Enhancing Agriculture with Liquid Formulations and Compost

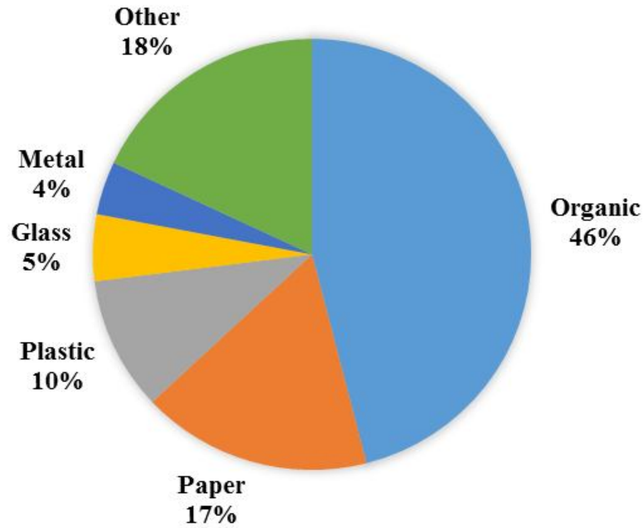
Abstract:

Liquid formulations, including aqueous, oil, and polymer-based products, often use polysaccharides to alter fluid properties. Liquid inoculants offer cost-effective alternatives to solid carriers, particularly benefiting small producers in India by overcoming transportation and processing challenges. Ideal liquid inoculants are non-toxic, low-cost, uniform, nutrient-supplemented, and support rapid microorganism release and growth. Effective formulations stabilize organisms, ensure easy field delivery, protect against environmental factors, and enhance microbial activity. Compost, rich in organic matter and nutrients, improves soil texture, structure, and moisture retention, enhancing soil properties and crop yield. It boosts soil enzyme activity and microbial populations, promoting nitrogen fixation and nutrient availability. Organic manure applications increase soil fertility, water retention, and reduce bulk density. Field and horticultural crops, such as potatoes, chillies, and tomatoes, show significant yield improvements with compost, which also suppresses plant diseases and weed populations.

Keywords: Composting, Organic manures, Soil enzymes, Soil microorganisms, Liquid bioinoculants

Introduction

Solid wastes are unwanted materials that cannot flow directly into streams or rise immediately into air. These wastes include garbage, paper, wood, glass, plastics, ash, agricultural wastes, sewage, sludge, automobile tyres, anatomical and pathological wastes from hospitals and mining wastes. Presence of pathogens, undesirable heavy metals, toxic concentration of micronutrients and nitrate hazards are some of the major problems of recycling solid and liquid wastes (Gupta *et al.,* 1998).



(Ranjith Kharvel Annepu, 2012)

Fig. 1 Composition of Municipal solid waste

In India the biodegradable portion which mainly includes food and yard waste dominates the bulk of MSW by making up approximately 50% of the total MSW. Some facts about Indian MSW Solid waste generation in India is about 1,15,000 tons per day with a yearly increase of about 5% (CPCB). The estimated annual increase in per capita waste quantity is about 1.33% per year (Preeti *et al.*, 2014).

Organic wastes

Organic wastes include solid and liquid wastes such as crop residues, excreta, garbage, domestic wastes and sludges etc., (Jain, 1993). In India, average per capita generation of rural and urban organic wastes has been estimated to be 0.3 to 4 kg/day (Gupta *et al.,* 1998). Rural wastes like field crop residues in one or the other forms constitute the largest source of recyclable organic materials. By conservative estimates, 350 to 375 million tonnes of crop residues are produced annually from all field crops (Bhardwaj *et al.,* 1998). The annual productions of residues by principal crops were 270 million tonnes, which could supply 5.6 million tonnes of NPK (Patil, 1998).

The biodegradable waste sent to landfills contain resources and with the right solid waste management system, these can be utilised. The carbon in the waste serves as a source for energy. The nitrogen, phosphorus and other elements are important nutrients.

The potential for recovery, reuse and substitution of alternatives sourced from other sectors makes the prospects for energy and fertiliser production from solid waste attractive (Gummar, 2010).

The major part of Indian MSW includes vegetable waste. The vegetable waste in MSW is mainly contributed by waste from vegetable markets, restaurents, canteens, juice centres and household kitchens. All cities, towns, districts have vegetable markets producing 221.43 million tonnes of waste (Dandotiya and Agrawal, 2014).

Agro-industrial wastes, being organic in nature, can be used in agriculture to increase the organic matter content of the soils. Apart from their nutritional value, these organic materials improve the physico-chemical properties of the soil and thereby, increase the fertility and productivity of soils (Naphade *et al.,* 1998). Manna *et al.,* (2012) estimated that about 679.3 and 369.5 million tonnes of crop residues and animal dung were produced annually in India. The most voluminous solid waste from sugarcane factories are pressmud, the annual generation of pressmud was 6.4 million tones (Manna *et al.,* 2012).

Composting

Composting is a biological conversion of heterogeneous organic substrate, under controlled conditions, into a hygienic, humus rich and relatively biostable product that conditioned the soil and nourished the plants (Kalaiselvi and Ramasamy, 1996). All available organic waste materials can be converted into value added organic manure by adopting suitable biodegradation process technology (Ramaswami, 1999).

Composting is an aerobic thermophilic process, widely used for the recycling of organic residues such as yard trimmings, agricultural wastes, food wastes and biosolids. Gradients of oxygen, nutrients and temperature that exist in compost support a diverse microbial population and rapid organic matter conversion (Michel *et al.,* 1996). Organic component of a solid waste is biologically degraded under controlled condition to supply plant nutrient without any detrimental effects on the environment and the crop (Kumaresan *et al.,* 2003).

