# 13. COMPOSTING AND INDUSTRIAL WASTE WATER UTILIZATION

## I. CROP RESIDUE COMPOSTING

Crop residues are the plant parts that are left in the field after harvest. The harvest refuses include straws, stubble, stover and haulms of different crops. Crop remains are also from thrashing sheds or that are discarded during crop processing. This includes process wastes like groundnut shell, oil cakes, rice husks and cobs of maize, sorghum and cumbu. The greatest potential as a biomass resource appears to be from the field residues of sorghum, maize, soybean, cotton, sugarcane etc. In Tamil Nadu 190 lakh tonnes of crop residues are available for use. These residues will contribute 1.0 lakh tonnes of nitrogen, 0.5 lakh tonnes of phosphorus and 2.0 lakh tonnes of potassium. However tonnes residues need composting before being used as manure.

**Waste collection**

Crop residues accumulated in different locations are to be brought to compost yard. The compost yard should be located in anyone corner of the farm with accessibility via good road. Water resource should also be available in sufficient quantity. The crop residues that are brought to compost yard should be heaped in one corner for further processing.

**Shredding of waste materials**

Particle size is one of the factor that influence the composting. It is advisable to shred all the crop residues that are used for composting. Shredding the waste manually is labour intensive. Shredder machine can be employed to shred all the crop residue biomass. Particle size of 5 cm is recommended for quick composting.

**Mixing of green waste and brown waste**

Carbon and nitrogen ratio decides the initiation of composting process. If C:N ratio is wide (100:1) composting will not take place. Narrow C:N ratio of 30:1 is ideal for composting. To get a narrow C:N ratio, carbon and nitrogen rich material should be mixed together. Green coloured waste materials like glyricidia leaves, parthenium, freshly harvested weeds, sesbania leaves are rich in nitrogen, whereas brown coloured waste material like straw, coir dust, dried leaves and dried grasses are rich in carbon. In any composting process these carbon and nitrogen rich material is to be mixed together to make the composting quicker rather than putting green waste alone or brown colour waste alone for composting. Animal dung is also a good source of nitrogen. While making heap formation, alternative layers of carbon rich material, animal dung and nitrogen rich material are to be heaped to get a quicker result in composting.

**Compost heap formation**

Minimum 4 feet height should be maintained for composting. The composting area should be elevated one and have sufficient shade. While heap formation, all the crop residues should be mixed together to form a heterogeneous material rather than a single homogenous material. Alternate layers of carbon and nitrogen rich material with intermittent layers of animal dung are essential. After heap formation the material should be thoroughly moistened.

**Bio-inputs for composting**

TNAU Biomineralizer consortium contains groups of microorganisms, which accelerate the composting process. If this inoculum is not added to the composting material, natural microorganisms establish on the waste material on its own and do the composting work. This process takes longtime. But if external source of inoculum is added, the microbial activity starts earlier and composting period will be reduced.

For one tonne of crop wastes 2 kg of TNAU Biomineralizer is recommended. This two kg Biomineralizer should be mixed with 20 liters of water and made slurry. When the compost heap is formed in between layers the slurry should be inoculated, so that it mixes with the waste material thoroughly for uniform coating of microorganism on the waste material. Cow dung slurry is also a good source for microbial inoculum. But it carries unwanted microorganisms also which may compete with composting organism. But when TNAU Biomineralizer is not available, cow dung slurry is a good source material. For one tonne of crop residues 40 kg fresh cow dung is required. This 40 kg fresh cow dung is mixed with 100 litres of water and it should be thoroughly poured over the waste material. Cow dung slurry acts as nitrogen source as well as source of microbial inoculum.

**Aerating the compost material**

Sufficient quantity of oxygen should be available inside the compost heap. For this external air should be freely get in and comes out of the material. Normally to allow the fresh air to get inside, the compost heap should be turned upside down, once in fifteen days. In this process top layer comes to bottom and bottom layer goes to top. This process also activates the microbial process and compost process is hastened. In some cases air ventilating pipe maybe inserted vertically and horizontally, to allow the air to pass through. The wood chip that is available as waste in wood processing industry may also be used as bulking agent in the composting process. This bulking agent gives more air space to the compost material.

**Moisture maintenance**

Throughout the composting period 60% moisture should be maintained. On any situation, compost material should not be allowed to dry. If the material becomes dry, all the microorganisms present in the crop residues will die and the compost process gets affected.

**Compost maturity**

Volume reduction, black colour, earthy odour, reduction in particle size are all the physical factors to be observed for compost maturity. After satisfying with the compost maturity index, the compost heap can be disturbed and spread on the floor for curing.

After curing for one day, the composted material is sieved through 4 mm sieve to get uniform composted material. The residues collected after composting has to be again composted to finish the composting process.

