Earthworms are important biological resources that have a tremendous potential in agro systems. India is a diverse country having a very high diversity of earthworms. Earthworms have gained renewed scientific attention in India and abroad because of their wide application in the production of vermicompost and as a source of animal protein for domesticated animals. They are secondary decomposers of organic waste in nature. The castings of earthworms are rich in nitrates, magnesium, phosphorus, potassium and calcium. In the rural areas huge quantity of agro waste is available which can serve as a good substrate for vermicomposting. Vermicomposts have plant growth promoters, which are responsible for lush growth of plants (Amojii et al. 1998, Bhatnagar and Palta, 1996, Edward and Bohlen, 1996). Many of our agricultural wastes can be recycled through earthworms, solving many of our current problems in respect of solid waste disposal and water pollution. India has made substantial advancement in agriculture sector by taking the advantage of physical and climatic conditions. The increasing utilization of chemical fertilizers and pesticides has spoiled the health of our soil. This leads to severe environment pollution and now a days problem of solid waste management is also crippling in our system.

Earthworms have been used for waste stabilization for many years especially in Southeast Asian and European countries. Highlighting the role of earthworms, Charles Darwin called them the unheralded soldiers of the soil. From then on, different experimental studies have been carried out to study the role of earthworms in maintaining the soil fertility and also in the degradation of the organic matter present in the soil. Different scholars have tried the possibility of utilizing earthworms for the breakdown of organic wastes such as animal wastes, vegetable wastes and municipal sludge. Earthworms maintain aerobic conditions in the mixture, ingest solids, and convert a portion of the organic matter into worm biomass and respiration products, and expel the remaining partially stabilized matter as discrete material (castings). Ronald and Donald (1977) have reported that the earthworms and the microorganisms act symbiotically to accelerate the decomposition of organic matter. Introduction of vermiculture and other reuse processes is the global need to recover organic material and return this to the natural cycle.
Earthworms made a large contribution to the total weight or biomass of invertebrates in soil. Aristotle first drew attention to their role in turning over the soil and called them intestines of the earth. By utilizing various vermiculture techniques we can, not only manage our wastes but also have a check on the environmental pollution. The basic aim of composting is to bring about decomposition of organic wastes without undue loss of nutrients and the production of end product rich in plant nutrients. Vermicompost substitution with fertilizers input will reduce the economic input in agriculture. The main source of food for earthworms is the organic waste such as agro-horticultural crop waste, weeds, forest leaf litter; agro-industrial wastes etc. which get defecates the faecal pellets known as vermicompost. This is rich in plant nutrients such as macro and secondary elements, beneficial micro flora and plant growth regulators. Survival and development of earthworms is highly influenced by environmental factors like temperature, bed moisture, rainfall and relative humidity (Kale et al., 1982, Reinecke et al., 1992, Nagavallemma et al., 2004) which determine the population in field. Constant high temperature is detrimental for the development of worms even though all other conditions are favourable. Production of worm biomass and vermicompost in open (field) vermicomposting sites is influenced by seasonal variation. Vermiculture technology is employed for composting of various non-toxic organic wastes. Earthworms serve as versatile natural bio reactors to harness the beneficial soil micro flora and destroy pathogen, thus converting organic waste into valuable products such as bio-fertilizers, bio pesticides, vitamins, enzymes, antibiotics, growth hormones and proteinaceous worm biomass.

Hundreds of tonnes of biodegradable organic waste is being generated in cities and towns in our country, creating disposal problems. This waste can be converted into valuable compost by applying vermi-composting technology. This approach reduces pollution and provides a valuable substitute for chemical fertilizers. Earthworms have been used for centuries as a means of decomposing wastes and improving soil structure. Increasing numbers of businesses worldwide are successfully employing vermiculture technology and marketing vermicompost as an excellent soil conditioner, to farmers and gardeners. The breeding and propagation of
earthworms and the use of its castings has become an important method of waste recycling throughout the world and now it is also gaining importance in various regions of the country.

Out of 418 species of earthworms known from the country (Julka and Paliwal, 2005) only half a dozen are frequently used for vermiculture and vermicomposting. Therefore, there is an urgent used to undertake extensive studies of Indian earthworms species. Two species of earthworms have consistently been used for commercial composting or worm farming, due to their relatively high tolerance of environmental variations, *Eisenia fetida* and *Perionyx excavates*. *Eisenia fetida*, popularly known as red wriggler/red worm/tiger worm is the most widely used earthworm for vermicomposting. *Perionyx excavates* is highly adaptable and can tolerate a wide range of moisture and quality of organic matter. These two species have also been in wide usages for various toxicological studies as test worm.