Principles of Composting

Microorganisms are the principal biological agents for operation of the composting process. They are active in the degradation of insoluble higher molecular weight organic compounds cellulose, chitin, protein, waxes and paraffin etc. They derived energy required for their growth and metabolism by mediating oxidation reduction reaction of the organic substrates and thereby decomposed the organic matter (Gaur *et al.*, 1980).

In using organic waste as a food source, the microorganism reproduced themselves and released carbon dioxide, water, other organic products and energy. The final product of the composting process consisted of most resistant residues of the organic matter breakdown product, the biomass of dead microorganism and other microorganism together with product from chemical reaction between these matters (Gaur *et al.*, 1980).

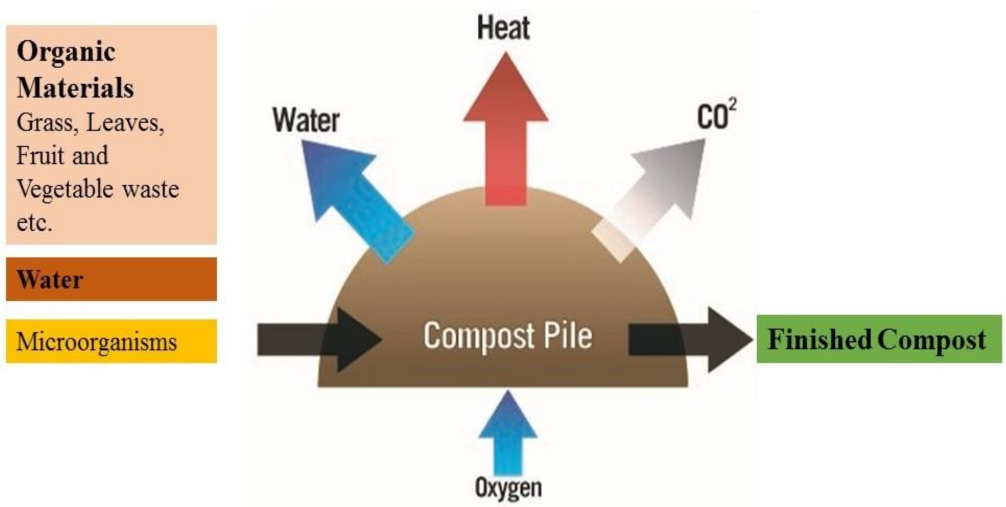


Fig. 2.2. Principles of composting process

Factors Facilitating Composting

The physical and chemical attributes of organic wastes are important in the microbial degradation process, as well as the ultimate quality of the product and its suitability for use as a fertilizer or soil amendment (Brink, 1995). The relative quantity of carbon, nitrogen, phosphorus, sulphur and other nutrients and also the quality of substrate is important to determine the rate of decomposition (Zibliske, 1998).

Sl.	Parameter	Optimum value for composting
1.	C/N ratio of feed	25 to 35
2.	Particle size	10mm for agitated systems and forced aeration, 50 mm for long heaps and natural aeration
3.	Moisture content	50 to 60 %
4.	Air flow	0.60 to 1.8 m^3air/day/kg volatile solids during thermophilic stage or maintain oxygen level at 10 to 18 %
5.	Temperature	55 to 60°C held for 3 days
6.	Agitation	No agitation to periodic turning in simple systems and short bursts of vigorous agitation in mechanized systems
7.	pH	Neutral
8.	Heap size	Any length, 1.5m height and 2.5 m wide for heaps using natural aeration. With forced aeration, heap size depends on need to avoid overheating
9.	Activators	Use of efficient cellulolytic and lignolytic microorganisms and bio fertilizers

(Gaur and Sadasivam, 1993)

Methods of Composting

Indore method of composting

Indore method has been developed by Howard and Ward, (1931). This method requires a heap of trapezoidal cross section. The heap is about 4 m in length, 1 m in breadth and 1 m in height. The heap was alternatively layered with 20 cm of carbon rich and 10 cm of nitrogen rich material. Finally it was covered with soil or hay as thermal insulator and the rate of decomposition is very rapid and high temperature develops quickly. All types of organic waste available in the farm such as crop residues, fallen leaves, stalks, stems, etc. This process is accelerated by periodically turning the materials.

