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VERMICULTURE BIOTECHNOLOGY FOR POLLUTION CONTROL

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ABSTRACT

Out of the four methods of solid waste disposal the most apt and appropriate one is vermiculture biotechnology from both ecology and economic viewpoint, since it is commercially viable and ecofriendly. The most fundamental action is performed by the verms on solid waste is change in C/N ratio. The present project deals with the change in C/N ratio by three different species of earthworm *Perionyx sansibaricus* (Michaelsen), *Dichogaster affinis* (Michaelsen) and *Lampito mauritii* (Kinberg) in laboratory condition to standardize a locally available species for use in vermiculture. The solid waste initially taken had a C/N ratio as 16.02, 14.77 and 13.75 for the three species, which after 90 days of earthworm inoculation showed the C/N ratio of 9.10, 9.42 and 9.65. The change in C/N ratio is due to feeding of waste by earthworms. The lowering of C/N ratio is basically achieved by combustion of carbon during respiration. Plants cannot assimilate mineral nitrogen unless the C/N ratio is in the order of 20:1 or lower in soil. The experiment with earthworms revealed considerable increase in both C and N in cast in comparison to the food material. The increase in carbon was less than that of nitrogen. The wormcast becomes microbially more active than the food the earthworms ingest, which further helps in degradation and consequently conversion of waste material into useful fertilizer without any harmful byproducts, which are otherwise obvious by decaying or decomposition.

INTRODUCTION

With more than 65% of India's 250 million urban population living in crowded Class-I towns (having a population of over one lakh) and 10% of it in the overcrowded metropolitan cities, the situation *vis-à-vis* solid waste disposal becomes more alarming. As a result, our cities and towns are facing the threat of being overrun by garbage, and the piled-up waste is threatening our health, environment and well-being. India spends about Rs. 230 million per year for waste disposal alone. This expenditure includes the cost of collection, transportation and disposal. Despite spending such a huge sum of money on waste disposal, air and water pollution remain unabated in India. This problem persists due to the inefficient, and improper disposal system. In India, at least 60% of the solid wastes are organic in nature. These wastes are often rich in plant nutrients (Table 1).

To get over this problem, in many countries and some parts of India, garbage is being used to produce manure. The multifarious benefits of earthworms have drifted the attention of scientists to vermicomposting, which employs earthworms as bioreactor. Earthworms are able to convert organic part of municipal solid waste to rich manure (Modena 1978, Senapati et al. 1980, Mitchell et al. 1980, Dash & Senapati 1985, 1986, Talukdar & Goswami, 1995) while it completely deodorizes the composting process (Edward et al. 1985, Bhawalkar 1992).

Since, vermitechnology is both ecologically and economically viable process and can be adopted with least technicality by a common man, it appears to be most suitable process of conversion of garbage into gold or the waste into the best in Indian environmental conditions. Keeping the above in background the preset work was undertaken as a solution to solid waste pollution through vermicomposting with locally available earthworm species like *Perionyx sansibaricus, Dichogaster*

affinis and *Lampito mauritii,* which are not being used as vermicomposting agents, and to have an idea of extent of bioconversion of garbage into manure.

MATERIAL AND METHODS

Earthworms were sampled from grassland and garbage sites of Ranchi University campus by Monolith method as per Dash and Patra (1977). The worms were then hand sorted and cultured in plastic trays (28 × 15 × 12 cm) having soil and garbage as bedding material. Three species of earthworms, *Perionyx sansibaricus* (Michaelsen), *Dichogaster affinis,* (Michaelsen) and *Lampito mauritii* were used to test their decomposition efficiency.

Ten culture trays were taken, one was designated as control and three replicates of each species were arranged. The culture trays were prepared one week prior to inoculation of earthworms and water was sprinkled on alternate days to induce decomposition. The bedding material was reshuffled every 15 days to aerate the culture.

