# ORGANIC MANURES

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# PREFACE

There is an increasing awareness about organic agricultural practices in the world. But, Indian farmers yet to be realize about ill effect of modern agriculture. Hence alternative farming particularly Organic Farming is hour of the need to get rid of chemical fertilizers, pesticides and growth regulators etc. To promote organic farming in India, Ministry of Agriculture, Govt. of India has launched a National Project on Organic Farming, during Ist October, 2004. Under the **National Programme, Training Programmes** for different level officials, farmers and input producers being implemented, while educating the people there is demand of books based on practical experience in relevant titles. So authors were attempted to collect the practical information and disseminate the details in the form of booklet on organic manures . We hope, this booklet will fulfill the practical as well as theoretical information about different organic manures as well as availability in South India. We hope this manual would be useful to trainees as well as farmers who are involved in promotion of organic farming or willing to convert their lands to organic cultivation.

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## I INTRODUCTION

The crop removes large quantity of plant nutrients from soil, particularly the removal of NPK nutrients at the present level of crop production has been estimated at 125 kg/ha/annum whereas the annual addition is not more than 75 kg resulting in depletion of the nutrient reserve of soil. The excessive reliance on chemical fertilizers and the negligence shown to the conservation and use of organic sources of nutrients have not only caused the exhaustion of soil of its nutrient reserves but also resulted in soil health problems not conducive to achieving consistent increase in agricultural production. Moreover, Indian soils are poor in organic matter and in major plant nutrients. Soil organic matter is the key to soil fertility and productivity. In the absence of organic matter, the soil is a mixture of sand, silt and clay. Organic matter induces life into this inert mixture and promotes biological activities. Although the beneficial influence of organic matter on the physical, chemical and biological properties of the soil is widely known, the full appreciation of the same remains largely ignored in modern agriculture.

The regular recycling of organic wastes in the soil is the most efficient method of maintaining optimum levels of soil organic matter. Recycling of organic matter in the soil should become a regular feature of modern agriculture. In the traditional agriculture, followed over generations in India, the use of plant and animal wastes as a source of plant nutrient was the accepted practice. The importance and aim of organic manures and green manure crops have failed to be recognized in modern agriculture. The average absorption of micronutrients by some crops given in Table –1.

Table – 1 **Average absorption of micronutrients by some crops**

| Crop | Economic Yield t/ha* | Total uptake , grams | | | | | |
|---|---|---|---|---|---|---|---|
| | | Zn | Fe | Mn | Cu | B | Mo |
| Rice | 1.0 | 40 | 153 | 675 | 18 | 15 | 2 |
| Wheat | 1.0 | 56 | 624 | 70 | 24 | 48 | 2 |
| Maize | 1.0 | 130 | 1200 | 320 | 130 | - | - |
| Sorghum | 1.0 | 72 | 720 | 54 | 6 | 54 | 2 |
| Pearl millet | 1.0 | 40 | 170 | 20 | 8 | - | - |
| Cassava | 1.0 | 45 | 120 | 45 | 5 | 15 | - |
| Potato | 1.0 | 9 | 160 | 12 | 12 | 50 | 0.3 |
| Chickpea | 1.5 | 57 | 1302 | 105 | 17 | - | - |
| Pigeonpea | 1.2 | 38 | 1440 | 128 | 31 | - | - |
| Soybean | 2.5 | 192 | 866 | 208 | 74 | - | - |
| Groundnut | 1.9 | 208 | 4340 | 176 | 68 | - | - |
| Mustard | 1.5 | 150 | 1684 | 143 | 25 | - | - |
| Sunflower | 0.6 | 28 | 645 | 109 | 23 | - | - |
| Sesamum | 1.2 | 202 | 952 | 138 | 140 | - | - |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Linseed | 1.6 | 73 | 1062 | 283 | 48 | - | - |
| Jute | 1.0 | 214 | 784 | 251 | 27 | - | - |
| Coffee | 1.0 | 35 | 83 | 62 | 82 | - | - |
| Tea | 1.0 | 276 | 2007 | 1933 | 632 | 101 | - |
| Guinea grass | 269 | 558 | 2940 | 1880 | 443 | - | - |
| Berseem | 112 | 980 | 650 | 580 | 95 | - | - |
| Alfalfa | 107 | 433 | 710 | 620 | 75 | - | - |

Notes: Data for crops 1-7 are on per tonne yield basis: rest for indicated yield levels.

## EFFECT OF INORGANIC FERTILIZERS AND OTHER AGRO-CHEMICALS ON SOIL AND PLANTS

Excessive use of chemical fertilizers and other agro chemicals, which are the important inputs in modern farming creates depletion in soil fertility and pollution in surface water bodies.

1. Water soluble fertilizers when applied to soil, a good portion of the added nutrients does not become available to the crop plants and lost either to the atmosphere up to the hydrosphere due to non stimulation of the activities of heterotrophic soil organisms but facilitate that of the autotrophic nitrifying organisms, thereby hindering the immobilization of nutrients.
2. As a matter of fact, it results in rapid rate of nutrients loss in different forms and increases the soil acidity with nitrification.
3. Emission of ammonia, methane, nitrous oxide and elemental nitrogen from the soil system as a result of denitrification.
4. Depletion of secondary and micronutrients especially Sulphur and Zinc.
5. Deficiency of these nutrients (S & Zn) along with that of Mg, Mn, Fe, Mo, B and Cu limits productivity of many field crops especially in rice.
6. Dhar (1962) cautioned that by adding large doses of N-fertilizers in modern agriculture without the use of organic manures, there is always the danger of humus depletion and fall in crop production, which can be avoided only by adding additional amounts of organic residues and manures.
7. When high levels of N-fertilizers especially nitrate forms are applied to soil, nitrate pollution of drinking water is a serious health hazard found in extensively irrigated coarse textured highly percolating soils of central Punjab, where 40-50% of applied nitrogen is lost in leaching and the mean concentrations of nitrate nitrogen was 3.88 ppm during 1982 (Rainy season) ans 1.02 ppm in 1975. In 10% of the ground water samples nitrate concentration was 10 ppm which was the upper tolerance limit in drinking water against nil in 1975 (Singh *et al*, 1987).

8. Alarming issue to human health is regular use of phosphatic fertilizer in large quantities often causes the build up of trace metal contamination such as arsenic, fluoride, cadmium etc. in soil and plants. Cadmium in single super phosphate is available to plants as the Cd in cadmium chloride. Similarly, chloride contained in MOP and $NH_4Cl$ creates toxicity to many crops like beans, citrus, grapes lettuce, potatoes etc. These trace metal toxic contaminants reach the human body, through food chain and cause health problems.
9. The water soluble nutrients when carried to lakes and stream through leaching and surface run off cause eutrophication as manifested by the luxurient growth of algae and other water weeds on the water surface leading to oxygen deficient condition. This situation is not conducive to healthy aquatic life.

## ADVANTAGES OF ORGANIC MANURES

1. Organic manure provides all the nutrients that are required by plants but in limited quantities.
2. It helps in maintaining C:N ratio in the soil and also increases the fertility and productivity of the soil.
3. It improves the physical, chemical and biological properties of the soil.
4. It improves both the structure and texture of the soils.
5. It increases the water holding capacity of the soil.
6. Due to increase in the biological activity, the nutrients that are in the lower depths are made available to the plants.
7. It acts as much, thereby minimizing the evaporation losses of moisture .from the soil.

### MAJOR ORGANIC SOURCES AND TRANSFORMATIONS

Carbon present in soil is in the form of organic matter. The organic materials most commonly used to improve soil conditions and fertility include farm yard manure (FYM), animal wastes, crop residues, urban organic wastes (either as such or composted), green manures, bio-gas spent slurry, microbial preparations, vermicompost and biodynamic preparations. Sewage sludge and some of the industrial wastes also find application in agriculture.

For all organic matter, atmospheric carbon dioxide serves as the main source of carbon. Carbon dioxide is converted to organic carbon largely by the action of photoautotrophic organisms; the higher green plants on land and algae in aquatic habitats. Carbon is being contentiously fixed into organic form through the process of photosynthesis and once bound; the carbon becomes unavailable for use in the generation of new plant life. Carbon fixation involves a reduction of carbon dioxide by hydrogen donor NADPH (reduced form of the co-enzyme nicotinamide adenine dinucleotide phosphate, NADP) and the synthesis of carbohydrate from reduced carbon through complex cyclic mechanism called the

Calvin cycle. Carbon dioxide constitutes only 0.03 percent by volume of the earths atmosphere. It has been estimated that the vegetation of the earth's surface consumes some 90 billion kg carbon dioxide per annum, about one twenty - fifth of the total supply of the atmosphere and that the total supply of carbon dioxide would be completely exhausted in twenty years at the present rate of photosynthesis , if not replenished by decomposition of organic materials. As the availability of carbon dioxide on the earth's surface is very limited, it must be recycled. Upon the death of the plants and animals, microbiological metabolism assumes the dominant role in cyclic sequence. The dead tissues added to soil undergo decay and are transformed into microbial cells and a vast heterogeneous body of carbonaceous compounds. According to the different stages of decomposition, the soil organic matter becomes available in distinct fractions. Farm yard manure made from cattle dung, excreta of other animals, animal tissues and excretory products, and compost from rural and urban wastes, crop residues and green-manure are collectively designated as bulky organic manures because of their low contents of major nutrients, while materials like oil cakes, fish meal, animal meal, poultry manures, slaughter house wastes containing comparatively higher contents of plant nutrients are grouped under concentrated organic manures. In general organic manures containing upto two percent nitrogen are included in bulky category and those with more than two percent nitrogen are treated as concentrated. Irrespective of source and composition, organic matter when added into the soil undergoes microbial decay and becomes the food for micro flora and fauna. Even the microbial cells serve as a source of carbon for succeeding generations of microscopic populations. A great variety of microorganisms live in soil which include bacteria, actinomycetes, fungi, algae and protozoa. In general the number per gram of soil is bacteria > actinomycetes $\geq$ fungi > algae > protozoa. The average nutrient content of bulky manures given in table –3

Table - 2 **Average nutrient content of bulky manure**

| **Manure** | **Percentage content** | | |
|---|---|---|---|
| | **N** | **$P_2O5$** | **$K_2O$** |
| Animal refuse | 0.3-0.4 | 0.1-0.2 | 0.1-0.3 |
| Cattle dung,fresh | 0.4-0.5 | 0.3-0.4 | 0.3-0.4 |
| Horse dung ,fresh | 0.5 -0.5 | 0.4-0.6 | 0.3-1.0 |
| Poultry manure,fresh | 1.0-1.8 | 1.4-1.8 | 0.8-0.9 |
| Sewage sludge,dry | 2.0-3.5 | 1.0-5.0 | 0.2-0.5 |
| Sewage sludge, activate dry | 4.0-7.0 | 2.1-4.2 | 0.5-0.7 |
| Cattle urine | 0.9-1.2 | trace | 0.5-1.0 |
| Horse urine | 1.2-1.5 | trace | 1.3-1.5 |
| Human urine | 0.6-1.0 | 0.1-0.2 | 0.2-0.3 |
| Sheep urine | 1.5-1.7 | trace | 1.8-2.0 |
| Ash, coal | 0.73 | 0.45 | 0.53 |

| | | | |
|---|---|---|---|
| Ash,household | 0.5-1.9 | 1.6-4.2 | 2.3-12.0 |
| Ash,wood | 0.1-0.2 | 0.8-5.9 | 1.5-36.0 |
| Rural compost,dry | 0.5-1.0 | 0.4-0.8 | 0.8-1.2 |
| Urban compost,dry | 0.7-2.0 | 0.9-3.0 | 1.0-2.0 |
| Farmyard manure,dry | 0.4-1.5 | 0.3-0.9 | 0.3-1.9 |
| Filter-press cake | 1.0-1.5 | 4.0-5.0 | 2.0-7.0 |
| Rice hulls | 0.3-0.5 | 0.2-0.5 | 0.3-0.5 |
| Groundnut husks | 1.6-1.8 | 0.3-0.5 | 1.1-1.7 |
| Banana,dry | 0.61 | 0.12 | 1.00 |
| Cotton | 0.44 | 0.10 | 0.66 |