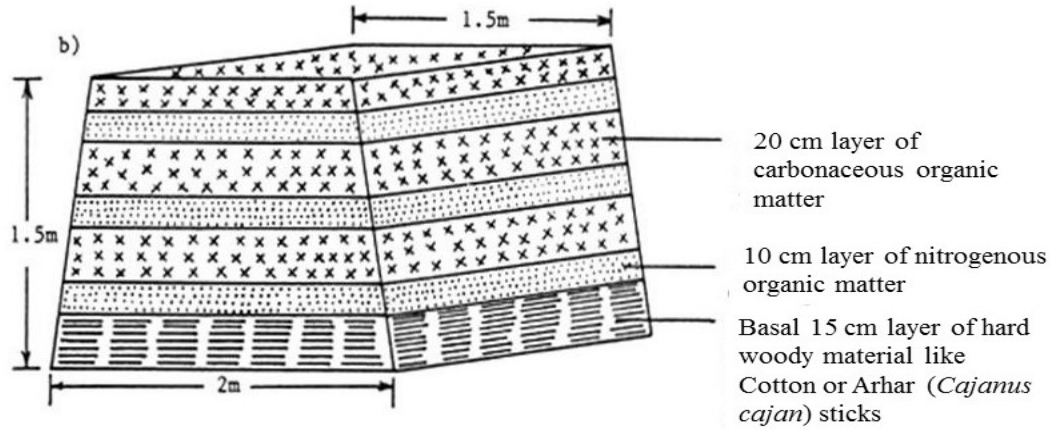


Fig. 2.3. Indore method of composting

Windrow composting

The organic material present in waste can be converted into a stable mass by aerobic decomposition. Aerobic microorganisms oxidize organic compounds to carbon di oxide and oxides of nitrogen and carbon from organic compounds is used as a source of energy, while nitrogen is recycled. Due to exothermic reactions, the temperature rises. In areas/regions were higher ambient temperatures are available, composting in open windrows is to be preferred. In this method, refuse is delivered on a paved/unpaved open space but levelled and well drained land in about 20 windrows with each windrow 3m long x 2m wide x 1.5m high, with a total volume not exceeding 9.0 cu.m. Each windrow would be turned on 6th and 11th days outside to the centre to destroy insect larvae and to provide aeration. Windrows are periodically turned by means of a front-end loader or a specially designed compost turner (Michel *et al.,* 1996). On 16th day, windrow would be broken down and passed through manually operated rotary screens of about 25 mm square mesh to remove the oversize contrary material. The screened compost is stored for about 30 days in heaps about 2m wide x 1.5m high and up to 20m long to ensure stabilization before sale (Kuchenrither *et al.,* 1984).

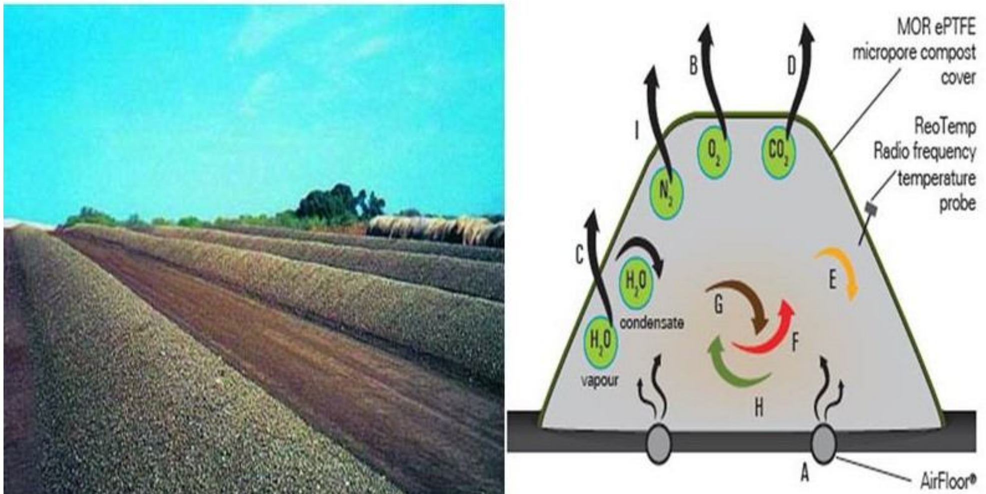


Fig. 2.4. Windrow method of composting

Passively aerated windrows

Under passively aerated windrow method, air is supplied to the composting materials through perforated pipes embedded in each windrow there by eliminating the need for turning. The pipe ends are open, air flows in to the pipes and through the windrow because of the chimney effect created as the hot gases rise upward out of the windrow. Aeration pipes are placed on top of the heap/compost base. If the composting period is completed, the pipes are removed, and the composted materials were collected (Taiwo and Oso, 2004).

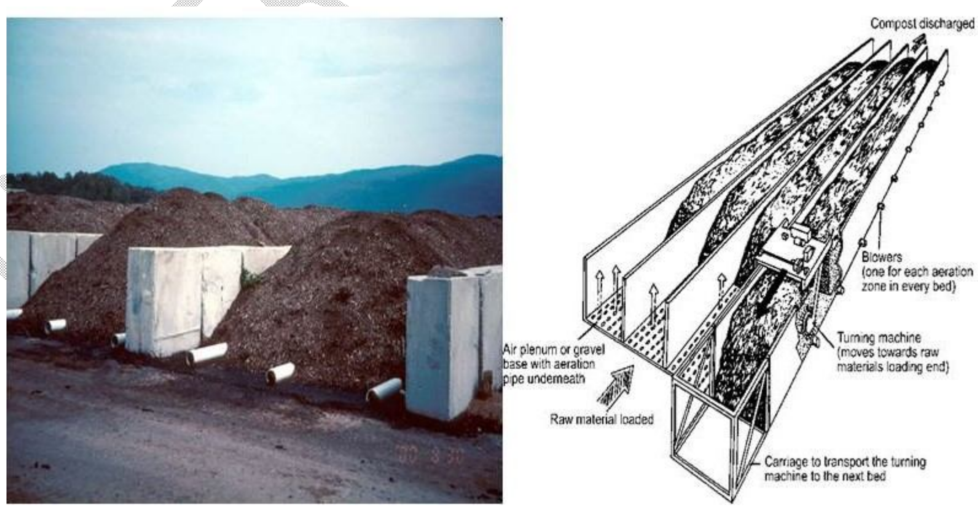


Fig. 2.5. Passive Aerated Windrow method of composting

Bangalore method

Acharya (1934) developed the Bangalore method to obtain compost from city refuse and night soil in pits. Pits of about 1m depth, 1m breadth and 1 m length were used in this process. At first the refuse was dumped into the trench and spread out with racks to make a layer of 15 cm. Night soil was then discharged and spread over the refuse in a layer of about five cm. This is then covered with a 15 cm layers of refuse thus follow in alternate layers until the pit is filled above 15 cm from ground level with a final layer of refuse on the top. This may be dome shaped and covered with soil. The anaerobic decomposition was comparatively slow but solving satisfactorily one of the most difficult problems of sanitary disposal of the offensive wastes and yielding high quality organic manure.

