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Leaf Litter Utilization through Composting: A Review

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Abstract—*Solid waste management is a major problem in most of the developing countries. Solid waste can be categorized into organic and inorganic. The organic fraction of the solid waste can be decomposed or recycled into beneficial products. Dumping- off the huge quantity of leaf litter in the forests, along the roads, backyard, rail lines, playgrounds, lawns etc. has always been a major problem. Inappropriate management of such wastes by dumping it in public places adds to the overall problem of solid waste disposal. In India, the residents in rural area use leaf litter as biomass fuel for cooking. Leaf litter burning causes air pollution which causes many health problems such as asthma, heart diseases, pulmonary tuberculosis, cataract and blindness. By using solid biomass for cooking, approximately 5 lakhs women and children die due to indoor air pollution in India. Leaf litter can be managed efficiently by composting. Composting can be done by using traditional enhancers such as cow dung, cow urine, earthworms, etc. and modern enhancers which includes combination of fermentation products of plant extracts, vermiwash, microbial culture, etc. Leaf litter compost will increase productivity of crops by providing sufficient amount of vitamin, hormones and nutrients. Utilizing leaf litter by composting will reduce air pollution, health problems caused by leaf litter burning, decrease in municipal solid waste disposal and fire incidents in forests.*

Keywords *: solid waste, composting, leaf litter, air pollution.*

1. INTRODUCTION

Solid waste consists of different types of wastes arising from various sources such as industrial, agricultural, biomedical, e-waste, construction and demolition etc.

Municipal solid waste consists of household waste and waste of similar nature generated by institutions, markets, offices and small businesses (Korean and Bisesi, 1999).

Based on the treatability, wastes can be categorized into inorganic and organic. Inorganic wastes are not amenable to biodegradation, these include non-degradable polymeric organic like certain types of plastics. Organic waste consists of all such carbonaceous wastes i.e., food scraps, garden waste, agricultural waste that can be degraded into useful and less polluting products by the action of various microorganisms, plants and animals (Abbasi, 1999). Garden waste includes huge amount of dry leaves fallen from trees which are also known as leaf litter.

Dumping- off the huge quantity of leaf litter accumulating in the forests, along the roads, backyard, rail lines, playgrounds, lawns etc. has always been a major problem. Leaf litter is often piled up and set on fire in India and several other countries in southern hemisphere. The ash resulting from leaf litter burning return only some amount of nitrogen, phosphorus and potassium content of the leaf litter to the soil but much of N, P and organic carbon gets lost in the atmosphere. Leaf litter burning also adds to air pollution (Abbasi, 1999).

In India, the residents in rural area use leaf litter as biomass fuel for cooking. By using solid biomass for cooking, approximately 5 lakh women and children die due to indoor air pollution in India (Sannigrahi, 2009).

Leaf litter play a very major role in the protection and enrichment of soil. Leaf litter protects soil from the direct solar heat and wind erosion. It is a source of food for soil microbes and invertebrates who, in turn, return much of the nutrients present in the leaf litter to the soil (Dash, 1993).

Leaf litter is also a source of food for higher organisms. It also helps in capturing rain water and prevents its run-off, therefore contributing to soil moisture and ground water recharge (Abbasi and Ramasamy, 2001).

For sustainable environmental management, recycling of waste is required. Converting the negative waste into beneficial product is an important aspect of resource recycling. Now a days, composting is an attractive option and key component of integrated solid waste management. Composting is an economically feasible option for solid waste management. It requires very less investment. In composting, the organic matter is degraded into nutrient rich compost. Compost prepared by organic solid waste can be utilized for agriculture and horticulture.

According to a study composts of municipal solid waste have been used to protect the soil environment from over cropping and to maintain long-term productivity of agro ecosystems, climatic condition changes and inadequate management. Municipal solid waste composts also have the additional benefit of reducing the waste disposal costs (Crecchio *et al*, 2004).

