Introduction
CHAPTER I

INTRODUCTION

Waste is an unwanted material thrown out on streets and roads. Waste is a pejorative term for unwanted materials. Wastes are substances or objects that are discarded or intended to be disposed by the provisions of National Law (Basel Convention, 1989). The average waste generation in Indian cities is about 500 g per day (CPCB, 2000). Wastes are generated during the extraction and processing of raw materials to get intermediate and final products. Waste is also generated during the consumption of final products, and other human activities. The recyclable or reusable at the place of generation are excluded. (UNSD, 1997).

The quantity and the composition of Municipal Solid Waste (MSW) vary in accordance with the socio-economic status and customs, climate, location, civil structure, density of population and nature of non-residential activities. MSW Management is one of the integral parts of urban planning and development that requires stake holder’s contribution to arrive at a technically feasible, cost effective, resource generating, compact, eco-friendly and pollution free scientific system. In addition to land filling, source reduction, resource recovery, recycling and incineration are the alternate strategic options for the urban planners to choose in lieu of open dumping (Swana, 2001).

In 1947, cities and towns in India generated a calculated million tonnes of solid waste; in 1997 it was 48 million tonnes. More than 25% of the MSW is not collected at all, 70% of the Indian cities need adequate capacity to transport it and there are no sanitary landfills to dispose of the waste. Indian cities generate 300-400 g/capita/day solid waste and of which only 60-80% of the waste is collected on daily basis and rest of the waste is left to decay on the streets, roads, drains etc., which attracts vector transmitting diseases (Geetha, 2007). The per capita generation of MSW also vary from one country to another country viz in the United States, municipal refuse is generated about 2 kg per person per day whereas Japan half this amount, but in Canada it is 3 kg per person per day. In some developing countries, the average rate can be lower than 0.5 kg per person per day (Jerry, 2003). In India,
there are 104 big cities and 295 small cities which are generating about 1,88,500 tonnes of MSW per day. In Tamil Nadu, there are 12 Municipal corporations including Corporation of Chennai and 124 municipalities. The per day generation of MSW in Tamil Nadu is about 10,870 tonnes excluding the garbage generated from the Corporation of Chennai (Ready Reckoner, 2008). The daily generation of garbage from the corporation of Chennai is about 6404 tonnes. Rapid industrialization and population explosion in India has led to the migration of people from villages to cities, which generate thousands of tonnes of MSW daily. The MSW amount is also increasing significantly as the country strives to attain an industrialized nation status by the year 2020 as predicted by Shekdar et al. (1992); CPCB (2004); Sharma and Shah (2005).

The waste can be classified into two namely, solid waste and liquid waste. Solid waste means any garbage, refuse, sludge from a wastewater treatment plant or water supply treatment plant or air pollution control facility and other discarded materials including solid or semi-solid, resulting from industrial or commercial or mining and quarrying or agricultural operations or from community activities. Liquid waste can be defined as such fluids as wastewater, fats, oils or grease, used oil, and hazardous household liquids. The territory’s landfills and transfer station do not accept liquid waste of any type (VIWMA, 2011).

Solid wastes are of different types. It can be classified depending on their origin and form. The different types of solid wastes based on their origin are MSW, hazardous waste, industrial waste, e-waste, biomedical waste and agriculture waste. MSW consists of construction and demolition debris, household waste, sanitation residue and waste from streets. This garbage is generated mainly from residences and commercial complexes. With the increase of urbanization and change in socio-economic system, lifestyle and food habits, the amount of MSW has been increasing rapidly and its composition is getting changed. MSW more commonly known as trash or garbage consists of everyday items such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint and batteries (Milestones in Garbage, 1990). Domestic and commercial wastes are commonly termed municipal solid wastes (MSW) and both account for a relatively small part of the total solid waste stream in developed countries (White, 1995), whereas it is the bulk of the waste in Nigeria (Adewumi, 1997).
Among the different types of solid waste, industrial and hospital waste is considered hazardous as they may contain toxic substances. Certain types of household waste are also hazardous. Eco-friendly management of hazardous wastes has become a major concern in India, because random dumping of hazardous wastes severely impairs the environment. The adverse effects of hazardous wastes as well as the significant potential risks posed by them to the life and its supporting systems are increasingly recognized (CPCB, 2003). India generates around 7 million tonnes of hazardous wastes every year, most of which are concentrated in four states viz., Tamil Nadu, Andra Pradesh, Uttar Pradesh and Bihar. Household wastes that can be categorized as hazardous wastes include old batteries, shoe polish, old medicines, medicine bottles and paint tins. The major industries generating hazardous waste are the chemical, pesticide, metal, paper, rubber good industries, refining and dyes. Direct exposure to hazardous waste such as mercury and cyanide are fatal. The term biomedical waste refers to waste generated during medical diagnosis, treatment or immunization of human beings or animals and in the production or biological testing and alike in the Health Care Institutions (Baverja et al., 2000). The Health Care Wastes (HCW) is categorized as infectious and non-infectious (Saini and Dadhwal, 1995) but not all HCW are not potential to transmit infection. It is estimated that 80-85% is non infectious waste, 10% is infectious and 5% is hazardous waste (CPCB, 2000).

Electronic waste or e-waste or e-scrap, or electrical waste is discarded electrical or electronic devices. There is a lack of consensus as to whether the term should apply to resale, reuse, and refurbishing industries, or only to product that cannot be used for its intended purpose. Informal processing of electronic waste in developing countries may cause serious health and pollution problems, though these countries are also most likely to reuse and repair discarded electronic and electrical devices.

There are two types of wastes based on their form, namely, recyclable waste and non-recyclable waste. Recyclable waste materials are subjected for reprocessing, to make some useful products. The non-recyclable materials and inert materials are disposed at landfill sites. Recycling is a process of resource recovery practice that
refers to the collection, segregation and reuse of waste materials. The materials recovered can be reprocessed into new products. Materials for recycling may be collected separately at source with the use of dedicated bins and separate collection vehicles which are sorted directly from mixed waste streams and are known as kerb-side recycling. The most common consumer products to be recycled include aluminium plates, aluminium paper, beverage cans, copper wire, steel, food and aerosol cans, old steel furnishings or equipments, polyethylene and PET bottles, glass bottles and jars, paper board, cartons, news paper, magazines, light paper and corrugated fibre board boxes.

PVC, LDPE, PP and PS are also recyclable. These materials are usually simple in composition which enables for easy recycling into new products. The recycling of complex products like computers and electronic equipment is more difficult, because it requires additional dismantling and assembling. The type of material accepted for recycling varies from city to city and country to country. Each city and country has its own recycling programme that will aid to handle various types of recyclable materials. However, certain variation is reflected in the resale value of the material once it is reprocessed.

Recyclable materials that are organic in nature, such as plant material, food scraps, kitchen waste, farm waste etc. can be recovered through composting and digestion processes. The resulting organic manure is then reused as such or as compost for agricultural or landscaping purposes. In addition, waste gas (such as methane) generated can be captured and used for producing electricity. The intention of biological processing of waste is to control and accelerate the natural process of decomposition of organic matter.

The energy content of waste can be harnessed by using them as a combustion fuel, or indirectly by processing them into another type of fuel. Thermal treatment ranges from using waste as a fuel source for cooking or heating and the use of the waste as fuel in boiler to generate steam and electricity in a turbine. Pyrolysis and gasification are similar forms of thermal treatment where waste materials are heated to high temperatures with limited oxygen supply. This process is usually done in a sealed vessel under high pressure. In Pyrolysis, solid waste is converted into solid,
liquid and gaseous products. The liquid and gases obtained can be burnt to produce energy or refined into value added other chemical products (chemical refinery). The solid residue (char) can be further refined into value added products such as activated carbon. Advanced Plasma arc and gasification can be used to convert organic materials directly into a synthetic gas composed of carbon monoxide and hydrogen. This gas is then burnt to produce electricity and steam.

Resource recovery uses LCA (life cycle analysis) attempts to offer alternatives to waste management. For mixed MSW, a number of broad studies have indicated that administration, source segregation and collection followed by reuse and recycling of the non-organic fraction and production of energy and compost/fertilizer from the organic fraction via anaerobic digestion.

Waste management practices may be different for developed and developing countries, for urban and rural areas, and for residential and industrial producers. Management of non-hazardous residential and institutional waste in metropolitan areas is usually the responsibility of local government authorities, while handling and management of hazardous, commercial and industrial waste is usually the responsibility of the generator subject to local, national or international controls. The solid waste sources could be urban or rural. The waste from the rural area is often rich in organic matter and easily bio-degradable, the composting of urban waste is based on the culture and practices of society (Chandrappa and Das, 2012) which varies among and within countries.

A lot of methods are available for the disposal of MSW. They are open dumping, landfills, composting, biomethanisation, power generation, pyrolysis, incineration, etc., The cheapest and the oldest easy method of MSW disposal is *open dumping* where the waste is dumped in low lying areas and levelled by bull - dozers from time to time. Open dumping is not a scientific way of waste disposal, where the waste is untreated, uncontrolled and unsegregated and there are no environmental controls. Open dumping is a method of disposing the waste in a landfill which involves burying the waste, and this remains a common practice in most countries.

The open dumping of MSW on roadsides and water bodies, continuous accumulation on dumping yards and unsafe disposal methods are causing degradation of lands, pollution of surface and underground water. The floating of solid wastes in
the atmosphere and unpleasant odour and noxious gases evolved during incomplete decomposition making the air polluted and contributing for global warming and other environmental degradation. The open dumping and improper handling and unscientific disposal methods of MSW is a serious nuisance, damaging the environment, polluting water and soil, interfering with the productivity of ecosystems which will tend to cause ecological imbalances and affects the sustainability of life on earth.

Pyrolysis is a case of thermolysis, and is most commonly used for organic materials. The pyrolysis of wood, which starts at 200–300°C (390–570°F) occurs for example in fires, where solid fuels are burning or when vegetation comes into contact with lava in volcanic eruption. In general, pyrolysis of organic substances gives gas and liquid as end products and leaves a solid residue richer in carbon content. High temperature pyrolysis, which leaves mostly carbon as the residue, is called carbonization.

The term composting, or aerobic biological treatment, is used to define bio-degradation under controlled aerobic conditions. This process is used for the stabilization of wastewater solids prior to their use as a solid amendment or mulch in landscaping, horticulture and agriculture (EPA, 2000). Among the various methods available for the disposal of MSW, the composting is found to be effective and eco-friendly. The composting is a recyclable process which involves the biological degradation of green MSW. The end product of composting is good organic manure rich in humus and essential plant nutrients which will be used for the promotion of organic farming. Bio-degradation is a natural and ongoing biological process that is very common in both man-made and natural environments. During composting, microbial decomposition aerobically transforms organic substrates into a stable, humus-like material (Brown and Subler, 2007).

Composting is a viable option, and the various positive outcomes of composting are simplicity in technology, environmental friendliness, cost and many other benefits (Tchobanoglous et al., 1993; Agamuthu, 2011). Compost enhances the slow release of necessary minerals and improves the soil physical and chemical characteristics and acts as a soil conditioner, thereby promotes the growth and
yield of crops. (Jakobsen, 1995; Brinton, 2000; Lynch et al., 2006). Composting has been increasingly popular as an alternative to dispose waste in these recent years as a benefiting waste recycling option (Agamuthu, 1997; Agamuthu et al., 2004; Gabrielle et al., 2005). Composting reduces the waste and stabilizes the nutrients and converts it into safe end products which add economic value to the final product (Jakobsen, 1995; Schenkel, 1996). The composting is a bio-degradation process which is brought about by several organisms such as bacteria, fungi, actinomycetes and protozoa and may also involve invertebrates such as nematodes, pot worms, earthworms, mites and various other organisms. (Macdonald et al., 1981).

There are various methods of composting. They are aerobic composting consisting of vermicomposting, windrow composting, street composting and anaerobic composting consisting of pit composting, anaerobic digestion, etc., Composting is a controlled process of decomposition used to transform complex organic materials such as kitchen scraps, yard wastes and other bio-degradable waste into stable organic manure rich in humus. Humus or compost is a dark, soil-like substance that enriches soil with nutrients, increases porosity and water holding capacity, improves soil structure and provides a good environment for the growth of beneficial soil organisms. Biological processes like composting and anaerobic digestion have advantages over other technologies due to its natural treatment process.

Anaerobic digestion is a waste treatment and resource recovery process. Anaerobic digestion also showed an excellent life style analysis performance when compared to other treatment technologies such as composting, incineration, etc., since it can improve the energy balance (Meta-Avarez, 2003). Biomethanation of organic fraction of MSW including vegetable market waste is in practice in most of the countries in EU. In view of the inherent characteristics of vegetable market wastes, biomethanation is seemed to be a lucrative process of bio-energy generation and manure production in recent years under Waste-to-energy programme (Sri Bala et al., 2007).

Anaerobic digestion is used for industrial or domestic purposes for the scientific management of waste and/or to recover energy. Most of the fermentation
used industries to produce food and drink products, as well as home fermentation, uses anaerobic digestion. Silage is produced by anaerobic digestion. Methanogens convert these products into methane and carbon dioxide as end products. The methanogenic bacterial population play an indispensable role in anaerobic waste water treatments (Meisam et al., 2010).