Fig. 2.6. Bangalore method of composting

Aerated static pile

It is a piped aerator system, using a blower to supply air to the composting materials. The blower provides direct control of the process and allows larger piles. No turning or agitation of the materials occurs once the pile is formed. When the pile has been formed properly and where the air supply is sufficient the active compost period is completed in about three to five weeks (Wilson *et al.*, 1980).

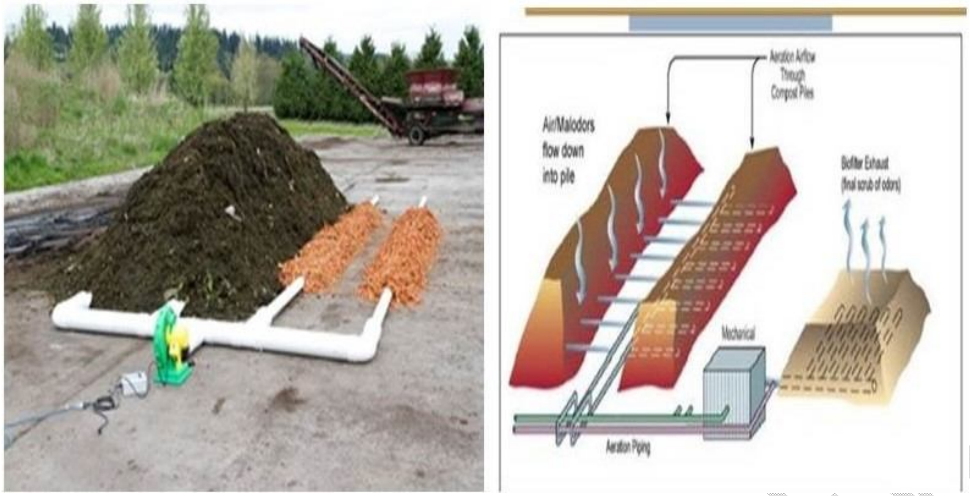


Fig. 2.7. Aerated static pile method of composting

In-vessel composting

In-vessel composting generally describes a group of methods that which confine the composting materials within a building, container, or vessel. In-vessel composting systems can consist of metal or plastic tanks or concrete bunkers in which air flow and temperature can be controlled, using the principles of a "bioreactor". Generally the air circulation is passed via buried tubes that allow fresh air to be injected under pressure, with the exhaust being extracted through a biofilter, with temperature and moisture conditions monitored using probes in the mass to allow maintenance of optimum aerobic decomposition conditions. This technique was generally used for municipal organic waste processing, including final treatment of sewage biosolids, to a safe stable state for reclamation as a soil amendment (Taiwo and Oso, 2004).

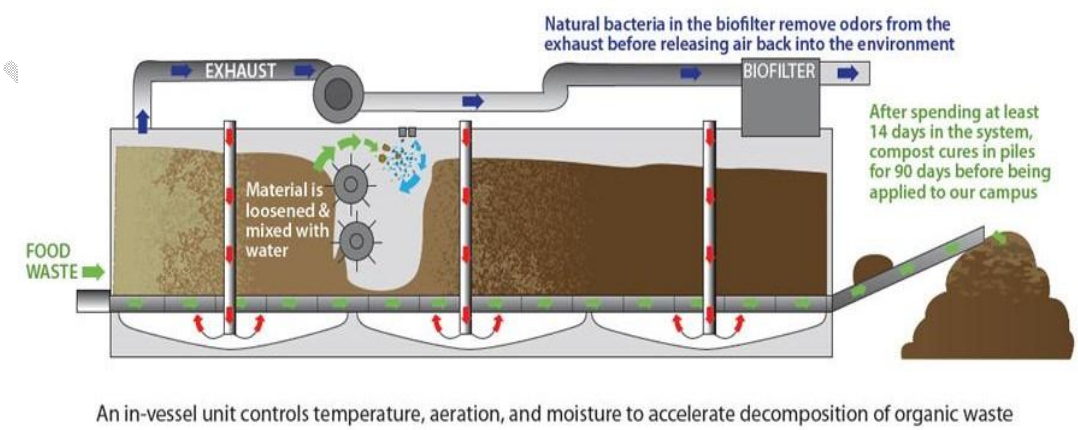


Fig. 2.8. In-Vessel method of composting

Biochemical changes in composting process

During the composting process, microorganisms decompose organic compounds, which consist of carbohydrates, sugar, proteins, fats, cellulose and lignin. Carbohydrates are more easily decomposed, whereas lignin is more resistance to decomposition. Many factors affect the composting process. Aerobic microorganisms need oxygen, water and nutrients for their metabolism and cell synthesis. As a result of microbial activity heat is liberated and, if contained within the composting mass, the temperature rises. Temperature increases through the mesophilic phase into a thermophilic phase and then back in to the mesophilic phase. During the course of these transitions, the microbial population changes, thereby affecting the rate of organic matter decomposition (Norbu, 2002).

The pH of compostable material influences the type of organisms involved in the composting process. There was an intrinsic relationship of temperature and pH variation with time during composting. The early mesophilic stages show a decrease in pH (acidic) and with an increase in temperature of the composting mass, there was corresponding increase in pH (Gray and Biddlestone, 1971). During composting, the most biodegradable organic compounds are broken down and part of the remaining organic material is converted into humic-like substances (Hsu and Lo, 1999; Sanchez *et al.*, 1999; Wu and Ma, 2002).

The macro and micro nutrients were increased during composting due to the loss of organic carbon content as CO_2 (Gaur, 1982). The enhancement in the concentration of nutrients with time was due to mineralisation of native carbon accompanied by a reduction in the total volume of the wastes (Metting, 1993).

Amylase, cellulase, dehydrogenase and phosphatase were recognized as very important enzymes participate in the mineralization of nutrients. The enzyme activities largely reflect the diversity of the microbial population and in turn reflect the composting process. Among the enzymes, cellulase has the degradative function of prime importance during the composting process (Francis *et al.*, 1978). The phosphatase plays a role in the use of alternative phosphorus sources and considered as a general terms of microbial activity in compost (Browman and Tabutabai, 1978). The level of this enzyme increased during the mesophillic period and remained constant during the later period of the process. Garcia *et al*. (2000) reported the involvement of enzymes such as dehydrogenase and catalase in intracellular microbial metabolism which increases with the addition of organic amendments.

Role of microbes in composting

Composts contain a large and very diverse microbial community (mainly bacteria and fungi), which plays a key role in the decomposition of organic matter during the various temperature phases of composting. At the beginning of the composting process, mesophilic bacteria, typically from the genera *Lactobacillus* and *Bacillus* (Partanen *et al.,* 2010), predominate. Their populations significantly increase during the early phase of composting, as they are capable of degrading the soluble and readily degradable compounds such as sugars, and heat is produced by their metabolic activities. As the temperature rises to about 40°C, thermophilic bacteria such as I, *Bacillus*, and *Thermus* take over the degradation and become the dominant groups in the microbial community. Composting is generally accepted as an aerobic microbial-driven process. However, anaerobic microbes such as *Bacteroidetes* and *Clostridia* have also been detected in composting processes (Partanen *et al.,* 2010; Danon *et al.,* 2008). This finding could be explained by the limitations in oxygen transfer from the free air space into the heterogeneous solid particles of the composting mass, making the composting process a co-function of anaerobic and aerobic processes (Reinhardt, 2002; Smith, 2009).

The study of composting microbes has mainly focused on bacteria, although fungi have been found to be the essential degraders of lignin and cellulose (Tuomela *et al.,* 2000). Yeasts and moulds have been detected in the mesophilic stages, while thermophilic fungi belonging to the Pezizomycota, Zygomycota and Ascomycota (e.g. *Penicillium*) have been found in the thermophilic stage; Basidiomycota become abundant in the cooling and curing phases of composting process (Hultman *et al.,* 2010). Thermophilic fungi grow at temperatures of up to 55 °C, and higher temperatures usually inhibit fungal growth (Insam *et al.,* 2010). Hence, fungi typically play a negligible role during the thermophilic phase. One exception is the composting of substrates that are particularly rich in cellulose and lignin, in which case fungi remain important degraders throughout the composting process. Usually, in the curing phase of composting, the ratio of fungi to bacteria increases due to the competitive advantage of fungi under poor substrate availability, meaning the predominance of difficult-to-degrade compounds such as lignin and humus.

Predominant microorganisms in composting process

Bacillus

Bacillus sp. is mesophilic bacteria which consume most of the readily degradable carbohydrates and proteins. They are involved, especially, in the degradation of proteins, aminoacids, peptones and blood meal (Gaur, 1982). Nasaki *et al*. (1994) observed that introduction of thermophilic bacterium *Bacillus licheniformis* accelerated the process of composting.

Many members of the genus *Bacillus* are able to produce a range of polysaccharide depolymerase and glycoside hydrolase enzymes and are potentially able to degrade the structural polysaccharides of plant cell wall (Williams and Withers, 1985). Kimura (1992) has given a patented process for the production of organic fertilizer from coral reef, animal manure, sewage sludge and powdered plant fibre inoculated with the cultures of *Bacillus megaterium, Trichoderma* sp. and *Azotobacter vinelandii*.

Fig. 2.9. Microscopic image of *Bacillus* sp.

Pseudomonas

Pseudomonas is a gram negative, heterotrophic bacteria and cellulolytic in nature (Arora, 1998) and also produce proteolytic enzymes (Pelezar *et al.,* 1996), which convert protein in the waste to aminoacids. Some species of *Pseudomonas* are the most efficient in dissolving phosphates (Gaur and Gaind, 1999).

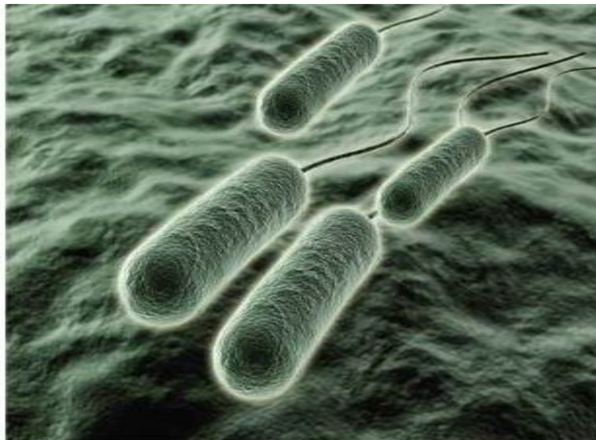


Fig. 2.10. Microscopic image of *Pseudomonas* sp.

Lactobacillus

Lactobacillus produce lactic acid from sugars and other carbohydrates. Apart from this, Lactic acid is a strong sterilizing compound and suppresses harmful microorganisms and enhances decomposition of organic matter, thereby removing undesirable effects of undecomposed organic matter (Kalpana *et al.*, 2011).

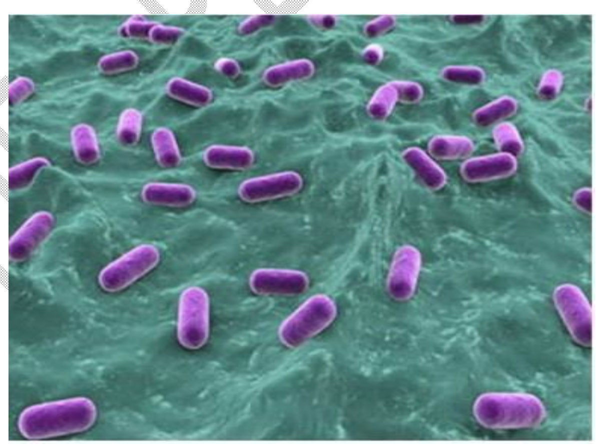


Fig. 2.11. Microscopic image of *Lactobacillus* sp.