Vermicomposting technology is one of the best options available for the treatment of organic-rich solid wastes. The term vermicomposting have been coined from the Latin word ‘*Vermis*’ meaning to the ‘worms’. Vermicomposting refers to composting or natural conversion of biodegradable garbage into high quality manure with the help of earthworms. Earthworms play a key role in the soil biology. They serve as versatile natural bioreactors to harness energy and destroy soil pathogens. The worms do so by feeding voraciously on all biodegradable roughage such as leaves, kitchen waste, vegetable roughage etc. The earthworm is one of nature’s pinnacle “soil scientists.”. The worms are accountable for a variety of elements including turning common soil into superior quality. They break down organic matter and when they eat, they leave behind castings that are an exceptionally valuable type of fertilizer.

Earthworms and its vermicompost works like ‘miracle growth promoter’ and is nutritionally superior to the conventional compost and chemical fertilizers. Reduced incidence of ‘pest and disease attack’, and ‘better taste of organic food products especially ‘fruits and vegetables grown with vermiculture are matter of great socioeconomic and environmental significance (Hand et al.1988 and Lee, 2003). Presence of earthworms in soil particularly makes a big difference in growth of
flowering and fruit crops and significantly aid in fruit development. The 18% increase in yield of wheat crops over chemical fertilizers in their farm studies made in India has great economic and agronomic significance. Earthworms benefit soil quality by shredding residues stimulating microbial decomposition, improving soil fertility, and improving soil physical properties such as soil aggregation and infiltration. Food availability is the major factor limiting earthworm numbers. Producing food through crop residues and cover crops and leaving them on the soil surface through the use of conservation tillage practices provides food to increase earthworm numbers.

Vermicomposting is an ecofriendly method to degrade this organic waste. Earthworm species convert this waste into better end product and provide solution to the problem of organic waste degradation as reported by (Nagavallemma et al., 2004) and (Bhatnagar and Palta, 1996). Earthworms are justifying the beliefs and fulfilling the dreams of Charles Darwin who called earthworms as ‘friends of farmers’ and that of Anatoly Igonin of Russia who said ‘Earthworms create soil and improve soil’s fertility and provides critical biosphere’s functions disinfecting, neutralizing, protective and productive’. It is like getting ‘gold from garbage’ (highly nutritive biofertilizer) by vermi-composting technology; ‘silver from sewage (disinfected & detoxified water for reuse in agriculture & industries) by vermi-filtration technology; ‘converting a wasteland (chemically contaminated lands) into wonderland (fertile land) by vermi-remediation technology harvesting ‘green gold’ (food crops) by using ‘black gold’ (vermicompost) by agro-production technology; creating a ‘worm factory’ to produce medicines & materials for societal use. In India, the earthworms have enhanced the lives of poor and the unemployed. Educated unemployed have now taken to vermicomposting business on commercial scale. They are truely called the protector of human environment. Vermicompost enhances germination, plant growth and thus overall crop yield. Vermicompost applications to field soils combined with 50% of the recommended inorganic fertilizers increased the yields of tomatoes (Kale et al. 1982).

Species of earthworm are adapted to decaying organic material. They thrive in rotting vegetation, compost, and manure. They are rarely found in soil and are used for vermicomposting. They are native to Europe, but have been introduced (both
intentionally and unintentionally) to every other continent, except Antarctica, occasionally threatening native species. When roughly handled, red wrigglers exude a pungent liquid, most probably as a chemical self-defense, thus the specific name fetida means fetid odor or having a rotten or offensive smell. This is presumably a defense. Like other earthworms, *E. fetida* is hermaphroditic. However, two worms are still required for reproduction. The two worms join clitellums (contains reproductive organs and only visible when ready to reproduce, large orangish band) and exchange sperms. The worms that hatch out of cocoons will show a rapid growth and by the time they are 5 weeks old, they reach the reproductive phase. With this phase, a thick band like structure called clitellum appears in the front portion, in about one-third of the body. Earthworms are hermaphrodites (bisexual). Cross fertilization is the feature wherein the exchange of sperms between the individuals takes place through a temporary mucilaginous tube during copulation. The cocoon case which is a mucilaginous, leathery tube envelopes the clitellum and moves with eggs anteriorly. As it moves, the spermatophores collected from the partner slips into the case and the cocoon case slips sown the body at the anterior end with spermatozoa and eggs.

