A REVIEW OF THE VALUE OF EARTHWORMS FOR THE WASTE MANAGEMENT INDUSTRY AND OTHER APPLICATIONS

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Abstract: *Earthworms can clean many waste streams and produce organic fertilizers, according to research. Vermicomposting bioconverts trash into earthworm biomass and vermicompost. The former can be used as a protein source, while vermicompost is an excellent product because it is homogenous, has desirable aesthetics, has reduced contaminates, has plant growth hormones, higher soil enzymes, greater microbial population, and holds more nutrients over a longer period without harming the environment. Earthworms absorb heavy metals via their skin and intestines while eating organic waste and dirt. This document reviews earthworm biology, species, vermiculturing, microflora interaction, waste stabilization, vermicompost generation for plant development, and heavy metal buildup.*

Key Words: *Vermicomposting, organic waste; earthworms*

Introduction

Industrialization and energy-intensive agriculture favored chemical methods for raw material conversion using petrochemical feedstock. Current approaches are unsustainable due to environmental damage and resource depletion. Biochemical pathways again get attention with living entities. Many garbage sources create degradable organic materials. Most MSW in India is discarded, and less than 10% is sporadically handled in mechanical compost factories (Shekdar, 1999). Although composting units are technically viable, competition from other manures and uncertainties regarding farm use prevent them from functioning at full capacity.

Dumped organic stuff from these wastes degrades aerobically or anaerobically. Fine organic materials and percolating water produce leachate in these unengineered dumpsites. Leachate may harm nearby water and soil. India has enough of solid organic waste and labour, thus the ecologically friendly vermicomposting method employing earthworms may be used to turn waste into riches. Vermicomposting of various organic materials has shown that epigeic earthworms can speed up the composting process and produce better composts than traditional methods. Hand, 1988; Logsdon, 1994; Madan, 1988; Singh, 2002) explored the use of earthworms to remediate or manage various organic waste streams. Vermicomposting industrial wastes produces nutrient-rich manure (Sundaravadivel, 1995). Hand et al. (1988) characterized vermicomposting as a low-cost approach for treating organic wastes.

Plant protection techniques and pesticide recommendations have rendered the soil barren. Compost and vermicompost are being used more in crop production due to a rising awareness of the negative economic and environmental effects of agrochemicals (Follet, 1981). Thus, food security must restore sustainability. Earthworms may be a sustainable, profitable, and socially acceptable technology. This article examines studies on vermicomposting organic waste and its benefits.

Biology of earthworm

Earthworms, from the family Lumbricidae, dominate temperate and tropical soils. Earthworms are hermaphrodites, however they seldom self-fertilize. Sexually mature worms have a characteristic epidermal ring-shaped region called the clitellum, which includes gland cells that produce material to make a viscid cocoon when they lay eggs. Species-specific cocoons are tiny. The cocoon progressively changes color from newly placed until hatching. Lumbricid worm cocoons contain one to twenty fertilized eggs (Stephenson, 1930), but only one or two hatch (Edwards, 1972).

Cocoons are produced from 6 weeks to 6 months. Earthworms may create 100 cocoons in 6 weeks to 6 months (Ismail, 1997). In tropical worms, cocoons incubate for 1-8 weeks, whereas temperate worms take 3-30 weeks. Earthworms repair missing segments. Earthworm species, food, climate, and other factors determine a population's doubling time. The mean doubling time for density and biomass of Lampito mauritii in varied organic inputs is 38.05 and 33.77 days, whereas Perionyx excavatus is 11.72 and 16.14 days (Ismail, 1997). Understanding the biology of all potentially helpful earthworm species is essential for using them in organic waste management (Edward, 1998) The life cycle of each earthworm is necessary to understand population dynamics and productivity. Earthworm life cycles and reproductive techniques have been studied in temperate (Lavelle, 1979), Indian (Julka, 2001), and tropical species (Dash, 1980). Earthworm reproductive techniques are mostly known from temperate species (Jimeneg, 1999). Battacharjee and Chaudhari (2002) studied the cocoon formation, shape, hatching pattern, and fecundity of seven tropical earthworm species for successful vermiculture. Organic waste quality affects reproductive onset and rate (Dominguez, 2000). Worms consume 100–300 mg/g body weight/day (Edwards, 1972). Earthworms eat organic matter, microorganisms, and dead animals. Deep-soil earthworms eat dirt, whereas surface worms eat selectively. Earthworm size, population, species variety, development rate, and cocoon formation depend on material availability.