Source:Organic Farming for Sustainable Agriculture by A.K.Dhama ,1996 Agro Benificial Publishers (India)

## CHEMICAL NATURE OF ORGANIC MATTER AND ITS DECOMPOSTION

Organic matter is a complex mixture of many chemical substances. These materials serve as precursors of soil humus. The most commonly found and well understood organic compounds finding their way into the soil and are subjected to normal decomposition processes are : 1. carbohydrates (sugars, starches, hemicelluloses, cellulose, pectins, gums, mucilages, etc.;), 2 proteins, amino-acids, amins, etc.; 3. fats oil, waxes, resins, etc; 4 alcohol, aldehydes, Ketones, etc; 5 organic acid; 6 lignin; 7. compounds having ring structures (phenols, tannins, hydrocarbons), 8. alkaloids and compounds with organic bases -- pyridine and purine, and 9 miscellaneous substances -- antibiotics, auxins, vitamins, enzymes and pigments. The inorganic constituents, usually present in ash containing major and minor elements amounting 12-15 percent by weight.The chemical composition of organic mater given in table 4

Table 4 Chemical composition of organic matter

| **Fractions** | **% (dry weight basis)** |
|---|---|
| Sugars, starches, amino acids, urea, | 2-30 |
| Ammonium salts (hot/cold water solubles) | |
| | |
| Fats, oils, waxes, (ether / alcohol solubles) | 1-15 |

| | |
|---|---|
| Proteins | 5-40 |
| Hemicelluloses | 10-30 |
| Cellulose | 15-60 |
| Lignin | 5-30 |
| Mineral matter (ash) | 5-30 |

Source: FAO Soil Bulletin (1987)56

Organic matter while entering into the soil, undergoes decay and finally gets converted into carbon dioxide, water, nitrogen, sulphur oxide and keeps replenishing naturally the carbon, nitrogen and sulphur cycles. On ageing, the water soluble constituents of the plant tissues like proteins and minerals decrease and the percentage abundance of cellulose, hemi cellulose and lignin rises. Compounds with linear chain structure are easily decomposed compared to those with cyclic (or) ring structures. Lignin is more resistant to microbial attack., the order of easy decomposition is protein > cellulose $\geq$ fats, waxes > lignin. Nearly all biological transformations that occur in soil are mediated by microbial activity. This means all the factors that influence microorganisms are important in the transformation of dead plant materials. The most important factors are temperature, soil moisture, rate of gas exchange, easy availability of nutrients and structure of the colloidal minerals materials. The age of the plant residues, it's lignin content, and the degree of disintegration of substrata also govern the rate of decomposition.

Microorganisms decompose the organic materials to obtain energy for growth and carbon for the synthesis of new cell material Carbon dioxide, methane, organic acids, alcohol and other oxidized and partly oxidized form of carbon may be metabolic wastes for one group of microorganisms. whereas they may serve as energy and carbon source for other group. To decompose complex compounds, microorganism are required to liberate more number of enzymes. Single organic compound like cytoplasm of blue green algae are decomposed readily in two and half days by 50 percent while corn stalk required two and half months.

Generally, if fresh organic matter with a carbon : nitrogen ratio (proportion of percentage of carbon to that of nitrogen) of greater than 30 is added to a soil, there is immobilization of nitrogen during the initial decomposition process. For ratios between 20 and 30, the mineralization and immobilization may be equal. Release of mineral nitrogen early in the process is caused when organic matter with a carbon : nitrogen ratio of less than 20 decomposes. The carbon : nitrogen ratio of stabilised humus is considered to be 10 : 1. This critical ratio is a reflection of the dynamic equilibrium that results from the dominating microbial population. The microbial protoplasm contains approximately carbon : nitrogen ratios of 5 : 1, 10 : 1 and 15 : 1 for bacteria, fungi and actinomycetes respectively (Hattori, 1973). Immobilization is a temporary locking up of the available plant nutrients.

Under both natural and agricultural conditions, an equilibrium is established between the humus being synthesized from fresh additions of organic materials and the native humus already present in soil. Under normal conditions the mineralization of native humus is compensated by synthesis of new humus.

## HUMIFICATION AND RESIDUAL EFFECT

All organic residues incorporated into the soil undergo decomposition from the original residues, a series of products are formed. As the original material and the initial products undergo further decomposition, they become a brown black organic complex known by the name humus.

Humus remain in dynamic yet fairly stable state. It is under continual attack by soil microorganisms. Decomposition and synthesis by microbial processes occur simultaneously, the rate depending on the nature and abundance of microorganisms involved, the moisture content, temperature, pH, aeration, quantity of freshly added organic matter and the extent of availability of carbon, nitrogen, phosphorus and potassium. Chemically humus has been characterized as ligno-protein or ligno-acid complex containing approximately 45 percent lignin compounds, 35 percent amino acids, 11 percent carbohydrates (4 percent cellulose, 7 percent hemicelluloses) 3 percent fats, waxes and resins and 6 percent other miscellaneous substances. (Finch et al., 1971). Martin et al. (1974) have shown that some fungal mycelium and lignin, and lignin like substances of plant origin are the main building blocks for synthesis of humic substances. The humus is a finally synthesized stable product in natural or agricultural conditions. During humification the nitrogen compounds react in most cases as organic amino compounds and to a lesser extent, as ammonia. Some losses of nitrogen occur in gaseous form as nitrogen or nitrous oxide. Sulphur is bound in the orginal organic compounds as sulphide very rarely as sulphate and transformed in the soil to sulphate, Phosphorus occurs in the organic compounds as phosphate esters, which are hydrolyzed. Potassium, calcium, magnesium and the heavy metals present in plant residues as complexes are liberated during humification into ions. Very often they form other complexes with newly formed organic compounds during humifiction and interact with the soil colloids (salycilic acids, sesquio-oxide and clay) depending on soil properties and environment.The mechanism leading to an increase in the nitrogen content in lignin residue of plants has not been clearly explained. It has been clarified to certain extent that amino acid, protein and amino sugar nitrogen and the products are stabilised against microbial decomposition by their entry during polymerization of humic materials (Verma et al., 1975). The nitrogenous substances formed in this way, serve as slow release nitrogen source for plant growth and have a residual effect because they are only gradually subjected to microbial attack. The isotopic labeled studies have shown that there is a loss of 70, 80 and 90-92 percent of incorporated organic matter into soil after 1, 2 and 8 - 10 years respectively. Table 5 shows the list of organic manures and their N.P.K . states

Table – 5 **List of Organic Manures**

| Manure | Percentage content | | |
|---|---|---|---|
| | **Nitrogen ( N)** | **Phosphoric acid ( $P_2O5$ )** | **Potash ($K_2O$)** |
| Coir pith | 1.20 | 1.20 | 1.20 |
| Blood meal | 10-12 | 1.2 | 1.0 |
| Press mud | 1-1.5 | 4-5 | 2-7 |
| **Bone meal** | | | |
| 1)Raw bone meal | 3-4 | 20-25 | - |
| 2)Steamed bone meal | 1-2 | 25-30 | - |
| Fish meal | 4-10 | 3.9 | 0.3-1.5 |
| Animal refuse | 0.3-0.4 | 0.1-0.2 | 0.1-0.3 |
| Cattle dung, fresh | 0.4-0.5 | 0.3-0.4 | 0.3-0.4 |
| Horse dung ,fresh | 0.5 -0.5 | 0.4-0.6 | 0.3-1.0 |
| Poultry manure, fresh | 1.0-1.8 | 1.4-1.8 | 0.8-0.9 |
| Sewage sludge, dry | 2.0-3.5 | 1.0-5.0 | 0.2-0.5 |
| Sewage sludge, activate dry | 4.0-7.0 | 2.1-4.2 | 0.5-0.7 |
| Cattle urine | 0.9-1.2 | trace | 0.5-1.0 |
| Horse urine | 1.2-1.5 | trace | 1.3-1.5 |
| Human urine | 0.6-1.0 | 0.1-0.2 | 0.2-0.3 |
| Sheep urine | 1.5-1.7 | trace | 1.8-2.0 |
| Ash, coal | 0.73 | 0.45 | 0.53 |
| Ash, household | 0.5-1.9 | 1.6-4.2 | 2.3-12.0 |
| Ash, wood | 0.1-0.2 | 0.8-5.9 | 1.5-36.0 |
| Rural compost ,dry | 0.5-1.0 | 0.4-0.8 | 0.8-1.2 |
| Urban compost ,dry | 0.7-2.0 | 0.9-3.0 | 1.0-2.0 |
| Farmyard manure ,dry | 0.4-1.5 | 0.3-0.9 | 0.3-1.9 |
| Filter-press cake | 1.0-1.5 | 4.0-5.0 | 2.0-7.0 |
| Rice hulls | 0.3-0.5 | 0.2-0.5 | 0.3-0.5 |
| Groundnut husks | 1.6-1.8 | 0.3-0.5 | 1.1-1.7 |
| Banana, dry | 0.61 | 0.12 | 1.00 |
| Cotton | 0.44 | 0.10 | 0.66 |
| Maize | 0.42 | 1.57 | 1.65 |
| Paddy | 0.36 | 0.08 | 0.71 |
| Tobacco | 1.12 | 0.84 | 0.80 |
| Pigeon pea | 1.10 | 0.58 | 1.28 |
| Wheat | 0.53 | 0.10 | 1.10 |
| Sugarcane trash | 0.35 | 0.10 | 0.60 |
| Tobacco dust | 1.10 | 0.31 | 0.93 |
| **Tree leaves, dry** | | | |
| *Calotropis gigantea* | 0.35 | 0.12 | 0.36 |
| *Careya arborea* | 1.67 | 0.40 | 2.20 |
| *Cassia ariculata* | 0.98 | 0.12 | 0.67 |
| *Dillenia pentagyna* | 1.34 | O.50 | 3.20 |

| | | | |
|---|---|---|---|
| *Madhuca indica* | 1.66 | 0.50 | 2.00 |
| *Pongamia pinnata* | 3.69 | 2.41 | 2.42 |
| *Pterocarpus marsupium* | 1.97 | 0.40 | 2.90 |
| *Terimalia chebula* | 1.46 | 0.35 | 1.35 |
| *Terminalia paniculata* | 1.70 | 0.40 | 1.60 |
| *Terminalia tomentosa* | 1.39 | 0.40 | 1.80 |
| *Xylia dolabriformis* | 1.37 | 0.30 | 1.61 |
| **Green manures, fresh** | | | |
| Cowpea (*vigna unguiculata*) | 0.71 | 0.15 | 0.58 |
| *Sesbania aculeata* | 0.62 | - | - |
| Cluster-bea *(cyamopsis tetragonoloba)* | 0.34 | - | - |
| Horse-gram *(Dolichos biflorus*) | 0.33 | - | - |
| Mothbean | 0.80 | - | - |
| Green gram *(vigna radiate)* | 0.72 | 0.18 | 0.53 |
| Sunnhemp(*Crotalaria juncea*) | 0.75 | 0.12 | 0.51 |
| Blackgram(*vigna mungo*) | 0.85 | 0.18 | 0.53 |
| **Non edible Oil Cakes** | | | |
| Castor cake | 4.3 | 1.8 | 1.3 |
| Cotton cake | 3.9 | 1.8 | 1.6 |
| Karanj cake | 3.9 | 0.9 | 1.2 |
| Mahua cake | 2.5 | 0.8 | 1.8 |
| Neem cake | 5.2 | 1.0 | 1.4 |
| Safflower cake | 4.9 | 1.4 | 1.2 |
| **Edible Oil cakes** | | | |
| Coconut cake | 3.0 | 1.9 | 1.8 |
| Groundnut cake | 7.3 | 1.5 | 1.3 |
| Niger cake | 4.7 | 1.8 | 1.3 |
| Rape seed cake | 5.2 | 1.8 | 1.2 |
| Sesame cake | 6.2 | 2.0 | 1.2 |

Source: “Hand book of Manures and Fertilizers” 1964.

