Composting Methods

From time immemorial it has been known that decaying organic wastes improve the fertility of the soil. The accumulation of raw sewage is increasing in every city in addition to city refuses like garbages. In the farm, animal wastes and crop residues are accumulating. However, as raw material these agricultural and city refuses cannot be used as organic manures because of high C/N ratio and having highly resistant. lignin like materials, other cellulose and hemicelluloses. Varying factors influence the maturity of the composts and also the rapidity and nutrient status of the composts. Different methods of biodegradation and composting are available for adoption depending on the source of material available and other facilities present in the farm.

FACTORS INFLUENCING COMPOSTING

In nature there are many internal and external factors affecting the rapidity of compost making. The nature of material to be composted influences greatly than the other factors.

1. Composition of waste materials:

The important factor in the type of waste material to be converted into compost is its nutrient composition. Generally the microorganisms act on these nutrients for. biodegradation. The carbon nitrogen ratio of the waste material influences significantly. The rate of decomposition of organic matter of the waste depends on the amounts of carbon and nitrogen present. The C:N ratio of the microbes is in the order of 30:1 and it is an ideal ratio for the organic wastes to undergo biodegradation. However, in nature many of the organic wastes available are having a wider C:N ratio than this. The microbes utilizes the carbon of wastes as energy source and nitrogen for their body cell build up. During this process the C:N ratio is narrowed down. because the carbon is degraded to gaseous carbon dioxide whereas N remains in the compost itself as part of microbial tissues. This process proceeds slowly and depending on the C:N ratio the time taken varied widely. Wider the C:N ratio greater the time it takes for getting a finished compost.

When we use wider C:N ratio materials like rice straw, ,wheat straw, sugarcane trash, leaf litter coir pith etc., it is advisable to mix these wastes with either FYM slurry or biogas slurry or green manure or legume green leaf manure or even limited application of nitrogenous fertilizers to narrow down the C:N ratio, i.e. optimum for quicker degradation. The time required for composting is reduced by the addition of the above materials.

Carbon: Phosphorus ratio optimum for better microbial activity is 100:1. Whenever waste materials having wider C:P ratio are to be composted it is recommended to apply phosphate fertilizer to narrow down the C:P ratio for quick degradation of the material and for conservation of nutrients. Composition of some of the waste materials available in and around farm area are given in Table 7.

In addition to C, N and P other nutrients like K, Ca, Mg, Na, S, Fe, Zn, Co etc are also needed for the microbial degradation. However, these nutrients are present in the waste materials to the required extent and have not created problem of external addition for composting.

2. Size of the waste materials:

The size of waste materials must be reduced to small pieces of about 5 cm to 10 cm length to provide higher surface area when the microbes can easily attack on these materials.

3. Moisture content:

There must be optimum moisture for quick degradation of the organic wastes. In general organics contain sufficient amount of moisture. While mixing for composting wet and dry materials can be mixed together to get a balanced moisture. Moisture to the level of field capacity is optimum. If the materials contains higher moisture we can mix it with soil or saw dust to reduce the moisture per cent. When the moisture content is in excess adequate per cent. When the moisture content is in excess adequate turning can be given at intervals to reduce the moisture content and to increase aerobic decomposition. About 40 to 50 per cent moisture is ideal to be maintained.

4. Aeration:

Adequate supply of gaseous oxygen is necessary specially for aerobic decomposition. In the absence of oxygen anaerobic decomposition will dominate with the survival of anaerobic microorganisms. Aeration is an important factor for proper decomposition. Turning of the compost/manure pits is carried out for providing aerobic decomposition.