Earthworms devour organic garbage and excrete most of it in a half-digested state. Earthworm intestines contain a variety of microbes, enzymes, hormones, and other substances that breakdown half-digested material into vermicompost quickly (Edwards, 1972; Kale, 1986).

Species of earthworms

India has 384 earthworm species out of 3000 worldwide (Julka, 1986). Most earthworms are terrestrial, soil-dwelling creatures. Pontodrilus burmudensis thrives in estuary water. Julka (1983) dominated Indian earthworm taxonomy. In India, peregrine species like Microscotex phosphoreus (Duges) are 20 mm long, while indigenous geophagous worms like Drawida grandus (Bourus) may grow to one meter.

Earthworms prefer organic materials like dung, compost, and litter, but they can live in hydrophilic environments near fresh and brackish water and may survive beneath snow. Most earthworms are omnivorous, but Agastrodrilus, a carnivorous species from the Ivory Coast, feeds on Eudrilidae earthworms (Levelle, 1983).

Vermiculturing Process

Earthworms are saprophages but detrivores or geophages depending on their diet (Lee, 1985). Detrivores eat on soil-surface plant litter, decaying roots, and mammalian excrement. Humus-forming worms are epigeic and anecic. Detrivorous earthworms include Perionyx excavatus, Eisenia fetida, Eudrilus euginae, Lampito mauritii, Polypheretima elongata, Octochaetona serrata, and curensis (Ismail, 1997). Geophagous endogeic earthworms like Metaphire posthuma and Octochaetona thurstoni devour vast amounts of biologically rich soil.

Surface-dwelling epigeics eat soil organic materials. Endogeic earthworms dig mostly in the minerals layer of soil. Anecic earthworms like Lumbricus terrestris dig upward. Vermicomposting uses epigeics and anecics from these three ecological earthworm species. Eisenia fetida, the tiger or brandling worm, is the most widely utilized earthworm (Haimi, 1990). Lumbricus rubelus, Eudrilus eugeniae, Perionyx excavatus, and Eisenia andrei are other acceptable species. For litter and soil management, Ismail (1993) advised the "in-situ" soil population of epigeic and anecic earthworms, which are well-adapted to local circumstances. He examined 50 earthworm distributions. Lampito mauritii dominated sandy loams while Octochaetona serrata dominated clay loams. Endogeic and anecic earthworms form the drilosphere with free-living soil microorganisms (Ismail, 1995).

Vermiculture requires the right earthworm species (Appelhof, 1996). varying earthworm species create vermicomposts with varying nutritional compositions. Moisture affected the development, maturity, and cocoon formation of European earthworm Dendrobaena venera. Its high moisture requirements made it a less effective vermicomposting species (Muyima, 1994). In a comparative investigation, Drawida nap1ensis grew slower than other earthworm species, suggesting it may be parthenogenetic (Kaushal, 1992). Population was not required for cocoon creation. Shanthi et al. (1993) in India examined the decomposition of vegetable waste by Metaphire posthuma, Eisenia species, and Perionyx excavatus earthworms. P. excavatus was best for vermicomposting because it could tolerate a wider range of moisture and temperature than the other two. Reinecke et al. (1992) found that E. fetida was more temperature-tolerant than Eudrilus eugeniae and P. excavatus. It tolerates soil temperatures below 50 C and 42°C. Food quality and quantity affect earthworm population size, species, growth, and fertility (Dominguez et al., 2000, Chaudhari and Battacharjee 2002). Hendriksen (1990) indicated that litter palatability in detrivorus earthworms is primarily affected by C:N ratio and polyphenol content.