Both worms then, rather than laying eggs directly, secrete cocoons that contain several eggs. These cocoons are lemon-shaped and begin as pale yellow when first laid, and become more brownish as four to six worms mature. These cocoons are clearly visible to the naked eye. *E. fetida* can adapt to even higher temperatures. Most temperate species of earthworms have optimal developmental temperatures between 12°C and 20°C (Graff, 1953). *E. fetida* is most productive at 20°C if both reproduction and rates of growth are taken into account (Edwards and Fletcher, 1988). The average rate of cocoon production was higher in the monsoon season. Higher the rate of cocoon production, lower the weight of individual cocoons (Biradar *et al.* 1999). Processing the waste material through controlled bio-oxidation processes, such as vermicomposting reduces the environmental risk by transforming the material into a safer and more stable product suitable for application to soil (Lazcano *et al.* 2009). It also reduces the transportation costs because of the significant reduction in the water content of the raw organic matter. Composted materials are therefore gaining acceptance as organic fertilizers in sustainable agriculture and there has been a considerable increase in research dedicated to the
study on effects of compost-like materials on soil properties and plant growth. This enhanced growth in vermicompost might be due to the presence of more amount of available nitrogen, which is essential for the synthesis of structural proteins (Edwards, 1988). The results of several long-term studies have shown that the addition of compost improves soil health/physical properties of the soil by decreasing bulk density and increasing the soil water holding capacity (Weber et al. 2007).

The effects of heavy metals on soil organisms depend on exposure to concentrations that are available for uptake. Therefore it is important to know which metal species can be taken up by organisms and to determine the relative importance of different uptake routes. Earthworms can be exposed by direct dermal contact with heavy metals in the soil solution or by ingestion of pore water, polluted food and/or soil particles. Literature indicates that soluble metal concentrations are the best descrip-tors of bioaccumulation in earthworms. Earthworms could be used to extract toxic heavy metals, including cadmium and lead, from solid waste from domestic refuse collection and waste from vegetable and flower markets. Toxic metals are metals that form poisonous soluble compounds and are not essential minerals. Heavy metals are introduced into the environment by a wide spectrum of natural and anthropogenic sources. Heavy metals such as mercury, zinc, arsenic, cadmium and lead are dangerous pollutants and are often deposited with natural sediment. These are chemical elements with a specific gravity that is at least 5 times the specific gravity of water which is 1 at 4°C (39°F). Cadmium (sp. gravity 8.65) and lead (sp. Gravity 11.34) are very toxic metals having fatal effects on living beings. If these metals are deposited on surface sediments, they may become incorporated in plants, food crops and animals (Neuhauser et al. 1985; Fitzpatrick et al. 1996; Neuhauser and Callahan, 1990). They interfere with the metabolic processes to cause ill effects.

Lead is a heavy metal that is toxic at very low exposure levels and has acute and chronic effects on human health. It is a multi-organ system toxicant that can cause neurological, cardiovascular, renal, gastrointestinal, haematological and reproductive effects. Cadmium is a non-essential and toxic element for humans mainly affecting kidneys and the skeleton. It is also a carcinogen by inhalation. Cadmium is accumulated in bone and may serve as a source of exposure later in life. In the
environment, lead and cadmium are toxic to plants, animals and microorganisms. Lead and Cadmium are metals that are mainly transported over local, national or regional distances. The export of new and used products containing lead and cadmium, remains a challenge for developing countries and countries with economies in transition which lack the capacity to manage and dispose of the substances in products in an environmentally sound manner. The diverse deleterious health effect upon exposure to toxic heavy metals in the environment is a matter of serious concern and a global issue. Much emphasis has been given to elucidate the mechanism of toxicity due to common environmental toxicants and to develop a safer chemotherapeutic approach to mitigate the toxic effects. Lead and cadmium are the two most abundant toxic metals in the environment. The concurrent higher levels of lead and cadmium have been recorded in several field situations. The common sources of lead and cadmium are diverse in nature including natural and anthropogenic processes.

Earthworms are efficient accumulators of heavy metals. Cadmium and lead are widely present in the soil of Haryana and are important in respect of their deleterious effects. Many authors have studied the toxic effects of various heavy metals. However, relatively few studies have been carried out on the adverse effect of metal mixtures at sub lethal levels on earthworm. Information about the effects of heavy metal on survival and biochemistry of earthworm is scanty. Thus the present investigation will be carried out to study the effect of cadmium and lead on the two earthworm species *Eisenia fetida* and *Perionyx excavates*. Keeping in view all the above mentioned points the present study will be proposed with the following objectives:

**Objectives**

1. To standardise the culture techniques of different earthworm species.
2. To study the effect of heavy metals on the growth, survival and reproductive potential of different species.
3. To study the effect of heavy metals on the carbohydrate constituents and amylase enzyme activity of earthworm species.
4. To study the effect of heavy metals on the protein constituents and protease enzyme activity of earthworm species.

5. To study the effect of heavy metals on the lipid constituents and lipase enzyme activity of earthworm species.