CHAPTER IV
COMPOSTING BY VARIOUS METHOD AND ITS ANALYSIS

“Producing quality compost is the important job in the organic farming. A lot of problems I see on the farms and by making better compost the problems are solved”.

-Elliott Coleman

India is the second most populous country in the world. With the increasing population, the cultivable land resource is shrinking day by day. To meet the food, fibre, fuel, fodder and other needs of the growing population, the productivity of agricultural land and soil health needs to be improved. Green revolution in the post independence era has shown path to developing countries for self-sufficiency in food but sustaining agricultural production against the finite natural resource base demands has shifted from the “resource degrading” chemical agriculture to a “resource protective” biological or organic agriculture.

Composting is the natural process of ‘rotting’ or decomposition of organic matter by microorganisms under controlled conditions. Raw organic material such as crop residues, animal wastes, food garbage, some municipal wastes and suitable industrial wastes, enhance their suitability for application to the soil as a fertilizing resource, after having undergone composting.

Compost is a rich source of organic matter. Soil organic matter plays an important role in sustaining soil fertility, and hence in sustainable agricultural production. In addition to being a source of plant nutrient, it improves the physico-chemical and biological properties of the soil. As a result of these improvements, the soil become more resistant to stresses such as drought, diseases and toxicity; it helps the crop in improved uptake of plant nutrients and possesses an active nutrient
cycling capacity because of vigorous microbial activity. These advantages manifest themselves in reduced cropping risks, higher yields and lower outlays on inorganic fertilizers for farmers.

Composting is a natural biological process which results in the degradation of organic waste to a stable end product, commonly referred to as compost, which can be utilized for various agricultural purposes. Increasing landfill costs and regulations which limit many types of waste accepted at landfills has increased interest in composting as a component of waste management (Goldstein and Spencer, 1990; Goldstein, 1991). Composition of waste varies as change in source, farm yard waste, Municipal solid waste (MSW), source separated Municipal solid waste (MSW), agricultural production and processing waste and various other industrial organic waste. With such diversity in waste products coupled with variation in the composting processes, one would expect extreme variability in the chemical and physical properties of final product as reported by Cook *et al.* (1994), He *et al.* (1992); Bugbee (1994), Elwell *et al.* (1994).

The variability in physical and chemical properties of composts resulting from different feedstocks and processes may account for the inconsistent results from the use of compost as reported by Cooke (1979). There are relatively few studies which have considered the composition of the waste stream when determining compost performance or compared composts from totally different feedstocks. Cook *et al.* (1994) evaluated the influence of disposable diaper content of the waste stream on properties of compost and Bugbee (1994) compared the effects of three different feedstocks on the response of Rudbeckia growth in compost from these feedstock. These results suggested that compost derived from various feedstocks can be effectively used to enhance soil productivity and as amendment in greenhouse and container growing media. However, as is the case with different soil types and fertilizer material, it is essential
that the properties of each type of compost be understood and that appropriate management systems be used. Utilization information is not generally available for composts formed from different waste streams, such as municipal solid waste (MSW), source separated Municipal solid waste (SSMSW), waste water biosolids (WB), wood waste (WW), and fish waste (FW) (Brinton and Seekins, 1994).

Adverse effects of chemical fertilizers on soil health resulted in practice of organic farming for sustainable agriculture, where on-farm organic waste recycling is of immense importance. Considerable interest has been shown to employ organic wastes such as urban wastes and sludge for manure preparation (Verdonck, 1998). In most instances, such organic wastes cannot be directly used because of phytotoxicity, nitrogen immobilization, high salt and structural incompatibility. Such disadvantages can be eliminated through composting the organic wastes. In tropics and subtropics, heavy nutrient leaching from soils affects the soil fertility status (Shuxin et al. 1992). Loss of nitrogen from the soil can be minimized on amending vermicompost (Shi-wei and Fu-zhen, 1986). Kale and Bano (1986) demonstrated that vermicompost application for paddy cultivation results in cut down the use of chemical fertilizers.