Table 1. Nutrient status of some organic waste materials:

Type	Source	Nutrient content (%)		
		N	P2O5	K2O
Animal	Cattle dung	0.40	0.15	0.20
	Cattle urine	0.80	0.02	0.70
	Sheap and goat	0.65	0.50	0.20
	dung	1.5	0.8	0.5
	Night soil	1.2	0.2	0.3
	Human urine	7.0	0.1	0.2
	Leather waste	12.3	0.1	0.3
	Hair and wool	12.5	7.5	1.2
	waste			
Oil cake	Horn and hoof	5.8	1.8	1.0
	wastes	3.2	1.8	1.7
		6.5	2.8	2.1
	Castor	7.8	1.7	1.4
	Coconut	4.0	1.0	1.3
	Cotton seed	5.2	1.0	1.4
	Groundnut	4.8	1.8	1.3
	Kararj-pongam	2.6	0.8	1.8
	Neem	5.1	1.8	1.0
	Niger	7.8	2.2	2.0
	Mahua	6.2	2.0	1.2
	Rapeseed			
Crop	Safflower	0.58	0.23	1.66
	Sesame	0.49	0.25	1.28
		0.40	0.23	2.17
	Rice straw	0.65	0.75	2.50
	Wheat straw	0.59	0.31	1.31
	Sorghum	1.60	0.15	2.00
	Pearl millet	0.35	0,04	0.50
	Maize	0.11	0.26	0.43
	Pulses			
Weeds	Sugarcane trash	1.79	0.28	0.43
	Banana stem	1.43	0.29	0.74
		1.31	0.35	0.55
	Water hyacinth	2.00	0.17	1.70
	Parthenium			
Industrial	Ipomoea	0.26	0.05	0.84
wastes	Legume weeds	1.15	2,40	1.98
		1.50	0.50	4.20
	Coir pith	1.40	0.60	1.20
	Pressmud	0.25	0.12	0.40
	Seaweed residue	0.25	0.20	-

	Cotton mill waste Bagasse Saw dust Sewage sludge	1.50	2.00	1.50

5. Temperature:

During decomposition of organic waste considerable amount of heat is developed. Initially mesophilic microorganisms dominate in the decomposition with temperature below 40_0C. As the temperature increases subsequently above 40_0C the thermophilic microorganisms dominate. If the moisture is maintained at optimum level the temperature will not rise above 50_0C. At higher temperatures the pathogenic organisms and weed seeds are destroyed.

6. Reaction:

In general, the reaction of the composting medium will be near neutral. It may fall down to slight acetic range dur1ng decomposition due to release of organic acids by microbes. The $_p$H may rise to slight alkaline range when the maturity of the compost is attained. When the $_p$H rises to alkaline range there is the possibility of loss of nitrogen in the form of ammonia volatilization. Therefore, the $_p$H is to be maintained at slightly acidic to near neutral level.

7. Micro Organisms:

In the early stage of composting fungi and acid producing bacteria dominate. It is the mesophilic stage. As the temperature increases above 40^0C thermophilic bacteria, actinomycetes and fungi dominate. Mesophilic organisms act on readily degradable carbohydrates and proteins. Actinomycetes degrade water soluble fractions. Thermophilic bacteria attack on protein, lipids, and hemicelluloses. Thermophilic fungi acts on cellulose and lignin. Depending upon the type of organic waste materials to be degraded the appropriate micro organisms are inoculated.

8. Blending materials:

When the organic waste to be composed has a wide C/N ratio, then the material is to be supplemented with a narrow C/N ratio materials like leguminous plants, water hyacinth, biogas slurry etc. Depending upon the necessity urea or ammonium sulphate or other nitrogenous materials can also be added. When wet materials are to be composed, they are mixed with dry materials like dry soil also to reduce moisture and to absorb the released ammonia. Phosphate is also added for hastening the composting process.

METHODS OF COMPOSTING

1. Indore method of composting farm wastes

Howard and Wad (1931) at Indore developed a method for composting the agricultural waste materials available in and around the farm. The materials used for composting include plant residues, animal dung and urine, wood ash, vegetable wastes, weeds, stems, fallen leaves, fodder remnants, etc. These materials are collected and chopped into small pieces of 5-10cm size. These materials are dried to 40-50 % moisture before stacking to avoid excess moisture.