Earthworms can be cultured to improve soil fertility, convert organic waste into manure, produce earthworm meal for livestock, provide drugs and vitamins, act as natural detoxicants (Paoletti, 1991), and bait for fish markets (Ghosh, 2004). Earthworms are cultivated in damp areas protected from ants, rodents, bandicoots, frogs, and toads. Shelter prevents rainwater and direct sunshine.

Vermiculture begins with choosing earthworm feed. Cattle dung, pig manure, poultry manure, and leguminous agricultural waste are nitrogen-rich organic compounds. Feed material should not exceed 40 C:N. Paper and damp cardboard may fatten worms due to their high C:N ratio (Ismail, 1997). Comparing non-standard vermiculturing materials. Eisenia fetida earthworms gained the most weight with 50g soil and 150g cellulose waste. 100g cow dung, 50g soil, and 50g cellulose waste produced the most. Cotton waste with 1:5 cow manure yielded the greatest results. Grape cake and tobacco trash increased somewhat, while earthworms did not multiply. In an outdoor trial utilizing polythene containers, Perionyx excavatus grew best on maize strover (Manna, 1997). Mba (1989) found that Eudrilus euginae may be raised on fermented Paspalum digitatus (Dallis grass).

Vermiculturing may be done in wooden boxes, cemented tanks, clay pots, and pits coated with stones or plastic. Earthworms develop quicker and make more cocoons in humid and somewhat gloomy areas, 40-50% bed moisture, 20-30°C temperature, pH of 7, and partly degraded organic materials rich in nitrogen (Kale, 1995). Vermiculturing produces fertilizer castings. Cuba has about 170 vermiculture centers for this. Earthworm castings from various feed sources are also chemically characterized (Werner, 1996).

Organic fertilizers provide a nutrient-rich substrate that increases earthworm populations, whether they feed directly on the organic matter or on the microorganisms that colonize it. Inorganic fertilizers may indirectly improve agricultural wastes returned to the soil (Edwards, 1995), but long-term usage of ammonia-based fertilizers may reduce earthworm abundance and biomass (Ma, 1990). Warner and Dindal (1989) found that manure additions sustained greater earthworm populations and biomass than inorganic ferilisers after five years of soyabean-corn-legume rotations. In long-term grain production, manure and inorganic fertilizers increased earthworm abundance and biomass, according to Edwards and Lofty (1982).

Vermicomposting process

Vermicomposting uses earthworms to compost organic matter and the latest biotechnology to produce biofertilizers for agricultural use and high-quality protein (earthworm biomass) to supplement animal nutritional energy needs faster. Vermicomposting yields earthworm castings, or vermicompost. Earthworms fragment, mix, and enhance microbial activity in this aerobic, bioxidation, and stabilizing non-thermophilic organic waste degradation (Gaundi, 2002).

Vermicomposting is based on earthworms fragmenting the substrate while eating, increasing its surface area for microbial colonization (Chan, 1988). Microbial activity converts feed material elements such nitrogen, potassium, phosphorus, and calcium into more soluble and plant-available forms (Ndegwa, 2001). Earthworms eat a lot of organic garbage yet excrete most of it in a half-digested state. Since earthworms' intestines contain many microbes, enzymes, hormones, etc., half-digested substrate decomposes quickly and becomes vermicompost (Lavelle, 1988).

This happens at mesophilic temperatures (35-40o C). Earthworms mix organic substances with soil particles to make organic manures. The stabilized, well-humidified organic fertilizer has soil-adhesive and plant-growth-stimulating properties and is ideal for agricultural use and ecologically friendly. Earthworms are biochemical and mechanical in this process. Physically fragmenting organic substrates increases surface area, turnover, and aeration. Enzymatic digestion, nitrogen enrichment, and transport of organic and inorganic materials degrade organic matter biochemically. The tissue absorbs 5-10% of ingested material for development and metabolic activity, while the balance is expelled as vermicast. Vermicompost is made from vermicast, gut wall mucus, and microorganisms (Edwards, 1972). The cast decomposes once microbes release it. Vermicomposting increases humic material polymerization, decreases ammonium N, and increases nitric N (Cegarra, 1992).