**Compost enrichment**

The harvested compost should be heaped in a shade, preferably on a hard floor. The beneficial microorganisms like *Azotobact*or, *Azospirillum, Pseudomonas, Phosphobacteria* (0.2%) and rock phosphate (2%) have to be inoculated for one ton of compost. Forty per cent moisture should be maintained for the maximum growth of inoculated microorganism. This incubation should be allowed for 20 days for the organism to reach the maximum population. Now the compost is called as enriched compost. The advantage of enriched compost overnormal compost is the quality manure with higher nutrient status with high number of beneficial microorganisms and plant growth promoting substances.

**Nutritive value of Biocompost**

The nutritive value of biocompost varies from lot to lot because of varying input materials. But in general biocompost contains all the macro and micro nutrients required for crops, which is given in the following table. Even though the quantity available is low it covers all the requirements of the crop.

**Nutrient content of biocompost prepared from different wastes**

| Biocompost | Nutrient content (%) | | |
|---|---|---|---|
| | **Nitrogen** | **Phosphorous** | **Potash** |
| **Animal refuse** | | | |
| Cattle dung | 0.3 - 0.4 | 0.1 – 0.2 | 0.1 – 0.3 |
| Horse dung | 0.4 – 0.5 | 0.3 – 0.4 | 0.3 – 0.4 |
| Sheep dung | 0.5 – 0.7 | 0.4 – 0.6 | 0.3 - 0.1 |
| Night soil | 1.0 – 1.6 | 0.8 – 1.2 | 0.2 – 0.6 |
| Poultry manure | 1.8 – 2.2 | 1.4 – 1.8 | 0.8 – 0.9 |
| Sewage sludge | 2.0 – 3.5 | --- | --- |
| Cattle urine | 0.9 – 1.2 | Trace | 0.5 – 1.0 |
| Horse urine | 1.2 – 1.5 | Trace | 1.3 – 1.5 |
| Sheep urine | 1.5 – 1.7 | 0.1 – 0.2 | 0.1 – 0.3 |
| **Wood Ash** | | | |
| Ash coal | 0.73 | 0.45 | 0.53 |
| Ash wood | 0.1 – 0.2 | 0.8 – 5.9 | 1.5 – 36.00 |
| Habitation waste & factory waste | | | |
| Rural compost | 0.5 – 1.0 | 0.4 – 0.8 | 0.8 – 1.2 |
| Urban compost | 0.7 – 2.0 | 0.9 – 3.0 | 0.3 – 1.9 |
| Farmyard manure | 0.4 – 1.5 | 0.3 – 0.9 | 2.0 – 7.0 |

| Straw and stalk | | | |
|---|---|---|---|
| Pearl millet | 0.65 | 0.75 | 2.50 |
| Cotton | 0.44 | 0.10 | 0.66 |
| Banana pseudo stem | 0.61 | 0.12 | 1.00 |
| Sorghum | 0.40 | 0.23 | 2.17 |
| Maize | 0.42 | 1.57 | 1.65 |
| Paddy straw | 0.36 | 0.08 | 0.71 |
| Tobacco | 1.12 | 0.84 | 0.80 |
| Pigeon pea | 1.10 | 0.58 | 1.28 |
| Sugarcane trash | 0.53 | 0.10 | 1.10 |
| Wheat | 0.53 | 0.10 | 1.10 |
| Tobacco dust | 1.10 | 0.31 | 0.93 |

**Benefits of biocompost**

- Quality and enriched manure from the crop and animal residues available in the farm. The manure contains both nutrients and beneficial microorganisms.
- There is improvement in the physical, chemical and biological properties of the soil due to regular addition of biocompost.
- Quality products will be obtained from the crop due to improvement in the soil fertility status.
- Soil organic matter content increased and soil biodiversity also improved due to enhanced soil organic matter content.

**Compost application**

Organic manures are highly regarded as good source of material to maintain soil health and increasing soil organic carbon content. Organic manures cannot be equated with inorganic fertilizers. But organic manures deliver all the nutrients to the soil but with little quantity. For one hectare of land 5 tonnes of enriched biocompost is recommended. It can be used as basal application in the field before taking up planting work.

**Limitation in biocompost application**

- While preparing the biocompost, it should be ensured that the material is composted thoroughly.
- If the materials are not fully composted, the material should be sieved through 4 mm sieve and sieved material will be taken as well as composted one. The residues will be put back for another round of composting.
- It is better avoid woody material like heavy branches from pruned trees and other wooden materials. It will take long time and it interferes with other material for composting.

