suitable for composting and all of respondents are using the plastic composting bins. During the monitoring process we did not observe any problem regarding the composting such as bad smell releasing or unwillingness to manage the composting process. The only thing that could be considered as a problem is the lack of proper knowledge of the correct managing process related to the long age of the composts in the composting bins, improper moisture content management and the presence of unsuitable materials in the feedstock.

It is important to demonstrate the positive effect of the compost on the plant production to the users for further dissemination of this easy and non-costly technology among the other farmers. With regard to low quality of soils, composting may be considered as one of the strategies how to improve land management in studied area.

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