Vermicomposting is commercially practiced in Japan, Canada, the US, the Philippines, and Asia. Ghosh (2004) reported that Ontario (Canada) started commercial vermicomposting in 1970 and now processes 75 tons of refuse per week, American earthworm company (AEC) started a farm in 1978-1979 with 500 tons capacity per month, and Aoka Sangyo Co. Ltd., Japan has three 1000-ton-per-month plants processing pulp and food industry waste. These are among 3000 vermicomposting facilities in Japan with 5- to 50-ton monthly capacity. Top feeding and bottom discharge of a raised reactor in advanced vermicomposting systems stabilizes temperature, moisture, and aerobicity (Price, 1988). Price et al. (1990) devised a new combing mechanical separator for separating live earthworms from vermicomposts.

Characteristics of vermicompost

Vermicompost, a peat-like substance produced by earthworms and microorganisms, has great porosity, aeration, drainage, water holding capacity, and microbial activity (Edwards, 1998; Atiyeh, 2000d). It includes most nutrients in plant-available forms, such as nitrates, phosphates, exchangeable calcium, soluble potassium, and others (Edward, 1998), and its huge surface area offers numerous microsites for microbial activity and nutrient retention. Vermicompost contains microorganism-produced auxins, cytokinins, humic compounds, and plant growth regulators (Atiyeh, 2002b; Muscolo, 1999). Carrots (Daucus carota) generate auxin-like cells and metabolize nitrate with vermicompost humic components (Muscolo, 1999). Humic compounds normally present in mature animal manure, sewage sludge, and paper-mill sludge, but vermicomposting substantially increases their production.

Vermicompost made from different organic waste has organic carbon 9.15 to 17.98%, total nitrogen 0.5 to 1.5 %, available phosphorus 0.1 to 0.3 %, available potassium 0.15, calcium and magnesium 22.70 to 70 mg/100g, copper 2 to 9.3 ppm, Zinc 5.7 to 11.5 ppm, and available sulphur 128 to 548 ppm (Kale, 1995).

Several studies have compared vermicasts to neighboring soils (Lavelle, 1978). Vermicasts have a higher Base Exchange capacity, are rich in total organic matter, phosphorus, potassium, and calcium, have reduced electrical conductivity, increased oxidation potential, and reduced water-soluble chemicals that may be environmental contaminants. Senesi et al. (1992) extracted HAL from animal manures, municipal solid refuse, and sewage sludge composted for 2-3 months with earthworms E. fetida or Lumbricus rubellus. Vermicompost HAL containing appreciable amounts of Fe and Cu in inner sphere complexes of definite chemical and geometrical forms, similar to humid acid (HA) from soil and other sources, can be considered adequate analogues of soil HA for metal complexion properties and behavior. Vermicompost is rich in microbial variety, population, and activity (Subler, 1998), and vermicast includes enzymes including proteases, amylases, lipases, cellulases, and chitinases that continue to degrade organic matter after being expelled. Casts have 2 times more magnesium, 5 times more nitrogen, 7 times more phosphorus, and 11 times more potassium than soil (Bridgens, 1981). Vermicompost is good because it is homogeneous, low in pollutants, and holds more nutrients for longer without harming the environment (Ndegwa, 2001).