## GREEN MANURES

Green manuring can be defined as a practice of ploughing or turning into the soil undecomposed green plant tissues for improving physical structure as well as soil fertility. Green manuring, wherever feasible, is the principal supplementary means of adding organic matter to the soil. The green-manure crop supplies organic matter as well as additional nitrogen, particularly if it is a legume crop, due to its ability to fix nitrogen from the air with the help of its root nodule bacteria. The green-manure crops also exercise a protective action against erosion and leaching. Green manure to be incorporated in soil before flowering stage because they are grown for their green leafy material, which is high in nutrients and protects the soil. Green manures will not break down in to the soil so quickly, but gradually, add some nutrients to the soil for the next crop. The nutritional potentials and nutritional contents of some important green manures are given in the Table 5 and 6 respectively.

**Table 5 : Nutrient potential of green manures**

| Green manure | Biomass (tones) | N accumulobase (Kg/ha) |
|---|---|---|
| | | |
| *Sesbania aculeate* | 22.50 | 145.00 |
| *S. rostrata,* | 20.06 | 146.00 |
| *Crotalaria juncea,* | 18.40 | 113.00 |
| *Tephrosia perpurea* | 6.80 | 6.00 |
| Green gram | 6.50 | 60.20 |
| Black gram | 5.12 | 51.20 |
| Cow pea | 7.12 | 63.30 |

**Table 6 : Nutrient content of important green matures**

| Crop | Nutrient content (% on dry weight basis) | | |
|---|---|---|---|
| | N | P | K |
| **Green manure** | | | |
| *Sesbania aculeate* | 3.3 | 0.7 | 1.3 |
| *Crotalaria juncea* | 2.6 | 0.6 | 2.0 |
| *Sesbania speciosa* | 2.7 | 0.5 | 2.2 |
| *Tephrosia purpurea* | 2.4 | 0.3 | 0.8 |
| *Phaseolus trilobus* | 2.1 | 0.5 | - |
| | | | |

| Green leaf manure | | | |
|---|---|---|---|
| *Pongamia glabra* | 3.2 | 0.3 | 1.3 |
| *Glyricidia maculeata* | 2.9 | 0.5 | 2.8 |
| *Azadirachta Indica* | 2.8 | 0.3 | 0.4 |
| *Calatropis gigantecum* | 2.1 | 0.7 | 3.6 |

**ADVANTAGES OF GREEN MANURES:**

Usage of green leaf manure is advantageous both for crops and soil. The advantages are:

1. As they decompose rapidly, it is easy to retain the organic matter in the soil.
2. Green manures improve both physical and chemical properties of the soil.
3. They provide energy to microbes.
4. They provide nutrients to the standing crop and also to the next crop.
5. Addition of green manure crops to the soil, acts as much and prevent soil erosion.
6. Leaching of nutrients in light soils can be prevented by addition of green manure.
7. Cultivating green manure crops can control weeds.
8. Majority of green manure crops being legumes, use of nitrogenous fertilizers can be minimized.

## There are different green leaf manure crops that can be cultivated and they are:

**1. COWPEA :** Cowpea is one of the important leguminous green leaf manure crops. As this plant is easily decomposable and very well suited for green manure purpose. June-July months are best suited for sowing of this manure. Even though it is being cultivated in summer months ( March to April). Use of effective *Rhizobium* bacteria increase the fixation of nitrogen up to 40 kg/ha.

2**. DHAINCHA (*SESBANIA ACULEATE*) :** Dhaincha is suitable for loamy and clayey soils. It is fairly resistant to drought as well as stagnation of water. It grows well even in alkaline soils and corrects alkalinity if grown repeatedly for 4-5 years. The roots have plenty of nodules. It yields about 10-15 tonnes of green manure per ha and requires a seed rate of 30-40 kg/ha. Use of effective Rhizobium strain with seeds fixes the Nitrogen 1 kg / day.

**3. *SESBANIA SPECIOSA* :** It is a valuable green manure for wetlands and can be grown in a wide range of soils. Seed production is prolific however, pods are frequently attacked by insects. This green manure can be raised on the field borders. Sesbania seedling (21days) can be planted in a single line at 5-10 cm apart in the borders of the fields. In about 90 days it produces about 2-4 tonnes of green manure per ha. It does not affect the rice yield by shading or root effect. If second rice crop is planted immediately after the first crop, the manure can be incorporated into the field. About 300-400g of seeds are sufficient to raise nursery and plant the seedlings around the boundary of one hectare. To control insects *Verticillium lacanii* ( Liquid ) fungi is useful.

**4. SUNNHEMP (*CROTALARIA JUNCEA*) :** It is a quick growing green manure crop and gets ready for incorporation in about 45 days after sowing. It does not withstand heavy irrigation leading to flooding. The crop is at times subject to complete damage by leaf eating caterpillars. The crop can produce about 8-12 tonnes of green biomass per ha. The seed requirement is 30 kg/ha.

**5. *SESBANIA ROSTRATA* :** One of the important features of this green manure is that in addition to the root nodules, it produces nodules in the stem. The stem nodulation is an adaptation for waterlogged situation since flooding limits growth of green manures and may reduce root nodulation. Under normal condition, both root and stem nodules are effective in N fixation. It has higher N content of 3.56% on dry weight basis. Biomass production is higher during summer (April – June) than in winter (Dec. – Jan.) season. This green manure can also be produced by raising seedlings (30 days old) and planted in the paddy field along the bunds or as intercrop with rice. Use of *Rhizobium* bacteria increase the nitrogen fixation about 60-100 kg/ha/year.

**6. WILD INDIGO (*TEPHROSIA PURPUREA*) :** This is a slow growing green manure crop and cattle do not prefer to graze it . The green manure is suitable for light textured soils, particularly in single crop wetlands. It establishes itself as a self sown crop and the seeds remain viable till the harvest of rice. On an average about 3-4 tonnes of green manure is obtained in one ha. The seed rate is 30 kg/ha. The seeds have a waxy impermeable seed coat and hence scarification is required to induce germination. Soaking seeds in boiling water for 2-3 minutes is also equally effective in promoting germination.

**7. INDIGO (*INDIGOFERA TINCTORIA*) :** It resembles wild indigo and is along duration crop with more leafy growth. It comes up well in clayey soils with one or two irrigations.

**8.PILLIPESARA (*PHESEOLUS TRILOBUS*) :** This is a dual purpose crop yielding good fodder for the cattle and green manure. Pillipesara comes up well in hot season with sufficient soil moisture. Loamy or clayey soils are best suited. After taking one or two cuttings for fodder or light grazing by animals, the crop can be incorporated into the soil. About 5-8 tonnes of manure can be obtained from one ha.

**9. GLYRICIDIA (*GLYRICIDIA MACULEATA*)** : This is a shrubby plant that comes up well in moist situations. Under favourable conditions, it grows well like a tree. It can be easily grown in waste lands, farm road sides, field bunds, etc. The crop can be established by stem cuttings or seedlings planted in the field borders. It can be pruned for its tender loppings and compound leaves for green leaf manuring at the time of puddling rice. On an average, a well-established plant yields 12-15 kg green matter. About 400 plants on the peripheral bunds yields 5-6 tonnes green manure/ha.

**10.KARANJ (*PONGAMIA GLABRA*)** : It is a leguminous tree grown in wastelands. On an average, a tree can yield 100-120kg of green matter. The leaves contain about 3.7% N (on dry weight basis).

**11. CALATROPIS (*CALOTROPIS GIGANTCA*) :** On roadsides and fallow lands, the plant grows wild under different soil and climatic conditions. The leaves are more succulent and a plant can produce about 4-5 kg of green matter. Besides it also helps in controlling soil born pests like termite.

## COMPOST

Large quantity of fresh crop residues, on application directly to soil, causes extremely severe nitrogen immobilization and development of excessive reduced condition in the soil. To overcome such problems organic residues are piled up, moistened, turned occasionally to aerate and allowed adequate time to decompose partially and bring down the carbon nitrogen ratio to about 30. This process is called composting. Compost, is utilized for improving or maintaining soil fertility. The collected organic refuse may be of rural and urban origin and may include straw, leaves, paddy husk, ground nut husk, sugarcane trash, bagasse, cattle dung, urine, crop residues, city garbage, night soil, sewage, kitchen and vegetable wastes, hedge clippings, water hyacinth and all other residues counting organic matter. During composting under thermophilic and mesophilic conditions in windrows, heaps or pits adequate moisture and aeration are essential. The final product is brown to black colored humified material which on addition to soil replenishes plant nutrients, maintains soil organic matter content and helps in improving the physical, chemical and biological conditions of the soil.

## REQUIREMENTS OF COMPOSTING

In general, composting is carried out in open pit or above ground, by filing alternate layers of organic wastes and other materials including top soil, cattle dung, half decompose farm yard manure, rock phosphate and other amendments. If the organic wastes are largely high-carbohydrate materials, some fertilizer nitrogen is needed. The addition of poultry waste and farm yard manure while layering the compost pit, tends to speed up decomposition and helps to improve the texture of the product. The optimum C:N ratio of the composting materials is below 40. Good aeration in the compost pile is essential. It is good to mix succulent organic materials with the materials that decompose slowly. This prevents packing into soggy anaerobic mixtures. Since composting is a biological process, sufficient moisture for the proper development of microorganisms is essential. The materials should not be too dry or soggy. The requirement of moisture for microorganisms is almost similar to that of higher plants. The optimum moisture content of the composting materials has been found to be 60 percent of the total water holding capacity of the substrate.

## MICROBIOLOGY OF COMPOSTING

At the initial stage, the easily degradable organic matters like carbohydrates, fats, proteins get degraded by the action of mesophilic fungi. Due to its action, some amount of heat energy is formed hence, the temperature of the composting substrates is $40^0$C or less, mesophilic fungi and acid producing bacteria appear. The proportion of the three groups of organisms -- bacteria, fungi and actinomycetes is related to dominance of organic constituents., Water soluble simple sugars encourage rapid bacterial proliferation while starch benefits the actinomycetes in particular substrates rich in proteins or amino acids stimulate the spore forming bacilli. Details of microbial genera capable of utilising cellulose, hemicelluloses, starch, lignin etc. may be seen in Table-5. At the end of mesophilic action, the thermophilic fungi/bacteria will start its action and degrade some part of organic matters. Hence the temperature of $65^o$ C to $70^o$C attained during aerobic decomposition in compost pit leads to the destruction of most of the pathogens, parasites and weed seeds present in the original material. In addition to the effect of higher temperature, some pathogens and parasites are also killed due to their failure to withstand the competition with other microorganisms. The Actinomycetes and spore forming bacteria start its action to decompose cellulose and Hemicellulose present in the waste. During anaerobic decomposition as prevailed in biogas plant and Bangalore method of composting, temperature does not rise to the extent lethal to parasites in a relatively short time. When sewage sludge or night soil is composted, anerobic decomposition should be proceded by aerobic composting atleast for a week. The natural death of pathogens and parasites occurs under anaerobic environment and the microbial antagonism eventually eliminates them in relatively longer period of six months. After decomposition of maximum amount of organic matters, the temperature of the medium will slowly decreases. During the temperature from $60^0$c to $40^0$c again, the thermophilic fungi start to decompose remaining part of organic matter. After this, the temperature again decreases further. The white colour fungi commonly appears on the waste that shows presence of mesophilic fungi.