2. COMPOSTING OF LEAF LITTER

Composting is an aerobic process which converts organic waste into nutrient-rich, humus like substance. The process involves various microbes such as bacteria, fungi and actinomycetes which helps in breakdown of organic matter (Bhardwaj, 1995). The two basic types of composting process are aerobic and anaerobic composting. In aerobic composting, the organic waste decomposes in the presence of oxygen and the different products from this process includes NH_3, CO_2, heat and water. This process can be used to decompose any type of biodegradable waste. In anaerobic composting, the decomposition process of organic waste takes place in the absence of oxygen. The products formed in this process are CO_2, methane, NH_3, organic acids and trace amounts of other gases. This process was traditionally used to treat human sewage sludge and animal manure but now it has become common to treat some municipal solid waste and green waste (Guanzon and Holmer, 2000). Composting is an eco-friendly and economically feasible option for waste management.

Subbareddy *et al* (1991) investigated that integration of leaves of white popinac or subabooul (*Leucaena lastisiliqua* L.), (*L. leucocephala* Lam.) and madre tree (*Gliricidia sepium* Jacq.) in the soil led to enhanced dry matter production, Nitrogen uptake, leaf area and yield of sorghum in comparison to equivalent amount of nitrogen as urea. The grain yield of sorghum (*Sorghum bicolor* L.) improved by 94, 181 and 229 % compared to the control. However, the lowest dry matter, grain yield and yield components were documented on application on pearl millet (*Pennisetum glacum* L.).

Dad (1992) studied two different composting methods i.e., Bangalore pit (anaerobic) and Nadep tank (aerobic) in relation to quality compost and time of maturity. Nadep method was found to be better in relation to quality of final compost prepared although the time required to prepare compost by both methods was almost same.

Composting of garden waste (plant litter) was done by Keeling *et al*, 1995 by windrow system. On four consecutive weeks samples were eliminated and integrated into growth media and different physical parameters were estimated. Higher nitrogen yields and dry matter was showed by the younger composts.

In a study Pine (*Pine roxburghii*) litter was pre-decomposed for 75 days with 0.5 % suspension of urea, DAP (Di-Ammonium Phosphate), lime, molasses, urea + lime +molasses, biogas slurry and daily urine as separate treatments. A major increase in yield of ragi (*Eleusine coracana*) was calculated with all the treated pine litter materials. Urea treated litter showed the best overall effect (Pal, 1995).

Whitbread *et al* (1999) conducted a study in which annual application of 1.5 kg dry matter $ha^1$of leaf litter which differed in the breakdown rate from a legume crop and three types of trees for five seasons was done. This process resulted in 23 – 48 % increase in rice grain yield above the no leaf litter control.

Huang *et al* (2001) prepared two piles in which Pile A was composed of pig manured sawdust with ratio 3:2 while Pile B constituted pig manure : saw dust : leaves at a mixing ratio of 3:1:1. The stabilization and maturation time for pig manure composting was abridged and humification process was enhanced by the addition of leaves.

A field experiment was performed by Soumare *et al*, 2002 to demonstrate the effect on soil properties and tomato growth by the addition of litter compost of *Casuarina equisetifolia* and ramial chipped wood. The tomato yield and growth was improved by the application of litter compost during both the croppings whereas the yield and growth was depressed in first cropping and enhanced in second by incorporation of ramial chipped wood. Litter compost incorporation also enhanced soil levels and tomato uptake.

Two field experiment was carried out by *Adediran et al*, 2003 to examine the effect of different biodegradable wastes compost mixed with poultry litter on yield of tomato and amaranthus. Three different methods used for composting were PACT-1(Passively Aerated Composting Technique) in a pile, PACT-2(Passively Aerated Composting Technique) in a plastic pot and Wdr.(Windrow). The results showed that the methods of composting affected the efficiency of the composts on the yield of both the crops.

Hu and Baker (2004) demonstrated the effect of sewage compost, agricultural compost and yard waste with or without peat moss and soil. The highest growth was given by agricultural compost and least by yard waste.

Sewage sludge, poultry manure, leaf compost and vegetable compost were incorporated by Tanu *et al*, 2004 in four different doses to evaluate their effect on three varieties of Java citronella. The herbage and dry matter yield was significantly increased by poultry manure followed by sewage sludge.

Maynard (2005) applied leaf compost (unscreened) in the soil which was rototilled upto six inches depth. The compost treatments showed differences in pH and organic matter.

