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Short communication

Earthworm as ecological engineers to change the physico-chemical properties of soil: Soil vs vermicast

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ABSTRACT

Earthworm is an important component in development and maintenance of physico-chemical properties of soil by converting biodegradable materials and organic wastes into nutrient rich vermicast. In this study, a comparison was done between the physico-chemical properties of soil and cast of *Metaphire posthuma* collected from botanical garden and agricultural field. *M. posthuma* was abundantly found in agriculture field due to its endogeic nature. It was found that earthworm of botanical garden was more efficient in cast production as compare to earthworm of agricultural field. Application of chemical fertilizer and pesticide in the field may be the possible reason for suppressing the activity of earthworm. *M. posthuma* increased the content of nitrogen, phosphorus and Organic Carbon (OC) while decreased the content of pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Na, K, Ca, Li and heavy metals. Ni was one of the key heavy metals which was efficiently decreased by the *M. posthuma* followed by Fe (95.01%), Pb (79.31), Zn (72%) and Cr (4.87%). Cast produced by earthworm has higher nutritional value and act as excellent soil ameliorating agent.

1. Introduction

In agriculture system, various activities have been performed by soil organisms like recycling of nutrients, control of local microclimate, detoxification of chemicals and regulation of abundance of undesirable organisms. The persistence of soil organisms depends upon the maintenance of biological integrity and diversity in agroecosystem (Altieri, 1999). Earthworms are one of the most important soil animals which have a capability to maintain the soil fertility and played a key role in sustainability. They are also known as ecosystem engineers (Jones et al., 1994). The important function of earthworm as ecosystem engineers and their role in soil formation and its contribution to the composition and functioning of soil ecosystem with varying species diversity was well explained by Jones et al. (1994), Lavelle and Spain (2001) and Jouquet et al. (2006). Earthworms enhances the incorporation of plant residue into soil aggregates, creates soil porosity and stable aggregate through their burrowing, humus formation, casting activities and also affect organic matter localization in the soil (Ketterings et al., 1997; Bossuyt et al., 2004).

Earthworm converts biodegradable materials and organic wastes into nutrient rich vermicast (Jansirani et al., 2012), which emerge from their burrows to deposit the fecal matter on the surface. The castings egested by earthworm have generally been assumed to be more stable than the parent soil aggregates and contain certain hormones, enzymes, microorganisms, inorganic and organic materials which it acquires during the passage of soil through the earthworm gut (Tersic and Gosar, 2012). The gut of earthworm contains many exogenic and endogenic enzymes to convert organic minerals into more exchangeable and available forms to plants (Suthar, 2012). Cast production in earthworm is an indicator of burrowing and soil turnover because 99.9% of ingested material is egested as cast (Chaudhuri et al., 2009).

The objective of this study was to know the role of earthworm as ecological engineer to change the physico-chemical properties of soil. The samples of vermicast from botanical garden and agriculture field were collected and their physico-chemical properties were compared with soil collected from the same field. Botanical garden and agriculture field were chosen for the present study to know the effect of application of pesticide and chemical fertilizer on the activity of earthworm. As a consequence more research is needed to understand the role of earthworm as soil engineers, influence soil properties and plant growth.

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Table 1
Description of study sites.

Sample site	GPS coordinates	Altitude	Vegetation	Soil moisture (%)	Soil temperature (°C)	Texture
Botanical garden (Site I)	N 31°63′22.3″ E 074°87′15.2″	220	Flowers	94	31	Sandy loam
Village Talwandi Rama (Site II)	N 31°56′53.3″ E 074°59′29.2″	235	Paddy	88	34	Sandy loam

2. Materials and methods

2.1. Site study

The study was conducted at botanical garden, Khalsa College, Amritsar (India) [Site I] and agriculture field [Site II] having latitude and longitude N 31°63′22.3″, E 074°87′15.2″ and N 31°56′53.3″, E 074°59′29.2″, respectively. The complete description of the study sites is given in Table 1. Only organic manure has been used for the cultivations of flowering plants in the botanical garden like *Rosa*, *Tagetes*, *Cosmos*, *Dahlia hortensis*, etc. On the other hand, Site II has paddy cultivation with more application of chemical fertilizer (Urea, Superphosphate, Diammonium phosphate, Potash) and pesticides (Chloropyriphos, Endosulfan).