**Types of Composting**

Composting may be divided into two categories by the nature of the decomposition process. Aerobic composting takes place in the presence of ample Oxygen. In this process, aerobic micro-organisms break down organic matter and produce carbon dioxide, ammonia, water, heat and humus, the relatively stable organic end product. Although aerobic composting may produce intermediate compounds such as organic acids, aerobic micro-organisms decompose them further. The resultant compost, with its relatively unstable form of organic matter, has little risk of phytotoxicity. The heat generated accelerates the breakdown of proteins, fats and complex carbohydrates such as cellulose and
hemi-cellulose. Hence, the processing time is shorter. Moreover, this process destroys many micro-organisms that are human or plant pathogens, as well as weed seeds, provided it undergoes sufficiently high temperature. Although more nutrients are lost from the material by aerobic composting. It is considered more efficient and useful than anaerobic composting for agricultural production.

The Aerobic Composting Process

The aerobic composting process starts with the formation of the pile. In many cases, the temperature rises rapidly to 70–80 °C within the first couple of days. First, mesophilic organisms (optimum growth temperature range = 20–45 °C) multiply rapidly on the readily available sugars and amino acids. They generate heat by their own metabolism and raise the temperature to a point where their own activities become suppressed. Then a few thermophilic fungi and several thermophilic bacteria (optimum growth temperature range = 50–70 °C or more) continue the process, raising the temperature of the material to 65 °C or higher. This peak heating phase is important for the quality of the compost as the heat kills pathogens and weed seeds.

The active composting stage is followed by a curing stage, and the pile temperature decreases gradually. The start of this phase is identified when turning no longer reheats the pile. At this stage, another group of thermophilic fungi starts to grow. These fungi bring about a major phase of decomposition of plant cell-wall material such as cellulose and hemi-cellulose. Curing of the compost provides a safety net against the risks of using immature compost such as nitrogen (N) hunger, oxygen (O) deficiency, and toxic effects of organic acids on plants.

Eventually, the temperature declines to ambient temperature. By the time composting is completed, the pile becomes more uniform and less active biologically although mesophilic organisms recolonize the compost. The material becomes dark brown to black in colour. The
particles reduce in size and become consistent and soil-like in texture. **In the process, the amount of humus increases, the ratio of carbon to nitrogen (C: N) decreases, pH neutralizes, and the exchange capacity of the material increases.**

**NADEP Compost**

The NADEP method of making miracle compost was first invented by Narayan Dewrao Pandharipande (also popularly known as “Nadepkaka”) living at Yeoatmal in Maharashtra (India). The method, which has become quite popular among the farmers in India, now bears his name.

A brick structure measuring 10'x6'x3' is prepared with holes in the side walls to ensure adequate supply of air during composting. The brick tank is filled with farm wastes, soil and cow dung and water is added to maintain moisture between 60-75 %. A tank is filled with soil, 16-18 q, farm wastes 14-16 q, dung 1-1.2 q. Water is added to moist the material and upper layer is plastered with soil and dung mixture. After 75-90 days of composting, microbial culture of *Azotobacter, Rhizobium* and phosphate solubilizing bacteria are added into the mixture. Compost becomes ready for use within 110-120 days. One tank provide about 2.5-2.7 t of compost sufficient for one hectare land.

Another kind of NADEP is known as BHU-NADEP. In this, construction of tank by bricks is not required. Method of filling is same as above.

**Indore Method**

This is an old method of compost preparation in the pit having size of 9' x 5' x 3'. A portion of pit is filled with farm wastes layer by layer. Each layer is around 7.5 cm thick and over it a layer 5 cm of cow dung slurry mixed with urine is spread. Pit is filled with farm wastes and plastered with 5 cm - 10 cm thick layer of soil and dung. This prevents moisture loss and allows the temperature to rise up to 60-65°C within 3-4
days. Material inside the pit is turned after 15-30 days and moisture is maintained by adding water. Another turning is given after an interval of 30 days. Good quality compost becomes ready within 3-4 months.