Rajagopal *et al* (2005) studied the decomposition of the litter and compared two methods i.e., bag and non-bag under teak plantation of age 30 years. They collected freshly fallen leaf litter of *Tectona grandis*. In bag method, they kept 25 g samples in nylon bags of size 30 x 30 cm and in an other method, same amount was placed on forest floor of the sample plot in direct contact with soil. At an interval of 30 days, the periodic retrieval of samples from both experiments was done. They continued the observations for a period of one year. There was a steady decline in decomposition of the litter in both the cases, the decomposition rate was faster in non-bag method than that of bag method.

Composting of municipal solid waste, leaves and poultry waste was done by Yaghmaeian *et al*, 2005 by pit and windrow process. On the basis of C/N ratio (25:1) and moisture content (55 %), the waste proportioning was done. In windrow, mixed wastes were located and pit with natural aeration tunnel. The study revealed that pit method was better than windrow method for maintaining moisture and nutrient contents.

Ashwini and Sridhar (2006) evaluated the effectiveness of pill millipede compost and farm yard manure(FYM) on the growth and dry matter yield of finger millet and black gram. The result showed positive effect on growth and dry matter yield of plant with application of pill millipede compost in combination with or without FYM.

Ashwini and Sridhar (2006) employed pill millipedes (*Arthrosphaera magna*) to generate compost from plantation crop residues on a pilot-scale. They used three combinations of residues (w/w), viz., mixed leaf litter (acacia, areca, cashew and cocoa) (1:1:1:1) , areca leaf litter and areca nut husk (1:1) and cocoa leaf litter and cocoa pod husk (1:1) in cement tanks along with millipedes with adequate moisture for two months for composting. The parameters such as C/N ratio, total nitrogen and phosphate significantly differed between control and treated residues.

Hu *et al* (2006) evaluate the effect of mixed leaf litters and single leaf litter on microbial and chemical properties of soil for two years. The forest soil quality and microbial properties could be enhanced by application of mixed leaf litter.

Composting can also be done by using worms and the process is known as vermicomposting. In vermicomposting process, the earthworms feed on organic matter with the help of some bacteria, as they quicken the decomposition process (Rostami, 2011). Earthworms have both male and female organs i.e., they are hermaphrodite. They are found in dark and moist habitats in almost all parts of the world. They are very sensitive to dryness, touch and light. Different factors such as pH, soil moisture and availabitiy of organic matter in the soil affects distribution of earthworms in soil. Depending upon the type of species and ecological situation, earthworms have a life span of 3-7 years(Thanooja, 2011). Earthworms release a coelomic fluid during the waste decomposition which has anti-bacterial properties and kill pathogens which makes the process odour free(Pierre *et al.* , 1982). The major waste eater earthworms species are *Eudrilus euginae, Eudrilus andrei, Eisenia foetida, Perionyx excavates and Lumbricus rubellus*(Graff, 1981).

Perumalsamy and Roobak (2009) worked on leaf litter composting using earthworm *Eisenia foetida* and microbial kinetizer in order to compare their efficiency in waste management. They showed that the quantity of composted leaf litter and the biomass(earthworm/microbial) recovered after composting were increased with increasing the quantity earthworm/microbial kinetizer. In microbial composting the production of compost was higher. Both the compost showed a stabilization pH of about 7.8 and 7.9. In vermicompost the electrical conductivity and moisture content were slightly higher. The organic carbon content increased in both the compost by increasing the number of earthworms and microbial kinetizer. Vermicompost had higher value of nitrogen, phosphorous and potash in comparison to microbial compost. Both the compost had more or less the same C/N ratios.

A study was conducted to evaluate the efficacies and the nutritional status of vermicompost processed by *Eisenia foetida* and *Eudrilus eugeniae* by leaf litter and sugarcane trash. The quantity of organic carbon of leaf litter vermicompost was reduced from 38.65 to 28.89 and 28.0% by *E. foetida* and *E. eugeniae*. The percentage of nitrogen, phosphorus, potassium and calcium was maximum in leaf litter vermicompost processed by *E. eugeniae* than *E. foetida*. The leaf litter compost processed by *E. eugeniae* treated with plant, *Abelmoschus esculentus* showed maximum height, number of leaves, leaf area, fruit length, fruit weight and total chlorophyll content than those treated with sugarcane trash (Alagesan and Dheeba, 2010).

