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Vermiremediation Technology for Converting 'Wasteland' into 'Wonderland'

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Introduction

Earthworms have been found to remove heavy metals, pesticides and lipophilic organic micropollutants like the polycyclic aromatic hydrocarbons (PAH) from the soil. Vermiremediationusing chemical tolerant earthworm species is emerging as a low-cost and convenient technology for cleaning up the chemically polluted/contaminated soils in the world. It is a self-promoted, self-regulated, self-improved, self-driven, self-powered, self-enhanced, low or no energy requiring zero-waste technology, easy to construct, operate and maintain. Any vermiculture technology involves about 100-1000 times higher 'value addition' than other biological technologies. Obtaining earthworms from vermiculture farms would be a one-time cost in any vermiremediation technology as the earthworms multiply rapidly creating a huge army of worms which further promote and enhance the process.

The earthworm assisted bioremediation (vermiremediation) approaches include direct application of earthworms to contaminated soils;co-application of earthworms to contaminated soils with another organic material, such as compost;application of contaminated media (soils) to earthworms as a part of feeding regime;indirect use of earthworms through its digested (composted) materials (vermicompost). Vermicast is high in degrader microbes and thus high in catabolic activities. It contains 32 million bacterial counts per gram as compared to 6-9 million/gram in surrounding soils.

Earthworms Species Suitable for Soil Remediation

Certain species of earthworms such as *Eisenia fetida*, *Aporrecto deatuberculata, Lumbricus terrestris, Lumbricus rubellus, Dendrobaena rubida, Dendrobaena veneta, Eiseniella tetraedra, Allobophora chlorotica and Pheretima Spp*. have been found to remove heavy metals,pesticides and lipophilic organic micro-pollutants from the soil. Keeping manyadvantages in view, the School of Natural Resource Management, College of Post Graduate Studies in Agricultural Sciences of Central Agricultural University hasalready

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started research on vermiremediation technology by utilizing native earthworm species coupling with phytoremediation technology to enhance the efficiency of reclamation of heavy metals in the coal mined polluted soils of Jaintia Hills of Meghalaya.

(Vermiremediation of heavy metals from coal mined polluted soil in Jaintia Hills of Meghalaya)

Mechanism of Worm Action in Vermiremediation:

Within the soil environment, an earthworm's sphere of influence is known as the 'drilosphere system'. This incorporates the burrow systems, surface and belowground earthworm casts, internal earthworm gut and process, the earthworm surface in contact with the soil, and associated biological, chemical and physical interactions, in addition to the soil microorganisms.

Earthworms have both 'abiotic' and 'biotic' effects on contaminated soils in the remediation process. Abiotic effects are burrowing actions and the resulting burrows act as inputs points and preferred pathways for water and particle movement, nutrient flow and aeration. This also results in the mechanical breakdown of soil particles exposing greater surface areas for biotic action. During burrowing, worms ingest and digest a large amount of contaminated soils. By digestion, the size of the soil organic matter containing contaminants is reduced significantly thus exposing more surface area of contaminated soil for microbial action and remediation. The biotic effects are the proliferation of degrader microbes (bacteria, fungi and actinomycetes) by the earthworms by their excretion in contaminated soil which includes urine, intestinal mucus, glucose and other nutrients. There are also direct biotic effects of earthworms in the form of 'feeding behaviours' upon contaminants fates in soil

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Studies indicate that earthworms increase their oral intake of soil particles when driven by 'hunger stress.' There were total petroleum losses in contaminated soil where earthworms were not provided with any food. Hydrophobic organic contaminants are taken up by the earthworms in two ways: by passive diffusion from the soil solution through the worms' outer membrane; and by intestinal re-sorption of the compounds from the soil while it passes through the gut (by digestion) and then their degradation by an enzymatic activity called 'Cytochrome P 450' system. This enzymatic activity has been found to operate particularly in *Elseniafetida* which survive the benzo (a) pyrene concentration of 1,008 mg/kg of soil.

Earthworm uptake chemicals from the soil through passive 'absorption' of the dissolved fraction through the moist 'body wall' in the interstitial water and also by mouth and 'intestinal uptake' while the soil passes through the gut. The passive diffusion is driven by the difference between the pore water in the soil and within the earthworm's tissues. The accumulation increases when the concentration of PAHs in their surrounding soil water or in their food increases Earthworms may take PAHs up through absorption by the body surface and also by feeding and ingestion, since PAHs sorb to the soil organic detritus, which the worms feed on. Earthworms apparently possess a number of mechanisms for uptake, immobilization and excretion of heavy metals and other chemicals. Earthworms either biodegrade or bio-transformthe chemical contaminants rendering them harmless.

Advantages of Vermiremediation Technology

There are several advantages in using earthworms for the bioremediation of chemically contaminated soils. Earthworms improve the total quality of soil in terms of physical, chemicalandbiological properties. They have been shown to both 'retard the binding of chemical compounds with soil particles' and also 'increase compound availability' for microbial action while also enhancing the population of degrader microbes within the system.

Earthworms have the potential to be employed not only in the recovery of contaminated soils as a part of bioremediation strategy, but also in the subsequent improvement of that soil and the land as a whole, for other beneficial uses. Significantly, vermiremediation leads to total improvement in the quality of soil and land where the worms inhabit. Earthworms significantly contribute as a soil conditioner to improve the physical, chemical as well as biological properties of the soil and its nutritive value. They swallow a large amount of soil everyday, grind them in their gizzard and digest them in their intestine with aid of enzymes. Only 5-10 percent of the chemically digested and ingested material is absorbed into the body and the rest is excreted out in the form of fine mucus coated granular aggregates called 'vermicastings' which are rich in NPK, micronutrients and beneficial soil microbes including the 'nitrogen fixers' and 'mycorrhizal fungus'. The organic matter in the soil undergoes 'humification' in the worm intestine in which the large organic particles are converted into a complex amorphous colloid containing 'phenolic' materials. About one-fourth of the organic matter is converted into humus. The colloidal humus acts as 'slow release fertilizer' in the soil. During the vermi-remediation process of soil, the population of earthworms increases significantly benefiting the soil in several ways. A 'wasteland' is transformed into a 'wonderland'. Earthworms are in fact regarded as 'biological indicator' of good fertile soil. One acre of a wasteland when transformed into fertile land may contain more than 50,000 worms of diverse species.