2.0. REVIEW OF LITERATURE

The literature pertaining to the study on, “Sensitizing Women on Solid Waste Management through Vermicomposting Technology”, are reviewed under the following headings:

2.1. Solid Waste Management: Issues and Challenges
2.2. Vermicomposting - Eco-friendly Waste Disposal and Recycling Revolution
2.3. Role of Earthworms in Waste Management
2.4. Vermicomposting: A Livelihood Micro-enterprise for Women

2.1. Solid Waste Management: Issues and Challenges

Modern times have plagued the humanity with new problems due to industrialization and simultaneous population explosion. Pollution has come to the forefront and has become a major threat to the very existence of mankind (Ramjee, 2005). The cry of pollution is heard from all corners of the world and it is the major challenge of our times (Sharma, 2004). The word pollution is derived from the Latin word pollutionem, meaning to defile or make dirty (Tripathi and Ranigovil, 2001). Today, pollution is widespread, substantial and real that the cry of ‘Pollution’ is heard from all the nooks and corners of the world and the very existence of life is at stake (Prabhakar, 2001). Pollution is an undesirable change in the physical, chemical, and biological characteristics of air, land and water which harmfully affects human life, industrial progress, living conditions and cultural assets. Though pollution by natural processes is known, the man made pollution poses a real threat to the mankind (Tripathi et al., 2002 and Chatterjee, 2006).
The environment is infested with different kinds of pollutants and is one of the major problems in all the major cities of the developing countries including India (Mukhopadhay et al., 2005). The quality of environment in India is rather substandard due to the dual problems - population growth and poverty, giving rise to environmental problems like denudation of forests, over grazing, pollution, poor environmental hygiene, malnutrition and communicable diseases (Sundar, 2002). The effect of environmental pollution is not only on India but encompasses the whole world. The environmental damage is now assuming a dangerous portion throughout the world. It arises due to rapid industrialization, urbanization, transportation, over population and lack of public awareness. It causes significant imbalance in all the natural activities (Verma et al., 2006). In cities the municipal services, such as water supply and sanitation, drainage, treatment and disposal of waste water, management of solid and hazardous wastes, supply of adequate and safe food and housing are unable to keep pace with urban growth. All these in turn lead to an increase in the pollution levels (Ganesamurthy and Paari, 2006).

Waste management is a challenging problem in all countries, more so in developed countries. Domestic waste from urban areas, without proper planning, is turning to be a problem unconquered (Lakshmanan, 2009). Organic wastes, which are produced in large quantities all over the world, create major environmental and disposal problems. These materials cause major unpleasant odour problems and use of large quantities of land for disposal and are often a source of contamination of ground water (Edwards and Bater, 1992, Kannaiyan and Lilly, 1999). Road side garbage from houses remains uncleared because its volume is more than what the corporation can handle. Rag pickers, stray animals
and birds scatter the garbage, looking for items useful to them. This results in the familiar site around the street corners of most towns and cities (Mani, 1996). The waste accumulation has increased simultaneously with the rapid increase in residential colonies, fast food outlets, vegetable vendors, fruit shops and other customer outlets in the respective areas. Garbage is also dumped in huge plastic bags that obstruct the traffic. Viswanathan (2005) says that the amount of large solid refuse has been gradually increasing and its treatment and disposal has become a major social and environmental problem as well as a challenge.

Problems of the environment and domestic hygiene are always related to poverty of population and the sanitation of settlements (Petrella, 2005). Most cities and towns in developing countries are characterized by overcrowding, congestion, inadequate water supply and inadequate facilities of disposal of human excreta, waste water and solid wastes. Inadequacy of housing for the urban poor invariably leads to poor home hygiene. Personal and domestic hygiene practices cannot be improved without improving basic amenities such as, water supply, waste water disposal, solid waste management and the problems of human settlements (Nath, 2003).

The insanitary methods adopted for disposal of solid wastes is a serious health concern with significant environmental, social and health costs associated with it. Open dumping of garbage facilitates the breeding of disease vectors such as flies, mosquitoes, cockroaches, rats, and other pests. Further, the poorly maintained landfill sites are prone to groundwater contamination because of leachate production (Maheswari, 2005). The recent estimates indicate that nearly two billion people (about a third of world’s population) are without adequate basic
facilities and by 2010 the number may increase to three billion. Waste generation increases with population expansion and economic development. Solid waste generation is one of the serious environmental issues in urban areas needing special attention (Rao, 2004). Today solid wastes are considered as one of the major sources for pollution in the human environment. Various types of pollution is spreading all over the world, posing various types of threats. The solid waste generated due to the human activities causes enormous environmental damages to the soil and water sources. The disposal of wastes causes serious water and land pollution (Setua et al., 2008). Improperly managed solid waste poses a risk to human health and the environment. There should be no doubt that a thickly populated area is the home of a large number of vehicles, reservoir for solid and liquid wastes, with poor sanitary conditions and management problems (Ramjee, 2005).

In fact, waste is a misplaced resource and it is not possible to destroy in toto. Actually, there is no waste in the natural world. Every possible substance use and throw away comes back as new and different material. Materials discarded after use may come to only two possible ends. One is discharge into the environment and the other is reuse or reclamation or recycling. Conditioning of organic waste can help in pollution abatement (Mani, 1996). Planning for and implementing a comprehensive program for waste collection, transport and disposal along with activities to prevent or recycle waste can eliminate these problems. Even under the prevailing conditions, there is significant scope for improving hygiene practices to prevent infection and cross infection (Nath, 2003).

Waste has created a plethora of problems in developing countries, as they themselves are facing problems in treating inhouse waste
generated (Anantharaman and Balaguru, 2008). India is on the brink of a massive waste disposal crisis, but solutions are not forthcoming. Urban India is likely to face a massive waste disposal crisis in the coming years. Till now, the problem of waste has been seen as one of cleaning and disposing as rubbish. But a closer look at the current and future scenario reveals that waste needs to be treated holistically, recognizing its natural resource roots as well as health impacts. Developing countries, such as India, are undergoing a massive migration of their population from rural to urban centers. New consumption patterns and social linkages are emerging. India, will have more than 40 per cent, (i.e. over 400 million people) clustered in cities over the next thirty years (UN, 1995).