Jayanthi *et al* (2010) conducted a study on the processed mixed leaves litter in which the litter was mixed with cured cow dung in three different proportions i.e., 50:50, 60:40 and 70:30 (each concentration in triplicates). The mixture of litter and cow dung were taken in the plastic trays in three different concentrations. Hundred mature *Eudrilus eugeniae* were added into each of these trays. A control (without earthworms) was also run for each of these concentrations. The conversion ratio of mixed leaf litter into vermicompost was same in all the concentrations. The vermicompost collected from all the concentration have desired level of plant nutrients. This study showed that the mixed leaves litter with cured cow dung at any of these three concentrations could be applied for converting into vermicompost by employing *E.eugeniae.*

An investigation was conducted to analyse the different physicochemical parameters like $_{P}$H, electrical conductivity, moisture content, organic carbon and C/N ratio in leaf litter vermicomposting by earthworm species *Lampito mauritti* (Priya and Prabha, 2011). The results showed significant increase in all the physicochemical parameters when the composting time increases except C:N ratio.

A study was performed by Jesikha *et al* (2012) to evaluate the potential of epigeic earthworm *Eudrilus eugeniae* to convert waste leaf litter and waste cattle manure into vermicompost. Vermicomposting caused major increase in different macro nutrients such as nitrogen 14.9%, potassium 1.69%, phosphorus 1.46% in leaf litter vermicompost and nitrogen

1.62%, potassium 0.56% , phosphorus 1.11% in cattle manure vermicompost, and decrease in carbon nitrogen ratio such as 0.33% in leaf litter vermicompost and 2.76% in cattle manure vermicompost.

Mujeebunisa *et al* (2013) analysed the outcome of leaf litter, vegetable waste, coffee waste, flower and may flower waste added vermicompost *Eudrilus eugeniae* weight gain. They observed an increase in weight gain of vegetable and flower waste exposed worms in comparison to coffee seed and may flower waste exposed worms. The study revealed that organic wastes vermicomposting accelerates organic matter stabilization and gives chelating and phytohormonal elements having high content of microbial matter and stabilized humic substances.

Arumugam *et al* (2014) investigated the augmentation of vermicomposting by the addition of leaf litter along with the post-consumer waste, the artificial paper banana leaf waste. Different physicochemical parameters such as pH, total organic matter, electrical conductivity, total nitrogen, C: N and total phosphorus were evaluated. They found that the aging of vermicompost decrease the microbial biomass. The study revealed that addition of leaf litter surely increased the post-consumer waste degradation evidently within a period of 50 days, but degradation without leaf litter took 90days.

Thangaraj (2015) studied the inter-specific relation in terms of growth, maturation, survival and vermicomposting competence of two earthworm species *Drawida modesta* (indigenous) and *Eudrilus eugeniae* (exotic) bare to leaf litter of *Pongamia pinnata*. Vermicompost was prepared in 40 days by the decomposition of leaf litter by both the species. The vermicompost had higher level of nutrients like total nitrogen, available potassium, available phosphorus and decreased level of pH, C:N ratio and organic carbon.

Sandeep *et al* (2017) carried out a study for 90 days to evaluate the nutrient level of vermicompost using earthworm species *Eisenia foetida*. They maintained three replicates of the substrate having cow dung and leaf litter in 3:1 ratio. For the analysis of carbon, nitrogen, potassium and phosphorus content, the samples of substrate were taken on initial, 30^{th}, 60^{th} and 90^{th} day of study. They recorded reduction in organic carbon from 13.130% to 10.780% while an increase in N, P and K level upto 17.90%, 44.73% and 18.24% on 90^{th} day. There was a significant decrease in C:N ratio upto 32.60% that stamps the enhanced ratio of nutrient due to earthworm activity.

3. CONCLUSION

Thus this extensive review on composting and vermicomposting of leaf litter suggests that leaf litter can be efficiently managed by converting it into manure. Sustainable management and utilization of leaf litter can be successfully applied in home gardening. Managing leaf litter by composting proposes an alternative approach to waste management since the leaf litter will neither be burnt nor be landfilled. This will also help in reduction of air pollution produce by leaf litter burning. Different types of nutrient rich compost prepared by leaf litter can be further used for organic farming which results in increased productivity of crops. Leaf litter utilization and management will help in making the residential areas cleaner.

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