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Research Article

Role of Earthworm in Metal Uptake And Synthesis of Nanoparticles

Gokul Prashanth V[1], Dr. M. lakshmi Prabha[2]

[1]IV B.Tech , [2]Asst. Professor(SG), Department of Biotechnolgy, Karunya University, Coimbatore-641 114.

Abstract

An earthwormis a tube-shaped, segmented worm found in the phylum Annelida. They are commonly found living in soil, feeding on live and dead organic matter. Its digestive system runs through the length of its body. It conducts respiration through its skin. An earthworm has a double transport system composed of coelomic fluid that moves within the fluid-filled coelemand a simple, closed blood circulatory system. It has a central and a peripheral nervous system. The central nervous system consists of two ganglia above the mouth, one on either side, connected to a nerve cord running back along its length to motor neurons and sensory cells in each segment. Large numbers of chemoreceptors are concentrated near its mouth. Circumferential and longitudinal muscles on the periphery of each segment enable the worms to move. Similar sets of muscles line the gut, and their actions move the digesting food toward the worm's anus.

Keywords: Earthworm, Bacteria, Fungi, Nutrients, Skeleton

Earthworms are hermaphrodites—each individual carries both male and female sex organs. They lack either an internal skeleton or exoskeleton, but maintain their structure with fluid-filled coelom chambers that function as a hydrostatic skeleton.They are the main contributors to enriching and improving soil for plants, animals and even humans. Earthworms create tunnels in the soil by burrowing, which aerates the soil to allow air, water and nutrients to reach deep within the soil. Earthworms eat the soil which has organic matter such as decaying vegetation or leaves. Plants cannot use this organic matter directly (Dash,1999).After organic matter is digested, the earthworm releases waste from their bodies called castings. Castings contain many nutrients that the plant can use. Earthworms have been called 'ecosystem engineers'.Much like human engineers, earthworms change the structure of their environments. Different types of earthworms can make both horizontal and vertical burrows, some of which can be very deep in soils.These burrows create pores through which oxygen and water can enter and carbon dioxide can leave the soil.

Decomposition and soil organic matter

Earthworms play an important role in breaking down dead organic matter in a process known as decomposition. Decomposition releases nutrients locked up in dead plants and animals and makes them available for use by living plants. Earthworms do this by eating organic matter and breaking it down into smaller pieces allowing bacteria and fungi to feed on it and release the nutrients.Earthworms are also responsible for mixing soil layers and incorporating organic matter into the soil. Charles Darwin referred to earthworms as 'nature's ploughs' because of this mixing of soil and organic matter. (Hirano and Tamae, 2011).

Bacteria and fungi

Earthworms have a positive effect on bacteria and fungi in soils. Where earthworms are present there are more bacteria and fungi and they are more active. Bacteria and fungi are key in releasing nutrients from organic matter

Corresponding Author: M. lakshmi Prabha, Department of Biotechnolgy, Karunya University, Coimbatore-641 114.
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and making them available to plants. They are also an important source of food in their own right for many other animals that live in soils.

- Recycling organic material: Earthworms, along with bacteria and fungi, decompose organic material. Earthworms do the same in pasture soils, decomposing dung and plant litter and processing 2–20 tonnes of organic matter per hectare each year, and recycling leaf litter under orchards and in other forested areas.
- Increasing nutrient availability: This happens in two ways: by incorporating organic materials into the soil and by unlocking the nutrients held within dead organisms and plant matter. Nutrients like phosphorus and nitrogen become more readily available to plants after digestion by earthworms and being excreted in earthworm casts. Scientists have measured up to five fold increases in nitrogen availability in earthworm casts compared to undigested soil. Earthworms also take nutrients down through the soil profile, bringing them into closer contact with plant roots.
- Improving soil structure: Earthworm burrows alter the physical structure of the soil. They open up small spaces, known as pores, within the soil. When earthworms are introduced to soils devoid of them, their burrowing can lead to increases in water infiltration rates of up to 10 times the original amount. This brings water and soluble nutrients down to plant roots. Burrowing also improves soil aeration (important for both plants and other organisms living in the soil) and enhances plant root penetration.
- Providing food for predators: Earthworms, like all creatures, are part of food webs. Birds are well known predators, but native earthworms are also food for endangered and endemic land snails.