OBSERVATIONS

The result of periodical estimation of two important parameters of bioconversion, i.e. total carbon and nitrogen by the three species used during the experiment has been presented in Table 2. *Perionyx sansibaricus* converted the constitution of the garbage by increasing both C and N content and decreasing the C/N ratio like other worms. An increase in carbon content was of the order of 31.25%, 80.68% and 122.15% by the species on 30th, 60th and 90th days of estimation. Similarly an increase by 55.45%, 145.45% and 290.90% was recorded on the same interval in total nitrogen content. A 2.22-fold increase in carbon content and 3.90-fold increase in nitrogen content were observed during the investigation. On 90th day 43.19% reduction in C/N ratio was observed which was 2.7-fold decrease over the initial ratio.

Dichogaster affinis revealed 14.68%, 46.32% and 86.44% increase in carbon content and 25.00%, 83.33% and 191.66% increase in nitrogen content on 30th, 60th and 90th day over the initial status of carbon and nitrogen. Thus C/N ratio was decreased to 9.42 from initial value of 14.75. On the whole 1.86-fold increase in carbon content and 2.91-fold increase in nitrogen content was observed by the species. On the days of estimation (30th, 60th and 90th days) 1.23, 1.63 and 1.79-fold increase in carbon and 1.43, 2.15 and 2.88-fold increase in nitrogen content were recorded in soil inoculated

Table 1: Potential of waste biomass resources in India. (After Vimal & Talshikar 1982 and Abbasi & Ramasami 1999).

Organic resources	Quantity 10^3 t yr^{-1}	Plant nutrients 10^3 t			Total
		N	P_2O_5	K_2O	
Animal wastes	17043.2	4111.9	1298.6	1952.0	7362.5
Crop residue	1599.5	810.9	562.7	2085.4	3459.0
Fruit and vegetable wastes	0.3	0.2	0.1	0.2	0.5
Forest residue	175.0	243.6	34.4	98.8	376.8
Fish and marine wastes	0.5	3.4	2.9	0.5	6.8
Human habitation wastes	3194.8	815.5	322.1	248.8	1386.4
Aquatic biomass and other wastes	30.8	60.0	30.0	60.0	150.0
Biofertilizers	640.0	1225.0	-	-	1225.0
Grand Total	22684.1	7270.5	2250.8	4445.7	13967.0

Table 2: Characteristics of different earthworm cultures during different durations (N = 3, Mean ± SEM).

Species	Days after worm inoculation	Carbon (%)	Nitrogen (%)	C/N ratio	% decrease in C/N ratio over initial culture
Perionyx sansibaricus	0	1.76 ± 0.02	0.110 ± 0.005	16.02	-
	30	2.31 ± 0.11	0.171 ± 0.002	13.57	15.29
	60	3.18 ± 0.04	0.270 ± 0.004	11.78	29.46
	90	3.91 ± 0.05	0.430 ± 0.020	9.10	43.19
Dichogaster affinis	0	1.77 ± 0.04	0.120 ± 0.001	14.77	-
	30	2.03 ± 0.01	0.150 ± 0.005	13.56	8.19
	60	2.59 ± 0.03	0.220 ± 0.003	11.77	20.31
	90	3.3 ± 0.05	0.350 ± 0.001	9.42	36.22
Lampito mauritii	0	1.79 ± 0.05	0.130 ± 0.010	13.75	-
	30	2.21 ± 0.10	0.186 ± 0.006	11.88	13.60
	60	2.93 ± 0.03	0.280 ± 0.005	10.46	23.92
	90	3.62 ± 0.01	0.375 ± 0.003	9.65	29.81

with *Lampito mauritii*. The decrease in C/N ratio by the species on 90th day, i.e. 29.81%, was a decrease by 2.16-fold over the initial ratio.

The experimental results showed that C/N ratio was reduced maximum by *Perionyx sansibaricus* (43.10%) followed by *Dichogaster affinis* (36.22%) and *Lampito mauritii* (29.81%). The percentage of decomposition on the basis of garbage and compost ratio was more than 90% in all the cases.

