INTRODUCTION

Abundant use of chemical fertilizer and pesticides affect the physico-chemical properties of soil as well as the environment (Levi, 2000; Meena, 2007) and enhance the level of heavy metals such as Cd, Pb and As in agricultural fields (Atafar *et al.*, 2010). Dao and Unger (1995) reported that the hazardous organic materials can also enter the soil through domestic, municipal, agricultural, industrial and military activities. Mall *et al.* (2005) has reported that the use of chemical fertilizer is a serious problem for the useful microorganisms, insects, worms in the soil etc. Abundant use of nitrogenous and phosphate fertilizer are use in agricultural field for good productivity of crops which causes loss of nutrient such as amino acid, ascorbic acid and proteins in foodstuffs (Marinari *et al.*, 2000).

Currently the fertilizer values of animal wastes are not being fully utilized resulting in loss of potential nutrients for the crops (Reinecke *et al.*, 1992). In India, the integration of crops, livestock and use of manure as fertilizer were traditionally the basis of farming systems (Wijewardena and Yapa, 1999). The development of chemical fertilizer industries during the green revolution period created opportunities for low-cost supply of plant nutrients in inorganic forms which lead to rapid displacement of organic manures derived from livestock excreta (Garg *et al.*, 2006a, b).

Heavy metals comes to environment by erosion of rocks, volcanic activities, forest fire but artificially by many industries, paper mills,

vehicles and human activites (Martin and Grisworld, 2009). Different heavy metals contaminations have increased soil pollution which is toxic to the human health and environment (Pereira *et al.*, 2003). Ebong *et al.* (2007) studied that phosphate fertilizers used as a source of plant nutrients are a major source of cadmium (Cd). The heavy metals entered in soil anthropogenically through the use of chemical organic pesticides and fertilizers (Eghball and Gilley, 1999; Zauyah *et al.*, 2004). The good yield of crops by the abundant use of chemical fertilizers is a major problem for soil flora and fauna (Lasat, 2002; Peyvast *et al.*, 2008). Reinecke *et al.* (1992) reported that the rapid industrialization has also increased the solid waste management problems. Many anthropogenic activities increase the toxic heavy metals into the environment (Kaplan *et al.*, 2011).

The anthropogenic activities such as household dust, batteries, disposable household materials; plastics, paints, inks, body care products, medicines and household pesticides generate heavy metals in environment (Bardos, 2004). Animal and municipal solid wastes contain toxic substances, compostable organic matter and heavy metals (Muthukumaravel *et al.*, 2008). The different types of municipal solid wastes caused environmental hazards and various ill effects on human health, if their proper management and practices are not available (Kaviraj and Sharma, 2003; Bhattacharya and Chattopadhyay, 2004). The livestock excreta, kitchen garbage, vine-fruit industries sludge, plant

litter and crop residues are also a serious problem for society (Elvira *et al.*, 1998; Gajalakshmi *et al.*, 2002a, b; Garg *et al.*, 2005)

Heavy metal is referred to any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations, i.e., Arsenic (As), Cadmium (Cd) Chromium (Cr), mercury (Hg) and lead (Pb) etc. Trace amount of heavy metals is essential for human metabolism, i.e., chromium is essential for metabolism of fatty acids, glucose and protein. However, at higher concentrations they can lead to poisoning. Heavy metal ions are used in various industries due to their technological importance and may become part of waste water released from these industries and hence could cause toxic effects through food chain (Baker *et al.*, 1994; Soltan and Rasheed, 2003).

Safe values for lead and cadmium in fruit and vegetables recommended by WHO/FAO are 0.3, and 0.2 mg/kg, respectively (Husain *et al.*, 1995). The concentrtion of above heavy metals exceed in soil and ranged from 7.8 to 8.8 mg/kg for lead and 3.1-5.1 mg/kg for cadmium in northeast Uttar Pradesh (Bhartiya and Singh, 2012).