Cities and towns in India generated an estimated six million tones of solid waste. In India, generation of municipal solid waste (MSW), industrial hazardous waste and biomedical waste have been increasing due to population growth, life style changes and economic development. On the other hand, waste management responses have not kept pace with the increasing quantities of waste resulting in a high proportion of uncollected waste, and poor standards of transportation, storage, treatment and disposal (Malarvan, 2005). Most local governments and urban agencies have identified solid waste as a major problem that has reached proportions requiring drastic measures. Municipal solid waste consists of household waste, construction and demolition debris, sanitation residue and waste from streets. This garbage is generated mainly from residential and commercial complexes. With rising urbanization and change in lifestyle and food habits, the amount of municipal solid waste has been increasing rapidly and its composition changing (www.wastetreatmentinfo.com/recycling-garbage.html).
Solid waste generation in India was 229 million tons in 2001 and solid waste generation per capita per day in India ranged from 100 to 500 grams (Arrifa and Jayalakshmi, 2005). According to a study by The Energy and Resources Institute (TERI), the annual per capita municipal solid waste generation in India is projected to grow from 1 to 1.33 per cent, which would lead to a generation of over 260 million tones of waste by 2047 - a five fold increase over 1997 levels. It is further projected that an additional 1400 km$^2$ of land is needed to dispose this waste, most of it in urban areas. Modern urban living brings on the problem of waste, which increases in quantity, and changes in composition with each passing day (Singh and Shekhawat, 2000).

Preliminary surveys on the municipalities’ preparedness of implementing the MSW rules 2000 show that majority of the cities are yet to embark on city level implementation of door-to-door collection of waste, source segregation, composting of organics, recycling and creating engineered and safe landfill sites for residual waste disposal. The municipalities were given three years time to make preparations but have not woken up to regard the apex court’s verdict. The municipalities in India therefore face the challenge of reinforcing the available infrastructure for efficient MSW management and ensuring the scientific disposal of MSW. However, this seems to be a complex task considering low awareness levels and precarious financial situation that most urban governance institutions are afflicted with. As far as MSW management is concerned, municipalities could achieve financial self sufficiency through appropriate user charges from the waste generators or by identifying activities that generate resources from waste management.
It has been estimated that overall municipal waste generated in urban centers, anywhere between 45 to 75 per cent constituted organic matter. It is also important to note that waste consumption varied significantly across areas of different economic levels of residents. The per capita solid waste reaching disposal sites in Bombay, Calcutta, Chennai and New Delhi ranges from 0.45 to 0.6 kilogram per person per day. While in other Indian cities it is from 0.15 to 0.53 kilogram per person per day (Manimozhi et al., 2006). It is established that about 500 grams of biodegradable kitchen waste is generated per day in a family consisting of four members. The sanitary condition in rural areas is very poor. Heaps of garbage and leftovers pollutes the environment particularly in villages and slums steeped in poverty, ignorance and squalor, brings about unbearable sight (Gupta, 2002).

Garbage is an unavoidable consequence of prosperous, high technology industrial world. It is a problem not only in India but throughout the world. The daily garbage production has increased causing a big problem to the municipalities. Each household produces solid wastes, which can be broadly classified as biodegradable (vegetable and fruit peels, leftover food etc) and non biodegradable (plastic bags, metal containers and glass bottles and hazardous or toxic wastes) (Venkataratnam, 2001). The household wastes include seeds of fruits, fruit peels and remnants, waste vegetables, wasted flower, rotten food, used tea dust, remnants of eaten food, egg shells, bones, paper, garden waste, glass, metals, used cosmetics, medicine bottles, rubber, leather, plastics, textiles etc (Karpagam, 2005). Inward migration inevitably results in an increase in the per capita amount of solid waste generated, thereby exacerbating the already serious problem of solid waste management. Uncontrolled dumping and improper waste handling causes
a variety of problems, including contaminating water, attracting insects and rodents, and increasing flooding due to blocked drainage canals or gullies. In addition, it results in safety hazards from fires or explosions (Ramaswamy, 2005).

Garbage scattered and strewn, makes the condition worse with debris turning out to be nauseating experience. Since common dumping yards overflow, wastes are dumped on any possible vacant land. The heaps of garbage left uncleared become breeding ground for mosquitoes and flies posing health risks (Venkatesan, 2005). The words “garbage”, “trash”, “refuses” and “rubbish” is used to refer forms of solid waste. Solid wastes are generated by many different activities. Very large quantities are produced by agriculture and mining. Waste generated from house, streets, shops, offices, industries and hospitals pose great health and environment problems. Solid waste management is considered as a simple affair where the act of simply putting waste into a vehicle and unloading at a dump is carried out. Many towns suffer from uncollected refuse blocking the streets and drains, harbouring flies and rats and degrading the environment (Viswanathan, 2005).

The effective management of solid waste has become a monumental challenge for country with a population density which is among the highest in the world, and also for a country which is also experiencing the problems of rapid urbanization (Sharmila and Sundari, 2003). Not only in India, but all over the world the urban planners continue to tackle the problem within the existing frame work but only succeed in shifting the solid wastes from densely populated to sparsely populated areas (Mani, 1996). Proper waste management helps to protect human health and the environment and preserve natural resources. Many do
not realize that solid waste impacts climate change. When organic waste decomposes in landfills and uncontrolled dumps, it produces methane, one of the major greenhouse gases contributing to climate change. Methane emissions from landfills are projected to reach 39 million tones by 2047, from seven million tones in 1997. Proper solid waste management can reduce greenhouse gas emissions (www.epa.gov/globalwarming). As most of our urban areas are already congested, waste disposal sites have to be located far from source, with considerable cost implications in terms of transport and infrastructure.

Traditionally, disposal of solid waste has been to ground. In the past, with low population densities and locally sourced biodegradable solid waste products such disposal presented few ecological problems. With high population densities and each household producing significant quantities of both biodegradable and non biodegradable solid waste, such materials are accumulating on both the limited areas of land and the marine waters at ecologically damaging levels (Ponniah, 2005). The traditional land tenure system has often constrained government led initiatives to improve the urban environment and conserve biological diversity. Landowners have often been reluctant to accept regulations pertaining to solid waste disposal or other measures that may affect their rights to do what they want on their land. This has presented significant problems for government led initiatives to manage solid waste.

The issue of urban poverty is inextricably linked with waste. In India, over a million people find livelihood opportunities in the area of waste, engaged in waste collection (popularly known as rag pickers) and recycling through well organized systems and also substantial population of urban poor in other developing countries earn their livelihood
through waste. It is important to understand issues of waste in this context. The informal sector dealing with waste is engaged in various types of work like waste picking, sorting, recycling and at the organized level, door-to-door collection, composting and recycling recovery. Governments can build on these practices by providing support to organize and improve recycling efforts (www.epa.gov/globalwarming).

In some countries, a great deal of recycling occurs before the waste reaches the landfill. Scrap dealers buy directly from households and businesses, waste pickers or scavengers collect materials from waste bins, and waste collectors separate materials that can be sold as they load their trucks. The municipalities in the developing countries do not indulge in recycling recovery on their own (Karthikeyan et al., 2003).

