EARTHWORM: THE ECOSYSTEM ENGINEER

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Existence of global ecosystem revolves around maintenance of soil health. Soil health not only renders soil ecosystem services but is invariably related to the global ecosystem which covers soil, air, marine and forest ecosystem as an inter-related matrix where each system is interdependent and complementary to one another. Soil flora and fauna both are critically important factors responsible for maintenance of soil health. When we narrow down our focus from soil to agriculture, boosting soil fertility comes as a major challenge as soil is the only sustainable platform where atmosphere, hydrosphere and biosphere interact for the plant growth. Over the years we have taken many progressive steps in agriculture and major thrust of soil biological research has been assigned to soil flora which includes bacteria, fungi, actinomycetes, mycorrhiza etc. But soil fauna viz., nematodes, collembolans, mites, and earthworms are the most commonly studied ones. Amongst the fauna, earthworms are the well-known burrowing animals due to their exceptional ability to churn the soil. It helps in formation of aggregates, nutrient enrichment as well as mobilization by decomposition of dead organic residue, thus stabilizing the soil ecosystem. They digest soil or organic matter 300 times of their body mass and form a large amount of worm cast transforming one form of humified organic matter to another. Hence they are rightly named as 'Soil or engineers' (Kooch and Jalilvand, 2008; Ojha and Devkota, 2014).

TYPES OF EARTHWORM

Based on their feeding and burrowing habit they can be essentially classified into 3 major categories i.e. Epigeic, Endogeic and Anecic (Table 1 & Figure 1, 2 3).

Figure 1. *Esenia fetida* (Eepigeic)

Figure 2 *Aporrectode acaliginosa* (endogeic)

Figure 3. *Lumbricus terrestris* (anecic)

Endogeic worms dwells in upper part of the soil (0-20 cm) and feed on organic materials and soil (called as soil feeders). They are not heavily pigmented and form extensive horizontal network of burrows. They can be further classified into polyhumic, mesohumic and oligohummic based on their decreasing feeding preference for organic rich mineral soil and increasing size. Anecic worms are large in size, dorsally pigmented, deep burrowing in nature, forming permanent burrows and several feet in length. They feed on the residues that they pull back into soil (Kooch and Jalilvand, 2008). Most common species of earthworms (composting and non-composting) along with their characteristic features are listed in table 2.

Table 1. Major categories of earthworm based on habitat preference and feeding habit

Category	Subcategory	Pigmentation	Estimated size (cm)	Substrate	Preferred habitat
Epigeic	Epigeic Epi-anecic/ Epiendogeic	Highly Partially	< 10 10-15	Leaf litter and decomposed materials	Litter and surface soil
Endogeic	Polyhumic Mesohumic Endo-anecic Oligohumic	No pigmentation	< 15 10-20 >20 >20	Soil with high organic content (0-10 cm) Soil from deeper layer (20-40 cm)	Surface rhizosphere 0-20 cm soil 0-50 cm soil 15-18 cm soil
Anecic	Anecic	Anterodorsal pigmentation	>15	Litter and soil	Deep burrows

(Source: Medina-Sauzaet al., 2019; Kooch and Jalilvand, 2008)

Table 2. Common species of earthworm

Species & Ecology	Common names	Characteristics
Composting Worms		
Eisenia fetida **(Epigeic)**	Tiger worm,manure worm, brandling worm	• Rust brown colour with yellow stripes throughout the length • 130 mm in length • Optimum Temperature Range for its activity is 15-25°C
Lumbricus rubellus **(Epigeic)**	Redworm, Bloodworm, red wiggler	• Dark red to maroon in colour, no strips in the body and light yellow on the ventral side • Up to 105mm in length • Optimum temperature range for its activity is 18-23°C
Eisenia andrei **(Epigeic)**	Red tiger worm	• Dark red to purple in colour with some stripes • Up to 130mm in length • Optimum temperature range for its activity is 18-23°C
Dendroba enaventa **(Epigeic)**	Dendras, blue noses	• Violet, purple or olive brown in colour and less often striped • Up to 155mm in length • Optimum temperature range for its activity 18-25°C
Eisenia hortensis **(Epigeic)**	European night crawlers	• Purple/ brown in colour • 150 mm in length • Optimum temperature range for its activity 18-25°C