Biological wastes

The biological wastes are a serious problem for society and caused various ill effects to the human health as well as the environment, if they are not properly manage (Kaviraj and Sharma, 2003; Bhattacharya and Chattopadhyay, 2004). Suthar *et al.* (2005) reported that 320 million tones of agricultural wastes generated annually in India. The use of animal manure for the good crop production is a common practice in

India and other developing countries (Wijewardena, 1993; Wijewardena and Yapa, 1999; Wijewardena, 2000; Garg *et al.*, 2005). Application of animal manure and chemical fertilizers for obtaining better productivity of crops causes increase of the heavy metals in a particular agricultural field (Wijewardena and Gunaratne, 2004). The biological treatments of these wastes are more effective process that converted it into the rich nutrient organic matter (Paraskeva and Diamadopoulos, 2006). Nair *et al.* (2006) reported that solid waste management is one of the biggest environmental challenges facing the world today due to the increasing population and urbanization.

With the progressive increase in the size of the world population resulted large volumes of biological wastes produced all over the developed and undeveloping countries (Chauhan *et al.*, 2010). Joshi and Chauhan (2006) reported that the growth of industries and human population have generated the thousand tonnes municipal solid wastes daily. The million tonnes of cattle dung and agro/kitchen wastes produce annually in India which contain various harmful microorganisms which cause various odour and environmental problem in surrounding area (Suthar and Singh, 2008). Kaviraj and Sharma (2003) reported that the noxious problem of municipal solid wastes that contain huge amount of metals such as Fe, Cu, Zn and Pb are toxic to human health and environment.

Municipal solid wastes

Municipal solid wastes cause human health problem and the hazardous to the environment (Garg and Kaushik, 2005). Disposal of municipal solid wastes (MSW) and household hazardous wastes including batteries, paint residue, ash, treated woods, and electronic wastes increase the heavy metals in soil (Pare *et al.*, 1999; Macki *et al.*, 2009). The municipal solid wastes, sewage sludge and manure of a long term field experiment can change micro and macro-nutrients of the soils (Bole and Bell, 1978; Kaushik *et al.*, 1993; Veeken *et al.*, 2000). Lee *et al.* (1996) observed that the municipal sludge contains many toxicants which may threaten crop yield, soil quality and human health. Disposal and effective management of municipal solids wastes are posing a great challenge to India and other developing countries. In about 750 million tonnes of MSW are produced annually. The management of municipal solid wastes is a global challenge due to lack of complicated technology to process and eliminate these wastes generated daily in metropolitan cities (Bardos, 2004).

Ogbonna *et al. (*2006) reported that a wide range of inorganic and organic compounds cause contamination which produces noxious odour gas and causes health hazard. The high rate of industrializations has also increased the problems of solid waste management (Reinecke *et al.*, 1992). The disposal of household hazardous waste increases the heavy metal content from municipal solid wastes to dumpsite environment (Pare *et al.*, 1999). The sewage sludge contains high concentration of lead, copper, chromium, manganese, nickel, cadmium and arsenic,

whereas mercury is typically present only at low concentrations (Marani *et al.*, 2003). The certain metal toxicants present in municipal sludge, may affect crop yield, long-term soil quality, and human health (Lee *et al.*, 1996). Smith (1976) reported that heavy metals can be introduced through high tension electricity supply lines, municipal solid wastes and building materials. The per capita rate of the average MSW in is America in is 2.1 kg/person/day, in Sweden 1.36 kg/person/day, in Germany 1.54 kg/person/day and in UK 1.58 kg/person/day (OECD, 2007).

The highest per capita solid waste generation rate in India is in Chennai (0.6 kg/day) (Esakku *et al.*, 2007). The use of redworm *Eisenia foetida* (Savigny)) for processing sewage sludge increases the content of nutrients in the vermicompost, which enhance quality of the plant biomass and prevents of some bacterial and fungal diseases (Anastasi *et al.*, 2005). Kaviraj and Sharma (2003) studied vermicomposting of municipal solid waste management by two exotic species, i.e., *Eisenia foetida* and local species *Lampito mauritii* (Kinberg).