During this fourth phase, the temperature comes down to amount 30-$40^0$c. In this stage, again mesophilic fungi start its action and degrade some amount of lignin. After this, i.e. in final stage of this composting process, the temperature remains constant. Table -7 shows organisms in compost.

Table 7 Organisms in compost

| Microflora / Microfauna | Organisms | Number/g of moist compost |
|---|---|---|
| | | |
| Microflora | Bacteria | $10^8$-$10^9$ |
| | Actinomycetes | $10^5$-$10^8$ |
| | Fungi, moulds and yeasts | $10^4$-$10^6$ |
| Microfauna | Protozoa | $10^4$-$10^5$ |
| Macroflora | Fungi (Mushrooms & Toadstools) | |
| Macrofauna | Mites, Ants, Termites, Spring tails, | |
| | Millipedes, Centipedes, Earthworms | |

Source: FAO Soil Bulletin (1987)56

## FACTORS INFLUENCING THE BIO COMPOSTING PROCESS

a) **Particle Size:** If particle is small, the space for the growth of microorganisms will be more which ultimately increases the microbial activity and fastened the composting process.

b) **Nutrients:** Any waste materials which do not contain heavy metals/toxic waste should be used. The list of nutrient value as in table-5 should be taken in account to increase the nutrition value of the waste. Preferably, the local waste with some available agro waste is always ideal.

c) **Moisture:** The total net weight moisture should be maintained 50-60% which is optimum for microbial growth. Hence, this percentage of moisture should be maintained throughout process which will increase the process of decomposition. If the moisture is below 50%, the microbial activity is less, which results slow down the composting process. If the moisture is above 60%, the anaerobic condition (clogging) will take place which also slows down the activity of microorganisms.

d) **Aeration and Agitation:**
For the growth and activity of microorganism, oxygen supply is most essential part. Any process to be adopted only to ensure the oxygen supply. The agitation, turning by any tools or by means of Aero tilling may be used.

## COMPOSTING PROCESS DESCRIPTION:

Biocomposting is a process for the rapid conversion of organic waste into a thoroughly decomposed, stable and humus rich compost for used as a fertilizer and soil conditioner. The process is aerobic and the technology highlights the following activities for large and commercial scale Bio-composting.

**Windrowing:** The waste materials should be chopped in small size and formed in windows of 3 meters width and 1.2 meters height, the length according to the availability of the land:

**Inoculation:** Mixed population of microorganisms are sprinkled over the windrows at the rate of 4kg/tone of waste materials. In case of liquid 2 litres/tone is enough as the population of fungus and bacteria is 100 times more than solid base inoculum.

**Aero tilling:** The windrow is aero tilled in alternative days by using special type of machine called "Aero tiller" or manual method. It helps for uniform mixing and provides oxygen to the microorganisms.

**Application of Spent wash:** To maintain the optimum moisture of 50-60% and to maintain temperature between 65-70$^0$c for high rate composting, the nutrient rich spent wash is sprayed on the windrows, if it is available. Otherwise, any wash like cow dung wash, vermiwash, kitchen wash, any animal wash etc. can be sprayed.

**COMPOSTING PROCEDURE**

A composting cycle takes 11 weeks to complete and involves the following activities.

**Ist week:**

1. Collection/Hauling of waste materials.
2. Formation of Windrows and Trimming.
3. Aero tilling-for uniform mixing of material and to bring down the moisture at optimum level.
4. Inoculation of microorganisms in windrows only high temperature tolerate fungus/bacteria should be used.

**2$^{nd}$ to 8$^{th}$ Week:**

Application of wash & Aero tilling

Monitoring moisture content and temperature of windrows (by any thermometer)

**9$^{th}$ to 11$^{th}$ week:**

After 11$^{th}$ week, the ready Biocompost is enriched with Biofertilizers .

**Enrichment of compost with Biofertilizers:**

N-fixing bacteria-Azotobacter, Azospirillum each 2 kg/tone if solid, 1 litre/tone if liquid.

P-solubilizing bacteria-*Bacillus polymixa* etc-4kg/ton if solid, 2 litres/ton,1 litre/tonne if liquid.

K-Mobilizing bacteria-*Fraturia aurantia* 4kg/ton if solid, 2 ltrs/ton if liqud.

**Enrichment of compost with Bio-Agents:**

Bio-Control agents like *Trichoderma viride, Pseudomonas Fluorescence* at the rate of 2kg/tone of each if solid, 500ml/tone if liquid form

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## OLD METHODS OF COMPOST PRODUCTION
## CHIMNEY AND WALL METHOD

For wall aeration technique two brick walls, 30 cm apart, 1 m high, 23 thick and having 40 holes of size 22 cm x 10 cm each are constructed in the centre of a 2 x 3 m pit. Chimney aeration is provided by constructing two one meter high chimneys, one metre apart on rectangular base of 23 cm. Each chimney has 40 holes of similar size as provided in wall aeration. Substrates are filled in layers with each layer consisting of three sublayers. In a trial carried out at Jabalpur, the sublayers were consisted of (1) overnight water soaked paddy straw 50 kg (air dry basis) (2) dung slurry (20 kg dung in 40 litres water) (3) mixture of 20 kg well pulverised soil, half kg urea and 1.5 kg urea and 1.5 kg rock phosphates (1.5 percent available phosphorus, 150 mesh passed) Total quantity of substrate in ten such layers in each pit was one tonne. After one month, the towers and chimney were sealed with dung and mud mixture. Chimney aeration yielded 60 percent recovery with nitrogen ranging form 1.10 to 1.70 percent. Further trials have shown that the biomass of obnoxious weed, *Parthenium histophorus* yields better quality compost than rice straw. However, before using the parthenium compost, it is to be ensured that the weed are not viable. Enrichment of compost with Nitrogen Phosphorus and Potassium can be achieved by *Azotobacter, Azospirillum* and phosphate solubilizing and potassium mobilizer Biofertilizers after the thermophilic phase is subsided at the rate of 2-4 kg each per tonne of substrate. The biofertilisers may be dissolved in 50 litres water and poured in holes previously made in compost piles. If biofertilisers are not available while composting is in progress, enrichment can be done by mixing biofertilisers with the harvested compost and heaping the treated compost in shed for at least two weeks. By doing so, increase in the population of *Azotobacter, Azospirillum* PSM,KMB has been noted. Inoculation of the substrates with celluloytic and lignolytic microorganisms like *Trichoderma harzianum*, *Aspergillus niger*, *Aterreus* etc. has been found to accelerate the decomposition during composting. Likewise, *Trichoderma harzianum* is the msot effective organism for making compost from rice straw.

**NADEP method**

NADEP method of compost making has been developed by a farmer, Narayan Rao Pandhari Pande, in Maharastra, India. This method is based on the principle of aerobic decomposition with natural flow of optimum air. The substrate is converted at the top by plastering with dung and soil to minimise the loss of moisture. To obtain 2-2.5 tonnes of compost with 0.6-1.0, 0.5-0.8 and 1.2-1.5 percent nitrogen, phosphorus and potash respectively, the required raw materials are 1.4 to 1.5 tonnes or organic refuse, 90-1000 kg of cattle dung, 1.7 to 1.8 tonnes of pulverised dry soil and 1500-2000 litres of water. These materials are filled layer by layer in a tank of 3 m x 2 m x 1 m size and made up bricks with holes (15-20 cm rectangular) on all four walls for easy entry and circulation of air. The tank is constructed above ground at high lying area to avoid entry of rainwater from surrounding place. Internal surface of tank is painted with dung slurry.

The tank is filled in layers. The first layer is made by spreading 100-110 kg of organic wastes on the floor of the tank. This is followed by a second layer containing a slurry of 4-5 kg cattle dung in 125-150 litres water. Over the second layer, 50-60 kg of pulverised good quality soil is spread. The three layer combination is repeated till the tank is filled upto 45-50 cm above the brick level. The complete filling is done within two days, using materials of 10-11 layers. Topping of the tank is done by 5 cm plastering with a paste of dung and soil. Cracks are not allowed to develop on the heap to prevent the gas leakage. After 15-20 days, when the substrate shrink down, a second filling is made in a way similar to that adopted in the beginning. The top is then arranged in a hut like shape and replastered. The moisture level of the mass is maintained at 15-20 percent by sprinkling with water and dung slurry through holes. Normally the substrate takes 3-4 months to attain maturity without turning. From one tank about 4.5 - 5.0 cubic metre mature compost 1.5 - 2.0 cubic metre undercomposed raw refuse, weighing about there tonnes are obtained. According to an estimate, from the annual collection of dung from one cow, 80 tonnes of compost can be prepared which contain 800 kg nitrogen, 560 kg phosphorus and 1000 kg potash (Bonbatkar, 1989).There are some limitations in using this method of composting like unavailability of dry soil during rainy seasons and water during summer. The ratio of organic refuse and soil is about 1:1. Soil is added to provide microorganisms for carrying out decomposition and nitrogen fixation. The compost harvested does not give dark brown colour, has a higher density and lower nutrient composition as compared to the product obtained from the chimney and tower aeration method.

**Padegaon method**

This method is recommended for composting resistant substrates like sugarcane trash and cotton stubbles. These materials are shredded into 30 cm size particles and trampled to make a 30 cm thick above ground layer. This layer is drenched with a slurry consisting of wood ash, cow-dung and soil. Four or five such layers are added to the pile. The completed heap is about 1.5 m high, 2m wide and as long as necessary. Since the material is very resistant to decay, the heap is turned each month, retrampled and sufficient water is added to keep it moist. The material is ready for use in about five months. The compost compares very well in composition with farm yard manure (Arakari et al., 1962).

**Indore method**

Sir Albert Howard (1924-26) at Indore, Madhya Pradesh, developed this method in which the conservation of cattle urine is effected by getting it absorbed in rice straw, straw dust and other organic wastes used as bedding in cattle shed. The urine soaked material along with fresh cow dung serves as major source of nitrogen for the microorganisms involved in composting. The material collected form cattle shed is spread evenly in a pit to form a layer of 10-15 cm thick. To this layer is added dung slurry made of 4.5 kg dung + 3.5 kg urine earth + 4.5 kgs inoculum from 15 day old compost pit. Water is then sprinkled to achieve 100 percent saturation. The layering is repeated to fill the pit within seven days. The material is turned three times, first two turnings in 15 days interval after filling the pit and third turning after one month of the first turning. To provide succulent biomass, seeds of sunhemp are grown on compost heaps and at the first turning, the green plants are turned in.During rainy season the piling of 20 cm carbonaceous material (leaves, hay, straw, saw dust, wood chips, corn stalks etc.) and 10 cm nitrogenous materials (fresh grass, weeds, digested sewage, sludge, poultry litter) in alternate layers is repeated until the pile is one metre high. The recommended size of the heap is 2.4 m square at the base and 2.1 m square at the top.The method is highly labour intensive and less suitable to those farmers who do not have enough cattle and irrigation facilities. The method being aerobic in nature, it hastens the maturity period and results in substantial loss of organic matter and nitrogen. Table 8 and 9 shows some bacteria ,fungi and actinomycetes capable of utilizing various components of organic matter.