## II. ENRICHED ORGANIC MANURE FROM COIR DUST

Enriched organic manure from coir dust is nutrient rich organic manure obtained by composting coir dust along with poultry manure, rock phosphate and microbial inoculants *Pleurotus sajor-caju*, *Bacillus* sp,*Trichoderma* sp and *Pseudomonas* sp. This is a simple and rapid technique to compost coir dust within 60 days.

**Inputs**

| | | |
|---|---|---|
| Coir dust | : | 1tonne |
| Poultry manure | : | 200 kg |
| Rock phosphate | : | 10 kg |
| *Pleurotus sajor-caju* | : | 2kg |
| Microbial inoculants | : | 2kg |

(*Bacillus* sp + *Trichoderma* sp + *Pseudomonas* sp)

**Methodology**

A partially shaded area should be selected for composting of coir dust. The floor of the selected area must be hard to prevent leaching of water or nutrients from the compost. Spread one tonne of coir dust over the floor selected for composting. A hard-cemented surface is ideal for composting. Otherwise the floor should be hardened by putting stones and other hardy materials. Poultry manure (200 kg) and rock phosphate (10 kg), *Pleurotus sajor caju* (2 kg), microbial inoculums (2 kg) consists of *Bacillus, Trichoderma,* and *Pseudomonas* are added to the coir dust. All the above materials are mixed together thoroughly with one tonne of coir dust. After thorough mixing it should be sprinkled with water and formed into a heap. The moisture level should be maintained at 60% level through out the composting period. However water should not be dripped out of the composting material. For uniform composting of coir dust, the compost should be turned once in every 10 days. There will be reduction in volume of coir dust and all the material will be changed to black in color after 60$^{th}$ day with an earthy odour from the composted material. It will have high water holding capacity. The enriched coir dust compost contains the following nutrients.

**Nutritive value of Enriched Organic Manure from Coir Dust**

| S. No. | Parameters | Composition |
|---|---|---|
| 1. | Carbon | 28 % |
| 2. | Nitrogen | 1.82 % |
| 3. | Phosphorus | 2.34 % |
| 4. | Potassium | 0.91 % |
| 5. | Cellulose | 4.20 % |
| 6. | Lignin | 15.39 % |
| 7. | C/N ratio | 15.94 % |

| | | |
|---|---|---|
| 8. | Iron | 1419 mg $kg^{-1}$ |
| 9. | Manganese | 116 mg $kg^{-1}$ |
| 10. | Zinc | 169 mg $kg^{-1}$ |
| 11. | Copper | 115 mg $kg^{-1}$ |

**Advantages of Enriched Organic Manure from Coir Dust**

1. The enriched organic manure from coir dust is produced within a period of 60 days, whereas in other methods the compost is produced 90 to 120 days.
2. The enriched organic manure from coir dust is environment friendly organic manure, suitable for all soils and crops. It is processed from natural biomass adopting organic method and utilizing bio-agents for decomposition of coir dust.
3. Application of the enriched organic manure from coir dust improves the physio-chemical properties of the soil by increasing the nutrient availability in the soil and improving the soil structure, aggregation, porosity and water holding capacity. The soil fertility is enhanced.
4. The enriched organic manure from coir dust supplies macronutrients (Nitrogen, Phosphorus and Potassium) as well as micronutrients (Iron, Manganese, Copper and Zinc) to the corps.
5. It is an excellent organic medium and basal manure for application in planting pits for crops and forest trees especially in areas of water scarcity and drought.
6. The enriched organic manure from coir dust is an excellent soil ameliorant and soil conditioner for correcting soil problems.Hence it can be used as a component of biological reclamation system for bringing alkaline, saline and also ill drained soils back to remunerative farming.

## III. COMPOSTING OF POULTRY WASTES

**Value addition of Poultry Waste through Composting technology**

Poultry industry is one of the largest and fastest growing livestock production systems in the world. In India, there are about 3430 million populations of poultry with a waste generation of 3.30 million tonnes per year. The localized nature of poultry production also means that it can represent a large percentage of the agricultural economy in many states or regions. Although economical and successful, the poultry industry is currently facing with a number of highly complex and challenging environmental problems, many of which are related to its size and geographically concentrated nature. From an agricultural perspective, poultry wastes play a major role in the contamination of ground water through nitrate nitrogen. Also, the eutrophication of surface water due to phosphorus, pesticides, heavy metals and pathogens present in the poultry wastes applied to soils are the central environmental issues at the present time.