Waste stabilization by vermicomposting

Agricultural, horticultural, animal, silkworm, plant biomass (leaf litter), weeds, kitchen waste, foul, acidic, spicy, and spoilt food, city refuse after removing non-degradable waste like glass, plastic, strong rubber, and metal can be vermicomposted (Kale, 1995). E. fetida generated humus-rich, odorless vermicast from pre-treated pig dung (Chan, 1988). Pheretima asiatica stabilized most treatment waste materials, including raw pig manure (Wong, 1991). Because Zn and Cu are troublesome elements in pig manure, Dominguez et al. (1997) examined Zn and Cu levels during vermicomposting. Although carbon losses through mineralization increase the overall quantity of heavy metals (25-30%), bioavailability heavy metals decrease by 35–55% in two months. Dominguez (1997) found 50-60% more nutrients in earthworm-composted pig dung than in the control. His early research also showed that human pathogens die in vermicomposting. After 60 days of vermicomposting, faecal coliform bacteria in biosolids reduced from 39000 MPN/g to 0 MPN/g, while Salmonella sp. dropped from < 3 MPN/g to < l MPN/g. Hand et al. (1988b) highlight cowslurry substrate's potential for vermicomposting, E. fetida's alterations to slurry, and its specific positive connections with slurry microorganisms. Top-feeding slurry promoted earthworm development and cocoon formation better than combining slurry with solid ingredients.

E. fetida has been recommended for sludge management (Mitchell, 1980; Neuhauser, 1980 b), but few large-scale field studies have been conducted. In Lufkin, Texas, USA, 4500 kg of E. fetida would consume 900kg of dry sludge everyday. This factory supplied 10,000–15,000 people (Prince, 1981). Haimi and Huhta 1986 examined the biomass of E. fetida that could digest a specific quantity of garbage in one month on various wastes. Long-term composting of miscellaneous garbage with activated sewage sludge generated odorless castings. The California worm Lumbricus rubellus was used to turn partly and non-decomposed sewage sludge into agricultural compost. Partial decomposition enhanced humus composition and P and K content (Delgado et al., 1995). Earthworms (Eisenia fetida) also increase mineralization and humification (Albanell, 1988). Saciragic et al. (1990) found that E. fetida worms only grew in aerated sludge.

Vermicomposting using worms might be used for non-foodland sludge (Frank, 1983). Earthworm composting toilets were found in Australia and New Zealand. The Dowmus Composting Toilet was the most advanced (Edwards, 1997). The Indian Aluminium Co. Ltd. Site in Belgaum treated solid waste and sewage from 500 houses using vermiculture. A 200 sq. mt. vermifilter, capable of processing 100 m3/day, cleaned the colony's sewage for garden irrigation (White, 1996).

Kaviraj and Sharma (2003) compared E. fetida (exotic) and P. excavatus (local) earthworms in MSW vermicomposting. Singh and Sharma (2002) examined the role of bioinoculants (Pleurotus sajor-caju, Trichoderma harzianum, Aspergillus niger, and Azotobacter chroococcum) in predecomposition of a mixed solid waste (MSW and horticulture waste, 70:30) for vermicomposting and found that this system improved product quality and reduced stabilization time.

Paper pulp makes good vermicompost. E. endrei hydrolyzed paper pulp mill substrate aerobically and mesophilically in Spain (Elvira, 1995). A comparative study on the quality of organic matter and heavy metal in different mixtures of paper mill sludge and sewage sludge before and after vermicomposting (E. endrei) found that a 1:6 mixture increased the weight of E. andrei the most. Vermicomposting increased total and OTPA extractable metals, but not beyond agricultural sludge limitations. Vermicomposting reduced plant availability of Mn, Cu, and Zn (Elvira, 1995). Elvira et al. (1998) found that pulp mill sludge combined with waste, pig, and poultry sludge at varied ratios had the maximum growth and mortality of E. andrei. Butt (1993) fed soil-dwelling earthworms (Lumbricus terrestris) solid paper mill waste and leftover yeast. Red earthworms were fed sewage sludge, husks, and low-quality bacterial preparations by Zharikov et al. (1993). In another work, Maple (Acer) lignocellulosic waste was composted aerobically and vermicomposted for 10 months under controlled circumstances. Chemical analysis and C-13 CPMAS NMR Spectroscopy were used to analyze organic matter change. The majority of organic matter and polysaccharides, including cellulose, decomposed quickly, whereas aromatic compounds and lignin degraded only after composting for 1 month, with the maximum rates in the next 3 months (Vinceslas, 1997).