Table - 8 : **Some Bacteria capable of utilizing various components of organic matter**

| **Substance** | **Bacteria** |
|---|---|
| | Achormobacter, Bacillus cellulomonas,cellvibrio,clostridium, cytophaga,pseudomonas,sporocytophaga, vibrio |
| Hemi- cytophaga, | Bacillus, achromobacter,cellulose pseudomonas, sporocytophaga,Lactobacillus, Vibrio. . |
| Starch | Achromobacter, Bacillus, Chromobacterium Clostridium,Cytophaga,Rhizopus Flavobacterium,Micrococcus, Pseudomonas,Sarcina, Serratia. |
| Hydro. carbons and Pesticides | Methanobacterium, Methanobacillus, Methanosarcina, Methanococcus, Pseudomonas |
| Proteins | Pseudomonas, Corynebacterium Mycobacterium, Bacillus, Vibrio |

Table – 9 **Some Fungi , Actinomycetes capable of utilising various components of organic matter**

| Substance | Fungi | Actinomycetes |
|---|---|---|
| Cellulose | Alternaria, Apergillus Fusarium Penicillium, polyporus, rhizoctonia, rhizopus, trichoderma | Micromonospora Nocardia, streptomyces, streptosporangium |
| Hemi-cellulose | Alternaria, fusarium, trichothecium, aspergillus corolus, rhizopus, Rhizopus, Zygorhynchus, Chaetomium, Helminthosprium Penicillium, FomesPolyporus. | Actinomycetes, streptomyces |
| Starch | Aspergillus, Fomes Fusarium, Polyporus | Micromonospora, Nocardia, |
| | Streptomyces | |
| Hydro. carbons and Pesticides | Streptomyces, -Nocardia. | |
| Proteins | Aspergillus | Nocardia, Streptomyces |

**Bangalore method**

In this method, the disadvantages of Indore method are overcome by slowing down the rate of decomposition and avoiding the turnings. The substrates usually composted in this method are town refuse and night soil which are spread in alternate layers of 15 cm and 5 cm in trenches or pits. When the pit is filled to 15 cm above the ground level, it is sealed to prevent loss of moisture. After the initial aerobic decomposition for 8 - 10 days the material undergoes semi anaerobic decomposition. During this stage the rate of decomposition slows down taking about 6 - 8 months for the compost to be ready. Often, the composting period is more than eight months due to high carbon : nitrogen ratio. Loss of organic matter and nitrogen is negligible and percentage recovery of compost is more. But, this method is not adaptable to heavy rainfall areas.

## FARM YARD MANURE (FYM)

FYM is partially composed dung, urine, bedding and straw. Dung comes mostly as undigested material and the urine from the digested material. More than 50 percent of the organic matter that is present in dung is in the form of complex products consists of lignin and protein which are resistant to further decomposition and therefore the nutrients present in dung are released very slowly. The nutrients from urine, becomes readily available. Dung contains about 50 per cent of the nitrogen, 15 per cent of potash and almost all of the phosphorus that is excreted by animals .Straw, saw dust or other bedding materials are used in cattle sheds to reduce the loss of urine and to increase the bulk of manure. On an average, about 3 - 5 kg bedding material per animal is used by farmers. FYM contains approximately 5 - 6 kg nitrogen, 1.2 - 2.0 kg phosphorus and 5 - 6 kg potash per tonne. The quantity and quality of FYM depend upon the type (draught, mulch) and age of the animals, the way they are feed and the care taken to collect and store the material. Though FYM is the most common organic manure in India, the farmer, in general, do not give adequate attention to the proper conservation and efficient use of the resource. For preparing better quality FYM, the use of pit method for areas with less than 1000 mm precipitation and heap method for other places is recommended. In the pit method, the cattle shed wastes are conserved in pits of 2 m wide, 1 m deep and of convenient length with a sloping bottom towards one end. In the pit an absorbent layer is created at the bottom by spreading straw at the rate of 3 - 5 kg per animal kept. The substrate containing well mixed dung, urine and straw is spread over the absorbent layer daily to form a layer of 30 cm thick and the process continued until the pit is filled. Each day's layer should be pressed, moistened if dry and covered with a 3 - 5 cm layer of well ground fertile soil to hasten the decomposition and to absorb the ammonia. The pit should be prepared on high lying area to avoid the entry of rain water. In the heap method, the daily collections from cattle shed are spread in uniform layers until the heap attains a maximum height of one meter above ground. The top of the heap is rounded and plastered with dung and mud mixture. In both the pit and heap methods aeration is allowed in the beginning and later on anaerobic conditions set in and continue for a long period. The manure is ready for use after 5 - 6 months. These methods should be initiated prior to rainy season and continued throughout the year. If properly preserved, the quantity of manure that can be produced per animal per year would be as much as four to five tonnes containing 0.5 per cent nitrogen. This is in contrast to one or two tonnes per animal per year containing 0.5 percent nitrogen, that is obtained by indigenous method. The materials should not contain any heavy metal.

## URBAN COMPOST, SEWAGE AND SLUDGE

Metropolitian areas are facing major problem in the disposal of large volumes of liquid and solid wastes generated by urban and industrial activities. In India the urban population of 240 million produces approximately 29 million tonnes of urban solid wastes (USW) annually (Jeewan Rao, 1992) and $10^{10}$ litres of liquid wastes per day. Broadly liquid wastes constituent sewage and sludge. Sewage is spent water consisting of water carried wastes from commercial and industrial areas and surface and ground water that enter the sewage system. The sewage and sludge are useful sources of water for irrigation and nutrients and the urban solid wastes can serve as nutrient source. The urban solid wastes presently available in India have the potential to supply 145, 70 thousand tonnes of nitrogen, phosphorus and potash (Jeevan Rao, 1992).

Urban composting methods are either-non-mechanical or mechanical. Mechanical composting (anaerobic) of city wastes is a natural process and in practice several months are required for the transformation of wastes into compost. The amount of heat generated in small and the required temperatures are not obtained for the destruction of pathogenic organism. For the reasons that anaerobic composting liberates bad odors, is of long duration and is incapable of destroying pathogenic organisms, it is not generally adopted.

## COMPOSTING OF URBAN REFUSE SEWAGE AND SLUDGE

Sewage effluent treatment is based on biological decomposition of organic matter present in it. Primary treatment includes removal of solid matter by physical means such as screening and sedimentation. It is possible to remove 30- 50 percent of the suspended solids. Secondary treatment is done through activated sludge process. In this process, the sewage is aerated either by diffusion or mechanical means and the aerobic microbial decomposition process is activated. The sludge is separated from the effluent in a settling tank after a suitable interval. An overall reduction of 85-95 percent of suspended solids and BOD and 90-98 percent reduction in bacterial are achieved through the use of this method combined with the primary treatment. The resultant effluent usually has been suspended solid content of 20 ppm which is well within the safe limit. Bureau of Indian Standards (BIS) has laid down tolerance limits for the effluents to be discharged on land for irrigation and the effluents to be discharged into public sewers.

## COMPOSTING SLUDGE

Sludge collected from sewage treatment process are composted with other organic materials for use as manure. While composting, most of the nitrogen in the sludge is assimilated by the organisms and toxic substances are diluted. Methods for composting de-watered sludge depend upon its moisture content. If the sludge contains less than 60 percent moisture, the use of organic absorbent to adjust the moisture content is not necessary. In fact air-dried lime sludge (55-60 percent moisture) and the mixture of de-watered sludge (70 percent moisture) and well composted sludge (30 percent moisture), whose moisture content does not exceed 55-60 percent are successfully stabilized under aerobic conditions for 7-10 days (Date, 1982). If the mixture of sludge and absorbent organic material containing less than 60% moisture the sludge can be stabilized without any difficulty. But, when slowly decomposing absorbents such as rice husk and saw dust are used the primary product must be stockpiled and matured for 1-2 months to accelerate decomposition of absorbents.

(Activated sludge decomposes relatively easily in soil, and thus most of the nitrogen is mineralized within one month. It has been estimated that one tonne of sewage sludge provides 46.9 kg nitrogen, phosphorus and potash but has the potential for heavy metal build up with continued application and resultant human health problems. Heavy metals like cadmium, lead, nickel, chromium etc. are generally not found in compost, FYM and city refuse in amounts that will be toxic to the soil, plants and mankind.

## COMPOSTING OF URGAN REFUSE

Before composting, non-organic and resistant materials like rags, plastics, glasses iron nails, tin, aluminum foils etc. are separated from the substrate. This is followed by shredding the organic components to particles of desired size (5 cm) and keeping the moisture level at 40 - 60 per cent. Aeration is promoted by turning the material during composting. Turning also facilitates the development of uniform temperature over the entire mass and subjects the material to high temperature.

The frequency of turning and the composting mass depends upon the type of refuse and moisture content. The schedule normally followed is : 1st day stacking and adding of moisture, 5th and 10th day turning and spraying of moisture, 15th day -- turning, and 20th day removal to process mill for screening. During rainy season frequency of turning is increased to promote aerobic condition in the piles. Fly control can be easily managed by not allowing the refuse to remain for long in the open but placed in stacks immediately for composting where the high temperature and environmental conditions are not favorable for the continued emergence and breeding of flees.

The carbon : nitrogen ratio of garbage available in India shows a range of 20 to 30 and it is possible to get stabilized compost in about 20 days (Jain 1980). Mechanical composting is aerobic which provides conditions for rapid conversion of organic wastes into compost. Non-mechanical method of composting is employed when volume of refuse to be handled is small. In this method readily computable materials, such as night soil, animal wastes, sewage – sludge and garbage and relatively resistant organic matter, such as straw, leaves and municipal refuse are piled in alternate layers on ground or in pits. The composting mass is turned regularly for 8 - 12 weeks and stirred on ground for a further period of 4 - 6 weeks. After about 5-8 turnings and a total period of four months, the compost is ready for use.

Table – 9 **Chemical characteristics of bio-gas slurry, sewage sludge, pressmud and city refuse**.

| Parameters | Biogas Slurry | Sewage sludge* | Pressmud | City** refuse |
|---|---|---|---|---|
| Total N.% | 1.40-1.84 | 1.08-2.34 | 1.1-1.19 | 0.58-0.61 |
| Total $P_2O_5$ % | 1.10-1.72 | 0.84-2.14 | 2.12-2.43 | 0.59-0.71 |
| Total $K_2O$ % | 0.84-1.34 | 0.53-1.73 | 1.98-2.03 | 0.67-0.73 |
| Organic carbon% | 35.00-38.40 | 19.50-31.80 | 23.50-26.70 | 12.79-16.04 |
| Zinc, mg/kg | 103.00-115.60 | 700.4-1245.70 | 237.50-285.40 | - |
| Copper mg/kg | 50.60-67.50 | 193.7-535.50 | 112.40-131.70 | - |
| Manganese mg/kg | 231-00-294.70 | 176.2-46520 | - | - |

Juwarkar et.all )1999)** Bhide (1975)*

**Vermi-Composting**

Vermiculture is the culturing of earthworms. Recent years, much interest in vermiculture has been paid by the large producers and farmers as earthworms play a major role in soil improvement, organic matter decomposition and in enhancing the quality of agricultural produce. Vermi-composting is applied for composting various non-toxic organic solids and liquid wastes available from cities, dairies, sugar and distillery units, pulp and paper mills, tanneries, fermentation industries and food processing units. Earthworms are used as biodegraders for composting such refuse, after the thermophilic activities have subsided. In vegetable and plantation crops where mulching with organic debris is a common practice, application of vermicastings at the rate of 5 tonnes/ ha as the first layer is recommended. Vermicastings consisting of excreta of earthworms and the cocoons released by them are rich in organic matter and plant nutrients. In the presence of vermicasts the declay of orgnic refuses and the formation of compost is accelerated. The process could be continued uninterruptedly by the addition of dung and other organic wastes at regular intervals to serve as food source for the earthworms.