2.2. Sampling of earthworm, soil and vermicast

The sampling of earthworm was done with hand sorting and digging method. The collected samples of earthworms with appropriate amount of soil (up to 10 cm depth) were placed in polythene bag labeled with place name, date of collection, surrounding soil biota, etc. Vermicast (Fig. 1) samples of *Metaphire posthuma* were also collected from the same sampling area. The samples were brought to research lab in Post Graduate Department of Zoology, Khalsa College, Amritsar. Earthworms were narcotized with 70% ethyl alcohol and fixed in 5% formalin for 6–8 h and finally preserved in 5% formalin.

2.3. Physico-chemical analysis of soil

Collected samples of soil and vermicast were analyzed for pH, Electrical Conductivity (EC), Total Dissolved Salts (TDS), Nitrogen (N), Phosphorus (P), Potassium (K), Organic Carbon (OC), Sodium (Na), Calcium (Ca), Lithium (Li) and heavy metals. pH, TDS and EC were measured by using Digital meter (Eutech Instruments, PCSTestr 35 series). The method of Bremner and Mulvaney (1982) was used for estimation of Total Kjeldhal Nitrogen. Content of organic carbon was measured by the method of Nelson and Sommers (1996). Phosphorus was estimated by method of John (1970). Sodium, potassium, calcium and lithium were analyzed by Systronics Flame Photometer-128. Heavy metals analysis of vermicast and soil was also measured by method of APHA (2012) by using AAS Thermofisher iCE 300.

Fig. 1. Vermicast of earthworm *Metaphire posthuma* in the agriculture field.

2.4. Statistical analysis

The linear relationship between different physico-chemical parameters of soil and vermicast was obtained by Pearson correlation analysis. The experimental data is presented as mean ± SE of triplicate experiment. Statistical analysis was done with the help of Minitab version 14.0 (Pennsylvania, USA) computer software programs.

3. Results and discussion

Ecological engineers like earthworms play an important role in agro-ecosystem on maintaining soil fertility by changing the physico-chemical properties of soil. The change in physico-chemical properties was due to reorganization of soil structure by movement of earthworm through soil and during gut transit. The organic materials are intimately mixed and become encrusted with mucus to create nuclei for stable aggregates formation (Barois et al., 1993). Physico-chemical properties of the soil also play an important role in maintenance of earthworm biodiversity. The physico-chemical properties of vermicast from (Site I) and (Site II) were analyzed and compared with respective soil from the same site (Table 2). It was found that earthworm decreased pH, EC, TDS, K, Na, Ca, Li and heavy metals, while increased N, P and OC in the vermicast. The percent increase in nitrogen was 49.3% and 27.2%, phosphorus was 2104% and 1919% and OC was 9.64% and 63.9% in Sites I and II respectively. There was a positive correlation between soil and vermicast of botanical garden ($r = 0.95$) and agricultural field ($r = 0.98$) as shown in Fig. 2. In the present study *Metaphire posthuma* (Valliant) have been abundantly found in agriculture soil due to its endogeic ecological category which protects it directly from effects of insecticides and pesticides and mechanical disturbance produced during agriculture management practices. The reduced tillage in garden has led to increased earthworm abundance and species diversity. More ploughing in agriculture field positively influence endogeic species by increasing organic matter availability and opposite effect on anecic species (Metzke et al., 2007; Capowiez et al., 2009; Ernst and Emmerlings, 2009). In our study, the efficiency of *M. posthuma* was more in botanical garden and cast from botanical garden contain more nutrient content then the cast in agriculture field. The use of more chemical fertilizer and pesticide in agriculture field may suppress the activity of earthworm. Capowiez et al. (2010) also studied the effect of pesticides on cast production and resulted that cast production and its nutrient content vary with variations in concentration of pesticides.

Vermicompost act as a buffer to maintain the pH of soil (Singh and Kaur, 2014). In the present study, decrease in pH (3.7%) was