Among the animal manures, poultry droppings have higher nutrient contents. It has nitrogen (4.55 to 5.46 %), phosphorus (2.46 to 2.82 %), potassium (2.02 to 2.32 %), calcium (4.52 to 8.15 %), magnesium (0.52 to 0.73 %) and appreciable quantities of micronutrients like Cu, Zn, Fe, Mn etc. In addition to this cellulose (2.26 to 3.62%), hermi cellulose (1.89 to 2.77 %) and lignin (1.07 to 2.16 %) are also present in poultry waste. These components upon microbial action can be converted to value added compost with high nutrient status. In poultry droppings, nearly 60% of nitrogen which is present as uric acid and urea is lost through ammonia volatilization by hydrolysis. This loss of nitrogen reduces the agronomic value of the product, besides causing atmospheric pollution. Composting with amendment seems promising in conservation of nitrogen in poultry droppings. Nitrogen in poultry waste can be effectively conserved by composting with suitable organic amendment. The technologies developed will be highly useful to the poultry farmers.

**Method of preparation of poultry waste compost using coir pith**
**Inputs required**

- Poultry droppings
- Coirpith
- *Pleurotus sajor-caju*

**Method**

A known quantity of the poultry waste as collected above along with coir pith is inoculated with *Pleurotus sajor-caju* @ 2 packets per tonne *to* speed up the composting process. This mixer should be placed under shade as heap. The moisture content of the heap should be maintained at 50 to 60%. Periodical turning must be given on $21^{st}$, $28^{th}$ and $35^{th}$ days of composting. Another two packets of *Pleurotus sajor-caju* is to be added during turning given on the $28^{th}$ day of composting. Good quality compost will be attained after $45^{th}$ day of composting. The nutrient contents of the composts of poultry litter collected from caged system and deep litter systems are as below;

| Nutrient content | |
|---|---|
| Nitrogen (%) | 2.08 – 2.13 |
| Phosphorous (%) | 2.40 -2.61 |
| Potassium (%) | 2.03-2.94 |
| C:N ratio | 13:1-14:1 |

**Points to be remembered**

- Elevated shady place is highly suitable.
- Within a period of 10 to 15 days, the temperature of the heap will raise to maximum. If the temperature drops below 50º C, the heaps should be spread and moistened with water to bring the moisture content to 60%.
- Colour of the compost will turn from brown to black.
- The matured compost will be odourless.
- The volume of the compost heap will be reduced to $1/3^{rd}$.

- Temperature of the heap will be same as the ambient air temperature and stable.
- Matured compost will be light and fine textured.
- Moisture content of the heap can be measured using moisture meter or by taking handful of compost from the heap and squeezing it with the fingers. If excess water drips out from the compost, then it is considered to have >60 % moisture. If small quantity of water oozes out as drops, then moisture content is considered to be optimum *i.e.*, 60%.
- Each compost heap should have a minimum of one tonne to retain the heat for post decomposition.

**Value**

Animal manures especially poultry manure are rich in N and the nutrient value of the manure is reduced by loss of N through ammonia volatilization and denitrification. Good quality poultry manure can be obtained by mixing the poultry waste with selective carbonaceous material such as coirpith and inoculation with suitable microorganism. It can be used as an eco-friendly technique for the conversion of poultry waste into valuable compost.

**Benefits**

Poultry wastes contain higher concentrations of nitrogen, calcium and phosphorus than wastes of other animal species and the presence of nutrients provides more incentive for the utilization of this resource. The loss of nitrogen from poultry droppings can be effectively conserved by composting with coir pith and serves as a good source of organic nutrients to agricultural fields. To make the organic nutrients present in poultry waste available to plants, the waste has to be composted suitably to minimize the volatilization of ammonia.

**Applications**

The poultry waste compost will be a very good organic manure @ 6 ton / ha for all the crops.

**Limitations**

The uninterrupted availability of the raw materials has to be ensured for continuous production on a commercial scale.

## IV. VERMICOMPOST

Earthworms live in the soil and feed on decaying organic material. After digestion, the undigested material moves through the alimentary canal of the earthworm, a thin layer of oil is deposited on the castings. This layer erodes over a period of 2 months. So although the plant nutrients are immediately available, they are slowly released to last longer. The process in the alimentary canal of the earthworm transforms organic waste to natural fertilizer. The chemical changes that organic wastes undergo include deodorizing and neutralizing. This means that the pH of the castings is 7 (neutral) and the castings are odorless. The worm castings also contain bacteria, so the process is continued in the soil, and microbiological activity is promoted.

*Vermicomposting* is the process of turning organic debris into worm castings. The worm castings are very important to the fertility of the soil. The castings contain high amounts of nitrogen, potassium, phosphorus, calcium, and magnesium. Castings contain: 5 times the available nitrogen, 7 times the available potash, and 1 ½ times more calcium than found in good top soil. Several researchers have demonstrated that earthworm castings have excellent aeration, porosity, structure, drainage, and moisture-holding capacity. The content of the earthworm castings, along with the natural tillage by the worms burrowing action, enhances the permeability of water in the soil. Worm castings can hold close to nine times their weight in water. “Vermiconversion,” or using earthworms to convert waste into soil additives, has been done on a relatively small scale for some time. A recommended rate of vermicompost application is 15-20 percent. Vermicomposting is done on small and large scales.

