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Impact of Earthworms on Soil Function and Ecosystem Services

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Introduction

Earthworms are the member of the phylum Annelida. The body is cylindrical with more or less uniformly placed ring annuli along the length of body. The dorsal surface of the body is recognized by its darker colour and a dark mid dorsal line which is due to the thick dorsal blood vessel situated just beneath the semi transparent skin. The ventral surface is marked by genital aperture and papillae located in anterior region of body. The eye, ear and lungs are absent. They breathe air that is present between soil particles diffuse through thin skins and they are forced through the surface if these are packed with rain water (Bhatnagar and Palta,1998). The worms are hermaphrodites i.e., both the sex organ are present in single individual but the requires another individual to mate because of the sexes are present at different sigment . The clitellum that surrounds immature breeding earthworms secretes mucus after mating sperm from other worms is stored in sacs. As the mucus slides over the worm it encases the sperm and eggs inside. After slipping free from the worm, both end seal, forming a lemon shape cocoon approximately 1/8inch long (Martin *et al*., 1976).

There are about 3,000 species of earthworm distributed all over the world (Dosani, 2008). Only half dozen species are beneficial to cultivation.The worms are detritivores as well as omnivore's animal but often selective in their food habit. They obtained their food from various organic matters, living bacteria, fungi, diatoms algae protozoan, nemotodes and decomposing animals (Crossley *et al*.,1971). They completely decomposed the wastes and stabilized it in to organic form. The worms are nocturnal and prefer the soil having sufficient moisture content, temperature and full of organic decaying matter (Barley,1961). Aristotal referred to eartworms as "intestine of earth" (Kale1991). Darwin (1881) treatise, the formation of vegetable mould through the action of eartworm with observation on their habits is regarded as the first modern scientific study of the beneficial role of erthworms and their casting in the soil (Bouche,1977). The earthworms prefer the food rich in nitrogen content which increase growth and power of reproduction (Ranganathan, 2006, Dhavan *et al*., 1991).

Generally the earthworms are called as bio-indicator of soil fertility. Earthworms support the healthy population of bacteria, fungi, actinomycetes, protozoan, insects, spiders, millipedes for sustaining a healthy soil (Ansari, 2008). They take organic wastes and process it with gut micro flora and excrete the vermicastings, which is the effective biofertilizer for the crops. The earthworms are isothermal bioreactor, all the biological processes are sensitive to high temperature therefore they have novel temperature regulating mechanism (Gupta, 2005) Generally the earthworms are classified in to epigeic, endogeic and anecic. The epigeic species live in the soil surface of 3 to 10 cm and feeds on organic matter like leaf litter or animal excreta and decomposed it to manure containing necessary plant nutrients. These worms are useful for organic farming due to their high rate of fecundity and doubling power capacity. The endogeic earthworms live deep in the soil bellow than 10 cm and feed on humic material. The epigeic in particularly and aneceic in general have largely harnessed for used in vermicomposting process. Epigeic like Eisenia fetida and Eudrillus eugenae have been used in vermicomposting (Ismail, 1994, Senapati *et al*., 1980). Surface dwellers are capable of working hard on litter layer and convert all organic wastes in to manure (Kale and Bano, 1988, Hartenstein *et al*., 1979).The anacics, however, are capable of both organic wastes consumption as well as modifying the structure of soil, such burrowing species are widely used in soil management like the earthworm Lampito marutii (Ismail, 1993). These worms are not useful for soil cultivation because of very long life cycle and limited doubling capacity. The anecic worms can go very deep in to soil up to 60 to 90 cm and form complicated burrows for their movement and the mucus secretion. Some species of earthworms are used in organic farming are Eisenia fetida, Perionyx excavatus, Perionyx sansibaricus, Lumbricus rubellus, Lempito mautri, Eudrillus eugenie, Dendrobeno veneta etc., Among the vast diversity of earthworms available in India the Allolobophora parvus, Pheretimas anomala, Octochaetona surnivsis etc holds the potential for vermicomposting. However, different species of earthworms are used for management of different type of waste (Gupta, 2005; Ranganathan, 2006).They are also used as livestock feed in poultry industries.

There is an important work in soil formation and soil health through earthworms, which is shown below:-

a) Effects of soil Particles Breakdown

Earthworms help nature in her overall soil building and plant growth processes by particle breakdown. It is probable that it occurs in the earthworms gizzard which uses ingested mineral particle, into smaller pieces. This grinding process, coupled with the weak acids and enzymes in the gizzards probably the small grinding stones down into even smaller pieces.

b) Effects on Soil particles aggregation

Aggregates are small particles bound together into water stable granules in such a manner that the soil will not crust or compact readily. Aggregation allows rain and irrigation water to enter soil easily, increase microbial activity, decreases soil erosion and allows easier cultivation of the soil. This aggregation or granulation is diffrent from that produced by cultivation, as the granules produced by cultivation will immediately dissolve in water but those produced by aggregation will continue in the same particle form. Cultivation by ploughing is only a temporary means of loosening and aeration of the soil, while aggregation has a more long term effects. The water stability of earthworm casts by a combination of many effects, calcium humate and polysaccharide gums synthesized by microbial activity in the earthworms's digestive tract, provide partial binding effect when the casts are excreted. Mucus secreted by the earthworms may be used to bind. to bind the soil particles in the earthworms burrows and may be used as a water-stabilizing element in the casts.