## BENEFITS OF EARTHWORMS

Earthworms help in the preparation of compost and maintaining soil health as follows :

1. Improvement in fertility of soil.
2. Mixing of sub-soil and top soil.
3. Use of earthworms in recycling of city and rural wastes, sewage waste water and sludge, and industrial wastes, e.g. Paper, food and wood industries.
4. Amelioration of physical condition of soil.
5. Correction of undetermined deficiencies in plants.
6. Used in Unani system of medicine for treatment of certain diseases Supplementing traditional feeds.

## VERMICOMPOSTING PROCESS

It is a process of decomposition of organic matters into humic rich manure by the action of earthworms.

Partly degraded Cow dung, Sheep dung, Elephant dung, Pressmud, Cane trashes, City solid wastes, Poultry farm wastes and other domestic wastes are brought to Vermicomposting unit.

There, it is formed as windrows of 1-2 feet height.

The windrows are provided with Green house shade in order to prevent from sunlight.

Water is sprayed on the windrows by Drip irrigation or manual system to maintain the optimum moisture of 50-55%.

A special type of African Earthworm (*Udrillus ugenous*) is inoculated on the windrows.

It starts acting on the partly decomposed materials in the windrows to give humic rich Vermicastings.

This process takes place to complete in 60-90 days. The time period depends upon no. of worms/square meter. Simple 1gm of weight of worms collects 5gm of waste material per day.

After completion of the process, harvesting the Earthworms from Vermicastings and earthworms are then inoculated in new windrows or top materials can be harvested layer by layer as and when vermicastings appeared.

## ADVANTAGES OF VERMICOMPOSTING :

1. Organic wastes are broken down and fragmented rapidly through earthworms resulting in stable, non-toxic material of potentially high economic value, which is used as a soil conditioner / fertilizer in agricultural and horticultural practices.
2. As with the composting process, vermicomposting provides a reduction in waste bulk density.
3. As an aerobic process composting leads to Nitrogen mineralization. In vermicomposting, earthworms increase and accelerate Nitrogen mineralization rate. The humification process is greater and faster during vermicomposting.
4. A decrease in fulvic acid carbon and increase in the percentage of humic acid carbon are observed in vermicompost. The humic substances show an increase of 40-60%, which was higher than the value obtained through composting process.
5. Vermicomposting also brings down the availability of heavy metals compared to composting.
6. Vermicomposting has hormone like compounds (auxins), which accelerate plant growth.
7. Higher percentages of germination have been recorded with vermicompost than with compost.
8. Chemical analysis of vermicomposts and composts have shown slightly lower pH value for vermicompost and slightly higher nutrient concentrations, particularly of Nitrogen. It is also quite common for vermicomposts to have very low concentration of Ammonia-nitrogen and very high concentration of Nitrate-nitrogen, whereas the opposite is true for many types of compost. The nutritional value of vermin-compost depends upon the raw materials used for feeding.

## COMPOSTING OF INDUSTRIAL WASTE MATERIALS AND OTHER ORGANIC RESIDUES

### I) Phospho Compost

The phospho-compost is a valuable amendment which could be prepared by mixing farm wastes, cattle dung, soil, compost, chopped grasses, crop residues and plant leaves with mussoorie rock phosphate at the rate of 30 per cent of the compostable materials. This mixture is made into a slurry so as to provide adequate moisture and after uniform mixing with decomposer fungus/bacteria. The slurry is allowed to decompose in a compost pit for about 60 to 90 days. The moisture is maintained at 60 per cent throughout the period of composting and the compost will be ready for use in 60 - 90 days. Once the compost is ready, 4kg/tonne of solid, liquid 400 ml/tonne of Phosphate solubizling bacteria is added and allowed for 21 days for release of fixed phosphate. Phospho-compost has better performance than other sources of phosphorus and it can be also used as an effective organic amendment in problematic soils.

**ii)Potassic Compost**

Potassic compost is a valuable amendment to the soil which could be prepared by mixing rich farm wastes, cattle dung, sugar cane trash, soil, potassium rich ores, banana wastes etc. The waste materials first decomposed with the help of fungus/bacteria using 400ml liquid cultures/tonne of waste. The use of decomposer culture decompose the materials within 45 days. About 60% moisture is maintained throughout decomposition process. Once the material is decomposed, 200ml/tonne of waste material potash mobilizing bacteria is to be added and allowed for 20 days. The compost will be rich in potassium, and hormones required for plant growth. Potassic-Compost has better performance than other sources of potassium, as it is in organic form.

**iiI) Sugar Factory Wastes and Sugarcane Trash**

The major sugar factory wastes are pressmud, filter cakes bagase and molasses. Pressmud contains about 1.2 percent N, 3.82 per cent $P_2O_2$, 1.42 per cent $K_2O$ and 11.1 per cent CaO (Palaniappan and Natarajan, 1993) and is a good source of organic matter (4.4 to 35.8%). Because of high calcium content in the pressmud, it is used mainly to reclaim acidic soils substituting gypsum to some extent. There are two forms of pressmud: pressmud with carbonate process having $CaCO_3$ (66%) and organic matter (4.4%); presumed with sulphitation process having $CaSO_4$ (9.3%) and organic matter (35.8%). The amount equivalent to one kg of 100 percent pure gypsum will be 0.88 kg and 10.75 kg of carbonated and sulphated pressmud, respectivley and in terms of sulphur 4.0 and 57.8 kg, respectively (Singh and Dagar, 1993). Addition of pressmud improves soil aeration and drainage in heavy soils, whereas in sandy soils it helps in improving the retention of moisture. When added to sugarcane fields it increased the cane yield, improved the juice quality and enhanced the ammonifying power of the soils (Mariappan et. al., 1983). In a pot experiment, pomogranate (*Punica granatum*) and *Eucalyptus tereticornis* grown in highly alkali soil (pH 10.5) when amended with pressmud could perform very well. The sugarcane trash removed during cropping to prevent lodging of the canes and the dead leaves collected at the time of cane harvest are generally burnt in the field itself. The valuable nutrients are lost during the process. The trash may be converted into a very useful organic amendment by proper composting and adding mussoorie rock phosphate at the time of composting. As the pressmud itself is rich in Potash and Phosphorus, use of 400ml/tonne of composted material with Potash Mobilizing Bacteria (*Fraturia aurientia)* and Phosphate Solubilizing Bacteria increases the availability of $K_2O$ and $P_2O_5$ in the wastes. This may be used later like other organic amendments.

**iv ) Oil Cakes**

Many oil cakes such as the castor, neem, madhuca, karanja, linseed, rape seed and cotton seed which are non-edible oil cakes may serve as useful organic manure as these contain high amounts of plant nutrients. Most of the non-edible oil cakes are valued much for their alkaloid contents which inhibit the nitrification process in soils. Neem cake contains the alkaloids - nimbin and nimbicidine which effectively inhibit the nitrification process . Similarly, Karanjin (Pongamia pinnata) and (*Madhuca butyracea*) is a potent nitrification inhibitor equal in efficiency to nitropyrin inretarding the nitrification process of ammoniacal nitrogen and increasing the yield, nitrogen uptake and grain protein content of rice . Madhuca cake has been successfully used in coastal saline soils for cultivatiion of rice. soils. Neem cake contains the alkaloids - nimbin and nimbicidine which effectively inhibit the nitrification process . Similarly, Karanjin (*Pongamia pinnata*) and madhuca (*Madhuca butyracea*) is a potent nitrification inhibitor equal in efficiency to nitropyrin inretarding the nitrification process of ammonical nitrogen and increasing the yield, nitrogen uptake and grain protein content of rice.

**v) Fly ash**

Fly ash is a useful organic amendment. At many places acidic mined lands exhibit reduced biological activity. In some strip mine sites with pH ranging from 2.6 to 4.7, the pH was found to range between 5.0 and 7.5 after 10 years of treatment with fly ash and the credit of vegetation on these sites was rated fair to good. With the exception of N, fly ash is rich in $P_2O_5$, $K_2O$, Ca and Mg and also contains elements like B, Mo and Zn which are essential for plant growth and are available to the vegetation raised on soils treated with fly ash. Mixing of potash mobilizing bacteria and phosphorus solubilizing bacteria at the rate of 400ml/tonne increase the availability of $P_2O_5$ and $K_2$ O with in 20 days

**vi) Industrial effluents**

Effluents from sugar factory, fertilizer factory and paper industry are rich in plant nutrients and can be used after proper treatments. The sewage sludge has been found to be as effective in increasing the yield of crops as inorganic fertilizers and also of forest tree species such as Eucalyptus and Populous. But from the sewage and industrial effluents toxic substances and heavy metals are to be removed completely as otherwise they can cause health-problems when they reach in food chain. Use of proper decomposing microorganisms also reduces the heavy metals . After decomposition mixing of potash mobilizing bacteria and phosphorus solubilizing bacteria at the rate of 400ml/tonne increase the availability of $P_2O_5$ and $K_2$ O with in 20 days

### vii) Coir pith compost

The coir dust is a waste product of the coir industry and could be used as organic amendment. the coir waste accumulates in large quantities near the coir industrial units and it can be converted into valuable organic manure by proper composting with the aid of the mushroom fungus *Pleurotus sojorcaju*. The composting reduces the volume by 42 per cent besides narrowing the C : N ratio. Once the compost is matured add potash mobilizing bacteria and phosphorus solubilizing bacteria at the rate of 400ml/tonne increase the availability of $P_2O_5$ and $K_2$ O with in 20 days.It has been found to be a good amendment for sodic soils and a moisture conserving material for rainfed crops . The use of coir pith without composting is, however, not advisable. In the fresh form it contains 8 - 12 per cent soluble tannin - related phenolics which can inhibit microbial activity in the soil and cause immobilisation of nitrogen. Table 10 shows Composition of raw and composed coir pith

Table 10 Composition of raw and composed coir pith

| Properties | Raw Coirpith | Composed coirpith |
|---|---|---|
| Lignin(%) | 30.00 | 4.80 |
| Cellulose(%) | 26.52 | 10.10 |
| Organic carbon(%) | 29.00 | 24.90 |
| N(%) | 0.26 | 1.06 |
| $P_2O_5$(%) | 0.01 | 0.06 |
| $K_2O$ (%) | 0.78 | 1.20 |
| Ca (%) | 0.40 | 0.50 |
| Mg (%) | 0.36 | 0.48 |
| Fe (%) | 0.07 | 0.09 |
| Mn (ppm) | 12.50 | 25.00 |
| Zn (ppm) | 7.50 | 15.80 |
| Cu (ppm) | 3.10 | 6.20 |
| C:N ratio | 112:1 | 24:1 |

### viii) Saw Dust

It is possible to use waste products from timber industry as organic matter. Inoculation with cellulolytic strains of *Bacillus sp.*, *Cephalosporium sp.* and

*Streptomyces sp*. has been reported to increase the decomposition of saw dust and bark . Mixing of potash mobilizing bacteria and phosphorus solubilizing bacteria at the rate of 400ml/tonne increase the availability of $P_2O_5$ and $K_2O$ with in 20 days

The following criteria for judging a good quality compost may be as follows :

1. Dark brown to black.
2. Crumbly structure not packed or lumpy.
3. Largely insoluble in water.
4. C:N ratio from 10 to 20.
5. Dissolves to a large extent in dilute alkali.
6. Beneficial effect upon soil and growing vegetation.
7. Pleasant earthy smell.
8. Will not attract flies.