Non-composting Worms		
***Lumbricus terrestris* (Anecic)**	Earth worker worms, common earthworm, lob worm, night crawler, Garden worms	• Pinkish to reddish-brown in colour • 110–200 mm in length • Cylindrical body in the cross section with flattened posterior part.
***Aporrectodea caliginosa* (Endogeic)**	Grey worm	• Grey in colour with three distinct shades of colour at anterior part • 60mm in length

BENEFICIAL EFFECTS

Organic Matter Decomposition & Nutrient Cycling: Earthworms are one of the major decomposing groups in soil. They can ingest up to one third of their body weight and break down the complex organic matter into simple soluble form using their gut flora. They usually feed on complex organic matter at night and burrow during the day. As they mix the soil and organic matter from surface soil to the deeper soil layers; the mobilization of nutrients occurs throughout the soil.

Stimulation of Microbial Activity: Even if earthworms derive their nutrition from microorganisms, many more microorganisms are present in their casts than in the organic matter that they consume. As organic matter passes through their intestines, it is fragmented and inoculated with microorganisms. Increased microbial activity facilitates the cycling of nutrients from organic matter and their conversion into simple forms which can be readily taken up by plants.

Increased Infiltration Capacity: Earthworms form network of channels while burrowing through the soil layers. As they decompose the soil residue, the volume of soil is increased. Due to this soil aeration capacity increases and also increases water infiltration capacity of soil. Some species make permanent burrows deep into the soil. These burrows can be a major conduit for soil drainage, particularly under heavy rainfall. At the same time, the burrows minimize surface water erosion. The horizontal burrowing of other species in the top several inches of soil increases overall porosity and drainage.

Helps in Pedogenesis and Aggregation: Soil pedogenesis and aggregation is invariably influenced by biological processes in soil. Earthworms help formation of stable soil aggregates by forming fresh humus and binding with micro aggregates with the help of their mucilaginous secretions to form organo-mineral complex (Figure 2).

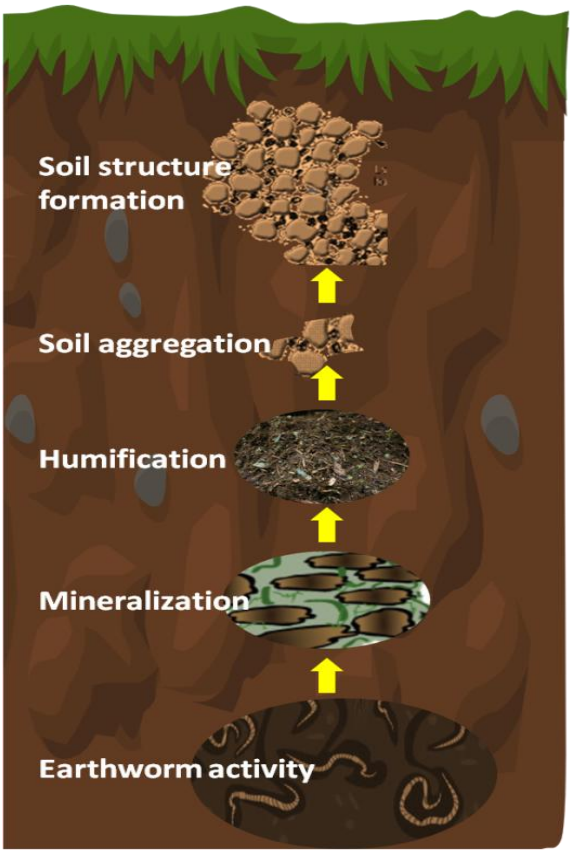

Figure 2. Role of earthworm in the formation of stable soil aggregates

Act as Bioindicator: Earthworms can effectively indicate level of heavy metal toxicity, toxic pollutants and other anthropogenic activities in soil. There are certain group of worms those can bio accumulate certain metal elements indicating level of contamination in soil (Suther, 2009). Also, land use changes also affect earthworm abundance (Tandohet al., 2007). For example, different management practices like integrated farming, organic farming, and conventional farming show differential response to earthworm abundance. Ecological indices viz., Shannon diversity (H), species dominance (C), species richness (S), and evenness (E) are used to indicate earthworm abundance (Suther, 2009).