DISCUSSION

Lindwist (1941) reported that earthworms increase the nitrate production by stimulating bacterial activity and through decomposition of their own bodies. The presence of earthworm has a marked effect upon nitrogen transformation in a tissue waste or cow slurry mixture. Nitrogen mineralization was greater in the presence of earthworms and this mineral nitrogen was retained in the NO_3 from, which is due to the favourable condition for nitrification product by earthworms. Earthworms assimilate organic nitrogen and excrete approximately equal amount of nitrogen as ammonium and muco-proteins (Needham 1957). Feeding on aerobic sewage sludge and domestic animal manure, earthworms increase their overall rate of decomposition (Mitchell et al. 1977, Hornor & Mitchell 1981). It has been observed that earthworms decrease the proportion of anaerobic to aerobic decomposition, which results in a decrease of methane and volatile sulphur compounds (Mitchell et al. 1980, Waugh & Mitchell 1981). Edwards (1981, 1982) found that worm activity in the animal waste changed most of the nitrogen from ammonium to the nitrate form. Riffalda & Leximinzi (1983) observed that manure samples inoculated with *E. foetida* decompose more rapidly and show a higher degree of humification than uninoculated samples. In general, pH values towards neutrality were maintained in the treatments inoculated with earthworms as compared to non-inoculated residues. As suggested by Wallwork (1983), all enzymes are active in a very narrow pH range and earthworm bioreactors efficiently maintain the high non-linear parameter like pH. The active calciferous gland in the earthworms contain certain large quantities of carbonic anhydrase, which catalyse the fixation of carbon dioxide in the form of calcium carbonate, preventing the fall in the pH of the body fluid. Albanell et al. (1988) concluded that earthworms accelerated the mineralization rate and converted the manures into castings with a higher nutritional value and degree of humification. The castings obtained from manure mixed with cotton wastes showed good fertilizing quality, suggesting that this kind of industrial residue may be used in the vermicomposting. Gaur (1992) showed that a C/N ratio of 30-40 is optimum for efficient

composting. The present finding support the above results, as decomposition was high with earthworms with considerable decrease in C/N ratio.

Hand et al. (1988) studied the changes during composting of cow dung slurry with and without *E. foetida* for a period of 35 days. Most of the initial ammonium nitrogen contained in the slurry was lost by 14 days, probably largely due to volatilization of ammonia. In the treatment containing earthworms, nitrate nitrogen was conserved throughout the experiment while in the slurry without worms, a small initial increase in NO_3 occurred, and the level of this constituent subsequently fell to a level below that of the beginning of the experiment. Organic carbon content of the mixture containing worms declined rapidly at the beginning of the experiment but stabilized after 21 days. At the end of this experiment, carbon content of the slurry was lower than that of slurry without worms. The C/N ratio of a slurry containing earthworms decreased rapidly. In the present investigation, however, both C and N increased after earthworm inoculation but C/N ration decreased probably because the garbage initially had lower C and N than that of Hand et al. (1988) experiment who used cow dung slurry having very high C and N.

Manna et al. (1994) studied the changes in ash content, water-soluble carbohydrate, C/N ratio, cation exchange capacity and biodegradability index of various organic wastes inoculated with vermiculture after 180 days of composting. The results indicated that inoculation of the material with earthworms significantly increased the ash content and CEC of all the waste materials, but the increase in CEC inoculation with earthworm was relatively less as compared to control. Though the C/N ratio was narrowed down in both the inoculated materials yet the magnitude of effect was larger in the former case. Similarly, significant reduction in both, water-soluble carbohydrates and water-soluble carbon was noted in both the treatments. The minimum value of biodegradability index value was recorded in the city garbage followed by maize stalk, chickpea straw, wheat straw and soybean straw by Manna et al. (1994) is in agreement with the present finding.