Pit composting is one of the simplest ways of eco-friendly disposal of bio-degradable wastes. In this method, dig a one foot deep pit, chop the green waste, mixed the waste, put into the pit and cover the sample with a thin film of soil. Depending on soil temperature, the ample microorganisms in the soil and the composting materials bring about decomposition and it will occur in one month to one year. Windrow composting is an aerobic bio-degradation process in which compost is produced by piling organic matter or bio-degradable waste, such as animal manure and crop residues in long rows. This method is suitable for producing large quantities of compost. These rows are generally turned to improve porosity, oxygen content, remove moisture, and redistribute cooler and hotter portions of the pile. Windrow composting is controlled by the parameters include the initial C:N ratio of carbon and nitrogen rich materials, the amount of bulking agent added to assure air porosity, the pile size, moisture content and turning frequency. The temperature of the windrows must be measured constantly to determine the optimum time to turn the windrows for quicker compost production (Coufal, 2008).

Vermicompost is the product obtained by the bio-degradation of organic matter by composting utilizing various species of worms, usually red wigglers, white worms and earthworms to create a heterogeneous mixture of decomposed vegetable or food waste (excluding meat, dairy, fats, or oils), bedding materials and vermicast. The other terms to denote the vermicompost are worm castings, worm humus or worm manure, which is the end-product of the breakdown of organic matter by species of earthworm (Daniel, 2009). Vermicomposting has gained popularity in both the industrial and domestic settings because, when compared to other methods of composting, this method enhances the quick decomposition of organic materials. (Lazcano, 2008).
Landfills are generally located in urban areas where a large amount of waste is generated and has to be dumped in a common place, because of non-availability of treatment facility for scientific disposal of waste. The most important environmental hazard due to landfill leachate is contamination of ground water. The leachate is being the long lasting problem of landfills (Kylefors et al., 2003). Therefore, the potential of ground water contamination hazard in different waste sites can be considered as an appropriate basis for their prioritisation. In most of the places, the existing landfills are neither well equipped nor well managed and are not lined properly to protect against contamination of soil and ground water.

In India, some municipal areas have banned the use of plastics and they seem to have achieved success. For example, today one will not see a single piece of plastics in the entire district of Ladakh where the local authorities imposed a ban on plastics in 1998. In Tamil Nadu usage of plastics has been banned and put it into practice in Ooty and Kodaikannal Municipalities. The other states in India and remaining municipalities in Tamil Nadu may follow the methods of Ladakh district and Ooty and Kodaikannal municipalities to ban the use of items that cause harm to the environment. One positive note is that in many larger cities, shops have begun the practice of packing in reusable or biodegradable bags.

In India, scientific and eco-friendly management of municipal solid waste is under stress, similar to that of other infrastructural services, it is still considered low priority areas. The solid waste management was never taken up seriously neither by public nor by agency or authorities and now the large amount of waste is threatening our heath, environment and well being (Mazumdar, 1994; Chouhan and Reddy, 1996). The Municipal solid waste poses a serious concern nowadays due to lack of attention on the use of proper technology or method for the effective handling and eco-friendly management of municipal solid waste on scientific lines. This leads to the degradation of land and impairing the quality of air and water. The overall effect of improper management of MSW is making the environment unsuitable for life on earth. The improvement of solid waste management is one of the greatest challenges faced by the Indian Government. The Government and the local municipal authorities have taken many initiatives towards the improvement of the current situation (The Expert Committee, 2000).
The hazardous effects caused due to improper handling and unscientific management of MSW attracted the attention of the scientists, environmentalists, rulers, beaurocrats, politicians, NGOs, etc., to find out a solution and suitable strategy on scientific lines for the proper handling and eco-friendly management of MSW with a view to sustain the quality of natural resources and to protect the natural environment without any damage to enable the future generation to harvest the fruits from the preserved universe to fulfil their basic requirements in this challenging world. In these circumstances, with a view to fulfil the requirements for the effective and eco-friendly management of the municipal solid waste and the use of its end product namely, compost manure for organic farming, the present study has been undertaken with the following objectives.

Objectives of the study

- Characterization of Municipal Solid Waste (MSW) for its ameliorative and nutrient value
- Development of eco-friendly methods for the disposal of MSW using Bio-accelerators and microbial consortia for the production of marketable bio-manure
- Evaluation of compost maturity with nutrient analysis
- Evaluation of bio-manures on fertility and productivity of the chosen crop.