**Heap Method**

During rainy seasons or in regions with heavy rainfall, the compost may be prepared in heaps above ground and protected by a shed. The basic Indore pile is about 2 m wide at the base, 1.5 m high and 2 m long. The sides are tapered so that the top is about 0.5 m narrower in width than the base. A small bund is sometimes built around the pile to protect it from wind, which tends to dry the heap. The heap is usually started with a 20 cm layer of carbonaceous material such as leaves, hay, straw, sawdust, wood chips and chopped corn stalks. This is then covered with 10 cm of nitrogenous material such as fresh grass, weeds or garden plant residues, fresh or dry manure or digested sewage sludge. The pattern of 20 cm carbonaceous material and 10 cm of nitrogenous material is followed until the pile is 1.5 m high and the material is normally wetted so that it may feel damp but not soggy. The pile is sometimes covered with soil or hay to retain heat and is turned at six- and twelve-week intervals. In the Republic of Korea, heaps are covered with thin plastic sheets to retain heat and prevent insect breeding.

If material is limited, the alternate layers can be added as they become available. All material may be mixed together in the pile if one is careful to maintain the proper proportions. Shredding the material speeds up decomposition considerably; most material can be shredded by running over them several times a rotary mower. When sufficient nitrogenous material is not available, a green manure or leguminous crop like sun hemp is grown on the fermenting heap by sowing seeds after the first turning. The green matter is then turned in at the time of the second mixing. The process takes about four months to complete (FAO, 1980; Mishra *et. al.*, 2003).
The Anaerobic Composting Process

In anaerobic composting, decomposition occurs where oxygen \( (O_2) \) is absent or in limited supply. Under this method, anaerobic micro-organisms dominate and develop intermediate compounds including methane, organic acids, hydrogen sulphide and other substances. In the absence of \( O_2 \), these compounds accumulate and are not metabolized further. Many of these compounds have strong odours and some cause phytotoxicity. As anaerobic composting is a low-temperature process, it leaves weed seeds and pathogens intact. Moreover, the process usually takes longer time than aerobic composting. These drawbacks often offset the merits of this process, viz. little work involved and fewer nutrients lost during the process.

Bangalore Method

This method of composting was developed at Bangalore in India in 1939 (FAO, 1980). It is recommended where night soil and refuse are used for preparing the compost. The method overcomes many of the disadvantages of the Indore method such as the problem of heap protection from adverse weather, nutrient losses from high winds and strong sun, frequent turning requirements, and fly nuisance. However, the time required for the production of finished compost is much longer. The method is suitable for areas with scanty rainfall. Trenches or pits about 1 m deep are dug; the breadth and length of the trenches can vary according to the availability of land and the type of material to be composted. Site selection is as per the Indore method. The trenches should have sloping walls and a floor with a 90 cm slope to prevent waterlogging.

Quality Compost Methods

Good quality compost free from weeds, pathogens and rich in nutrients is a prerequisite for adopting organic farming practice. Different methods have been developed for the preparation of quality compost from
farm wastes, depending upon the nature and quantity of raw material available with farmer, any one or combination of following methods may be adopted for the production of compost.

**Vermicompost**

Vermicomposting is a simple biotechnological process of composting, in which certain species of earthworms are used to enhance the process of waste conversion and produce a better end product. Vermicomposting differs from composting in several ways (Gandhi *et al.*, 1997). According to Gaveo *et al.* (2001) earthworms are extremely important in the breakdown of organic matter into soil, the release of nutrients, the aeration and drainage of soil and the formation of aggregates. It is a mesophilic process, utilizing micro-organisms and earthworms that are active at 10–32°C (not ambient temperature but temperature within the pile of moist organic material). **Composting** objectives may also be achieved through the enzymatic degradation of organic material as they pass through the digestive system of earthworms. This process is termed as vermicomposting. The process is faster than composting; because the material passes through the earthworm gut, a significant but not yet fully understood transformation takes place, whereby the resulting earthworm castings (worm manure) are rich in microbial activity and plant growth regulators and fortified with pest repellence attributes as well. In short **earthworms, through a type of biological alchemy, are capable of transforming garbage into ‘gold’** (Vermi Co, 2001).

Earthworms are used to prepare compost from farm and livestock wastes. Earthworms continuously feed upon the organic residues and produce casts. This casts is generally termed as vermicompost. Casts of earthworms are usually rich in nutrients and organic matter and therefore, serves as a good source of manure for growing crops. Certain earthworms like *Eisenia foetida*, *Perionyx excavatus* and *Eudrilus eugeniae* are
specifically suited for the preparation of vermicompost. The African night crawler, *Eudrilus eugeniae* are more suitable for the climatic conditions of Southern India for vermicompost production (Bano and Kale, 1988; Kale and Bano, 1988; Chowdappa *et al.* 1999).