Earthworms and vermicompost for plant development Vermicompost, rich in macro and micronutrients, is a suitable organic manure for crop biomass development (Vasudevan, 1997b; Hidalgo, 1999; Pashanasi, 1996). Many researchers have examined the role of vermicompost in agriculture, horticulture, waste management, and soil protection (Edwards, 1995; Riggle, 1994; Kaviraj, 2003). Darwin (1881) said earthworms prepare the ground well for fibrous-rooted plants and all seedlings. Earthworms may benefit plant development for causes other than the large amounts of macro and micronutrients in vermicasts and secretions. Earthworms may release B or D-group vitamins into the soil (Nielson, 1965). Martinez and Gomez (1995) recommended earthworm compost for commercial Chrysanthemum morifolium cultivation.

Earthworm castings (EW) outperformed compost and commercial potting mixture additions in a Rothamsted study of 25 vegetables, fruits, and ornamentals, according to Edwards (1995). Earthworm cast benefits other horticulture (Hidalgo, 1999). Due to organic matter protection in dry castings, fast nitrification stabilizes both nitrogen forms (Decaens, 1999). Fresh casts have high ammonium levels. As aggregate structure collapses, cast nutrients lose physical protection (McInerney, 2000). Casts have more N, C, P, K, Ca, and Mg than initial feed material (Orozco, 1996). Earthworm cast increases plant dry weight and N absorption (Edwards, 1995; Tomati, 1994).

Cantanazaro (1998) showed that slower-release fertilizers boost plant output and prevent nutrient leaching by synchronizing nutrient release and plant absorption.

Earthworms promote vesicular-arbuscular mycorrhizal fungi (Kale, 1992). Mycorrhizal fungi propagate through earthworms (Redell, 1991). Soil aggregates impact water retention, gas diffusion, root growth, and soil quality. Earthworms transfer water-stable aggregate-forming AM fungus, limiting soil erosion and aggregate formation directly and indirectly (Wright, 1998). Earthworms in nursery pots improved mycorrhizal infection in three tree species (Patrick, 1998), and vermicompost increased protein synthesis in Lactuca sativa seedlings by 30% (Galli et al., 1992). Earthworm compost from municipal wastes (CPEMW) decreased soil pH and increased maize dry matter yield (Ferreira, 1992). CPEMW with lime or mineral fertilizer increased this significantly. Casts have more auxins and nitrogen-fixing capacity than compost. Without N at planting, 15 tons manure or 3 tons vermicompost added early in winter oilseed rape boosted survival by 9–23% (Bury, 1996). In California, Lumbricus terrestris introduced into irrigated apple orchard soils decomposed surface mulch and fertilized the soil (Werner, 1997). Cuba has around 170 vermiculture centers that produce earthworm castings for fertilizer (Werner, 1996). Cow dung, pig and sheep manure, coffee pulp, sugarcane pulp, crdp-residues, and rubbish are utilized for vermiculture on the island. Before feeding earthworms, manure and agricultural waste heaps are changed twice a week for 15–30 days. Coffee pulp pre-decomposes for 45 days. In Australia, vermicomposted organics from grape processing put to plants beneath shadow mulches boosted grape production by 20-50% during the first harvest (Edwards, 1997). In Cuba's Pinar del Rio district, castings substitute manure as tobacco fertilizer. 4 t/ha castings replace 45 t/ha cow dung. This increased output by 31% and quality by lowering leaf chlorine from 1% to 0.4 percent (Werner, 1996). Vermicompost reduces bioavailable heavy metals and pathogens, according to Dominguez (1997). Worm castings were not used in floriculture. Floriculturists said increased organic matter causes crop illnesses. Worms feed on floriculture trimmings (Logsdon, 1994). Earthworm inoculation increases birch seedling net output and nitrogen content (Haimi, 1992). In India, Parry Agro Ltd. inoculated trenches with organic inputs between tea plantations with earthworms to increase tea production by 75–240% (Patrick, 1998).