In domestic activities 30 to 40 per cent of the domestic wastes are organic in nature, which needs to be disposed on day to day basis. The bins overflow and the entire street becomes dirty and attracts the street dogs and rag pickers (Kumar and Singh, 1999). The average collection efficiency for MSW (Municipal Solid Waste) in Indian cities is about 72.5 per cent as a result of which, a substantial part of the waste generated remains unattended, affecting the quality of life of millions of people. Solid waste should be managed through a number of activities - waste prevention, recycling, composting, controlled burning, or land filling. Using a combination of these activities that protects the community and the local environment is referred to as Integrated Solid Waste Management (ISWM). The ISWM program can help reduce greenhouse gas emissions and slow the effects of climate change (www.epa.gov/globalwarming).
Urban planners, municipal agencies, environmental regulators, labour groups, citizens’ groups and non-governmental organizations need to develop a variety of responses which are rooted in local dynamics, rather than borrow non-contextual solutions from elsewhere. Expensive technologies are being pushed to deal with our urban waste problem, ignoring their environmental and social implications. It is particularly true in the case of thermal treatment of waste using technologies such as gasification, incineration, pyrolysis or pellatisation. The improved technologies are now available for collection, treatment and processing the waste which enables to improve the quality of the garbage to meet the pollution standards with the additional advantage of power generation (Kumar, 2002).

World over, many innovative approaches are being adopted for sustainable solid waste management viz. reduce waste generation at source (fees and tax incentives, mandatory standards, education and voluntary compliance), technological interventions (in collection,
treatment and disposal of wastes), and institutional reforms (rag pickers, NGO and private sector participation). India could learn from these experiences and devise strategies and approaches that best suit its own MSW management requirements (Rampal, 2000).

2.2. Vermicomposting - Eco-friendly Waste Disposal and Recycling Revolution

Soil micro nutrients and cause water pollution. Some of these as chain reaction affect human health. Higher nitrogen application in leafy vegetables leads to accumulation of nitrates in leaves which affect body functions in humans (NIIR, 2004). There is need to stop using harmful chemical fertilizers in agriculture, since they are responsible for soil, air and water pollution and thus, ultimately affect the health of human being (Sathe, 2004).

Soil is the basis of the life in the universe, directly or indirectly. The hope of a healthy world rests on a good, healthy and fertile soil. Therefore, there is an urgent need for rejuvenating the tired, overworked, degraded, polluted and malnutritious soil to make it potent for future food production (Singh and Shekhawat, 2000). Man has a role in shaping his environment. He has been responsible for degrading the quality of his environment ever since he appeared on this earth. Environment is our essential resource for development and its optimum utilization and wise management is necessary for progress and national planning. Man’s very survival depends on protection and adjustment to the environment (Manimozhi et al., 2006).

The diversion, remediation and recycling of organic matter from the waste stream can be achieved by a range of alternative treatment methods that create a marketable product for sale instead of disposal to landfill sites (http://www.recycledorganics.com). Waste disposal fees
are becoming extremely costly and landfill is also becoming increasingly expensive and unacceptable (Divya, 2001). Thus enhancing our environment through proper handling of garbage is the essential need of the hour (Manimozhi et al., 2006). Composting is ideally a recommended method of waste treatment (Rao, 2004). The organic wastes can be utilized to obtain useful rich nutrient compost through composting. It ensures good, hygienic environmental condition and helps to lead a better quality life. Composting is a biological process in which microorganisms, mainly fungi and bacteria, convert degradable organic waste into humus like substance. This finished product, which looks like soil, is rich in carbon and nitrogen and is an excellent medium for growing plants (http://www.schoolsahead.com/greenearth/didenvi.html).

Composting system is an environmentally superior and cost-effective alternative to landfill that produces top quality compost. The process of composting ensures that kitchen waste - a significant contributor of every household’s bulky volume of garbage - is not thrown (The Lion, 2009). The use of earthworms in waste management by utilizing and breaking down organic wastes has received increasing attention over the last 20 years. The growing recognition in developed countries is that the organic matter in the waste stream can be used as a resource rather than going to landfills where it creates a range of environmental problems that are costly to ameliorate. Composting imitates nature’s way of rebuilding soil by encouraging the decomposition of organic substances, but it does so more rapidly because heat, microbes, and the worms combine to speed up the process. Compost prepares the soil for plant roots to penetrate. It is a natural way of recycling organic material back into the ecosystem which easily accepts and contains a higher percentage of humus that is nitrogen in the soil.
(Setua et al., 2008). Besides, it is the cheapest, most practical and environment-friendly method of disposing organic wastes (http://www.erfindia.org/waste_resource.asp). The volume of solid waste is considerably reduced during composting and it is made free of pathogens. This is a hygienic method which converts the solid waste into manure (Satyanarayan, 2009).

Organic waste is a potential resource of both nutrients and organic matter that can be used to replenish the soils under pressure from traditional agriculture. However, direct use of waste is impractical. Composting offers a method of biological stabilization that eliminates odour and pathogens and renders a product that is safe and pleasant to use (Divya, 2001). Compost acts as a natural fertilizer by providing nutrients to the soil, increasing beneficial soil organisms, and suppressing certain plant diseases, thereby reducing the need for chemical fertilizers and pesticides in landscaping and agricultural activities (www.epa.gov/globalwarming). The chief objective to compost organic wastes should not be for the disposal of solid organic wastes but to produce superior quality manure to feed our “nutrient-organic-matter-hungry” soils. Composting of wastes controls the pollution of soil and water and ensures the survivability and growth of fish, prawns and other organisms (Setua et al., 2008).

Vermicomposting can act as a tool for recycling degradable organic wastes into useful product, the compost (Hemalatha et al., 2003). The effective way of attaining sustained crop production is the complimentary use of organic manure along with inorganic fertilizers. Huge potential of organic sources remain untapped. The organic wastes from different sources could be recycled, reprocessed and put to productive use. The wastes are of different kinds, including crop residues,
domestic wastes, vegetable wastes, etc. All the available organic waste materials can be converted into added organic manure or compost by adopting suitable biodegradation process and technology says Anitha et al (2004). The waste must be segregated into recyclable, biodegradable and non biodegradable. It is necessary that the waste is segregated, reduced, recycled, recovered and reused before disposal.

Vermicomposting utilizes earthworms for the purpose of producing value added manure (http://www.erfindia.org/waste_resource.asp). Composting is attractive to municipal waste authorities for several reasons, the two most important being - saving landfill space and returning organic matter to the soil. Composting is not generally a profitable process. Worldwide municipalities have found that the composting process only becomes financially viable when alternative methods of disposal are less attractive (Mohan, 2005). In countries where the cost of landfill has risen above the composting cost threshold, composting presents an attractive disposal option. The mechanization of composting has several advantages such as environment to minimize pollution, recovery of discarded materials and production of compost in less time. Presence of pathogens, undesirable heavy metals, toxic concentration of micronutrients and nitrate hazards are some of the major problems of recycling of solid and liquid municipal wastes. However, compost can be profitably enriched with phosphorus source to improve the phosphorus use efficiency in the crops and also to utilize low grade and cheaper sources of phosphorus like rock phosphates (Rao, 2004).