Earthworm and Vermicomposting: Vermicomposting is nothing but composting of complex organic matter into humus with the help of earthworms. Earthworm species like *Eudrilus eugeniae*, *Eisenia fetida*, Lumbricus rubellus, and Perionyx excavatus, are well known for their efficiency in vermicomposting. Vermicomposting is a cost effective, non-destructive and environmentally sound technology for converting biomass into potentially useful plant nutrient enriched compost.

EARTHWORM IN THE MATRIX OF FOOD WEB

Earthworms and microbes are the neighbours that are closely intertwined throughout their life cycle (Figure 3). Earthworm devours on microbes like bacteria, fungi, and possibly nematodes and protozoa for their nutrition and also promotes microbial activity by decomposing and increasing the surface area of the organic matter. Wide range of birds and mammals feed upon earthworms. Thus, earthworm occupies a crucial position in the food web.

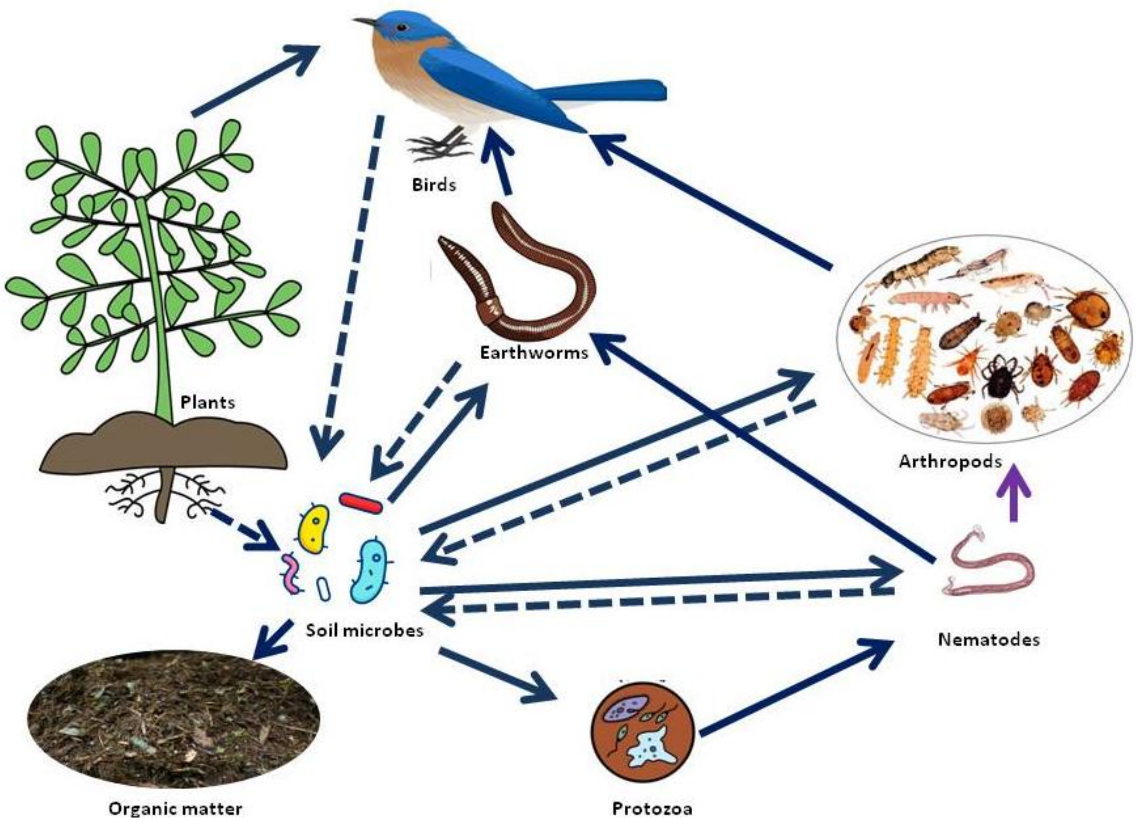

Figure 3. Position of earthworm in the matrix of food web

CONCLUSIONS AND FUTURE THRUST

The presence of earthworm in soil speaks a lot about soil health status. These ecosystem engineers are one of the most important detritivores and their activity directly governs soil fertility and plant growth. They not only alter soil physical, chemical and biological properties but also have potential to act as bio indicators of soil health. Though research have been done regarding earthworms in relation to soil fertility, there is need for more field and laboratory investigations to find out earthworm community structure, species interrelations, and the most efficient species to be used in biomonitoring of ecosystem degradation due to various anthropogenic activities.

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