Earthworms' interaction with microflora

Earthworm digging and casting stimulate soil microorganisms (Edwards, 1996), and nutrient-rich earthworm castings boost microbial development (Lee, 1985). Many writers have researched earthworm gut microbes (Fisher, 1995; Karsten, 1997). Gram-negative bacteria are prevalent in earthworm digestive canals (Reyes, 1976). Eisenia lucens (Marialigeti, 1979) and Pheretima sp. earthworms had several Vibro and Aeromonas hydrophila. By scanning electron microscopy, Daane et al. (1998) observed several rod-shaped bacteria in E. fetida egg capsules, suggesting a mutualistic relationship. Fungi, bacteria, and actinomycetes dominate vermicompost, according to Edwards (1998).

Earthworms have a throat, oesophagus,

gizzard, anterior intestine that secretes enzymes, and posterior intestine that absorbs nutrition. Microorganisms proliferate 1000-fold in the digestive tract. Microorganisms feed earthworms experimentally. Bacteria are small, algae are moderate, while protozoa and fungus are substantial dietary sources. Under sterile circumstances, worms lived on individual cultures of bacteria, fungus, and protozoa but thrived on microorganism mixes. The numbers of microorganisms of different groups were determined during and after vermicomposting rabbit dung and compared to those from a parallel spontaneous maturation phase of the same material to evaluate microflora alteration. Vermicomposting produced less microbial change than rabbit manure spontaneous maturation (Allievi, 1987). However, E. fetida and microorganisms interacted nutritionally. Earthwoms immediately ate microorganism cells. Other species were found to be toxic to E. fetida. Acinetobacter calcoaceticus inoculation of vermiculture beds increased earthworm development and substrate consumption (Hand, 1988), but Acetobacter diazotrophicus did not affect worm reproduction (Aquino, 1994).

In earthworm-worked soils, worm symbiotic microflora degrades lignin (Kale, 1991). Worms' overall microbial load shows that bacteria colonize the anterior intestine more than the rest. Earthworm biotechnology and indegenous microbial activity under ambient temperature and seasonal fluctuations accelerate biological sludge stabilization and turnover, according to Bisesi (1990). Earthworms prefer distinct plant material (Piearce, 1989) and fungal species on filter paper discs (Cooke, 1983). Earthworms are known to spread beneficial mycorrhizal fungi and reduce soil-borne animal and plant fungal disease (Parle, 1963). Actinomycetes and bacteria proliferated in the stomach, but yeast and fungus did not, according to Parle (1963).

Metals and agrochemicals accumulation fromsoil by earthworms

Earthworms are simple to handle and assess for metal buildup and metabolic reactions, making them a popular soil ecotoxicological study topic. Earthworms eat a lot of dirt and absorb heavy metals via their skin and intestines (Morgan, 1999). Earthworms may detect pesticides such polychlorinated biphenyls, polycyclic hydrocarbons, and heavy metals (Saint-Denis, 1999; Spurgeon, 1999a). Earthworms bioconcentrate lead, cadmium, zinc, and copper (Cortet, 1999). Zinc is perhaps the most hazardous metal for these species (Spurgeon, 2000). Earthworm mortality and fecundity as bio-indicating creatures may be accurate, but slow, indicators of environmental contamination (Morgan, 1999).

VCE chelation and pH-induced precipitation suppressed labile aluminum in acidic soils. Mitchell (1993). In 1992, the same authors observed that pH effects reduced total Al by 98% at pH 6, whereas chelation reduced it by 90% at pH 4 (Alter, 1992). Ireland (1977) examined how pesticides and heavy metals affected earthworms. This reduces contaminant penetration into plant systems and the food chain. Worms used for this should not enter the food chain since their tissue concentrates high quantities of these poisons.

Conclusion

Vermicomposting uses earthworms as bioreactors to decompose organic debris, maintain soil fertility, recycle nutrients, and boost plant development.

Vermicomposting may be done using residential, animal, agro-industrial, and human wastes. Vermicompost has several benefits: surplus worms may be utilized in medications, as protein-rich animal feed, and as an anti-soil pollutant.

Thus, mass growing and sustaining worm cultures and tapping organic wastes for their upkeep may be developed as a cottage business in poor nations like India where organic wastes are scarce.

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