The composting can be carried out in pits or in heaps. The pit size is normally 1m width, 1m depth and 3 to 6m length depending upon the wastes available for composting. In the pit initially the waste materials are spread in layers of 10 to 15 cm height. Over this layer a slurry of 4.5 kg dung, 3.5 kg urine earth ad 4.5 kg of inoculum from a 15 days old composting pit is spread uniformly. Sufficient quantity of water is sprinkled over this to wet the composting materials to the level of 50% moisture. This process of waste, slurry, sprinkling of water is repeated to fill the pit in a weeks time. The material in the pit is to be turned three times during composting. First 15 days after filling, seconds 30 days after filling and third 60 days after filling the pit. Each time the materials is mixed thoroughly, moistened with water and then replaced in the pit. The materials can be covered finaly with a thin layer at soil of about 2-3 cm.

The bioconversion takes place under aerobic conditions. Because it is aerobic digestion, the finished compost will be ready in about three months time.

In the heap methods of composting also the same steps are followed and the top width of the heap may be 0.5 m less than the bottom width of the heap. At the top it can be 1 to 1.5 m and at the bottom it can be 1.5 to 2.0 m width. The pits/heaps are to be protected from wind and rain. As turning is to be given it consumes comparatively high labour. Because of turnings there will be losses of carbonaceous materials and nitrogen. Sufficient amount of water is also needed for watering. A finished compost by this Indore method will contain 0.8 per cent N, 0.3 per cent P_2O_5 and 1.5 per cent K_2O.

The site selected for this composting must be at a high level to prevent entry of rain water. It should be nearer to cattle shed and water resource to avoid transporting these materials.

2. Bangalore Methods of Composting:

Acharya (1939) has developed this method of composting the town-refuse and night soil. Trenches of about one metre deep and 1.5 metre width are dug. The length of the trench can be based n the availability of raw materials for composting. The trenches are located at the outskirts to transport the night soil and organic residues. The trenches should have a sloping wall.

The organic residues and night soil are put in alternate layers of 15 cm and 5 cm height respectively. After filling the pit like wise, it is covered with a 15 to 20 cm thick layer of organic residues at the top. The materials are allowed to remain in the pit as such without turning and watering for abut three months. During this period there us reduction in volume of the biomass as the materials settle down. Then additional organic residues and night soil in alternal layers are added on the top and plastered or covered with mud or red earth to prevent loss of moisture and to prevent breeding of flies. In the beginning there is aerobic composting for about 10 days time and subsequently the materials undergo anaerobic decomposition. Since it is under anaerobic condition for a longer period the decomposition proceeds at a slow rate. It takes about six months to get the finished compost. The finished compost will have 1.5% P_2O_5 and 1.5% K_2O.

As there is no watering needed it is suitable for areas having less water availability. As there is no turning or sprinkling of water the labour requirement for the preparation of the compost is less. As the decomposition is anaerobic there is less loss of ammonia during composting. Since night soil is also handled in this process, the problem of odour and fly breeding are to be reduced. This method provided a method of disposal of any kind of waste. In this method higher temperatures do not develop in the lower layers. As there .is no turning or mixing of materials the finished compost may not have homogenous mass of manure. The C/N ratio is reduced to less than 20:1 in about six months.

Organic wastes and night soil can also be composted in above ground heaps of 1m height, 1m width and of any convenient length by placing organic waste and night soil in alternate layers as in trenches and adding the organic wastes to the top layer. Turning is also not needed in the heap method. The material decomposes comparatively quickly than in pits and can be used after four months (Gaur et al., 1984).