Pleurotus

Pleurotus is a basidiomycetous lignolytic fungi capable of growing on a wide range of agricultural wastes of different compositions (Buswell *et al.*, 1996). Composting of coir pith enriched with urea and inoculated with the culture of *Pleurotus sajor-caju* has been found to be an effective way of dealing with the waste. The organism is also capable of detoxifying phenolics and producing biopolymerising enzymes (Balasubramanian *et al.,* 1995). Fungal attack on lignin polymer involves several enzymes including lignin peroxidase, manganese peroxidase and laccase (Buswell *et al.*, 1995).

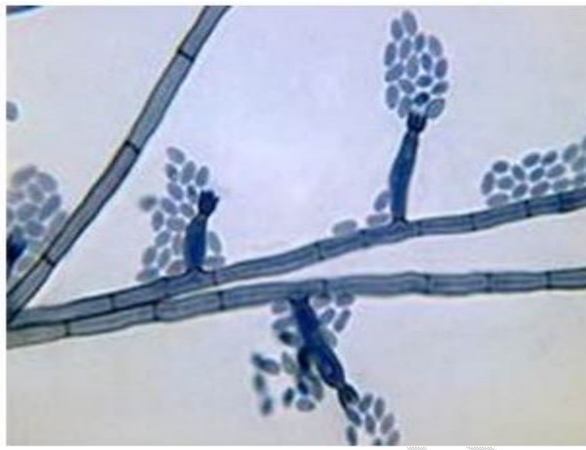


Fig. 2.12. Microscopic image of *Pleurotus* sp.

Trichoderma

Trichoderma is a mesophilic fungi capable of degrading cellulose to glucose. The cellulose complex of organism consists of three different hydrolytic enzymes-endoglucanase, which attack cellulose derivatives such as carboxymethyl cellulose and amorphous cellulose, exoglucanases and cellobiase (Sheirr Neiss and Montenecourt, 1984). Efficient cellulolytic cultures such as *Trichoderma* sp. accelerate composting by about one month (Gaur, 1987). An efficient strain of *Trichoderma* sp. shortened the composting time for rice straw by 20 days (Ramat, 1989). While studying the composting of a mixture of crop residues, grass and tree leaves, Pore *et al.* (1992) found appreciable effect of fungal inoculation on compost quality. It was also reported that *Trichoderma viride* was the best when compared to *Paecilomyces fusisporus* and *Aspergillus niger*. Inoculation with *Trichoderma viride* enhanced the organic matter degradation process and the degree of organic matter humification (Requena *et al.,* 1996).

Fig. 2.13. Microscopic image of *Trichoderma* sp.

Aspergillus

Aspergillus sp are considered as the major microbial sources for production of cellulose-degrading enzymes *Aspergillus* sp produces high amounts of β-glucosidase in the extracellular medium and is commonly used for commercial production of this enzyme. *A. terreus* NIH 2624 genome is known, and it contains genes encoding 5-exoglucanases, 22-endoglucanases, 18-β -glucosidases, and 7-xylanases and other genes with conserved domains that encode several putative cellulose-degrading enzymes and strongly establishes that multiple cellulase genes (Kumar and Bhumika 2015).

Fig. 2.14. Microscopic image of *Aspergillus* sp.

Actinomycetes

In composting, actinomycetes play an important role in degrading complex organic molecules such as cellulose, lignin, chitin, and proteins. Although they do not compete well for the simple carbohydrates that are plentiful in the initial stages of composting, their enzymes enable them to chemically break down resistant debris, such as woody stems, bark, and newspaper, that are relatively unavailable to most other forms of bacteria and fungi. Some species of actinomycetes appear during the thermophilic phase, and others become important during the cooler curing phase, when only the most resistant compounds remain. Actinomycetes thrive under warm, well-aerated conditions and neutral or slightly alkaline pH.

Actinomycetes form long, thread like branched filaments that look like gray spider webs stretching through compost. These filaments are most commonly seen toward the end of the composting process, in the outer 10 to 15 cm of the pile. Sometimes they appear as circular colonies that gradually expand in diameter.

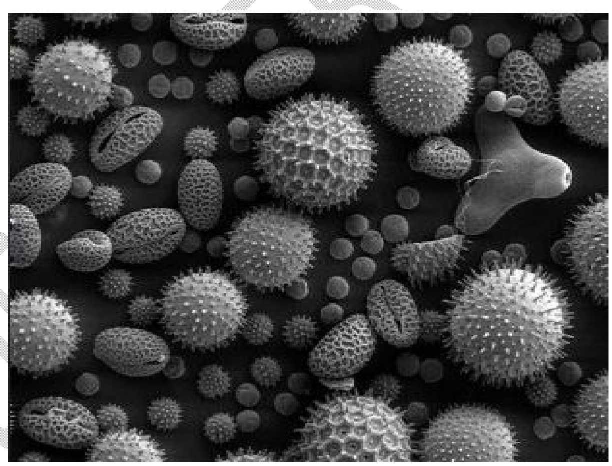


Fig. 2.15. Microscopic image of *Actinomycetes*

Different formulations of microbial inoculants

Formulation is a crucial aspect for producing inoculants containing an effective bacterial strain that can determine the success or failure of a biological agent (Bashan, 1998). Formulation typically consists of establishing the active ingredient i.e., microorganisms in a suitable carrier together with additives that aid in the stabilization and protection of the microbial cells during storage and transport, and at the target site. Whether a product is new or improved, it is imperative that the formulation be stable during production, distribution, storage, and transportation. The formulation should also be easy to use, protects the desired organism from harmful environmental factors, and maintain or enhance activity of the organism in the field (Jones and Burges, 1998). Another important consideration is the cost-effectiveness of the formulation. Therefore, several critical factors including user preference have to be considered before delivery of the final product.

Powder Formulation

Groundnut wastes, namely, shells in pulverized form, were evaluated for the suitability as carrier material for starter cultures of cellulolytic fungal inoculum designed for rapid composting of organic residues (Kolet, 2013). Zeolites are crystalline, hydrated aluminosilicates that contain alkali and alkaline-earth metals. Their structure is based on a three dimensional honeycomb negatively charged porous network of silica-oxygen tetrahedral. The negative charges are balanced with exchangeable cations of calcium, magnesium, potassium and sodium. The survival of *Pseudomonas* sp on zeolite as well as other air dried mineral powders has been reported for use in plant pathology biocontrol (De Lucca *et al.,* 1990).

Slurries

The inoculant is based on powder-type, and suspended in liquid (usually water) (Bashan, 1998).

Granulars

The inoculants are applied directly to the furrow together with the seeds. Size ranges are from 0.35 to 1.18 mm. These inoculants are popular and have been successfully commercialized since 1975 (Tang, 1994; Tang and Yang, 1997). Bead-like forms are synthetic variations of granular forms. These can be in macro sizes (1 to 3 mm in diameter) used as granules form, or in micro size (100 to 200 μm) used as a powder for seed coating. These inoculants are a new, as yet unproven, possibility in inoculation technology (Bashan, 1998).

Liquid Formulation

To overcome the problems faced with solid carrier based formulations, there is need to develop new inoculant formulations which would ensure longer survival, no contamination, ease of applicability. In recent years, many of the formulations of the liquid based inoculants are introduced which have been shown to tolerate adverse environmental conditions in a better way and are free from other problems that are encountered with solid carrier based preparations (Hynes *et al*. 2001).

Liquid bioinoculants are special formulations containing not only the desired microorganisms and their nutrients, but also, special cell protectants or substances that encourage the longer shelf life and tolerance to adverse conditions (Vora *et al.*, 2008).

Fig.. Liquid formulation of microbial inoculants

Liquid formulations typically are aqueous, oil, or polymer-based products. Polysaccharides such as gums, carboxymethylcellulose and polyalcohol derivatives are frequently used to alter the fluid properties of liquid formulations (Paau, 1988). A liquid inoculants formulation with good field performance characteristics that uses low cost materials and are easily attainable by small producers, could overcome many problems associated with processing solid carriers (Singleton *et al.,* 2002). Liquid inoculants has got wider scope, particularly in India where high cost is involved in using carriers for its transportation, pulverization, neutralization, sterilization etc. (Gupta, 2005).

Characteristics of a good liquid inoculant include non-toxicity, low cost, readily available uniform materials, adaptable to normal cell culture conditions, amenable to nutrient supplements, rapid release of microorganisms in the soil, support their growth and survival and are easily manageable in the mixing and packaging operation (Smith, 1992; Singleton *et al.,* 2002).

Basic concept of liquid formulation

Chandra *et al.,* (2000) reported that there are four basic characteristics in formulation. They are:

- To stabilize the organism during production, distribution and storage.
- To easily deliver to the field in the most appropriate manner.
- To protect the microorganism from harmful environmental factors at the target site (field), thereby increasing persistence.
- To enhance activity of the organism at the target site by increasing its activity, reproduction, contact and interaction.

Values of compost in agriculture

Compost application to agricultural soil needs to maximise agronomic benefits while protecting soil and water quality. The main determinant for efficient agronomic use is nitrogen availability (Gutser *et al.,* 2005).

Effect of organic manure on soil properties

Compost comparable to natural humus preserves the soil at minimum cost. Scientific tests showed that compost can be effective manure even though the nutritive value of the compost was less in comparison with mineral fertilizers. The organic components, presence of macro and micronutrient add to the value (Parr *et al.,* 1994).

It has been shown that the use of compost can improve the physical, chemical and microbiological characteristics of cultivated soil, reduces the water requirement for plant growth by increasing the availability of moisture and increase the crop production (Gaur and Singh, 1995).

Physical properties

The addition of organic manures improves soil texture, structure and tilth. Sandy soils become more compact whereas clayey soils become more arable (Gaur, 1982).

Composted coir pith being a source of organic matter has extremely high water holding capacity (more than 5 times its dry weight) contributing towards increased soil moisture (Biswas and Khosla, 1971).

Selvi Ranganathan and Augustine Selvaseelan (1997) reported that application of organic manures resulted in increased water holding capacity of alluvial soil, which ranged from 11.9 to 22.8 %. A marked increase in porosity values was observed in the organic manure applied plots.

The bulk density of both the surface (10-15 cm) and subsurface (15-30 cm) soil reduced to considerable extent in organic manure applied plots (Appavu and Saravanan, 1999). Organic manures increases both the soil pores favourable for water retention and specific surface of soils thereby increasing the soil water retention (Sharma and Bhushan, 2001).

Chemical properties

As compost is prepared from plant residues and their by-products, it contains all elements of which the plant is made up of. Its addition therefore, increases the total stock of these elements in the soil. It provides both micro and macronutrients. Organic manure also neutralizes the toxic effect of certain minerals like Aluminium on plants by reducing their uptake (Gaur, 1982).

In light textured soils, coir pith applied plots recorded highest CEC capacity and organic C content of the soil (Jagannathan *et al.,* 1993). Application of poultry manure either alone or with FYM increased the available N content of the soil (Amanullah, 1997).