**Green Manures**

Green manures, often known as cover crops, are plants which are grown to improve the structure and nutrient content of the soil. They are a cheap alternative to artificial fertilizers and can be used to complement animal manures. Growing a green manure is not the same as simply growing a legume crop, such as beans in a rotation. Green manures are usually incorporated into the soil when the plants are in flowering stage. They are grown for their green leafy material which is high in nutrients and improves physical condition of the soil. Several green manure crops provide sufficient organic matter and nitrogen for growing crops. Green manuring also help in providing large amount of easily decomposable organic matter to the soil, which accelerate the nutrient cycling processes and make available nutrients to the crops.

**Leaf Litter Compost**

The decomposition of leaf litter is a key element in the natural nutrient cycle in terrestrial systems; and is a commonly composted material. Plant cell wall material is made up of cellulose, lignin and hemicellulose. Both cellulose and hemicellulose are readily degradable under bacterial action whilst lignin generally undergoes fungal degradation and takes the longest time to degrade. Although leaves compost it is not considered to be a fertilizer (as it is low in nutrient), but it is considered to be a beneficial soil conditioner (Shanta and Paul, 2003).

**Raw material and composting process**

In experiment I, the freshly fallen dead leaves of trees present in the Botanical garden and Central oval garden were collected from the plantation floor and transported to experimental field for use as raw
material to prepare composts during June to October by NADEP tank (aerobic) and Bangalore pit (anaerobic) methods. Each pit used for composting was 105 cm x 75 cm x 90 cm (l x w x h). The leaf litter was spread on the hygienic floor and subsequently sprayed with 5 % urea and single super phosphate (SSP) and another lot of litter was also sprayed with 5 % dung slurry to enhance the composting process. This pretreated material was arranged alternately along with well composted inoculum and soil on each layer in the aerobic tanks and anaerobic pits. Sufficient water was sprinkled in order to maintain the optimal moisture 70 % over the material. The pits were enclosed with dung-mud paste to prevent loss of moisture or heat and allowed to decompose. The trenches were watered whenever the dampness was less than 50 per cent. After one month intervals, turning the whole material upside down was employed for airing and achieving uniform homogenous decomposition of the organic wastes. The pits were again irrigated and closed by dung-mud mixture. Finally, amorphous, dark brown, well-fermented composts were obtained.

The uniformly mixed samples (100 g) of each treatment were collected immediately from the pits for nutrients analyses. The raw material and composting processes applied for all the experiments were same.

For the experiment II, the freshly fallen dead leaves (leaf litter) were collected from Dr. Babasaheb Ambedkar Marathwada University campus composted in to a pit of size 12’ x 22’ x 3’ on 27 Jan 2004. Water was sprayed to this dumped material whenever necessary; turning was also given after 15 days of dumping. The decomposed material was taken out after 270 days which weighed up to 5775 Kg. A part of this decomposed material was transferred into a tank (5’x 5 ’x 5’) for the preparation of vermicompost by anaerobic method on 24 March 2005. Final weight of the compost was taken after 167 days; the weight of vermicompost was 1415 Kg. Again this was repeated on 16 Sept. 2005, the final weight of compost by aerobic method was taken after 140 days
and the weight of compost was 750 Kg. Another compost preparation was started at 29 Sept. 2006 for performing experiment III. For this, freshly fallen dead leaves collected from university campus and dumped into the NADEP pit for decomposition. The weight of final compost from this method was 625 Kg pit$^{-1}$ in 141 days.

Again the leaf litter was collected on 19 Sept. 2005 for the preparation of compost by heap method (experiment IV). The final weight of the compost was taken after 125 days (10775 kg). In experiment V compost was prepared from leaf litter by anaerobic method in the month of Sept. 2005- Jan. 2006 which was 960 Kg in 115 days. While for the experiment VI, the preparation of compost by NADEP pit method was carried out during 20 Feb. 2006 to 3 Aug. 2006 by using leaf litter. The finally which weighed 1212 kg (164 days). In experiment VII, compost was prepared from leaf litter by aerobic method from 5 Aug. 2006 to 16 Oct.2006. The final weight of compost was taken after 72 days (522 kg). For the experiment VIII, about 800 kg leaf litter was dumped in NADEP tank on 15 July 2007 which gives 590 kg of compost within 46 days.