**ix) Poultry Waste Compost**

Poultry waste comprises waste feed, solid and liquid dropping, litter, eggshell, diseased and dead birds, culled birds, feathers and the wastes from poultry sheds. Poultry waste management is highly complex and challenging because of associated problems like nitrate and heavy metal contamination in soil, crops, surface and ground water, air quality and odor; disposal of dead and diseased poultry and food safety. Poultry manure is good source of nutrients, particularly manure is good source of nutrients, particularly for vegetable. The decomposition of the waste must be done with the use of fungus/bacteria. Once the decomposition is completed, KMB, PSM and Paceli-T.V. in liquid 100ml/tonne suppresses the disease causing pathogens. Table 11 shows nutrient status in poultry waste

**Table - 11 Plant nutrient status in poultry waste[a]**

| Source | Percent | | | |
|---|---|---|---|---|
| | **Nitrogen** | **Ammonia** | **Phosphorus** | **Potassium** |
| Fresh chicken manure | 3.7-8.8 | 0.4.1.1 | 1.2-2. | 1.2-2.7 |
| Poultry litter manure | 1.4-6.8 | 0.5-1.1 | 0.5-3.51. | 1-2.7 |
| Broilier litter[b] | 2.3-6.0 | - | 0.6-3.9 | 0.7-5.2 |

a. Adapted from Sims and Wolf (1994)

b. Broiler litter also contains 23-125 boron, 25-1003 copper, 125-667 manganese and 106-669 zinc in parts per million.

## Biogas slurry applications:

**Biogas slurry is a good source organic manure**

The following are the different methods of applying biodigested slurry as manure:

a) Air dried biogas slurry can be applied by spreading on the agricultural land at least one week before sowing the seeds or transplanting the seedlings.

b) The liquid slurry can be mixed directly with the running water in irrigation canal which will enable spreading of the slurry uniformly in the cropped area or in cultivation land

c) Biogas slurry can also be coated on the seeds prior to sowing. This acts as insecticide and prevents seeds or plants from insect attack. This helps in early germination and healthy growth of seedlings.

d) The digested slurry is fed through the channel, flowing over a layer of green or dry leaves and filtered in the bed. The water from the slurry filters down which can be reused for preparing another fresh dung slurry. The semi-solid slurry can be transported easily as it was in the consistency of fresh dung and used for top dressing of crops like sugarcane and potato.

e) Biodigested slurry is also being used to fish culture, which acts as a supplementary feed. On an average, 15-25 litre of wet slurry can be applied per day in a 1200 sq pond. Slurry mixed with oil cake or rice-bran in the 2-1 ratio increases the fish production remarkably. In general, organic manures about

10t/ha in the form of FYM or compost or biodigested slurry is recommended to be applied once in three years to maintain the organic content of soil, besides providing nitrogen, phosphorus and potassium in the form of organic fertilizers to the crop.

f) The digested slurry, if mixed with Azospirillum, KMB and PSM @ 200ml each/acre ensures increase of yield minimum 30% over slurry alone. Table 12 Nutrient content in biogas slurry and FYM

Table 12 Nutrient content in biogas slurry and FYM

| Particulars | Nutrient content | | | | | | |
|---|---|---|---|---|---|---|---|
| | Major element (per cent) | | | | Trace element (ppm) | | |
| | N | P | K | Fe | Mn | Zn | Cu |
| Biogas slurry | 1.43 | 1.21 | 1.01 | 4200 | 550 | 150 | 52 |
| Farm Yard manure | 0.94 | 0.56 | 0.72 | 4000 | 490 | 100 | 45 |

## Leaf Compost

Leaf composting, can be achieved by heap or ditch composting or by windrow composting. Windrow are preferred as they allow efficient handling of materials. Provide good aeration, allow sufficient absorption of water and are easy to be formed.

Formation of uniform-shaped windrow from 2.40m – 3.60 m at the base and 2.40m-3.00m high and of any convenient length. Windrow built too high will have excessive compaction at the base resulting in anaerobic conditions. Windrows built too low will not allow sufficient insulation to sustain thermophilic temperature during cold weather. To ensure proper aeration, it is important to break apart tightly compacted leaves.

Though reduction in size may aid in rapid decomposition, it is not desirable in leaves because it increases the compaction making more frequent aeration necessary. When the incoming leaves are not adequately moist, it is desirable to add water to maintain a proper moisture regime of 40 to 60%.

The C:N ratio of leaves is relatively high. It can be as high as 80, and needs to be amended with nitrogen. Sewage sludge, green manure and grass clippings are good sources of nitrogen. Proper aeration can be maintained by periodical mixing of the material.

Under optimum environmental composting conditions, leaf compost will be ready between 180 and 270 days. Leaf mould will have $p^H$ range of 6-7.

Further the use of finished compost (leaf mould) as covering material (10-15 cm) in the subsequent preparation of leaf compost to supply a heavy inoculum of micro-organisms.

## USE OF BIOFERTILISERS IN COMPOSTING

Biofertilisers are microbial preparations which on application to soil help in augmenting agricultural production. Preparations containing cellulose decomposing, phosphate solubilizing, potash mobilizing and nitrogen fixing microorganisms come under biofertiliser. *Azotobacter*, a nitrogen fixer, and phosphate solubilising microorganisim, *Fraturia ausintia*, a potash mobilizing microorganism, *Aspergillus awamori* and *Bacillus polymyxa* are heterotrophs. Inoculation of compost, one month after starting the process, when thermophilic activities have subsided at around 30 - $38^{O}$C, with *Azotobacter* and phosphate solubilising and potash mobilizing bacteria biofertilisers in rice straw + rock phosphate (3% of substrate) improves the nitrogen content and phosphorus and potash availability of the mature compost.

### BIODYNAMIC PREPARATIONS

The (biodynamic - energy) means working with the energies which create and maintain the life. Biodynamic is not bio-organic because biodynamic preparation do not contain plants nutrients and are required in every small quantities after energising and many fold dilutions. There are eight known biodynamic preparations, namely biodynamic preparation 500 (Cow-horn manure), 501 (Horn silica), 502 (Yarrow), 503 (Chamobile), 504 (Stinging nettle), 505 (Oak bark), 506 (Dandelion), and 507 (Valerian). These preparations are easy to formulate and can be done by farmers at their own farms. The detail of the preparation were described by Menon (1993) and Proctgor (1991). These preparations were made and applied at the College of Agriculture, Indore, Madhya Pradesh, under the technical instructions of Proctor, a Biodynamic Field adviser from Newzealand.

**To increase Humus in soil :-**
**(Cow-horn manure)**

| Ingredients | Amount | Methods | Results/Effects |
|---|---|---|---|
| 1. Dung from lactating cows<br>2. Horns of the cows | Sufficient cow-dung to pack the cow horns (about 500gms in one horn) in Autumn (Sept.-Oct) | Six months fermentation in the soil (during ascending moon days in autumn (sept. –Oct) leaving to accumulation of fecal bacteria and humus forming bacteria. The property of this dung is similar to that of earth-worm castings. It should be dug out during descending moon days in Spring i.e., April-May. | Increase in $NO_3$ – N contents (from 0.06% to 1.7%) in the soil. Promotion of humus forming process and better root growth. An increase of 75% in $O_2$ absorption. Bacterial count 500 million/gm of farm soil or pasture. More active root system resulting in promotion in vegetative growth. |

**Applications:-**

After dilution in water, it is sprayed directly on land during autumn(March-April-May and early spring September-early October) concentration 30-35 gms in 12 litres of boiled cool water and stirred for one hour in the evening before sowing or transplanting.Mixing of PSM, KMB, *Azotobacter, Azosprillium* and *Bacillus subtilis* 100 ml each in solution ensures better yields in all crops.

**To increase photosynthesis:-**
**(horn silica)**

| | | | |
|---|---|---|---|
| Finely powdered silica (quartz) | Silica powder in one horn 500-600g | Treated for 6 months in cow horns in the soil and used as foliar spray. The horn is buried on full moon day or | Growth of stem and leaf as well as assimilation process stimulated. Increase in assimilation effect in leaves up to 3.5 times. In the powdered rock silica aerobic bacteria count increases |

| | | | |
|---|---|---|---|
| | | descending moon. | from 0 to 40 million per gram. Photosynthesis enhanced, resulting in good yield. Improvement In nutrient quality of fruits and grains. After spray the plants response to atmospheric environmental factors like air, light, temperature etc. increases. |

**Applications:-**

After dilution in water, it is sprayed directly on acres land during early spring October,concentration 30-35 gms in 12 litres of boiled cool water and stirred for one hour in the evening before sowing or transplanting.Mixing of PSM,KMB, *Azotobacter ,Azosprillium* and *Bacillus subtilis* 100 ml each in solution ensures better yields in all leafy crops like tea, cabbage, spinach etc..

**To increase metabolic activity in soil (Preparation 502):-**

| | | | |
|---|---|---|---|
| 1. Yarrow blossoms (Archillea milefolium) 2. Male Deer (stag) bladder | 1 kg blossoms in 1 bladder | The blossoms are fermented together with deer bladder for 6 months in soil during winter. Before that, it is hanged from a tree for 5-6 months for absorbing energy from the sky. | Use of sulphur potassium by the plant (for their growth) stimulated resulting building up of proteins and carbohydrates is also a ‘biocatalyst. This has 9-10 millions aerobic bacteria. |

**Applications:-**

After dilution in water, it is sprayed directly in one acre land during concentration 30-35 gms in 12 litres of boiled cool water and stirred for one hour in the evening before sowing or transplanting.Mixing of PSM,KMB, *Azotobacter ,Azosprillium* and *Bacillus subtilis* 100 ml each in solution ensures better yields in all crops.

**Soil Conditions**
**Preparation 503**

| | | | |
|---|---|---|---|
| 1. Chamomile blossoms (Matricaria recutita) 2.Small intestines of cows 3. Good soil humus (for enriching soil building bacteria) | Blossoms in one intestine 500-600 gms | Both are fermented together inside the soil in winter | Increase in aerobic bacterial count to the extent of million no anaerobic growth. Increase in microbial population in the soil improves soil physical and chemical conditions. The net results may be observed after continuous use of preparation upto 4 years. |

**Applications:-**

After dilution in water, it is sprayed directly in one acre land during concentration 40-50 gms in 12 litres of boiled cool water and stirred for one hour in the evening before sowing or transplanting.Mixing of PSM,KMB, *Azotobacter ,Azosprillium* and *Bacillus subtilis* 100 ml each in solution ensures better yields in all crops.

**To increase N-Fixing bacteria activity:-**
**(Preparation 504)**

| | | | |
|---|---|---|---|
| 1. Stinging nettle (Urtica dioica) leaves & stems | In one place 1-2 kg | Buried about 2 feet deep in soil humus separated from soil by a thin layer of peat moss | Stinging nettle is rich in vitamins and iron. Its humus is enriched (about 100 times) molybdenum and vanadium which are trace elementary necessary for the activity of nitrogen fixing bacteria. The bacterial count around Fifty million one billion aerobic 470 million anaerobic per gram. |

**Applications:-**

After dilution in water, it is sprayed directly in one acre concentration 50 gms in 12 litres of boiled cool water and stirred for one hour in the evening before sowing or transplanting.Mixing of PSM,KMB, *Azotobacter ,Azosprillium* and *Bacillus subtilis* 100 ml each in solution ensures better yields in all crops.