Our present findings are in agreement with the reports of Edwards and Lofty (1977), Satchell (1983), Lee (1985) and Reinecke et al. (1992) who demonstrated more or less similar changes in the chemical composition of earthworm bedding materials as a result of casting activity. Dash and Senapati (1985, 1986) showed a decrease in the C/N ratio of earthworm cultures by 31-61%. Julka and Mukherjee (1986) have also documented an increase in carbon, nitrogen and organic matter and the decrease in the C/N ratio of culture soil after worm inoculation.

Overall, the chemical composition of the vermicompost produced by the activities of the earthworms studied was somewhat better than the widely acclaimed Cuban worm humus (Rosset & Benjamin 1993). Therefore, the breeding and composting potential of these three species of earthworms may be effectively utilized in vermitechnology as one of the important components of organic farming and sustainable agriculture in India.

On the basis of the experimental results it can be concluded that vermitechnology is a suitable tool to be used for organic solid waste management with locally available species of earthworms giving double fold benefit – the environmental pollution control as well as means of livelihood.

REFERENCES

Abbasi, S. A. and Ramasami, E. A. 1999. Biotechnological methods of pollution control. Universities Press, (India) Limited, p.150.

Albanell, E., Plaixats and Carbrero, T. 1988. Chemical changes during vermicomposting (*Eisenia foetida*) of sheep manure mixed with cotton industrial wastes. Biology and Fertility, 6(3): 266-269.

Bhawalkar, U. S. 1992. Chemical fmg. to natural fmg. A quick changeover without loss of yield. In: L. L. Somani, K. L. Totawat and L. Baser (Ed.) Proc. Natl. Sem. Natural Fmg.

Dash, M. C. and Patra, U. C. 1977. Density, biomass and energy budget of a tropical earthworm population from a grassland site in Orissa, India. Rev. Ecol. Bio. Sol., 16: 79-83.

Dash, M. C. and Senapati, B. K. 1985. Vermitechnology: Potentiality of Indian earthworms for vermicomposting and vermifeed. In: Soil Biology, M. M. Mishra and K. K. Kapoor (Eds) Haryana Agricultural University, India. pp. 61-69.

Dash, M. C. and Senapati, B. K. 1986. Vermitechnology, an option for organic waste management in India. In: Verms and Vermicomposting, M. C. Dash, B. K. Senapati & P. C. Mishra (Eds.) pp. 157-172.

Edward, C. A., Burrows, I., Fletcher, K. E. and Jones, B. A. 1985. The use of earthworms for composting farm waste. In: Composting of Agricultural and other Wastes. J. K. R. Gasser (Ed.) Elsevier Applied Sci. Pub., pp. 229-242.

Edward, C. A. 1981. The use of earthworms in waste disposal and protein production. Rothamsted Expt. Stn., England.

Edward, C. A. 1982. Report Rothamsted Expt. Stn., pp. 103-106.

Edward, C. A. and Lofty, J. R. 1977. Biology of Earthworms, 2nd Ed. Chapman and Hall, London, 333 pp.

Gaur, A. C. 1992. Bulky organic manures and crop residues. In. Fertilisers, Organic Manures, Recyclable Wastes and Biofertilizers. H. L. S. Tandon, (Ed.), F.D.C.O., New Delhi pp. 36-53.

Hand, P., Haynes, W. A., Satchell, J. E. and Frankland, J. C. 1988. The vermicomposting of cow slurry. In: Earthworms in Waste and Environmental Management. C. A. Edwards and E. F. Neuhauser, (Eds.) pp. 49-63.

Hornor, S. G. and Mitchell, M. J. 1981. Effect of the earthworm, *Eisenia foetida* on fluxes of volatile carbon and sulphur compounds from sewage sludge. Soil Biol. Biochem., 13: 307-572.

Julka, J. M. and Mukherjee, R. N. 1986. Preliminary observations on the effect of *Amynthas diffringens.* (Oligochaeta: Megascolecidae) on the C/N ratio of the soil. In: Verms and Vermicomposting, M. C. Dash, B. K. Senapati and P. C. