



## SUMMARY

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Indiscriminate use of chemical fertilizers and pesticide disturbs the soil texture and its physicochemical properties as well as affects the human health and environment. The use of chemical fertilizers has posed a serious threat to the environment and caused destruction of useful microorganisms, insects and worms in the soil. The biological wastes caused environmental hazards and various ill effects on human life and their domesticated animals, if their proper management and disposal practices are not available. Organic farming through vermicomposting is a better option for management of wastes by the earthworms and improvement of soil quality. It is one of the interesting aspects, since it contribute to a broad relationship among food, environmental quality and safety of human and animal health.

Vermicomposting is an easy and effective way to recycling of biological wastes in to nutritious compost by earthworm activities. During these process important plant nutrient such as nitrogen, phosphorus potassium, calcium etc. present in feed materials are converted in to more absorbable form for the plants. Not only these, the plant nutrients also have growth regulators, beneficial bacterial and actinomycetes population in large number of worms' eggs. It increases the porosity aeration, drainage water holding capacity, which reduced the irrigation water requirement for crops. It improves nutrients availability and could act as complex fertilizer granules and evolves great reduction in the population of harmful pathogenic microorganism.

*Eisenia foetida* is commonly known as red worm because of their red colour of body and distributed throughout the country because of their migratory habits. The worms are hardy and can tolerate wide variation of temperature, humidity and also survive on a wide variety of degradable wastes. Earthworms play an important role in stabilization of inorganic plant nutrients to organic form and increased the soil fertility. The worms added their cast with compost and increased the inorganic nutrients many times along with some plant growth hormones and vitamins. They also help in the problems of management of rotting solid organic waste in dumping site which caused odour problems, polluted the soil, water, air and health of human population.

In present investigation the concentration of different heavy metals, namely, cobalt (Co), chromium (Cr), lead (Pb), nickel (Ni), cadmium (Cd) and arsenic (As) were determined in vermibeds prepared from different combinations of animal (buffalo, cow, goat, horse and sheep) dungs with municipal solid wastes (MSW) and kitchen waste (KW) in ratio of 1:1, 1:2 and 1:3 in initial feed mixture of vermibeds and in vermicompost during vermicomposting by earthworm *Eisenia foetida*. It is clear from the result that the earthworm, *Eisenia foetida* is effective in lowering down the heavy metals in different animal dungs, MSW and KW tested during vermicomposting (60 days). Cobalt was observed to decrease significantly ( $P < 0.05$ ) in the vermicompost of combination of buffalo dung with municipal solid wastes (1:1) as well as in the combination of buffalo dung with kitchen waste (1:3). The concentration of chromium was also observed to decrease in the vermicompost when vermibeds were prepared with different

combinations of buffalo dung with kitchen waste during vermicomposting by earthworm *Eisenia foetida*. The amount of nickel was decreased in all the combinations of different animal dung with municipal solid wastes even below the detectable limit during vermic-activity. The concentration of cadmium also significantly decreased in vermicompost of buffalo dung with municipal solid wastes in the ratio of 1:3. The arsenic concentration was also observed significantly to decrease in the combination of cow dung with kitchen wastes (in the ratio of 1:1, 1:2 and 1:3) below detection limit. It implies that the earthworm *Eisenia foetida* was suitable species for accumulation of heavy metals from different animal dungs along with municipal solid wastes.

The concentration of above heavy metals inside the body of *Eisenia foetida* before and after vermicomposting of different combinations of animal (buffalo, cow, goat, horse and sheep) dungs with municipal solid (MSW) wastes and kitchen wastes (KW) in the ratio of 1:1, 1:2 and 1:3 was observed. The results show that the accumulation of all the heavy metals examined in the body tissue of *Eisenia foetida* significantly increased during vermic activity after vermicomposting (60 days).

*Eisenia foetida* was observed to accumulate significantly more amount of cobalt from the vermibed of animal dungs MSW and KW after vermicomposting media and thus making it less available to the crops and higher trophic level. The cobalt and arsenic were significantly increased in the earthworm *Eisenia foetida* body in the combination of buffalo dung with municipal solid waste in ratio of 1:3. The lead was

observed in earthworm body after preparation of vermicompost in the combination of goat dung with municipal solid waste in the ration of 1:2 as well as the chromium, nickel and cadmium were also observed in earthworm body after preparation of vermicompost in the combination of buffalo dung, goat dung and cow dung with municipal solid waste in the ration of 1:2.