Kitchen wastes

The household kitchen wastes contribute 70-80 % of total municipal solid wastes in India (Kale, 1998). Kitchen wastes create the odour problem at the pollution level which is also a serious problem for human, animal and environment (Nath and Singh, 2011). Chaudhuri *et al.* (2000) find chemical changes during the vermicomposting of kitchen wastes by an endogenous species of earthworm *Perionyx excavates* (Perr.). Kale (1998) reported that each house hold of four family

members generates 0.50-0.75 Kg kitchen wastes per day. The million tonnes of agro, animal and kitchen wastes are produced annually in India (Reinecke *et al.*, 1992; Gupta, 2005; Suthar *et al.*, 2005; Garg *et al.*, 2006b). Nath *et al.* (2009) reported the effect of various animal, agro and kitchen wastes on the growth and development of an epigeic earthworm *Eisenia foetida* under laboratory conditions and observed significant growth and development of earthworm among different combinations of animal agro and kitchen wastes.

Sharma *et al.* (2008) and Luo *et al.* (2011) reported that vegetable wastes contain huge amount of Cd, Pb and Cr which ultimately reached into agricultural field. Heavy metals are accumulated in fruit and vegetables by intake of plant from polluted soil. Vegetable wastes are one of the major sources of municipal solid wastes that caused environmental and health problems (Kale, 1998). Recycling of wastes through vermibiotechnology reduces the problem of biological wastes. Vermicomposting is one of the suitable ways for the management of biological waste by *Eisenia foetida* (Reinecke *et al.*, 1992; Ndegwa and Thompson, 2001). The vegetable wastes produced from the different polluted agriculture fields in India have higher concentration of Cd, Ni, Cr, Pb (Singh and Kumar, 2006; Sharma *et al.*, 2007). The vegetable and fruit wastes of the market have increased the level of heavy metals in the soil (Bouallagui *et al.*, 2004). The use of vermicomposts obtained from kitchen wastes have increased crop yield and soil nutrients status (Singh and Sharma, 2003; Roberts *et al.*, 2007).

Animal wastes

In India, million tonnes of cattle dung and agro-wastes are produce annually (Gupta, 2005; Garg *et al.*, 2006b). The microbial decomposition of these wastes produce unpleasant odour at pollution level causesing several diseases that compose serious human and livestock health problem (Reinecke *et al.*, 1992).

The different animal and biological wastes have problem and a challenge for developing countries (Hartenstein *et al.*, 1979; Edward, 1998; Nogales *et al.*, 1999; Garg *et al.*, 2005). The applications of animal manures in soil contain toxic heavy metals which enter the human body through the food chain and caused several health problems (Hernandez *et al.*, 1991; CRI, 1994; Hu, 2002). The livestock excreta and industrial sludge are also a serious problem for the society (Garg *et al.*, 2005). Kaplan *et al.* (2011) reported that heavy metal pollutants are environmental pollution is a major global problem posing serious risk to animal and human health. The of different animal wastes converted into useful product by use of earthworm *Eisenia foetida* through vermicomposting (Edward *et al.*, 1998; Gunadi *et al.*, 2002; Kaushik and Garg, 2003).

Heavy metals in soil

Soils give a suitable natural environment for biodegradation of wastes (Ekundayo, 2003). The heavy metals such as Cr, Fe, Ni, Pb, Zn and Cu are present in considerable amount in the soil of Jharia coal field

of Jharkhand (Nikhil, 2006). Li-wenfan *et al.* (1995) reported that the soil samples in the area near a problem refining factory had higher concentration of Pb, Cd and Cu. Rajaganapathy *et al.* (2011) studied heavy metal contents in soil, water, fodder and its consequences in livestock where it accumulate in their vital organs including liver, kidney causing adverse effects on their health. Kotwal *et al.* (2005) also observed accumulation of heavy metals and toxicants are accumulating in liver of animal populations. Bioaccumulation of heavy metal toxicity from the food chain is one of the major environmental health problem and potentially dangerous and it can cause hazardous effect on livestock and human health (Aschner, 2002; Aycicek *et al.*, 2008). Pereira and Arruda (2003) also studied the soil pollution from heavy metal contamination.

