CHAPTER V
SUMMARY AND CONCLUSION

Productivity of soils cannot be sustained with chemical fertilizer alone. Application of chemical fertilizer has led to deterioration of health and productivity of aerable soils. The realization of side effects of chemical fertilizer, when used continuously in large quantities in the absence of organic supplements, has triggered a renewed interest in India and many other countries for the use of organic manures in agriculture. The modern civilization is posing a threat to environment by way of bulk disposal of city waste. At private and government level, much attention has been paid to safe disposal of city garbage and safe use of city waste for crop production. So, recycling of different organic waste would be a good source of organic manures to increase the yield and nutrient uptake besides, ensuring hygenic disposal of the organic waste.

*Capsicum annuum* L. (Chilli)

India is the largest producer of chillies in the world. It is an important cash crop in India and is valued for its diverse commercial uses. It is grown for its pungent fruits, which are used both in green and ripe (the latter in the dried form) to impart pungency to the food. Green chillies are rich in Vitamin A and C, minerals and protein. Dry chillies are also rich in Vitamin A and D. As a condiment, it has become indispensable in every Indian home. It is also used medicinally. Its paste is externally used as rubefacient and as local stimulant for the tonsils in tonsillitis. It is used with many ingredients for local remedies. The enzyme isolated from chilli is used in the treatment of certain type of cancers. Oleoresin is used in pain balms and vaporubs.

The present research is to brighten the possibilities of assessing the efficiency of some cellulolytic fungi *Paecilomyces variotti* and *Chaetomium globosum* and actinomycetes, *Streptomyces lavendulae* and *Thermobifida fusca*
that partake in the decomposition process for the conversion of MSW and WH into an ecofriendly, nutrient enriched, cost effective biomanure. The efficacy of biomanure was analyzed on the test crop, *Capsicum annuum* L. (chilli).

The results are summarized under two heads:

I. Making of Biomanure

II. Testing its efficacy on *Capsicum annuum* L. (chilli)

1. MAKING OF BIO MANURE

1.1 β-glucosidase activity of microorganisms (extra and intracellular)

Among the microflora used in the study, β-glucosidase activities (both extra and intracellular) were much pronounced on the 6th day of incubation in the cellulolytic fungus, *Paecilomyces variotti* and actinomycete, *Thermobifida fusca*.

1.2 Compost Preparation

The composting materials [MSW (U)], [MSW (I)], [WH (U)], [WH (I)], [MSW+WH (U)] and [MSW+WH (I)] were allowed to decompose in compost pits. The physical and biochemical parameters like color, appearance, odor, pH, electrical conductivity, temperature, cellulose, organic carbon, organic matter, total nitrogen, C: N ratio, total phenol, reducing sugars and enzymes like dehydrogenase, urease and β - glucosidase were analyzed at an interval of 15 days for 90 days to assess the compost maturity.

1.2.1 Physical parameters

1.2.1.a Appearance, color and odor

Among the treatments [MSW(U), MSW(I), WH(U), WH(I), MSW+WH (U) and MSW+WH(I)], inoculated MSW+WH compost [MSW+WH (I)] was black in color, granular and fibrous with pleasant earthy smell after 90 days of decomposition, a characteristic feature of mature compost.
1.2.1. b pH and EC

The initial pH value of waste ranged from 8.15 to 8.64 and as decomposition progressed, a decrease in pH value was observed in all the treatments. At 90 days of biodegradation, the pH value of composted waste was nearer to the neutral range when compared to uninoculated treatments.

The significant decrease in pH in microbial consortium inoculated samples during 90 days of decomposition might be due to the ammonification and mineralization of organic matter through microbial activities. The significant decrease in EC in microbial consortium inoculated samples might be due to the bioconversion of organic materials into various intermediate types of organic acids and higher mineralization of the nitrogen and phosphorus into nitrites/nitrates and orthophosphates respectively.

1.2.1.c Temperature Profile

The initial temperature of all the composts ranged from 29 to 30 °C. This was followed by a gradual rise in temperature and it reached to a peak of 50.4 to 60.7 °C within 12-15 days of composting. This represented the thermophilic phase of composting. After that, it decreased gradually but remained in thermophilic range (>45 °C) up to 60-75 days, except in inoculated WH compost [WH (I)], where the thermophilic phase was of shorter duration (up to 45 days). A drop in temperature was observed which represented the cooling phase with temperature ranging from 34.6 to 42.7 °C. Finally, an ambient temperature of 29 to 31 °C was observed at the end of composting which indicated compost stability.

1.2.2 Biochemical parameters

1.2.2.a Cellulose, organic carbon and organic matter

A decrease in cellulose, organic carbon, and organic matter was recorded in all the composted waste. Among the treatments [MSW(U), MSW(I), WH(U),
WH(I), MSW+WH (U) and MSW+WH(I)], inoculated MSW+WH compost [MSW+WH (I)] showed a significant decrease which might be due to higher mineralization of organic matter and the decomposition process by micro flora which led to stabilized end - products, a slow released organic manure for crops.

1.2.2.b Total nitrogen

Nitrogen is an important nutrient for composting process and its quantity determines the growth of microorganism population. Among the inoculated and uninoculated treatments, the total nitrogen content showed a significant increase in microbial consortium inoculated MSW+WH sample after 90 days of decomposition. The apparent increase in total nitrogen content in the biocompost was not only due to enhancement of nutrients but also due to the mineralization of organic matter by microorganisms. The increase in total nitrogen content added agricultural significance to MSW+WH biocompost because organic manure with high nitrogen content was a welcoming trait for enhancing the yield of agricultural crops.

1.2.2.c C :N ratio

A drastic reduction in C:N ratio was observed in inoculated MSW+WH (I) treatment. The drastic reduction in C: N ratio (14:1) of inoculated MSW+WH treatment was due to microbial consortium treatment which contained efficient decomposing organisms and it enhanced carbon oxidation and mineralization. The low C: N ratio indicated stabilization, maturity and the manural value of the decomposed MSW+WH biocompost.

1.2.2.d Total phenol and reducing sugars

A significant reduction in total phenolic content and reducing sugars were registered in inoculated MSW+WH biocompost, which might be due to metabolic activity of cellulolytic and actinomycetous organisms that partake in the
degradation process, which utilized sugar as their carbon source and indicated the antitoxicity effect of the compost for application to agricultural crops.

1.2.2.e Enzyme activity

Dehydrogenase, urease and β-glucosidase activities showed a significant increase up to 60 days and the enzyme activities gradually declined over 90 days of degradation in inoculated MSW+WH than the other treatments. The increase in enzyme activities to a certain period (60 days) might be due to an increase in microbial metabolism in the compost, as a result of the mineralization of biodegradable carbon fractions found in the MSW+WH biocompost and the decrease in enzyme activities indicated depletion of easily available sources of carbon, nitrogen and energy for microorganisms, stability of organic matter and consequently, attainment of maturity by the compost.

1.2.3 Comparitative analysis of composted MSW, WH, MSW+WH and commercial organic manure

The inoculated MSW [MSW (I)], inoculated WH [WH (I)] and inoculated MSW+WH [MSW+WH (I)] were compared against commercial organic manure (marketed by a private company), which was produced from the same waste and was procured from Vellalore Municipal Corporation waste disposal yard, Coimbatore. Among the composted waste, MSW+WH (I) was found to be an efficient biomanure, because of the reduction in cellulose, organic carbon, organic matter, C: N ratio, total phenol, reducing sugars and significant increase in total nitrogen content and enzyme activities.

2. Testing the efficacy of biomanure on Capsicum annuum L. (chilli)

2.1 Germination percentage and vigor index

Germination percentage and seedling vigor indicated the maturity of compost and phytotoxicity effect of compost extracts on Capsicum annuum L.
seeds (chilli). Germination percentage and vigor index of T₅ treatment [MSW+WH (I) biocompost] were higher when compared to other compost extracts [T₁ -control, T₂ - commercial organic manure, T₃ -MSW(I) biocompost and T₄ -WH (I) biocompost].

The higher values of germination percentage and vigor index in T₅ treatment suggested that MSW+WH biocompost was mature and did not pose any toxic effect on the plant growth, as phytotoxic inhibitors had been eliminated. The application of immature compost to soil might inhibit seed germination, cause net immobilization of soil nitrogen into the microbial mass and might induce N deficiency in crops.

2.2 Pot culture experiment

A pot culture experiment was conducted with *Capsicum annuum* L. (chilli) as the test plant to evaluate the influence of inoculated biocompost [MSW (I) biocompost, WH (I) biocompost and MSW+WH (I) biocompost]. The biocompost effect on test plant was compared against a standard check, NPK, commercial organic manure and absolute control.

2.2.1 Biometric parameters

The biometric parameters analyzed on the test plant at 30, 60, 90 and 120 DAS (Days After Sowing) were plant height (cm), root volume (cu.cm), number of leaves/plant, fresh and dry weights of plants (g) and number of flowers/plant. All the biometric parameters showed a statistically significant increase in T₆ treatment [MSW+WH (I) biocompost]. The increase in biometric parameters in T₆ treatment of chilli could be due to the presence of nitrogen, macro and micronutrients found in MSW+WH compost in available forms. Nitrogen, an active constituent of protoplasm, enzyme, chlorophyll etc act as a catalytic agent in accelerating cell division and the photo assimilation which in turn, boosts the plant growth thus improving the plant building structures.
2.2.2 Yield parameters

The yield parameters like number of fruits/plant, length of fruit (cm), fresh and dry weights of fruit (g), number of seeds/fruit and hundred seed weight (g) were analyzed at 90 and 120 DAS (Days After Sowing). Among the treatments, T₆ treatment [MSW+WH (I) biocompost] showed a significant increase in yield parameters which might be attributed to the fact, that the incorporation of compost (MSW+WH) into the soil increased microbial population, enzymatic activity, photo assimilation and released nutrients at a slow and steady rate. The use of MSW+WH compost enhanced the humus content and improved soil conditions resulted in healthier and more nutritious status of plants.

2.2.3 Biochemical parameters

The biochemical parameters of test plant determined at 30, 60, 90 and 120 DAS were chlorophyll, total protein and total carbohydrate. The biochemical parameters showed an increase up to 60 days and after that, they declined gradually. T₆ [MSW+WH (I) biocompost] treatment attained a significant increase when compared to other treatments. The incorporation of MSW+WH compost enhanced the nitrogen content of the soil, which was an important constituent of compounds like aminoacids, ATP, ADP, chlorophyll and enzymes. The increase in chlorophyll, protein and carbohydrate upto 60 DAS might be due to the enhanced amount of microbes present in compost which enhanced faster decomposition of organic matter there by, enabling increased availability of nutrients especially nitrogen, amino acids, enzymes and vitamins. The decline in chlorophyll, total protein and total carbohydrate were due to breakdown of protein, ageing of the leaves and microbial cell lysis and their utilization for flower and fruit formation.

2.3 SOIL PROFILE
2.3.1 pH, EC and NPK in initial and post-harvest soil samples of test plant, *Capsicum annuum* L.(chilli)

The increase in pH, EC and available NPK levels in T₆ [MSW+WH (I) biocompost] treatment were probably due to the production of NH₄ during proteolysis by microbes and also due to progressive increase in mineral constituents of WH and MSW+WH compost incorporation into the soil. WH as a green manure increased the availability of NPK through the mechanism of reduction, chelation, water retention capacity and favourable changes in soil pH and microbial population.

2.3.2 Enzyme activities in initial and experimental soil of chilli (30, 60, 90 and 120 DAS)

Dehydrogenase, urease and β-glucosidase enzyme activities were much pronounced in T₆ [MSW+WH (I) biocompost] treatment which showed maximum activity at 60 DAS and declined at 90 and 120 DAS. The increase in enzyme activities up to 60 DAS might be due to increase in microbial metabolism in the soil, as a result of mineralization of biodegradable carbon fractions contained in MSW+WH compost and the decrease at harvest might be due to its utilization by plant and microbes.

**CONCLUSION**

- MSW+WH biomanure produced by the degradation of cellulolytic organisms like *Paecilomyces variotti*, *Chaetomium globosum*, *Streptomyces lavendulae* and *Thermobifida fusca* was found to be an efficient organic manure compared to commercial organic manure produced from the same Municipal Corporation yard waste, as it enhanced the biometric, yield and biochemical parameters of *Capsicum annuum* L.
• The enhancement in growth and yield parameters of chilli might be due to the synergistic interaction of constituents present in MSW and green manure (WH).

• Thus, it can be inferred from the present investigation that municipal solid waste and water hyacinth, a menace can be effectively harnessed as a value added product, organic manure.

• The treatment of MSW and WH with cellulolytic microorganisms led to more efficient degradation of this waste material, which would promote cycling of nutrients in the environment and reduce the impact of waste accumulation on terrestrial and aquatic ecosystem.

• This technology would therefore, provide an alternate solution for the disposal of municipal solid waste and water hyacinth in Coimbatore city.

• The cost effective, pilot study of composting municipal solid waste and water hyacinth by cellulolytic degraders can be carried out on a large scale.

• This research would provide a new source of revenue to SHG and entrepreneurs who could turn all the waste that they have access to, into cost effective, value added organic manure.

• A profitable business can be build up using this technology, as 19.2 kg of efficient biomanure was obtained from 50 kg of inoculated MSW+WH waste.

• Water hyacinth contains considerable amounts of available potassium, it can be used as an inexpensive source to enrich compost. Currently coconut husk and other nut pericarps are used which is in limited supply and hence becoming expensive so the critical obstacle faced by farmer to find a good organic source of potassium could be solved.
RECOMMENDATIONS FOR FUTURE STUDY

- The root system of water hyacinth accumulates large quantities of inorganic nitrogen and phosphorus. So, it can be used either as a green manure or mixed with municipal solid waste and ash and composted by microbes to produce nutrient enriched, pathogen free organic manure. It can be sold to local farmers and gardeners which is an elegant solution to the problem of water hyacinth proliferation and water pollution.

- The biomanure can be tested on other plants with leafy vegetables that need high nitrogen supply within a short time period.

- The biomanure can be enriched with phosphorus, as the study shows that the release of phosphorus is less in the process when compared to N and K.