Vermicomposting

The term vermicomposting means the use of earthworm for composting organic residues. Earthworms can consume practically all kinds of organic matter and they can eat their own body weight per day, e.g. 1 kg of worms can consume 1 kg of residues every day. The excreta (castings) of the worms are rich in nitrate, available forms of P, K, Ca and Mg. The passage of soil through earthworms promotes the growth of bacteria and *actinomycetes*. *Actinomycetes* thrive in the presence of worms and their content in worm casts is more than six times that in the original soil.

Vermicomposting is the breaking down of organic material through the use of worms, bacteria, and fungi. In nature, organic matter is decomposed through these organisms. The end product of vermicomposting is a substance called vermicompost or "worm castings". This is a nutrient rich organic substance that can be added to soil to increase it's organic matter content and available nutrients. A common way to use this process is to build "worm bins"; basically boxes that contain worms. Organic matter is added to the bin for the worms to eat! An advantage of "worm bins" over traditional composting, is that if they are inside during the winter, they allow this process to work all year.Using earthworms to convert organic wastes is an ecologically safe method that leads to an environmentally safe product. (Dash, 1999).

Bioremediation

Bioremediation is a bioengineering technique to clean up contaminated lands and soils using microbes, plants and earthworms. It is also a technique to stabilize the eroded lands and prevent soil erosion. Microbes are adapted to thrive in 'adverse conditions' of high acidity, alkalinity, toxicity, and high temperature. (Kaur and Kalra,2007)Under favourable conditions of growth, microbes can biodegrade and biotransform the complex hazardous organic chemicals into simpler and harmless ones. Environmentalists are viewing microbes such as yeast,bacteria, algae diatoms and actinomycetes as an 'eco-friendly nano-factories' for metal remediation (Rajiv *et al*., 2010).

Vermi-Remediation technology

The vermi-remediation technology for land remediation by removing chemical contaminants from soils and reducing soil salinity while also improving the physical, chemical and biological properties of soil. Earthworms can bio-accumulate fairly large amounts of heavy metals, pesticides and lipophilic organic micro-polllutants like the polycyclic aromatic aromatic hydrocarbons from the soil. They either biotransform or biodegrade the chemical contaminants rendering them harmless in the environment. Earthworms have also been found to desalinize soils containing nearly half the amount of salt found in seawater(Rajiv et al., 2009).

Vermi synthesis of Nano particles

The earthworm's metal detoxification pathway can be exploited to produce luminescent, water soluble semiconductor cadmium telluride quantum dots that emit in the green region of the visible spectrum when excited in the ultraviolet region. (Lee, Kim, Hyun, and Kim,2009) Luminescent quantum dots were isolated from chloragogenenous tissues surrounding the gut of the worm, and were successfully used in liv-cell imaging. The addition of polyethylene glycol on the surface of the quantum dots allowed for non-targeted, fluid-phase uptake by macrophage cells(sturzenbaum et al., 2012).The formation of silver nano particles (AgNps) via reduction of silver ions in the presence of humic acids under various environmentally relevant conditions is described(Davies, Hodson, and Black,2002).

Conclusion

The energy expended by the organism to survive in high concentrations led to altered physiological mechanism whichcauses decrease in bioaccumulation in earthworm tissueat higher concentration of heavy metal. The remediation of soils contaminated with low concentration of heavy metals could be affected by inoculationof earthworms. The population and presence of earthwormsis, therefore, an indicator of soil health and these findings could be of potential use in the implementation ofremediation strategies of metal polluted soils in areas of risk.

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