Subbiah and Kumaraswamy (2000) studied the effect of different manure schedules on the soil properties and reported that application of organic manures had positive and significant influence on the fertility status of soil. The organic carbon content was significantly higher in the treatments that received organic manures.

The combined application of coir pith with inorganic fertilizers increased the available nitrogen content (Rani Perumal *et al.,* 1991), phosphorus and potassium content by 30 and 44 % respectively (Santhi *et al.,* 1991) and improved the potassium use efficiency of crops (Krishnakumar and Jawahar, 2001).

The availability of zinc and iron was increased by the incorporation of organic manures with no effect on the availability of manganese and copper (Appavu *et al.,* 2000).

Biological effects

Soil microorganisms

Compost carries with it a very large population of actinomycetes, fungi and bacteria and by their incorporation into soil not only are millions of microorganisms added but those already present in the soils are stimulated by the fresh supply of humic materials (Gaur, 1982).

Ammonification, nitrification and N fixation are increased due to improved microbiological activity. Compost also stimulates the mycorrhizae, which live in symbiotic association with the roots of plants and trees and play an important role in transferring certain nutrients from soil to plant (Gaur, 1982).

The soil microbes are sole agents responsible for all of the biological transformations in the soil. These are carried out through a variety of biochemical reactions carried out or catalysed by group of enzymes (De and De, 1988).

Soil enzymes

Soil enzymes activity is considered as an index of microbial activity in the soil. Therefore any management practice that influences the microbial population of the soil would be expected to produce changes in the soil enzyme activity and level of enzyme activity can be used as an indicator of soil fertility (Burns, 1982).

The measurement of dehydrogenase activity in soil gives correlating information on biological activities of microbial populations in soil (Casida *et al*, 1964). Organic manures stimulate soil phosphatase activity (Golian, 1968). Addition of organic matter increased activities of urease, catalase, dehydrogenase and amylase in soil (Garcia *et al.,* 1993; Reddy and Chhinkar, 1991).

Effect of organic inputs on crops

All crops respond to organic manuring and the extent of response depends on several factors such as degree of humification, maturity of the compost, its C/N ratio, the time and method of its application and on soil type, agro climatic conditions and moisture regime of soil during the growth of the crop (Gaur, 1982).

From various pot culture and field experiments, it is evident that increased yield and nutrient uptake were related mainly to the improved physical condition or to the nutrient contents of the organic manure or wastes (Narwal *et al.,* 1993; Kapur, 1995; Omar *et al.,* 1998).

Organic manure added plots invariably recorded 10 to 30 % higher yield than organic fertilizer alone application (Ramaswami, 1999). From the field experiment conducted at Research Farm, Department of Sustainable Organic Agriculture, Tamil Nadu Agricultural University, Coimbatore to test the effect of Jeevamruth and Beejamruth on Fenugreek, it is inferred that, the plant height, root length and single plant weight are highest in the treatment T3 (Jeevamruth @ 5% spray)(Goveanthan et al., 2020). A study was conducted to find the shelf life of panchagavya using groundnut oil cake and sesame oil instead of ghee as it is costly. Samples were collected one month after adding the ingredients and six months after the addition of ingredients. Extract was prepared and were analysed in GCMS for various biochemical properties. Derivatives of phenols, alcohols, esters and fatty acids were present in all the formulations of Panchagavya. The presence of vitamin E and gamma tocopherol in panchagavya produced with groundnut oil cake was responsible for the hindering of the rancidity of the organic product. But, fatty acids present in panchagavya prepared with sesame oil wasresponsible for rancidity thereby decreasing the shelf life of panchagavya (Sugumaran *et al.,*2018).

Field Crops

Dwivedi *et al.* (1993) reported that the application of Nitrogen through compost accelerated the metabolic activities, which enhanced the synthesis of aminoacids, protein and carbohydrate resulting in higher assimilation of these contents in black gram and wheat.

Subbaraj and Ramaswami (1995) studied the effect of organic amendments on oil yield of groundnut and recorded the highest oil content in composted coir pith treatment, which ranged from 34.7 to 47.7 %. Thilagavathi and Mathan (1995) reported an increase in panicle length, grain per panicle, root length, density and grain yield of coir pith amended soils.

Amanullah (1997) reported that the growth parameters and yield of cassava increased due to application of organic manures especially composted poultry manure either alone or with FYM. Math and Trivedi (2000) reported an increased wheat yield and grain yield in organic amended soils over control.

Horticultural crops

The results of more than thirty experiments with potato showed that there has been an increase in yield with application of organic manure varying from 4 to 30% over control (Gaur, 1982). The yield increase was also reported in Chillies, Fenugreek, Onion, Sweet potato and Tomato. Organic waste materials can be used a medium for growing cucumbers in glass house condition with encouraging results (Tzvetkove and Vargov, 1991). According to Kostov *et al.* (1995), the production of fruits on the compost applied field started 10 to 12 days earlier and compost treatments showed a significantly higher yield. Compost application has an added advantage of being suppressive to numerous plant diseases (Shyng, 1994) and weed population (Son, 1995).

Conclusion:

In conclusion, liquid formulations and compost play crucial roles in enhancing agricultural productivity and sustainability. Liquid formulations, particularly inoculants, provide cost-effective and efficient means of delivering beneficial microorganisms to the field, addressing the logistical challenges faced by small producers. They offer advantages in terms of stability, ease of application, and environmental protection. Compost, rich in organic matter and nutrients, significantly improves soil physical, chemical, and biological properties, leading to better crop yields and soil health. The use of compost enhances soil structure, moisture retention, and microbial activity, contributing to sustainable agricultural practices. Both liquid formulations and compost applications are vital for improving crop performance, supporting environmental conservation, and promoting sustainable agriculture, especially in resource-constrained settings.

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