Vermicomposting is a technique of converting decomposable wastes into valuable plant fertilizers (vermifertilizers), through the activity of earthworms and microorganisms; which has now become the
Vermicomposting is the process of turning organic debris into worm castings (Anantharaj et al., 2009). Vermicast is the excreta of worms in their purest form, whereas, vermicompost is a mixture of vermicast and unprocessed organic matter (http://www.recycledorganics.com). Sharma (2003) says that the vermicomposting of organic material with earthworms provide most useful organic matter on one hand and on the other hand minimizes the environment pollution and health hazard. In recent years, there has been an increased emphasis on organic farming leading to formulation of new methods of composting and production of biopesticide foliar sprays like vermiwash (‘worm-tea’) and vermiprotein (www.nripulse.com). Waste water from sewage dairy, sugar mills, paper mills, distillery wastes, and food processing units pose major problems in disposal or treatment. Bhawalkars have stated that with their process, using vermicomposting systems if managed correctly,
are odorless, efficient and produce a high quality range of value added products (http://www.recycledorganics.com).

Vermicomposting helps in ‘Low External Input Sustainable Agriculture’ (LEISA). The ‘Fatigue of the Green Revolution’ due to stagnation in yield levels and to a larger quantity of nutrients required to produce the same yield as in the early periods, can now be changed or rejuvenated by eco-technologies like vermicomposting. In the scenario of vermicomposting, waste management and utilization finds an increased welcome space. The emerging techniques make earthworms ‘Biomanagers’ in worm composting (www.nripulse.com). Vermiculture and vermicomposting in fact help in solid waste management, where organic solid wastes are considered resources.

A large concentration of mineral nitrogen and potassium in soil disturbs biological relationships between soil, plants and human health. It is possible to prevent this by replacing mineral fertilizers with vermicompost (Premalatha et al., 2003). Vermicompost is an organic fertilizer, which can be produced from different organic waste, using worms at a high population density in cooperation with a lot of other soil animals (http://www.unu.edu/env/plec/cbd/abstracts/Kostecka.doc). Experts have expressed possibility of utilizing earthworms and their capability of accumulating materials. Several experts have shown that earthworms have capabilities to accumulate lead, cadmium, copper, nickel, mercury and zinc. Earthworms have also been shown to develop more of metal binding proteins (www.worms.com). Technically this is feasible but aspects warrant developmental researches. In pollution abatement and management, essential step is diagnosis of occurrence of pollution. With appropriate research, development possibility exists on using various earthworm species as biological indicator. These warrant development and miscellaneous usages of vermiculture (NIIR, 2004).
In countries where food is scarce, inorganic fertilizer is expensive, and waste disposal is an issue, vermicomposting appears to be a boon to the economy (www.vermicoast.com). From both the technical and economic point of view, the vermicomposting as a method of waste treatment, represent a technology that is environmentally sound and which is not energy capital and equipment intensive (Agarwal, 2005). The ideal species of earthworms help to convert waste into wealth compost. If this operation is made successful by the farming community, certainly one can hopefully convert the waste land into a fertile land (Sharma, 2003).

Utilizations of earthworm’s natural activities reduce the pollution problems (NIIR, 2004). Earthworms minimize the pollution hazards caused by organic waste by enhancing waste degradation. The material passes through the body of the earthworm to produce vermicast. Soils with vermicasts have roughly 100 times more bacteria than soil without worms. Moreover plant growth promoting substances have been reported to be present in vermicasts (http://www.erfindia.org/waste_resource.asp) The worm castings in the vermicompost have nutrients that are 97 per cent utilizable by plants and the castings have a mucous coating which allows the nutrients to “time release” (http://www.happydranch.com).

Earthworm is known to be a good biological element for recovery of vermicompost, vermicast, vermiwash and vermicprotein for the use in agriculture and aquaculture (Prasanthrajan et al., 2006). Vermicompost is entirely a natural product and has no question of polluting the air and water. Cow dung is the main source of farm yard manure (FYM) which contains 5 to 6 kilo grams nitrogen, 1.5 kilo grams phosphorus and 5 to 6 kilo grams potassium per ton. It also improves the soil health.
Cow dung, fish manure and vermicompost are useful and potential biofertilizers used in modern agriculture. Amongst the above biofertilizers, vermicompost is on top. Vermicomposting is a richer source of nitrogen, phosphorus, potassium, calcium, magnesium, vitamins and growth hormones which enhance the plant growth and microbial population (Singh and Shekhawat, 2000). It is ten times effective than cow dung fertilizer. It contains almost all components essential for healthy growth of plants (Sathe, 2004). Worm castings provide a rich source of a variety of essential plant nutrients. Microbial activity in worm castings is 10 to 20 times higher than in the soil and organic matter that the worm ingests (http://www.apluswriting.net/garden/earthworm.htm).

Limited studies on vermicompost indicate that it increases macropore space ranging from 50 to 500 \( \mu \text{m} \), resulting in improved air-water relationship in the soil which favorably affects plant growth (Marinari et al., 2000). The application of vermicompost favorably affects soil pH, microbial population and soil enzyme activities (Maheswarappa et al., 1999). It also reduces the proportion of water soluble chemical species, which cause possible environmental contamination (Mitchell and Edwards, 1997). Worm castings have been found to improve the condition of the soil and the growth of plants. Vermicompost is five times richer in nitrogen, seven times in phosphorus, eleven times in potassium, two times in magnesium and two times in calcium in ordinary soil. It’s a rich source of vitamins and growth hormones like gibberellin which regulates the growth of plant and microbes (Anantharaj et al., 2009). Several researchers have demonstrated that earthworm castings have excellent aeration, porosity, structure, drainage and moisture holding capacity.
It is this hope of the possibility of producing the needed top soil or humus by earthworms that has encouraged this effort. This may help in reaching the goal of green revolution from a different angle (NIIR, 2004).

The slogan worth remembering is: “Do not waste waste, because waste is a precious resource”.