3. Coimbatore methods of composting:

It is an anaerobic method of degradation followed by aerobic method. Composting is carried out in pits of A m length x 2 m width x 1 m depth. The crop residues of farm wastes are filled 'to a thickness of about 15 cm in the pit uniformly. Over this layer cow dung slurry is sprinkled to a thickness of about 5 cm. Above this layer bone-meal/rock phosphate at the rate of 1 kg is spread. This process of residue, cowdung slurry and bone meal is repeated till the height reaches 0.5 m above the ground level. Then the material is covered with mud plasters to prevent the entry of rain water. After 4-5 weeks, the material is turned and then it becomes an aerobic process. The compost will be ready within five months.

Application of cowdung slurry enhances the rate of biodegradation. The application of bone meal/rock phosphate helps to conserve the nitrogen loss from the composting pit and at the same time adds phosphorus to the composting materials.

4. Coir pith composting:

Coir pith is light in weight and occupies more space. Heap method of composting is recommended. The site for composting must be an elevated place and the composting is carried out under shade. An area of 5 metre length and 3 metre width is selected for composting one ton of coir pith. One hundred kilogram of coir pith, is spread uniformly (approximately 2 cm height) on the marked area. It is then inoculated with one bottle (250 g) of spawn of pleurotus sajor-caju by applying uniformly over the coir pith. Another one hundred kg of coir pith is spread uniformly over the Pleurotus sajor-caju inoculated layer. One kilogram of urea is spread uniformly above this second layer of coir pith. Then the urea layer is covered with third 100 kg of coir pith. This process of sand witching the Pleurotus sp. and urea alternately with 100 kg layers of coir pith is repeated for the one ton of coir pith. To compost one ton of coir pith by this method it requires 5 bottles of spawn and 5 kg of urea (Nagarajan et al., 1989). Water is sprinkled it the moisture content is below 60 per cent. Normally the moisture content of raw coir pith is 75 per cent and it has about 500 to 600, per cent moisture holding capacity. If the coir pith is excessively dried then water is to be sprinkled. At the top coir pith layer is spread and it is allowed for biodegradation by the fungus for a period of 30 days. In the middle water is to be sprinkled depending upon the necessity. At the end of 30 days the composted coir pith turns to black mass and the C/N ratio is considerably reduced. The chemical composition of raw and composted coir pith is given in Table.8.

The raw coir pith has the bulk density of 0.15 and particle density 0.49. The urea @ 5 kg per ton of coir pith is used to reduce the C/N ratio of the finished compost. Spawn Pleurotus sajor-caju is inoculated as it can degrade the lignin present in the coir pith. Addition of excess of nitrogen is not needed since it may lead to volatilization loss of ammonia. After composting there is reduction in volume from 100 to 60. Lignin is reduced from 30.0 per cent to 5.00 per cent. Composted coir pith is a good manure and has many favourable-influence on soil properties. Composting of coir pith has the advantages of detoxifying phenolic compounds which are deleterious to microbial growth reducing the bulk of the material arid converting plant nutrients to a form more readily available to plants.

5. Sugarcane trash composting:

Instead of burning the sugarcane trash in the field. It can be efficiently composted by adopting 'Bioconversion technology' and used as organic manure. Heap method of composting is to be practiced. The site for composting must be in an elevated place of the farm and free from water stagnation. The trashes are spread in 5 m x 3 m space up to a height of 15 cm. Over this layer, the pressmud, a solid waste material from sugar factory is spread to a thickness of 5 cm. Rock phosphate, gypsum and urea in the ratio of 5:4:1 is mixed and applied at the rate of 10 kg per 100 kg of sugarcane trash. Enough water is sprinkled over this layer to keep the moisture content above 40 per cent. This type of layering of sugarcane trash, pressmud and nutrients along with watering is to be repeated to a height of 1 m or 1.5 m. At the surface the heap is covered with cowdung paste. Water is sprinkled once in 15 days to maintain the moisture per cent. After 3 months a thorough turning is given, mixed and heaped again. One more turning is given after a month. Outside material is mixed with that from inside. The compost is ready in about five months time.

Table 2. Chemical composition of raw and composted coir pith.