**Materials for preparation of Vermicompost**

Any types of biodegradable wastes can be used for vermicomposting

1. Crop residues
2. Weed biomass
3. Vegetable waste
4. Leaf litter
5. Hotel refuse
6. Waste from agro-industries
7. Biodegradable portion of urban and rural wastes

## PHASE OF VERMICOMPOSTING

| | | |
|---|---|---|
| Phase 1 | : | Processing involving collection of wastes, shredding, mechanical separation of the metal, glass and ceramics and storage of organic wastes. |
| Phase 2 | : | Pre digestion of organic waste for twenty days by heaping the material along with cattle dung slurry. This process partially digests the material and fit for earthworm consumption. Cattle dung and biogas slurry may be used after drying. Wet dung should not be used for vermicompost production. |
| Phase 3 | : | Preparation of earthworm bed. A concrete base is required to put the waste for vermicompost preparation. Loose soil will allow the worms to go into soil and also while watering, all the dissolvable nutrients go into the soil along with water. |

| | | |
|---|---|---|
| Phase 4 | : | Collection of earthworm after vermicompost collection. Sieving the composted material to separate fully composted material. The partially composted material will be again put into vermicompost bed. |
| Phase 5 | : | Storing the vermicompost in proper place to maintain moisture and allow the beneficial microorganisms to grow. |

**Bedding**

Bedding is any material that provides the worms with a relatively stable habitat. This habitat must have the following characteristics:

**High absorbency**

Worms breathe through their skins and therefore must have a moist environment in which to live. If a worm's skin dries out, it dies. The bedding must be able to absorb and retain water fairly well if the worms are to thrive.

**Good bulking potential**

If the material is too dense to begin with, or packs too tightly, then the flow of air is reduced or eliminated. Worms require oxygen to live, just as we do. Different materials affect the overall porosity of the bedding through a variety of factors, including the range of particle size and shape, the texture, and the strength and rigidity of its structure. The overall effect is referred to in this document as the material's bulking potential.

**Low protein and/or nitrogen content (high Carbon: Nitrogen ratio)**

Although the worms do consume their bedding as it breaks down, it is very important that this be a slow process. High protein/nitrogen levels can result in rapid degradation and its associated heating, creating inhospitable, often fatal, conditions. Heating can occur safely in the food layers of the vermiculture or vermicomposting system, but not in the bedding.

## VERMICOMPOST PRODUCTION METHODOLOGY

### i) Selection of suitable earthworm

For vermicompost production, the surface dwelling earthworm alone should be used. The earthworm, which lives below the soil, is not suitable for vermicompost production. The African earthworm (*Eudrillus engeniae),* Red worms (*Eisenia foetida)* and composting worm (*Peronyx excavatus)* are promising worms used for vermicompost production. All the three worms can be mixed together for vermicompost production. The African worm (*Eudrillus eugeniae)* is preferred over other two types, because it produces higher production of vermicompost in short period of time and more young ones in the composting period.

**ii) Selection of site for vermicompost production**

Vermicompost can be produced in any place with shade, high humidity and cool. Abandoned cattle shed or poultry shed or unused buildings can be used. If it is to be produced in open area, shady place is selected. A thatched roof may be provided to protect the process from direct sunlight and rain. The waste heaped for vermicompost production should be covered with moist gunny bags.

**iii) Containers for vermicompost production**

A cement tub may be constructed to a height of 2½ feet and a breadth of 3 feet. The length may be fixed to any level depending upon the size of the room. The bottom of the tub is made to slope like structure to drain the excess water from vermicompost unit. A small sump is necessary to collect the drain water. In another option over the hand floor, hollow blocks / bricks may be arranged in compartment to a height of one feet, breadth of 3 feet and length to a desired level to have quick harvest. In this method, moisture assessment will be very easy. No excess water will be drained. Vermicompost can also be prepared in wooden boxes, plastic buckets or in any containers with a drain hole at the bottom.

**iv) Vermiculture bed**

Vermiculture bed or worm bed (3 cm) can be prepared by placing after saw dust or husk or coir waste or sugarcane trash in the bottom of tub / container. A layer of fine sand (3 cm) should be spread over the culture bed followed by a layer of garden soil (3 cm). All layers must be moistened with water.