2.3. Role of Earthworms in Waste Management

“Earthworm is the pulse of the soil, Healthier the pulse healthier the soil”

Soil fertility has become one of the most important jargons of a conventional agronomist (Balaraman, 2005). This term has been directly correlated to fertilizers. The traditional concept to evaluate the soil had been its quality or health. Soil health is a more appropriate term as it reflects the entire system and not just the chemical status of the soil. Soil health includes the physical and chemical characteristics of the soil and also the biotic components of the soil. It is the “living” soil. Though multitudes of soil organisms are related to soil health, earthworm is the pulse of the soil. Thus, healthier the pulse, healthier the soil (http://www.erfindia.org/waste.asp).

Earthworms are generally called the biological indicators of soil fertility. Since they support the healthy populations of bacteria, fungi, actinomycetes, protozoans, insects, spiders, millipedes and a host of others essential for sustaining a healthy soil (Sharma, 2003). Earthworms improve the soil in several ways. Earthworm acts as an aerator, crusher, mixer, grinder, chemical degrader and biological stimulator in soil (Murugappan, 2005). They mix organic matter with mineral soil, release nutrients and make available to the plants, aerate the soil and improve infiltration of water through burrowing and contribute to the formation
of stable soil aggregates, producing the crumbly texture of a fertile soil by the intimate mixing of organic matter, microorganisms, mineral soil and secretions from the worm skin and gut (Ramesh et al., 2000). Earthworms are well known to help the soil in respiration, nutrition, excretion and stabilization. They cause tunneling, show buffering action, regulate soil temperature and thus stimulate useful activity of aerobic microorganisms (Kannaiyan and Lilly, 1999).

Earthworms, the soil invertebrates, along with soil microorganisms carry out a yeomen’s service of degrading organic waste materials and thus maintain the nutrient flux in the system. Earthworms form a major component of the soil biota and together with a large number of other organisms constitute the soil community (Talashilkar and Dosani, 2005). The chief source of food to the soil biota is the litter contributed by plants. Although the dead plant tissues constitute the bulk of the food ingested by the earthworms, living microorganisms, fungi, microfauna and mesofauna and their dead tissues are ingested as an important part of the diet.

Earthworms have been on the earth for over 20 million years and have faithfully done their part to keep the cycle of life continuously moving. Their purpose is simple but very important (www2.widener.edu). They are nature’s way of recycling organic nutrients from dead tissues back to living organisms. The Egyptian Pharaoh, Cleopatra said, “Earthworms are sacred”. She recognized the important role the worms played in fertilizing the Nile Valley croplands after annual floods (http://www.unu.edu/env/plec/cbd/abstracts/ Kostecka. doc).

Earthworms play a major role in land reclamation by way of their high efficiency of harvesting energy from a nutrient poor soil
(Mani, 1999). Earthworms burrow deeply into the mineral strata and return periodically, to cast faecal material at the soil surface facilitating the transport of certain elements to the surface from deep in the profile. There is abundant evidence that concentration of exchangeable calcium, sodium, magnesium, potassium and available phosphorus and molybdenum are higher in earthworm casts than in the surrounding soil (Kumar et al., 2000). Earthworms have been aptly named as the ‘Cinderellas’ of organic farming (www.nripulse.com). The conversion of organic wastes in the form of vermicompost is the major role played by the earthworm in nature. In the vermicompost, the secretions of worms and the associated microbes act as growth promoters along with other nutrients. It improves physical, chemical and biological properties of soil in the long run on repeated application (Jayakumar et al., 2005).

Earthworms, besides producing enormous amount of worm casts over the years, modify the structure of the soil. They act as ‘natural miniature factories’ (Kitturmath et al., 2007). Bhawalkar et al (1993) designated earthworms as the ‘Natural Bioreactor’. They play a key role in soil biology as versatile natural bioreactors. They effectively harness the beneficial soil micro flora, destroy soil pathogens and convert organic wastes into valuable products such as biofertilisers, biopesticides, vitamins, enzymes, antibiotics, growth hormones and proteinous worm biomass (Sharma, 2003). Earthworms are the major secondary decomposers. The manure formed from the dead tissues of plants and animals is naturally the source of macro and micro nutrients in limited quantities. The weather conditions and the soil type in the tropical countries do not favour the restoration of carbon resource in the soils. The application of organic manure replenishes organic carbon to the impoverished soils. The presence of high level of oxidisable organic
carbon helps in the slow release of nutrients from the manure and curbs the leaching of nutrients. This beneficial activity is because of the nutrient availability (Gunathilagaraj et al., 2000).

Earthworms have occupied an important position in the ecosystem, that made the famous biologist Charles Darwin conclude, “It may be doubted whether there are many other animals which have played so important a part in the history of the world as have these lowly organized creatures” (http://www.erfindia.org/waste_resource.asp). There can be little doubt that humankind’s relationship with worms is vital and needs to be nurtured and expanded. The following sections discuss on the most important areas in which our natural environment can be preserved and sustained through a partnership with these engines of the soil. Earthworms can also be described as microbioves as they are potentially important vectors of microbial propagation and have been shown to influence plant fungal pathogens. Earthworms live on the upper part of the soil profile and transport a large amount of (200 - 400 ha/yr) soil through their bodies. They have been implicated in both reduction and dispersal of organisms and spread a variety of beneficial microorganism such as Pseudomonas, Rhizobia and Mycorrhizal fungai (Raja, 2004).

Earthworms, through a type of biological alchemy, are capable of transforming garbage into ‘gold’ (http://www.dainet.org/livelihoods/default.htm). Worms are nature’s garbage men, honing their waste devouring skills over the millennia to produce the perfect organic waste disposal system. They live under the topsoil dragging down dead organic matter from the surface to be recycled and harnesses natural recycling system. Earthworms have been known as the ‘farmer’s friend’ and the ‘gardener’s manure factory’ (www.cityfarmer.org). Worms are not only
the gardener’s best friend; they are also the recycler’s as well. Nature’s little waste disposal experts have found a new place in eco-conscious household’s across the globe as more and more people are catching on to the idea of using worms’ special talents to dispose their organic household waste (http://www.unu.edu/env/plec/cbd/abstracts/Kostecka.doc). Earthworms are useful not only for making compost and waste management but also have a utility in the context of developing countries as a ready recknor for knowing the soil health at farmer level. They are one of the easily available biological indicators of soil activities and this natural facility need to be used for monitoring and maintaining the biological health of the soil (Sharma, 2003).

