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Published

2009

Journal Title

The Environmentalist

DOI

[10.1007/s10669-009-9242-4](https://doi.org/10.1007/s10669-009-9242-4)

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## Earthworms: the miracle of nature (Charles Darwin's 'unheralded soldiers of mankind & farmer's friends')

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A revolution is unfolding in vermiculture studies (rearing of useful earthworms species) for achieving quicker and cheaper solutions to several social, economic and environmental problems plaguing the human society from 'waste management' to 'land and soil remediation' and 'safe and sustainable food production' without recourse to dangerous agro-chemicals. Earthworms have over 600 million years of experience as waste and soil managers. No wonder, Charles Darwin called them 'friends of farmers and unheralded soldiers of mankind working day and night under the soil'. The great Indian scientist Surpala in tenth century A.D. wrote *Vrikshayurveda* (Science of Tree Growing) where he recommended to add earthworms in pomegranate plants to get good quality fruits.

About 4,400 different species of earthworms have been identified. The Tiger Worms (*Eisinea fetida*), the African Night Crawler (*Eudrillus euginae*) and the Indian Blue Worm (*Perionyx excavatus*) are most versatile waste eaters and biodegraders. Several of them are bio-accumulators and bio-transformers of toxic chemicals. After the Seveso Chemical Disaster in Italy (1976), when a vast area was contaminated with 'dioxin', only the earthworms *Eisinea fetida* survived. Most worms eat waste organics almost equivalent to its own bodyweight everyday. Under favorable conditions, they can multiply by  $2^8$ , i.e. 256 worms, every 6 months from a single individual, doubling their population every 60–70 days.

Earthworms promises to provide quicker and cheaper solutions to several environmental problems.

1. *The vermi-composting technology* for efficient management of most municipal and industrial organic wastes, including sewage sludge by biodegradation and stabilization and converting them into nutritive organic fertilizers (vermicompost).

Earthworm participation enhances natural biodegradation and decomposition of organic waste from 60 to 80%. Given the optimum conditions of temperature (20–30°C) and moisture (60–70%), about 5 kg of worms (numbering approximately 10,000) can vermiprocess 1 ton of waste into vermicompost in just 30 days. When compared to the normal aerobic composting systems, it takes nearly half the time to convert waste into compost and the process becomes faster with time as the army of degrader worms grows, further proliferating several battalions of aerobic decomposer microbial army (Published in *The Environmentalist*, vol. 22 (2), June 2002.)

2. *The vermi-filtration technology* for the treatment of municipal and nontoxic industrial wastewater, purification and disinfection for their reuse. Earthworms' body work as a 'biofilter', and they have been found to remove the biological oxygen demand (BOD<sub>5</sub>) by over 90%, chemical oxygen demand (COD) by 80–90%, total dissolved solids (TDS) by 90–92% and the total suspended solids (TSS) by 90–95% from wastewater. Most significant is that there is no sludge formation. Worms eat the solids and also devour on the pathogens in the wastewater (Published Online in *The Environmentalist*, 8 April 2008.)

3. *The vermi-remediation technology* for land reclamation 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-pollutants like the polycyclic aromatic hydrocarbons (PAHs) from the soil. Cadmium levels

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of up to 100 mg per kg dry weight have been found in tissues. They either bio-transform or biodegrade the chemical contaminants rendering them harmless in the environment. (Published online in *The Environmentalist*, 14 May 2008.) Earthworms have also been found to desalinize soils containing nearly half the amount of salt found in seawater.

4. *The vermi-agro-production technology* for restoring and improving soil fertility and significantly boosting crop productivity by worm activity and its metabolic products. Vermicompost is a highly nutritive ‘miraculous growth promoter’ (5–7 times more powerful than conventional compost) rich in NKP, micronutrients and beneficial soil microbes. As high as 7.37% of nitrogen (N) and 19.58% of phosphorus as  $P_2O_5$  in worms vermicast has been reported. Predominant among beneficial microbes are the ‘nitrogen-fixing bacteria’, the ‘actinomycetes’ and ‘mycorrhizal fungi’. Vermicompost contains plant-growth-promoting hormones auxins, gibberlins and cytokinins secreted by the worms. Vermicompost also has very ‘high porosity’, ‘aeration’, ‘drainage’ and ‘water holding capacity’, and hence greatly increases the moisture-retaining capacity of the farm soil. Still more significant is that vermicompost increases ‘biological resistance’ in plants and protect them against pest and diseases either by repelling or by suppressing them. This is perhaps due to the fungus actinomycetes present in large amounts in vermicompost. Our study indicated that the application of vermicompost reduces the use of chemical pesticides by over 75%.

Vermi-composting, vermi-filtration, vermi-remediation and vermi-agro-production systems are self-promoted, self-regulated, self-improved and self-enhanced, low-energy- or no-energy-requiring zero-waste technology, easy to construct, operate and maintain. They outperform all bio-conversion, biodegradation and bio-production technologies in that it can utilize organics that otherwise cannot be utilized by others. They outperform all bio-treatment technologies because they achieve greater utilization than the rate of destruction achieved by other technologies. They involve about 100–1,000 times higher ‘value addition’ than other biological technologies. The vermi-composting and vermi-agro-production technologies can together maintain the ‘global human sustainability cycle’—‘using food wastes of the society (negative value) to produce food for the society (positive value) again’.

## 1 Commercial vermicomposting: a good business opportunity

Earthworms not only converts ‘waste’ into ‘wealth’ but also becomes a valuable asset as worm biomass. They have

enhanced the lives of the poor in India and generated self-employment opportunities. It has become good source of livelihood for many from the sale of both worms and their vermicompost. Worms are rich in protein (65%) with 70–80% high quality essential amino acids lysine and methionine. It is a wonderful probiotic feed for fish, cattle and poultry industry. They are also finding new use as a source of collagen in the manufacture of pharmaceuticals and in the making of antibiotics from the anti-pathogenic ceolomic fluid.

## 2 Tribute to the earthworms

Earthworms are justifying the beliefs and fulfilling the dreams of the great visionary scientist Sir Charles Darwin. Darwin wrote, ‘*there may not be any other creature in world that has played so important a role in the history of life on earth*’. Dr. Anatoly Igonin of Russia said, ‘*Nobody and nothing can be compared with earthworms and their positive influence on the whole living Nature. They create soil and everything that lives in it. They are the most numerous animals on Earth and the main creatures converting all organic matter into soil humus providing soil’s fertility and biosphere’s functions: disinfecting, neutralizing, protective and productive*’.

There can be little doubt that mankind’s relationship with the earthworms is vital and needs to be nurtured and further expanded.