Nannipieri and Badalucco (2003) observed that soil is complicated heterogeneous system with predominance of a solid phase constituted of soil organic matter, minerals, plant debris, microbes and soil fauna. The toxicity of heavy metals is influenced by several factors such as soil pH, metal solubility and metal bioaccumulation (Morgan and Morgan 1999; Neuhauser *et al.* 1995; Van Straalen and Bergema 1995). The high concentration of heavy metals in soils is reflected by higher concentrations of metals in plant, animal and human bodies (Mccrady and Maggard, 1993). The ability of some plants to absorb and accumulate xenobiotics makes them useful as indicators of environmental pollution (Mccrady and Maggard, 1993; Hauk *et al.*, 1994; Farago, 1994;

Berthelsen *et al.*, 1995; Gorna-Binkul *et al.*, 1996; Pandolfini *et al.*, 1997; Namiesnik and Wardencki, 2000).

Effect of heavy metals on animal and human health

Heavy metals release naturally by erosion of rocks, volcanic activity, forest fire, .industries, paper mills, vehicles and human activities which directly affect the flora, fauna as well as the environment (Martin and Griswold, 2009). Heavy metals enter the human body by ingestion of contaminated foodstuff specially grains, cereals and leafy vegetables (Hu *et al.*, 1996). Volcanic rocks and gases are responsible for the presence of metals such as As, Hg, Pb, Al, and Zn in soils of volcanic origin (Ferreira and Oskarsson, 1999; Kelepertsis *et al.*, 2001). The lead (Pb) is responsible to damage liver, kidney and brain cells which cause ultimately death, miscarriage in pregnant women whereas cadmium (Cd) also causes acute and chronic toxicity symptom in human (Mueller and Anke, 1994; Hu *et al.*, 1996). Martin and Griswold (2009) reported that the chromium (Cr) is non essential heavy metal and hazardous elements causing several respiratory irritation lung disease, cancers and kidney problems. The arsenic (As) is carcinogenic and causes cancer of skin, lung and liver (Ye *et al.*, 2000; Suwazono *et al.*, 2002). Cobalt (Co) can be responsible for the beer heart syndrome in the human (Brown, 1968).

Different kind of heavy metals cause many disorder in human body (Mueller and Anke, 1994). Roels *et al.* (1997) reported that Cd, Cr and Ni encountered in industries dealing with pigments, metal plating, some plastic and batteries. The high level of Pb exposure to the body caused

damage to brain, liver and kidney which ultimately leads to death (Goyer, 1993; Martin and Griswold, 2009). Heavy metals contamination has increase soil pollution and change physical, chemical and biological properties of the soil and environment (Pereira *et al.*, 2003). Heavy metals are considered as serious pollutants because they are toxic and non-degradable (Nwuche and Ugoji, 2008; Aina *et al.*, 2009). Heavy metal contamination can change the activities of soil fauna in soil ecosystem (Cortet *et al.*, 1999). Dumpsites contain various kinds and concentration of heavy metals (Odukoya, *et al.*, 2000; Ebong *et al.*, 2007; Saedi and Amini, 2007). Earthworms are major macro soil fauna component in soil functioning and play an important role in chemical element transformation and accumulation of heavy metals from soil and disease risk of heavy metals to the to human and livestocks (Odoh *et al.*, 2011).

The heavy metal such as Cd, Pb and Hg etc. pollution in drinking water, food and air has become a serious health concern in recent years (Tam and Wong, 2000), and cause harmful effect on man and animals (Yuan *et al.*, 2004). The high level of cadmium is known to cause damage to kidney, liver, bones and lungs (Nawrot *et al.*, 2010). Rajaganapathy *et al.* (2011) reported that many toxic heavy metals accumulate in one or more of the body organ and these metals cause acute or chronic poisoning to public health. Arsenic is a carcinogen and causes cancer of skin, disfunction of lungs, kidney, digestive tract and liver (Mazumder, 2008). Its lower level of exposure cause nausea and vomiting, decreased

production of blood cells and damage to blood vessels (Martine and Griswold, 2009).