There is no doubt that earthworms, ‘nature’s unpaid labor force’ have an important place in the world as Charles Darwin claims. Recent studies have revealed that the intelligent use of selected species of earthworms (especially in the ‘decomposer industry’) can produce benefits to mankind in different ways with the help of vermitechnology (www.nripulse.com). Earthworms are underground farmers who turn the soil over like a plough. They form a major component of the soil system and have been efficiently ploughing the land for millions of years and assisting in the recycling of organic nutrients for the efficient growth of plants (Sharma, 2003). In just one acre there can be a million or more, eating ten tons of leaves, stems and dead roots a year and turning over 40 tons of soil (www.webdirectory.com). According to Lester R. Brown, “civilization can survive the exhaustion of soil resources, but not the continuing wholesale loss of the top-soil.” It is not worthy that earthworms can be used as biological tools for rebuilding of the top-soil, at no cost to the farmers, in easy sustainable soil management. Earthworms are also known as ‘earth-angels’ that can produce ‘heavenly’
humus (www.nripulse.com). They are considered as scavengers of land. They burrow in moist soil and mud, feeding on decomposed plant materials and other organic matter (Prema et al., 2004). Due to their burrowing and casting activities the earthworms turn over the soil from bottom to the top.

Dahama (2003) estimated that 1800 worms which is an ideal population for one square meter can feed on 80 tons of humus per year. Darwin calculated that earthworms bring up about 18 tons of soil per acre, per year (Tripathi, 2003). Nature takes as much as 200 years to build up a ten millimeter layer of humus rich soil. Given a proper supply of wastes, earthworms can achieve the same result in a single year (Abbasi and Ramasamy, 2001). Earthworms inevitably consume the soil microbes during the ingestion of litter and soil. It has been recently estimated that earthworms necessarily have to feed on microbes, particularly fungi for their protein or nitrogen requirement (Ranganathan et al., 2000). The use of earthworms in waste management is largely a straightforward process. All the earthworm species have a specific range of environmental conditions and ecological requirements that must be met to thrive. The most successful vermicomposting species are those with a fairly broad range of tolerances (http://www.recycledorganics.com). Earthworms can ingest more than their own body weight of organic matter each day while some species can process vast quantities very rapidly given optimum conditions. This rate of ingestion is more commonly observed to be between 50 to 100 per cent of worm biomass. Each earthworm weighs about 0.5 to 0.6 gram (http://www.vermico.com/summary.htm). However, the rate of ingestion is largely dependent upon the species of earthworm, the maturity of individuals, the rate of reproduction, the population
densities and several feedstock variables, given optimum environmental conditions (http://www.recycledorganics.com).

Earthworms play a major role in the breakdown of organic matter and in the cycling of nutrients in natural ecosystems (Singaram, 2005). They are a part of a complex chain of chemical, biochemical, biological and ecological interactions. Earthworm mouthparts are not capable of chewing or biting and so rely on the decomposition of organic matter by microorganisms such as bacteria, algae, fungi, nematodes, protozoa, rotifers and actinomycetes, before they can ingest the softened material along with the microorganisms (http://www.recycledorganics.com). Earthworms possess a grinding gizzard that fragments the organic residuals (Edwards and Bohlen, 1996).

The earthworm gut secretes mucus and enzymes that selectively stimulates beneficial microbial species (Bhatnagar, 1996). Earthworms promote further microbial activity in the residuals so that the faecal material or casts they produce, is much more fragmented and microbially active than what the earthworms consumed (www.nyworms.com/vermicomposting.htm). Effectively, earthworms inoculate the soil or organic matter, with finely ground organic residuals and beneficial microorganisms which increase the rate of decomposition and enables further ingestion of microorganisms by earthworms (http://www.recycledorganics.com). They crush the soil and the organic matter and after consumption, the matter undergoes a complex biochemical process in its digestive system which is excreted out in the form of granular casts of earthy smell (Mani, 1999).

Enhanced decomposition and nutrient mineralization are the most important and critical factors where earthworms play a vital role and
thereby increase the growth and productivity of plants (www.lancasster.unl.edu). Earthworms transport minerals and subsoil compounds from deep in the soil. In this process the earthworms transform these compounds into nutrients that plants use much more readily. Earthworms help to increase the healthier plants, more beautiful flowers, bigger and more luscious fruits and vegetables. Earthworms are ancient and respected creatures in many cultures. The Chinese translation, earthworms is ‘Angels of the Earth’. Aristotle called them ‘The Intestines of the Soil’. The scientist, Charles Darwin studied earthworms for more than 40 years in the last century. He said that worms are the great promoters of vegetation, perforating and loosening the soil (NIIR, 2004). Earthworms serve as prime fishing bait as a high protein and low cost cattle feed particularly in Japan. They are also used as bioindicators of heavy metal contamination. They form an important group of soil animals that are known to improve soil productivity by enhancing the physical, chemical and biological characteristics of soil. They play a vital role in the breakdown of dead plant and animal material and in soil structure aeration and fertility (Prema et al., 2004). The tunnels made by the worms serve the purpose of air passage for root growth and for drainage of water. Mucus containing worm casts absorb soil moisture and nutrients for better crop production. Earthworms are considered as nature’s plough and natural fertilizer manufacturers. They have played an important part in the history of mankind in preserving fertility of the soil and thereby sustaining crop production. The only animal that exclusively devoted itself to mass production is the earthworm (Venkataratnam, 1994).

Earthworm ensure ground water recharge and prevent run-offs causing soil erosion and flash floods (Ganeche and Swaminathan, 2000).
Chemical analysis of earthworm castings shows that they can contain up to two times as much available magnesium, five times as much available nitrogen, seven times as much available phosphorus and eleven times as much available potassium as the surrounding soil (Abbasi and Ramasamy, 2001). Earthworm processes more than 20 per cent of the total energy input into the system; stimulate composting activity by decreasing 25 per cent of the composting period. Earthworm is not only the biofertilizing agent and composting element but also aerator, moisture retainer, crusher, biological agent, nature’s best soil chemist and agriculturist (Mani, 1996). Earthworms produce worm casts about 4 to 36 tonnes per acre and in terms of nitrogen it comes to 20 to 180 kilograms per acre per year and it is much more than the average need of nitrogen for any crop (www.wormdigest.org).

The action of compost by worms prevents bad odours. They are quite unobstructive and clean and the job they do is incomparable to anything else. They like to eat, and need very little care to live. Worms create conditions that promote beneficial aerobic bacteria and optimal composting conditions (Subash, 1998). Earthworms are nature’s clean up crew, aiding in the production of lush, humus rich top soil from spent plant and animal materials. These elegantly efficient organisms have been on earth for hundreds of thousands of years longer than humankind, largely untouched by evolution due to their perfect adaptation to their role in nature. Earthworms form a major component of the soil system and these organisms have been efficiently ploughing the land for millions of years and assisting in the recycling of organic nutrients for the efficient growth of plants (Ramakrishnan, 2005). Earthworms can minimize the pollution hazard caused by organic waste by enhancing waste
degradation. The ideal species of earthworms help to convert waste into wealth (www.wrangler.com).