**v) Worm Food**

Compost worms are big eaters. Under ideal conditions, they are able to consume in excess of their body weight each day, although the general rule-of-thumb is ½ of their body weight per day. They will eat almost anything organic (that is, of plant or animal origin), but they definitely prefer some foods to others. Manures are the most commonly used worm feedstock, with dairy and beef manures generally considered the best natural food for *Eisenia*, with the possible exception of rabbit manure. The former, being more often available in large quantities, is the feed most often used.

## Common Worm Feed Stocks

| Food | Advantages | Disadvantages |
|---|---|---|
| Cattle manure | Good nutrition; natural food, therefore little adaptation required | Weed seeds make pre-composting necessary |
| Poultry manure | High N content results in good nutrition and a high-value product | High protein levels can be dangerous to worms, so must be used in small quantities; major adaptation required for worms not used to this feedstock. May be pre-composted but not necessary if used cautiously |
| Sheep/Goat manure | Good nutrition | Require pre-composting (weed seeds); small particle size can lead to packing, necessitating extra bulking material |
| Hog manure | Good nutrition; produces excellent vermicompost | Usually in liquid form, therefore must be dewatered or used with large quantities of highly absorbent bedding |
| Rabbit manure | N content second only to poultry manure, there-fore good nutrition; contains very good mix of vitamins & minerals; ideal earth-worm feed | Must be leached prior to use because of high urine content; can overheat if quantities too large; availability usually not good |
| Fresh food scraps (e.g., peels, other food prep waste, leftovers, commercial food processing wastes) | Excellent nutrition, good moisture content, possibility of revenues from waste tipping fees | Extremely variable (depending on source); high N can result in overheating; meat & high-fat wastes can create anaerobic conditions and odours, attract pests, so should NOT be included without pre-composting |
| Pre-composted food wastes | Good nutrition; partial decomposition makes digestion by worms easier and faster; can include meat and other greasy wastes; less tendency to overheat. | Nutrition less than with fresh food wastes. |
| Biosolids (human waste) | Excellent nutrition and excellent product; can be activated or non-activated sludge, septic sludge; possibility of waste management revenues | Heavy metal and/or chemical contamination (if from municipal sources); odour during application to beds (worms control fairly quickly); possibility of pathogen survival if process not complete |
| Seaweed | Good nutrition; results in excellent product, high in micronutrients and beneficial microbes | Salt must be rinsed off, as it is detrimental to worms; availability varies by region |

| Food | Advantages | Disadvantages |
|---|---|---|
| Legume hays | Higher N content makes these good feed as well as reasonable bedding. | Moisture levels not as high as other feeds, requires more input and monitoring |
| Corrugated cardboard (including waxed) | Excellent nutrition (due to high-protein glue used to hold layers together); worms like this material; possible revenue source from WM fees | Must be shredded (waxed variety) and/or soaked (non-waxed) prior to feeding |
| Fish, poultry offal; blood wastes; animal mortalities | High N content provides good nutrition; opportunity to turn problematic wastes into high-quality product | Must be pre-composted until past thermophillic stage |

**vi) Selection for vermicompost production**

Cattle dung (except pig, poultry and goat), farm wastes, crop residues, vegetable market waste, flower market waste, agro industrial waste, fruit market waste and all other bio degradable waste are suitable for vermicompost production. The cattle dung should be dried in open sunlight before used for vermicompost production. All other waste should be predigested with cow dung for twenty days before put into vermibed for composting.

**vii) Putting the waste in the container**

The predigested waste material should be mud with 30% cattle dung either by weight or volume. The mixed waste is placed into the tub / container upto brim. The moisture level should be maintained at 60%. Over this material, the selected earthworm is placed uniformly. For one-meter length, one-meter breadth and 0.5-meter height, 1 kg of worm (1000 Nos.) is required. There is no necessity that earthworm should be put inside the waste. Earthworm will move inside on its own.

**viii) Watering the vermibed**

Daily watering is not required for vermibed. But 60% moisture should be maintained throughout the period. If necessity arises, water should be sprinkled over the bed rather than pouring the water. Watering should be stopped before the harvest of vermicompost.

**ix) Harvesting vermicompost**

In the tub method of composting, the castings formed on the top layer are collected periodically. The collection may be carried out once in a week. With hand the casting will be scooped out and put in a shady place as heap like structure. The harvesting of casting should be limited up to earthworm presence on top layer. This periodical harvesting is necessary for free flow and retain the compost quality. Otherwise the finished compost get compacted when watering is done. In small bed type of vermicomposting method, periodical harvesting is not required. Since the height of the waste material heaped is around 1 foot, the produced vermicompost will be harvested after the process is over.