About 22624 kg compost was prepared by various methods from leaf litter during this investigation period. From this, a part was utilized for the field experiments of this investigation while remaining compost was utilized for the garden maintenance and research farm maintenance. All the methods of preparation of different compost are suitable according to season and environmental conditions. In winter NADEP tank and in rainy season Open heap method, Bangalore pit method is most suitable for the preparation of compost.

In future, we are planning to prepare compost by different methods on large scale and to sale the farmers at very cheapest rates. It will increase soil fertility and yield of crops. This plan will also increase
income of Dr. Babasaheb Ambedkar Marathwada University, Aurangabad and gives support to enrich the society.

**Chemical Analysis**

The chemical analysis was done by adopting standard analytical methods. Organic carbon was determined by loss in weight method (ignition method). Ash values were obtained by the moisture-free samples in a muffle furnace at 600°C for 2 hours and calcium (Ca) content was analyzed by titrating the sample against 0.01 N KMnO₄ solution using methyl red as indicator (AOAC, 1995). Nitrogen (N) was estimated by micro-Kjeldahl method after digesting the sample with AR grade Conc. H₂SO₄ (Bailey, 1967). Phosphorus (P) was analyzed by reacting the sample with ammonium molybdate solution at 660 nm (Oser, 1979) and potassium (K) content was determined on a flame photometer (model Mediflame- 127) as suggested by Jackson (1973).

**Chemical analysis of compost**

**Chemical composition of leaf litter used for compost**

(Oven dry matter)

Table 1 shows that, the nitrogen content was found maximum in the *Neem* (*Azadirachta indica* A. Juss.) leaves, followed by *Ashoka* (*Polyalthia longifolia* (Sonner.) Thw.) Leaves and minimum in *Muchkund* (*Pterospermum aserifolium* Willd.) leaves. The phosphorous content was found in *Muchkund* leaves followed by *Ashoka* leaves while it was minimum in the *Neem* leaves. The potassium content was more in *Ashoka* leaves followed by *Neem* leaves while it was less in *Muchkund* leaves. The percentage of Ash and Organic carbon shows similar trend i.e. maximum in *Neem* leaves, followed by *Muchkund* leaves and minimum in *Ashoka* leaves. C: N ratio ranged from 2.88 to 4.76.
Chemical composition of compost

The chemical composition of compost is given in table 2. The dry matter was 88.33%, Nitrogen 1.11%, Phosphorous 0.57%, Potassium 0.05 %, Ash 66.09%, Organic carbon 38.33 % and C: N ratio 34.99.

Analysis of vermicompost

Table 3 shows the analysis of vermicompost from Upper, Middle and Lower layers for fresh weight, percentage of DM (Dry matter), N, P, K, Ash, Organic carbon and finally the C: N ratio. C: N ratio ranged from 27.19 to 35.13, middle and lower layer C: N ratio was near the ideal range as 25 to 30: 1.

Analysis of open (heap) method compost

Heap method: - pipes were used to control the spreading of the material and compost. Four pipes of the size height 5 ft X 1.5 ft were used for each heap method. Table 4 shows the analysis of Open heap compost for Fresh wt, percentage of Dry matter, N, P, K, Ash, Organic carbon and C: N ratio ranged from 28.75 to 35.44.

Conclusion

The preparation of composts by various method is to maintain and improve productivity of land as for as possible by encouraging and enhancing natural biological process in the soil. Discarding the use of expensive resources and chemicals, it lays emphasis on the need to understand natural process and non-destructive management. Organic manures favour the natural activities and thus ecosystem is maintained making it sustainable allowing the whole existence of plant, insects and microbes. They are eco-friendly, low cost and non bulky agricultural input which significantly improves the soil fertility and plant nutrition. A strong extension of training programme, actively supported by research
and Industry is the need of hour. We should recognize that in adopting National approach to the use and management of natural resources. In sustainable agriculture, the microbial fertilizers hold vast potential for the future. Judicious combination of chemical fertilizer and organic manures not only improves the quality of crop but also improves quantity of crop. It is clear that the fertilizer value of agricultural wastes has a greater potential for agricultural production if properly used.