Earthworms have long been described as the ‘intestine of the earth’ and ‘friends of the farmers’, because of their manifold functions in the soil (Darwin, 1881). The role of earthworms is breaking down of dead plant and animal residues in soil. “Nothing can be compared with earthworms in their positive influence on the whole living nature. They create soil and the lives in it. They are the most numerous animals on Earth and the main creatures converting all the organic matter into soil humus providing soil’s fertility and biosphere’s functions: disinfecting, neutralizing, protective and productive” (Igonin, 2004).

Species of earthworms

India possesses a very rich Earthworm’s fauna. There are about 3000 species of earthworms in the world and about 500 species in India (Ramesh et al., 2000). Earthworms are generally called as saprophages. According to Lee (1992), they are classified based on the feeding habits into detritivores and geophages.

1) Detritivores - feed at or near the soil surface, mainly on plant litter or dead roots and other plant debris in the organic matter rich surface soil horizon or on mammalian dung. These worms are classified as humus formers and comprise of epigeic and anecic forms. *Perionyx excavatus, Eisenia foetida, Eudrilus eugeniae, Lampito mauritii* and *Polypheretima elongate* are a few examples of detritivores earthworms.

2) Geophages – feed deeper beneath the surface, ingesting large quantities of organically rich soil. The worms are generally called as humus feeders and comprise of the endogeic worms. *Octochaetona thurstoni* and *Metaphire posthuma* are two common examples.
A different classification has been proposed by Bouche (1977) laying stress on ecological strategies. He classified earthworms into:

- **Epigeics** (e.g. *Eudrillus eugeniae*)
- **Anecics** (e.g. *Lampia mauritii*)
- **Endogeics** species of earthworms.

The **epigeic** groups are generally surface dwelling species that inhabit and feed on decomposing litter on the soil surface, rarely ingesting soil. Epigeics are surface dwellers serving as efficient agents of comminution and fragmentation of leaf litter. They have rapid mobility, are relatively short-lived, small to medium in size, grow and reproduce quickly. The earthworm species that have evolved with these characteristics are predominantly used in vermicomposting (http://www.recycledorganics.com). These are broadly classified as Phytophagous earthworms. They generally have no effect on the soil structure as they cannot dig into the soil.

The **anecic** groups are burrowing earthworms that construct large, permanent, vertical burrows and feed on decomposing litter at the soil surface or pull it into their burrows. They have a rapid withdrawal response, are large in size, relatively long-lived and have a longer growth and reproduction time than epigeic species. Anecic species may be used in vermicomposting but usually in combination with epigeic species. Anecics feed on the leaf litter mixed with the soil of the upper horizons and are called as geophytophagous earthworms. They may also produce surface casts generally depending on the bulk density of the soil (Talashilkar and Dosani, 2005).

The **endogeic** group of earthworms live in extensive horizontal burrows and feed on mineral soil and rich organic matter. These species
are never used in vermicomposting. Endogeics species of earthworms are Geophages (Singh, 2007). They live deep within the soil deriving nutrition from the organically rich soil they ingest (NIIR, 2004).

Each of these has its own preferred habitat. Some live deep in the soil, while some prefer garden soil and others are most at home in the woods under decaying logs. However, for gardening we need re-worms also called red wrigglers or manure worms. Two species especially suited for vermicomposting are the *Eisenia fetida* and *Lumbricus rubelus*. The most popular species of earthworm used for producing vermicompost is *Eudrillus eugeniae*. These earthworms exhibit maximum activities between June and December and have better efficiency of producing more compost (Prema et al., 2004).

**Basic characteristics of suitable species**

- Worms should be efficient converters of plant and animal biomass to body proteins, so that its growth rates are high.
- It should have high consumption, digestion and assimilation rate.
- It should have wide adaptability to environmental factors and have feeding preference and adaptability for wide range of organic material.
- It should reproduce in large number with less hatching time, so that multiplication and organic matter conversion is fast.
- Growth rate, maturity from young one to adult should be fast.
- Worm should have compatibility with other worms at different strata.
- Worms should be disease resistant.
- Worms should have least inactivity or vermistabilization period.
- Worms should feed near the surface of organic matter.
Earthworms have come to be recognized as one of the bioreactors due to their ability to degrade organic waste materials into available vermicompost and technology is being described as vermiculture technology or vermitechnology.

**Be tender to these little critters!**

*They are helping to save the Earth, by*

*Creating fertile soil around the World!*

2.4. Vermicomposting: A Livelihood Micro-enterprise for Women

Women and environment are inseparable as women contribute significantly to protect the environment and it is a bounden duty too. Women have to play a major role in promoting healthy environment. Participation of women in creating healthy milieu and protecting the environment is the key to the success of any programme on "women and eco-development". Educating women on environment related issues are a shot in the arm for speedy progress and back to roots. Women must be made the ambassadors of environmental issues, for the environment starts from the home.

Waste disposal fees are becoming extremely costly and can be achieved by no cost. To create a clean and healthy environment, sanitation activities need to address the problem of solid waste disposal. Solid waste management involves the disposal of waste matter by reducing, recovering, recycling or reusing wastes and restoring resources. Recycling of solid waste has long been an income earning enterprise for the urban poor (en.wikipedia.org/wiki/vermicompost). From the perspective of the municipality, organic waste recycling through composting not only reduces disposal costs and prolongs the life span of disposal sites, but also reduces adverse environmental impacts caused by landfill sites, as organic waste is mainly responsible for leachier contamination and methane problems.
Involving the women in the use of compost promotes awareness of waste resource recovery while composting activities can also create employment and generate income. The diversion, remediation and recycling of organic matter from the waste stream can be achieved by a range of alternative treatment methods that create a marketable product for sale instead of disposal to landfill sites (http://www.recycledorganics.com). One of the most environment-friendly methods to treat organic waste is vermicomposting. This is a simple process where solid waste, which has low carbon content, is mixed with material of high nitrogen content, mostly vegetation, and fed to certain species of earthworms. The digestion of this mixture by earthworms constitutes the vermicomposting process.

The disposal of most agricultural and cellulose wastes represents vermiculture operation at substantial cost. The quality of compost depends upon the nature of waste, species of earthworm and overall efficiency of vermicompost system. The resultant product is a value added biofertilizer and protein biomass. Value added biofertilizer is produced which can be a saleable product from rupees five per kilogram to Rs. 20 per kilogram. Liquid formulation to mix with drip irrigation system or to be sprayed as foliar spray is made from cultured earthworm biomass which is saleable from Rs.60 to 92 per litre. Arvindkumar (2002) opines that vermicomposting and vermiculture is indeed key to overcome energy crisis, maintain the environment and improve the economy.