Composition	Raw coir pith	Composed coir pith
Nitrogen (per cent)	0.26	1.10
Phosphorus (per cent)	0.05	0.10
Potassium (per cent)	0.80	1.20
Calcium (per cent)	0.40	0.50
Magnesium (per cent)	0.36	0.48
Iron (per cent)	0.07	0.09
Manganese (ppm)	1.25	5.56
Zinc (ppm)	5.00	12.50
Copper (per cent)	2.90	5.00
Carbon (per cent)	30.0	24.20
C/N ratio	115.0	22.00
Lignin (per cent)	30.0	5.00
Cellulose (per cent)	25.0	10,00
pH	5.40	5.80
Colour	Brown	Black

The turnings provide aerobic decomposition. The addition of rock phosphate and gypsum helps to minimise the ammonia loss during decomposition. The compost contains 2.73% N, 1.81 per cent P_2O_5 and 1.31 per cent K_2O.

7. Biodegradation of weeds:

Weed materials are available in the farm holdings, in the road sides and water stagnated areas. They are available with different moisture contents. According to the moisture content the sprinkling of water can be regulated. The weeds can be biodegraded individually or by pooling all the weeds together depending upon the quantity available and necessity. There is a problem faced by farmers when the Ipomoea cornea weed is incorporated in the wetlands. It germinates in the field after incorporation. This problem can be overcome by bioconverting the ipomoea weed during composting by using lignolytic and cellulolytic organisms for composting. The seed viability of parthenium is destroyed during composting. The high moisture content of water hyacinth is conserved during this bioconversion process.

A common bioconversion technology is suggested for all the weed materials. The weeds are collected and cut into 7 to 10 cm pieces and used for composting. The site selected for composting must be an elevated place with provision for free drainage. Water stagnation is to be avoided to prevent excess moisture. Pit or heap method of composting can be adopted. The size of pit/heap can be 1.5 m width and length of convenient. Pit depth or the heap height is 1m. The chopped weed materials are spread to a thickness of 10 cm. Over this the inoculum containing the microbial consortia of Trichoderma virida, Aspergillus niger and Fusaricm sp. Is spread uniformly.

Above this another weed material to a thickness of 10 cm is spread. Over this layer 0.5 per cent urea (5 kg urea per ton of weed material) is spread. This process of layering of weed microbial consortia. Weed, urea is repeated till about 1 m height us obtained. Sufficient water is sprinkled depending upon the moisture content of weed material to maintain the moisture per cent of the heaped material around 50 per cent. At the surface the material is covered with a thin layer of mud to prevent carrying away by wind and to facilitate to maintain the moisture. Sprinkling of water is to be repeated depending upon the necessity to maintain the moisture around 50 per cent. A turning is given at the end of 15 to 20 days to give a thorough mixing of outside material with that of the inside ones. The bioconverted compost will be ready in about 30 to 40 days time. The composition of different waste materials biodegraded at the end of 40 days is given in Table.9.

Bioconversion of weed materials and other wastes using microbial consortia indicated that the organic carbon content is reduced considerably due to the biochemical action of lignolytic and cellulolytic micro organisms. There is increase in the NPK content of the composted material compared to the raw weed and waste materials. The C/N ratio is considerably reduced due to decomposition.

The biodegradation of ipomoea is confirmed by the cellulolytic ability of cellulose enzyme. Trichoderma sp. and Aspergillus sp. exhibits high cellulolytic activity and hence used for degradation of cellulosic materials. On addition of Ipomoea cornea stem to wetland soils, water soluble compounds viz., sugars reducing sugars, protein and phenol are attacked first. The treatment with mixed culture (Trichoderma sp. Aspergillus sp. And Fusarium sp.) inoculation recorded maximum per cent reduction in cellulose.

6. Biogas Technology:

Biogas is a renewable source of energy. By this technology we can get fuel gas from the waste materials and at the same times the slurry released is a very good organic manure. It provides improved rural sanitation and health care and more importantly it prevents deforestation for fuel and thus ecological balance ca be achieved. Energy crisis is now a big problem to the mankind in a global level. So, also ecology and environment management is a global concern.