The concentrations of different heavy metals (Co, Cr, Pb, Ni, Cd and As) in the soil and in the soil with vermicompost of different animal dungs (buffalo, cow, goat, horse and sheep) as well as after inoculation with the earthworm *Eisenia foetida* before sowing and after harvesting the crops were observed. Simultaneously, the heavy metals were estimated in the seeds of crop before sowing and in the grains of crop after its harvesting. The data demonstrated that the earthworm *Eisenia foetida* was responsible for the accumulation of heavy metals from different combination of soil with vermicompost of different animal dungs. It implies that the earthworm *Eisenia foetida* is a suitable species for vermicomposting that accumulates the heavy metals from the soil.

The cobalt and arsenic were significantly decreased in soil before sowing the maize grain of soil in the combination of soil with vermicompost of goat dung and soil with vermicompost of sheep dung due to inoculation of earthworm *Eisenia foetida* in maize (*Zea mays*) crop field whereas, in maize crop the cobalt was BDL (below detection limit) in the combination of soil with vermicompost of cow dung. The chromium and nickel were significantly ( $P < 0.05$ ) decreased in the combination of soil with goat dung. The lead and cadmium

concentration were observed in the combination of soil with vermicompost of sheep dung.

The maximum decreased in concentration of arsenic (As) were observed in the combination of soil with vermicompost of sheep and goat dung in soil due to inoculation of earthworm *Eisenia foetida* activity in pea (*Pisum sativum*) crop field whereas maximum decrease in the concentration of cobalt and arsenic were observed in the pea grain after harvesting of pea crop from the both combination of soil with vermicompost of goat and horse dung.

The concentration of arsenic was significantly ( $P < 0.05$ ) decreased to the BDL in wheat (*Triticum aestivum*) grain in combination of soil with vermicompost of goat dung as well as soil with vermicompost of horse dung, respectively. The concentration of cobalt was significantly ( $P < 0.05$ ) decreased to the BDL in rice (*Oryza sativa*) grain in combination of soil with vermicompost of goat dung as well as soil with vermicompost of sheep dung, respectively.

The heavy metal (Co, Cr, Pb, Ni, Cd and As) concentration were significantly ( $P < 0.05$ ) increased in earthworm *Eisenia foetida* body from agricultural field of maize (*Zea mays*), pea (*Pisum sativum*), wheat (*Triticum aestivum*) and also observed in rice (*Oryza sativa*) crop field due to the accumulation of these metals in its body tissue. The cobalt concentration was remediated from the combination of soil with vermicompost of horse dung in maize (*Zea mays*) crop field. The As concentration was remediated from pea (*Pisum sativum*) crop field due to the accumulation of metals in earthworm *Eisenia foetida* body in the combination of soil with vermicompost of horse dung whereas, wheat

(*Triticum aestivum*) and rice (*Oryza sativa*) crop field due to the accumulation of metals in earthworm *Eisenia foetida* body in the combination of soil with vermicompost of buffalo dung, respectively.

From the present study, it is apparent that the *Eisenia foetida* is a suitable earthworm species which is able to accumulate the heavy metals (Co, Cr, Pb, Ni, Cd and As) in their body and decreased the heavy metal contents present in soil and different biological waste materials. Through vermicomposting different wastes can be converted into rich organic vermicomposts which enhanced the plant growth and productivity in crop field and safe for soil, environment and human health. Vermicompost is easily producible, biodegradable, less expensive, and manageable. Its use will be ecologically safe and culturally more acceptable among farmers. The inoculation of earthworm *Eisenia foetida* in crop fields can decompose the different wastes and plough the soil and have ability to accumulate the heavy metals in body tissues. The effect of heavy metals on human health can be managed by the use of earthworms *Eisenia foetida* in vermicomposting as well as their habitats. Therefore, vermibiotechnology is a useful process for the management of the heavy metals from soil and different wastes thus protecting the human health and environment.