Earthworms

The earthworms are cylindrical, metamerically segmented invertebrate belong to phylum Annelida and class Oligochaeta. The distribution of earthworm in soil is influenced by several factors such as soils textures, aeration, temperature, moisture, pH, organic matter, dung and their reproductive potentials (Garg, *et al.*, 2006a; Suthar, 2006). Earthworms could serve as useful biological indicators of toxic metals contamination of soil (Van Hook, 1974). They are major borrowing invertebrate and due to their burrowing activity water holding capacity of soil increased along with providing optimum aerobic growth condition for bacteria and plant roots (Wurst *et al.*, 2003). Majority of earthworms occurred in soil where the moisture ranges from 12-45% (Govindan, 1998). The external biotic parameter and the nutritive resources of the soil are primary controlling factor for their earthworm population (Albanell *et al.*, 1988; Edwards and Bholen, 1996).

Generally earthworms are classified into as anecic, endozoic and epigeic. The anecic worms are burrowing that come to the surface at night to drag the food down into the permanent burrows deep with the mineral layer of soil (Arancon *et al.*, 2004). The epigeic species worm live in the surface litter and feed on decaying organic matter. They are very active with high regenerative capacity within a short period of time (Gupta, 2005). Earthworms are important link in the food chain and they

can accumulate the hazardous elements from the soil (Handriks *et al.*, 1995; Spurgeon and Hopkin, 1996b). Earthworms are also ubiquitous invertebrate animal living in soil, which affect the soil physic-chemical properties (Ponder *et al.*, 2000), and distribution of microbes and soil animals (Salmon, 2001). The earthworms are a beneficial species which breakdown, a wide range of organic residue such as animal wastes, sewage sludge and industrial wastes to produce vermicompost (Hartenstein and Bisesi, 1989).

Earthworms and microbes symbiosis act as controlling system of enzyme during the metabolism and keep the content of nutrient in vermicast (Parthasarathi and Ranganathan, 2002). Several species of earthworms such as *Eisenia foetida, Denderobaena vaneta*, *Lumbricus rubellus, Eudrilus eugeniae* and *Peryonix excavatus,* have been recommended for breakdown of organic matter in vermicomposting (Talashilkar and Dosani, 2008). In India, two species are extensively used for vermiculture, namely *Eisenia foetida* and *Eudrilus eugineae* along with the exotic species like *Denderobaena vaneta, Peryonix excavatus,* and *Lumbricus rubellus* (Edwards *et al.*, 1998; Kaushik *et al.*, 2003). Scott (1988) observed that earthworm digested animal wastes are as much supplement to peat in loam-less composts for horticulture. Annually applications of poultry litter and animal wastes lead to increased nutrient and metal concentration in soil (Kpomblekou *et al.*, 2002). Ghosh (2004) reported that vermiculture is an innovative vermibiotechnology, in which the breeding and propagation of

earthworm *Eisenia foetida* and the use of its castings become an important tool of wastes recycling converting in to vermicomposts. Sharma *et al.* (2008) have studied the use of earthworm as natural bioreactors for cost-effective and environmentally appropriate waste management.

Ismail (1993) reported that the species *Lempitto mauritii* and *Perionyx excavatus* are suitable for vermicomposting and soil management in South India. Ranganathan (2006) observed that *Denderobaena vaneta*, *Perionyx excavatus*, *Lumbricus rubellus* and *Perionyx sensibaricus* are suitable for the solid wastes management. Epigeic species *Eudrilus eugeniae* have been extensively used in converting organic wastes in the vermicompost during vermicomposting (Sharma *et al.*, 2008). Venkatesh and Eevera (2008) studied that the different combinations of fly ash and cow dung with inoculation of *Eudrilus eugeniae,* and observed availability of the plant nutrient. Phosphate solublizing microbes such as *Micrococci, Pseudomonas* spp., *Bacillus* spp., and *Aspergillus* spp. were observed in gut and cast of *Lempitto maurotii, Perionyx excavatus* and *Eudrilus eugeniae* (Parthasarathi and Ranganathan, 2000).