On the energy front, it is now well known that we cannot fully depend on fossil fuel as their availability is not unlimited. Frantic efforts are being made all over the world for adoption of renewable sources of energy. Biogas is one of the potential renewable sources of energy. There are about 1.65 million family size biogas plants in operation in our country. However, we are not fully utilizing the entire farm and animal wastes through biogas plants. When the production of biogas is increased it can meet the energy requirement in sectors like agriculture, rural industries and even the urban requirements.

Table 3. Composition of raw and composed wastes

Waste	Status	Composition (per cent)				
		N	P	K	Organic carbon	C/N ratio
Coir pith	Raw	0.26	0.02	0.75	32.4	124
	Composted	1.18	5	1.35	23.3	20
Ipomoea	Raw	1.31	0.11	0.12	65.1	50
	Composted	2.49	0	5	50.4	20
Water	Raw	1.19	0.15	0.50	55.8	47
Hyacinth	composted	2.11	0.32	0.36	45.4	22
Parthenium	Raw	1.43	0.12	0.73	60.9	43
	composted	2.49	0.36	0.62	51.3	21
Paddy	Raw	0.54	0.12	1.37	45.3	84
straw	composted	1.60	7	0.85	35.5	22
	Raw	0.57	0.73	1.43	58.0	102
Sugarcane	composted	1.88	0.02	0.73	45.5	24
trash			2	1.50		
			0.12			
			5			
			0.03			
			5			
			0.15			
			0			

It is well known that physical structure of the soil is as important as its nutrient content. Biogas plant manure, in addition to providing macro elements like NPK and trace elements like Fe, Cu, B etc., it also improves the sols water retention capacity because of the humus content in it.

In addition to animal dung other feed stock materials for the biogas plant can include night soil. Pig manure, poultry droppings, agricultural crop residues, vegetable wastes, weeds and other such organic wastes. If all the available animal, human and agricultural wastes could be used for generation of biogas, the impact could be spectacular.

The gas which is produced by the anaerobic digestion of organic wastes is a mixture of methane and carbon dioxide. In addition, it contains traces if H, H_2S and NH_3. The gas is released due to fermentation process carried out by microbial consortia. The degradation of organic wastes takes place by hydrolysis, acidogenesis and methanogenesis. At the last stage the methanogenic bacteria convert the volatile acids formed in the second stage by acidogenic bacteria to methane and carbon dioxide. Some excess CO_2 in the medium is also converted to methane gas by reacting with the hydrogen present in, the environment.

The biogas slurry manure in general contains 1.40 to 1.84% N, 1,72% P_2O_5, 0.84 to 1.34% K_2O, 35.0 to 38.4% organic carbon, 103.0 to 115.6 mg/kg zinc, 50.6 to 67.5 mg/kg Cu, 231.0 to 294.7 mg/kg Mn (Juwarker et al., 1992). The composition of biogas slurry and methane gas production from some different sources of organics are given in Table 10.

The biogas release per kg of organic material used varied from 32.0 to 122.0 litre. The slurry obtained after biogas extraction is rich in nutrient content than the raw organic wastes.

Table 4. Composition of biogas slurry and CH_4 from organics:

Sources	Biogas yield (1/kg)	Composition of slurry (%)		
		N	P	K
Kitchen waste	122.0	2.58	1.24	0.96
Cattle dung	32.0	1.40	0.72	0.83
Buffalo	40.0	1.50	0.80	0.92
Pig	70.0	1.96	1.12	1.20
Poultry	60.0	2.5	0.7	0.8
Horse	40.0	1.48	0.86	0.96
Human excreta	70.0	2.50	0.92	0.96
Wheat straw	36.0	1.3	0.7	0.65
Water Hyacinth	37.0	1.98	0.88	0.98