**Disease resistance and NPK-enricher to soil ;-**
**Preparation 505**

| | | | |
|---|---|---|---|
| 1. Oak bark (Quercus robur or Quercus alba from not too old tree) | 500-600g in one skull | Buried together resulting in dark blackish brown humus of a fine structure | Highest calcium ash content in oak trees growing even in sandy Ca deficient soil. Ca content is very high (more than 10%) of which 0.1% is readily available. K content 0.13%, $PO_4$ content 0.03% in available |

| | | | |
|---|---|---|---|
| 2. Skull of cows | | | fraction. Bacterial count two billion aerobic and 70 million anaerobic. It develops disease resistance in plants. |

**Applications:-**

After dilution in water, it is sprayed directly in one acre land during concentration 50 gms in 12 litres of boiled cool water and stirred for one hour in the evening before sowing or transplanting.Mixing of PSM,KMB, *Azotobacter ,Azosprillium* and *Bacillus subtilis* 100 ml each in solution ensures better yields in all crops.

**Preparation 506**

| | | | |
|---|---|---|---|
| 1. Dandelion (Taraxacum officianale) | 500-600 gm blossoms in one mesentery | Pack the blossoms in mesentery, tie it and bury it soil below 2' deep. | This has Ca, Mg, $NO_3$-N, $PO_4$and $So_4$ Bacterial count 360 million (aerobic) + a spreading species and 180 million anaerobic/gram of soil. |

**Applications:-**

After dilution in water, it is sprayed directly in one acre land during concentration 50 gms in 12 litres of boiled cool water and stirred for one hour in the evening before sowing or transplanting.Mixing of PSM,KMB, *Azotobacter ,Azosprillium* and *Bacillus subtilis* 100 ml each in solution ensures better yields in all crops.

**Compost enricher:-**

**Preparation 507**

| | | | |
|---|---|---|---|
| Pressed out cold extract from Valeriana flowers which is used for spastic nervous condition | 1-2 kg Valeriana blossoms | In high dilution (5-10 drops/10 lit. of water) as spray over the base and cover of manure and compost heaps | Attracts earthworms and stimulates their propagation. This has one million aerobic bacteria.<br>Juice Composition<br><br>K-0.335%<br>Ca-0.425%<br>Mg-0.005%<br>$NO_3$-N O.145%<br>$NH_4$-N showed an<br>Increase from 0.02%<br>to 0.6%<br>$PO_4$-0.06%<br>Mn-Trace |

**Applications:-**

After dilution in water, it is sprayed directly in one acres land during Winter,concentration 30-35 gms in 12 litres of boiled cool water and stirred for one hour in the evening before sowing or transplanting.Mixing of PSM,KMB, *Azotobacter ,Azosprillium* and *Bacillus subtilis* 100 ml each in solution ensures better yields in all crops.

**Preparation 508**

| | | | |
|---|---|---|---|
| ried herb of Equisetum arvenae (Horse tail) | 2-3 kg herb | Mix it in 100 litres of water and keep for 1-2 months and then spray | Mineralcontents<br>Silicon 10%<br>K 1.15%<br>Ca 0.42%<br>Mg 0.01%<br>$No_3$-N 0.47%<br>$NH_3$ –N Trace<br>$PO_4$ 0.06%<br>$SO_4$ 0.36%<br>Aerobic bacterial count 21000/g; No anaerobic bacteia |

**Applications:-**

After dilution in water, it is sprayed directly in one acre land during Winter,concentration 30-35 gms in 12 litres of boiled cool water and stirred for one hour in the evening before sowing or transplanting. Mixing of PSM,KMB, *Azotobacter ,Azosprillium* and *Bacillus subtilis* 100 ml each in solution ensures better yields in all crops.

**Biodynamic with Carriers:-**

Different carriers can be used for commercialization and preservation of different bio-dynamics for longer shelf life. It was observed that, different products of biodynamic are available in the market of our own country as well as some imported products. The carrier used talcum powder, Kelvin powder, china clay etc. as a carrier after mixing 15-20% of the preparation, which can be kept for minimum 6 months. Otherwise, the preparation have to be used quickly to avoid deterioration of the product. For the preservation of the fresh product, the container has to be kept in cool place away from direct sunlight at $20^0$c temperature. Some products are available in the market on the name of Energy, bacterial preparation, etc. It is nothing but only bio-dynamic preparation.

**Table 13 shows the status of Organic Manure and Soil Conditions in Organic Farming**

Table - 13 **Status of Organic Manures and Soil Conditioners in Organic Farming**

| **Sl. No** | **Substances description, Compositional requirements** | **Conditions for use** |
|---|---|---|
| **I** | **Plant & Animal Origin** | |
| 1 | Farmyard manure, slurry and urine | Permitted |
| 2 | Vermicastings/Vermicmpost | Permitted |
| 3 | Blood meal, meat meal, bone, bone meal | Permitted |
| 4 | Hoof, and horn meal, feather meal, fish and fish products, wool, fur, hair, dairy products | Permitted |
| 5 | Biogradable processing by products, plant or animal origin e.g. by product of food, feed, oilseed, brewery, distillery or textile processing | Permitted |

| | | |
|---|---|---|
| 6 | Crop and vegetable residues, mulch, green manure, straw | Permitted |
| 7 | Wood, bark, sawdust, wood shavings, woo dash, wood charcoal | Permitted |
| 8 | Seaweed and seaweed products | Permitted |
| 9 | Plant preparations extracts | Permitted |
| 10 | Urban composts from separate sources which are monitored for contamination | Permitted |
| **II** | **Mineral Origin** | |
| 1 | Basic slag | Permitted |
| 2 | Soil amendments like lime, limestone, gypsum, Calcarious and magnesium soil amendments. | Permitted |
| 3 | Magnesium rock, kieserite and Epson salt (magnesium sulphate) | Permitted |
| 4 | Naturally occurring potassium minerals | Shall be obtained by physical procedures but not enriched by chemical process. |
| 5 | Natural phosphates (like rock phosphate) | Permitted |
| 6 | Trace element | Permitted |
| 7 | Sulphur | Permitted |
| **III** | **Microbiological** | |
| 1 | Biodegradable processing by-products of microbial origin, e.g. by-products of brewery or distillery processing, microbiological preparations based on naturally occurring organisms – Biofertilizers | Permitted |
| **IV** | **Others** | |
| 1 | Biodynamic preparations | Permitted |

**BENEFITS OF ORGANIC FARMING**

i.It helps in maintaining environment health by reducing the level of pollution

ii.It also reduces human and animal hazards by reducing the level of residue in the product .
iii.It helps in keeping agricultural production at a higher level and makes it sustainable.
iv.It reduces the cost of agricultural production and also improves the soil health; sustainable.
iv.It reduces the cost of agricultural production and also improves the soil health.
v.It ensures optimum utilization of natural resources for short-term benefit and helps in conserving them for future generation.
vi.It not only saves energy for both animal and machine, but also reduces risk of crop failure.

Besides these, it has been demonstrated extensively that plant products produced from organic farming are substantially better in quality like, bigger in size, look, flavor and aroma. Even animal products like milk, meat etc. have been observed to be of better quality when they are fed with feed and fodder produced organically. The underground water of the area where such farming systems in practice has been found to be free of toxic chemicals.

## STANDARDS FOR INPUTS TO BE USED IN ORGANIC AGRICULTURE

Organic Agriculture uses a lot of inputs, which are basically organic in nature and are expected to be produced on the farm where the farming is being done. There is a wide variation in the quality of inputs that are currently used in organic farms. It is therefore important and necessary that efforts should be taken up develop standards for these inputs. An initial effort is being made here to do the same.

### Compost

Compost is the most important input in organic agriculture. Various compost – making techniques are available and different practices are in vogue.

Definition : "A solid mature product resulting from composting, which is managed process of bio-oxidation of a solid heterogeneous organic substrate including a thermophilic phase."

There are three criteria applicable as standards as standards for correct compost :

#### a. Maturity

Several indicators are available to determine compost maturity.  Presently the indicators tobe applied are :

1. Compost must be cured for at least 15 days.
2. Compost will not reheat after the composting process to greater than $20^0$C above ambient temperature.

**b. Trace elements**

Trace elements are defined as a chemical element present in compost at a very low concentration. The compost standards identify trace elements that are essential to plant growth in addition to identifying heavy metals which depending on their concentration in the soil could be harmful to human health and the environment.

**c. Pathogens**

Pathogenic organisms are sometimes present in the feed stocks used make compost. As result the compost may also contain pathogens. To reduce any potential health concerns, treatment processes as well as biological specifications have been identified. All the pathogens generally present in the compost feed stock get de-activated at a temperature f around 55 C. Hence it is recommended that :

i) Using universal composting method, the solid waste shall be maintained at operating conditions at $55^0$C or higher for three days.

ii) Using WINDROW composting method, the solid waste attain a temperature of $55^0$C or higher for atleast 15 days during the composting period. Also during the high temperature period the WINDROW shall be turned at least five times.

iii) Using an aerated static pile composting method, the solid waste shall be maintained at operating conditions of $55^0$C or higher temperature for three days. The preferable practice is to cover the pile with an insulating layer of material such as cured compost or wood chips to ensure that all areas of feed material are exposed to the required temperature.

While organic farming envisages the production of required inputs in the farm itself, there will be instances particularly during in-conversion period when organic inputs from other farms are obtained.

If these inputs are obtained from other organic farms then the above standards will apply.

**Farm Yard Manure**

Farmyard manure can be used directly in its natural form without any restrictions. There should be no contamination. The composting pits should be free from inorganic material, which is not generic to the manure like plastics, metals and dry cells. Care should be taken to avoid any contamination from heavy metals and plastics. Source of heavy metals is from municipal wastes, industrial wastes or from sub soils.

For example, Arsenic contamination can occur from the sub-soil water where there is excessive ground water withdrawal. Periodic checks have to be done to ascertain the presence of contaminants through water sampling.

**Poultry Manure**

High nitrogen content in the poultry manure gives rise to the problem of nitrate leaching and contamination of ground water which in turn effects sources of drinking water with subsequent impact on the health of human beings particularly children.

It is difficult to prescribe any uniform standard but care has to be taken to spread poultry manure thinly on the soil instead of dumping in a heap. Since soil condition also varies widely it is difficult to prescribe any limit.

**Poultry manure when composted**

In view of what has been mentioned above it is suggested that poultry manure should be used through compost rather than directly.

**Green Manure and Green Leaf Manure**

These are generally used directly on the soil. Care should be taken whenever the green leaves or branches are cut from the roadside trees, which attract the fuel residues like lead. It is suggested that the green leaves and branches are given a water wash before they are put on the soil or in the compost pit.

**Crop Residue**

While they are good source of manure and needed for soil building, there is a danger of contamination from bacteria and heavy metals. It is therefore suggested that crop residue should be used only after composting which will deactivate the bacteria like Salmonella and / or Aflatoxin. In cases where composting cannot be done, crop residues should be washed with water and then dried before they are used.

**Kitchen Waste**

This is very extensively used in organic farms. Kitchen waste may not be of organic origin. Hence, they should be used only when it is properly compensated.

**Plantation By-products and Wastes**

There is no restriction in using the by-products of existing organic plantation farms.  Restrictions put when the plantation is under conversion. The plantation waste in that case should be used only after composting.

**Oil Cakes**

Traditionally, oil cakes have been used as manures in cultivation. Unfortunately, presently all the oil cakes available are from the solvent extraction plants. These are known as deoiled cakes, which always have the petroleum residue of about 0.2 percent. These cakes come inflake/chip. The residual petroleum gets reduced substantially if the cakes are powdered. It is therefore suggested that oil cakes should be allowed to be used only in powder form. It is also advisable to sprinkle water on these cakes while they are used.