**x) Harvesting earthworm**

After the vermicompost production, the earthworm present in the tub / small bed may be harvested by trapping method. In the vermibed, before harvesting the compost, small, fresh cow dung ball is made and inserted inside the bed in five or six places. After 24 hours, the cow dung ball is removed. All the worms will be adhered into the ball. Putting the cow dung ball in a bucket of water will separate this adhered worm. The collected worms will be used for next batch of composting.

**xi) Nutritive value of vermicompost**

The nutrients content in vermicompost vary depending on the waste materials that is being used for compost preparation. If the waste materials are heterogeneous one, there will be wide range of nutrients available in the compost. If the waste materials are homogenous one, there will be only certain nutrients are available. The common available nutrients in vermicompost is as follows

| | | |
|---|---|---|
| Organic carbon | : | 9.5 – 17.98% |
| Nitrogen | : | 0.5 – 1.50% |
| Phosphorous | : | 0.1 – 0.30% |
| Potassium | : | 0.15 – 0.56% |
| Sodium | : | 0.06 – 0.30% |
| Calcium and Magnesium | : | 22.67 to 47.60 meq/10 |
| Copper | : | 2 – 9.50 mg kg-1 |
| Iron | : | 2 – 9.30 mg kg-1 |
| Zinc | : | 5.70 – 11.50 mg kg-1 |
| Sulphur | : | 128 – 548 mg kg-1 |

**xii) Storing and packing of vermicompost**

The harvested vermicompost should be stored in dark, cool place. It should have minimum 40% moisture. Sunlight should not fall over the composted material. It will lead to loss of moisture and nutrient content. It is advocated that the harvested composted material is openly stored rather than packed in over sac. Packing can be done at the time of selling. If it is stored in open place, periodical sprinkling of water may be done to maintain moisture level and also to maintain beneficial microbial population. If the necessity comes to store the material, laminated over sac is used for packing. This will minimize the moisture evaporation loss. Vermicompost can be stored for one year without loss of its quality, if the moisture is maintained at 40% level.

**4. Advantages of vermicompost**

- Vermicompost is rich in all essential plant nutrients.
- Provides excellent effect on overall plant growth, encourages the growth of new shoots / leaves and improves the quality and shelf life of the produce.
- Vermicompost is free flowing, easy to apply, handle and store and does not have bad odour.
- It improves soil structure, texture, aeration, and waterholding capacity and prevents soil erosion.
- Vermicompost is rich in beneficial micro flora such as a fixers, P- solubilizers, cellulose decomposing micro-flora etc in addition to improve soil environment.
- Vermicompost contains earthworm cocoons and increases the population and activity of earthworm in the soil.
- It neutralizes the soil protection.
- It prevents nutrient losses and increases the use efficiency of chemical fertilizers.
- Vermicompost is free from pathogens, toxic elements, weed seeds etc.
- Vermicompost minimizes the incidence of pest and diseases.
- It enhances the decomposition of organic matter in soil.
- It contains valuable vitamins, enzymes and hormones like auxins, gibberellins etc.

**5. Pests and diseases of vermicompost**

Compost worms are not subject to diseases caused by micro-organisms, but they are subject to predation by certain animals and insects (red mites are the worst) and to a disease known as “sour crop” caused by environmental conditions.

## INDUSTRIAL WASTE UTILIZATION FOR LAND RECLAMATION AND CROP PRODUCTION

**Application of Untreated Distillery Effluent (Spentwash) for the Reclamation of Sodic Soils**

Amendments generally used to reclaim sodic soils are gypsum, phosphogypsum, iron pyrites and elemental sulphur. All these are inorganic in nature. Some of the organic amendments to reclaim the sodic soils are press-mud, farmyard manure (FYM), coir dust and green manures. The direct discharge of untreated distillery effluent (spentwash) to reclaim and improve the productivity of the sodic soils is now advocated. Untreated distillery effluent (spentwash) is acidic (pH: 3.8 – 4.2) with considerable quantity of potassium, calcium and magnesium and traces of micronutrients. Organic compounds, mainly the humic related melanoidins improve the bio-catalytic potential of the treated soil.

Hence, only one time application of 3.75 to 5.00 lakhs litres of untreated distillery effluent (spentwash) per hectare of sodic soils in summer months is recommended.

Natural oxidation can be induced for a period of six weeks with two intermittent dry ploughing at a particular interval. Then, after 45 – 60$^{th}$ day of application, soil is to be irrigated with fresh water and drained. This treatment reduces the pH and exchangeable sodium percentage to normal level and increases the productivity of the sodic soils. After this reclamation practice, rice crop can be raised in the effluent applied field adopting the conventional cultivation technique. Application of this effluent again to the next crop/season or year after year and also to the land nearby drinking water sources is not advocated.

**Application of Treated Distillery Effluent to Crops**

- Treated distillery effluent contains nitrogen 1200 mg $L^{-1}$, phosphate 500 mg $L^{-1}$, potash 12000 mg $L^{-1}$, calcium 1800 mg $L^{-1}$ and iron 300 mg $L^{-1}$. Since the effluent has higher dissolved salts, 50 times diluted effluent can be irrigated to sugarcane, banana, ragi, sunflower, grasses, cotton and soybean.

- It can also be used as one time application to fallow land at the rate of 20,000 to 40, 000 litres per hectare. It should be allowed for complete drying over a period of 20 to 30 days. The effluent applied field is to be thoroughly ploughed two times for the natural oxidation and mineralization of organic matter. After that, crops can be raised in the effluent applied field adopting the conventional methods. Application of this effluent again to the next crop/season or year after year and also to the land nearby drinking water sources is not advocated.

**Irrigation of Pulp and Paper Mill Effluents**

Pulp and paper effluents contain lot of dissolved solids and stabilized organic matter. The properly treated effluent with EC less than 1.2 $dSm^{-1}$ as such can safely be used for irrigation with appropriate amendments *viz.,* pressmud @ 5 tonnes $ha^{-1}$ (or) fortified pressmud @ 2.5 tonnes $ha^{-1}$ or daincha as in -situ green manure (6.25 tonnes $ha^{-1}$).

Though there were perceptible changes in soil pH, EC, available NPK, exchangeable cations, exchangeable sodium per cent and sodium absorption ratio, there is no detrimental effect due to sodium either on soil or plants grown in sandy loam soils with good drainage facilities. This treated effluent can be used for irrigation in these soils for the following crops and varieties along with recommended doses of amendments *viz.,* pressmud @ 5 tonnes $ha^{-1}$, or fortified pressmud @ 2.5 tonnes $ha^{-1}$ or daincha as in situ green manure (6.25 tonnes $ha^{-1}$).

| Crops | | Varieties |
|---|---|---|
| Rice | : | IR 20, TRY 1, CO 43. |
| Maize | : | CO 1 |
| Sunflower | : | CO 2 |
| Groundnut | : | TMV 7 |
| Soybean | : | CO 1 |

| | | |
|---|---|---|
| Sugarcane | : | CO 6304, COSi 86071, COC 95071, CO 86032 |
| Tapioca | : | CO (TP) 4, CO 2, CO 3, MVD 1 |

However, irrigating this treated effluent to oil seed crops like gingelly and castor, pulses like greengram and blackgram is not advocated as they were found to be sensitive for this type of effluent irrigation.

**Reclamation of papermill effluent irrigated soil**

Application of 7.25 t $ha^{-1}$ of gypsum is recommended to reclaim the TEWLIS area soils of Karur district (Moolimangalam, Pandipalayam, Pazhamapuram, Thadampalayam and Ponniagoundanpudur) where the treated paper mill effluent is being continuously used for irrigation since 1995. Application of pressmud @ 6 t $ha^{-1}$ along with Blue Green Algae (15 kg $ha^{-1}$) and Gypsum (50% Gypsum requirement) is also effective in reclaiming the saline sodic soil with continuous papermill effluent irrigation and to increase the green fodder yield of *Lucerne.*

**Crops and Varieties Suitable for Tannery Waste Affected Soils**

Based on the results of field trials conducted at Vellore district, the following crops, trees and their varieties are recommended for the tannery waste affected soils

| Crops | Varieties |
|---|---|
| Cereals | : Rice (TRY 1, CO 43, Paiyur 1, ASD 16) |
| Millets | : Ragi (CO 12, CO 13) |
| Oilseeds | : Sunflower (CO 4, Morden) and Mustard |
| Cash crops | : Sugarcane (COG 94076, COG 88123, COC 771) |
| Vegetables | : Brinjal, Bhendi, Chillies, Tomato (PKM 1) |
| Flowering crops | : Jasmine, Neerium, Tuberose |
| Trees | : Eucalyptus, Casuarinas and Acacia |

**TNAU constructed wetland technology**

TNAU constructed wetland technology is recommended for treating the papermill effluent using species *viz., Typha latifolia, Pharagmitis australis* and *Cyperus pangorei* with plant density of lakhs shoots $ha^{-1}$ (25 shoots $m^{-2}$). Around 1 ha of wetland area is required to treat 1000 $m^3$ of wastewater per day with a retention time of 2 – 3 days.

The wetland beds should be lined with an impermeable liner made of PVC or high-density poly ethylene (HDPE). The bottom most layer of wetland should be filled with ½ to 1” pebbles to a depth of 6 cm followed by Pea gravel of 6 cm, coarse sand and fine sand each of 7 cm and the top layer with soil to a depth of 9 cm.