c) Effects on Soil Turnover

Earthworms as they burrow and feed, swallow great quantities of organic matter and soil. They digest it, extract its food value,and excrete the residue, The earthworm takes in organic matter from the soil surface and deposit it as castings in the lower soil levels and then takes soil from the lower levels and deposits it in the upper levels, providing decaying organic matter rich in nutrients and minerals at a level where they can be used by plant roots and build a layer of fine stone-free topsoil rich in minerals extracted from therocks in the subsoil. It is estimated that earthworms turn over 100 tons of soil, or more, per acre per year and build a fine topsoil laver at the rate of two inches per year. Soil turnover by earthworms also has mixing effect. In soil, without earthworms, there are generally distinct horizontal layers of material, fresh organic matter, decaying organic matter, humus, topsoil, subsoil, etc. But earthworms generally mix the layers so that they are indistinguishable. This action keeps the soil loose and more porous, providing better aeration, drainage and moisture retention, in addition to distributing the organic matter and minerals throughout for better utilization by plants.

d) Effects on Soil Moisture, Porosity and Drainage

The burrowing action of earthworms can improve the physical structure of the soil. As the earthworms burrow through the soil, they create a large number of interconnecting channels extending several inches down into the soil, even into the subsoil. The aggregates formed by the earthworms casts hold the moisture for future use. The earthworms burrows are coated with a mucus secretion which keeps the channels stable against collapse due to moisture.

e) Effects on Soil Aeration

The aggregation of soil particles, the soil turnover and the burrowing effects of earthworms all affect soil aeration. As the soil is aggregated into a 'crumb' structure, the actual air space between crumbs increases and the earthworm burrows tend to provide larger tunnels of air space between the crumbs. The constant mixing, or turnover of soil by the earthworms maintains the entire topsoil layer in a loose and porous condition. The loosening of the soil caused by the aggregation of particles and the burrowing effects of earthworms are entirely different from that provided by the ploughing method of cultivation. Cultivation by tractor provides a immediate loosening effect but unless there is a large amount of organic matter in the soil, this effect will last only until the first hard rain or watering occurs. The soil will then start to get compacted again causing waterlogging, followed by salinisation.

f) Effects on Soil Nutrients

Earthworm castings and soils with earthworms contain more phosphorous and molybdenum, exchangeable calcium, magnesium and potassium and have a higher base-exchange capacity than soils without earthworms.

However, the nutrients in the casts, building both, those which are available and those still in an unavailable form, depend on the content of the organic material and mineral soil. The earthworm cannot provide or make available nutrients which are not in the original material. Experiments at the Connecticut Agricultural station have shown that earthworm casts contain approximately 5 times more nitrate, 7 times more available phosphorous, 3 times more exchangeable magnesium, 1.5 times more calcium, 11 times more potassium than the surrounding soil.

g) Effects on Soil Microbiology

Many researchers have found quantities of a significant difference in micro-organisms, in earthworm's digestive tract and casts. Quantities of micro-organisms is three to five time greater in the casts, than the surrounding soil. It has also been reported that there were greater, number of bacterial and actinomycetes earthworms digestive tract than the in the surrounding soil. These numbers increase exponentially from the front to the rear of the digestive tract. There were more actinomycetes, fungi, butric acid forming bacteria, and cellulose decomposing bacteria in the casts than in the surrounding soil. The number of micro-organisms in the cast and digestive tract is proportional to the quantity and quality of organic matter in the soil. It also depends on the environmental conditions.

It is also reported that earthworms may produce antibiotic substance which inhibits the growth of certain fungi and non-acidfast pathogenic micro organisms. Earthworms appeared to have helped control apple-scab caused by substances. Being released in the spring time from leaves which fell the previous fall. The earthworms remove the leaves from the surface, preventing at least part of infection. Hence, studies have proved that earthworms can improve a soil, both structurally and chemically for the better providing the by their actions, accelerating compost formation, missing link between natural farming and farming. The objective of this research was to find the ways of rapid recycling of natural resources. The earthworms themselves provide lots of bacteria and microbes to the soil through their excreta i.e., wormcast.

h) Earthworm and Biological Degradation of Waste

Earthworm is probably one of the major contributors to the initial breakdown as well as to subsequent breakdowns of organic material, including the final process of breakdown or humification. Sequentially, the role of earthworm in organic matter decomposition is summarised as follows:-

- The earthworm ingests fresh or partially decomposed organic matter from the soil surface, including the rougher or more decay stones, roots and leaves.
- The ingested organic matter, especially the tougher matter, is then fragmented or broken into smaller pieces by the grinding action of the earthworm's gizzard.
- The fragmented organic matter is mixed with enzymes in the earthworm's digestive tract. These enzymes, in turn synthesize organic compounds which stimulate microbial activity in the earthworms intestines. The microbial activity then starts the decomposition process
- Approximately 24 hours after ingestion, the earthworms excrete this fragmented organic matter in the form of casts, on the soil surface and at various levels within the soil.
- Since the organic matter is in smaller pieces, and contains some synthesized organic compounds and micro-organisms from the earthworms digestive tract, microbial activity and subsequently decomposition processes are enhanced.
- As the earthworm burrows through the soil, it reingests the fragmented and partially decomposed matter previously excreted as casts. This organic matter is again processed through the earthworms digestive tract and excreted as cast. In the soil, further enhancing the decomposition or humification processes.

Conclusion

These processes are probably repeated earthworms burrow through the original organic matter becomes many times as the soil. After final ingestion, the orginal organic matter becomes a fine smooth humus, containing nutrients and minerals which are readily available for absorption by plant roots. Earthworms consume a large amount of food. It is estimated that a typical earthworm population (nearly one lakh) may consume 12 tons of manure per year per acre.

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