Women are playing an important role in agriculture and allied activities, to bring out a greater demand for organically produced food items both in domestic as well as in export market. Possession of strong knowledge and skill in these areas can help women to start home based enterprises like mushroom cultivation, floriculture, vermicomposting and
vermiculture. The demand for vermicompost as an important input in organic agriculture is increasing with leaps and bounds. Vermicomposting holds a good promise for entrepreneurial generation (Dhawan et al., 2005).

Vermicomposting has a number of advantages. It is one of the most appropriate and a cost effective method of solid waste management as it does not involve major costs or expenditure. Moreover, wastes can be treated as source (www.vusat.org/learning/agri/vermicomposting/benefits.htm). Excellent quality compost is generated through this method, which restores rich soil nutrients and reduces the need for chemical fertilizers. Composting units can be set up in houses, neighbourhoods, market places as well as at the municipal level and on cooperative basis. If undertaken on a large scale, vermicomposting can become a promising income generating activity. One ton of degradable waste yields approximately 950 kilo grams of compost, which can be sold at rupees five per kilo gram. The capital cost is estimated to be Rs. 2,500 and the recurrent cost minimal. On an average, a household in India generates approximately one kilo gram of degradable waste, a typical panchayat ten tons and a small city 400 tons every day. These huge amounts of waste if not properly managed, drinking water sources will get polluted, leading to the spread of water borne diseases (Jayanthi, 2005).

Vermicomposting is a noble approach which offers not only better employment than the usual composting techniques but also helps for preparation of better quality compost from variety of crop residues in a minimum time period. Compost making and vermicomposting goes a long way not only in reducing energy intensive inputs like chemical fertilizers in agriculture but is in consistence with employment demands on decentralized basis (Thilakam and Sudha, 2008).
Vermicomposting holds a good promise for entrepreneurial opportunities and employment generation especially for the women (Dhawan et al., 2005). The money making potential of vermicompost and vermiculture is so attractive that it is rapidly becoming a growth industry. A big market exists for the products of the vermicomposting process, namely the earthworms, the castings and the vermiwash. There are three key components of commercial vermiculture which explain its present appeal and future potential:

1) Earthworms are capable of transforming huge amounts of waste which is of growing concern in our society. For those who are raising worms for profit, the feedstock is generally plentiful and free.

2) The worm population can double in two to four months. Thus after acquiring an initial inventory as breeding stock, sales of worms can be realized in a relatively short time, particularly when comparing their prolific breeding rates to other forms of livestock.

3) The production of castings (worm manure) is a highly prized soil amendment, sought by landscapers, gardeners and horticulturists.

Worms fetch a fancy price depending on the desire of a person to pay for them (NIIR, 2004). Live earthworms are sold as bits for fishing and for agricultural process while dried or processed earthworms are used as soil additives, animal or fish food and high protein diet supplement for human beings (Agarwal, 2005).

Marketing vermicompost is now a potential and flourishing industry due to the growing awareness among the people about the ill effects of chemical fertilizers and the relative benefits of organic farming. The cost of vermicompost ranges between (Indian) Rs. 2000 to 5000 per ton of compost. The retail market in urban areas is more promising
with the sale price of vermicompost in neatly designed and printed packets, fetching rites as high as Rs.15 per kilogram. For a kitchen garden or for growing ornamental plants, the compost prepared at home is sufficient and will not only serve as excellent manure but will also save money spent on fertilizers (http://www.resourceconservation.mb.ca/cap/vermi.html).

Earthworm castings provide a natural organic soil amendment with good structural properties. They are rich in microorganisms especially bacteria and free growth regulators. Vermicomposting is an appropriate cost-effective and efficient recycling technique for the disposal of non-toxic solid and liquid organic wastes (http://www.erfindia.org/waste_resource.asp). All these, explain the high fertilizer value of the castings (Agarwal, 2005).

Vermitechnology is popular because it is a simple methodology with low investment. The technology does not need sophisticated infrastructure. All that is required is some pits or containers to initially decompose organic waste and tanks made out of stone slabs or wooden planks, trenches or any convenient material to protect earthworms from pests and predators. Therefore, the investment is directly related to the choice of the material used to build tanks (Sharma, 2003).

Vermicompost is a valuable input for sustainable agriculture and wasteland development. This also can be used widely in pot culture and in home gardens (http://904green.sask.com/home/garden/compost5.html). Several farmers are successfully using vermicompost. The demand for organic fertilizer (the vermicompost) is expected to rise. During the Green Revolution of the 1970s, excessive use of chemical fertilizers depleted the topsoil of organic nutrients. This caused drastic reductions
in crop production. Organic matter is now estimated at less than three per cent (the required critical level) in 83 per cent of the cultivable land (UNEP, 2001). In an attempt to meet previous production levels, farmers scatter an estimated 3.5 million tonnes of chemical fertilizer every year, further breaking down the natural ecology of the soil. From the perspective of food security, use of compost produced from city waste, can increase crop production and at the same time restore organic nutrients to the soil (Chitra, 2005).

Studies in Maharashtra have shown that usage of vermicompost has improved the production and quality of grapes. There are many successful farmers’ experiences of using vermicompost from different climatic zones of the country (http://www.nsic.co.in/Schemes/documents/projprofiles/Vermi%20Composting.pdf). Experience has shown that in developing countries large centralized and highly mechanized composting plants often fail to reach their targets and are abandoned due to high operational, transport and maintenance costs. Small scale decentralized community based composting plants are more suitable option for treating municipal solid waste as they reduce transport costs and make use of low cost technologies, based mainly on manual labour and minimize problems and difficulties encountered with backyard composting (Sharma, 2003).

Various factors can create a unique opportunity for partnerships in solid waste management: limited local government budgets, community willingness to pay for solid waste collection services, private sector companies that are able to market compost and recyclables, the availability of a proven technology to make compost out of organic waste and a demand for organic fertilizer. Partnerships can optimize the application of available public and private resources by working
together with local governments, businesses and communities. Pooling resources and using expertise and unique approaches can help to solve and overcome the waste management problem (http://www.unescap.org/pdd/prs/ProjectActivities/Ongoing/Best%20practice/Bangladesh.pdf).

It should be realized that vermiculture and vermicomposting can be considered a useful cottage industry for the underprivileged and economically weak, especially the women as it can provide a supplementary income. By becoming an earning member of the family, they can be involved in the decision making process in the family. This can raise their status in the society (Nagavallemma et al., 2006). If every local community can formulate a cooperative society of unemployed youth and women, it could be a wise venture to produce vermicompost and sell it back to the market at recommended price. The youth and women will not only earn money, but also aid society by providing excellent quality organic manure for sustainable agro practices. Moreover, with garbage recycled, the environment will be kept clean and tidy, which is a formidable task at the best of times for any organization to cope with (NIIR, 2004). In this line women should be imparted systematic and scientific training, pertaining to day to day life situation and issues.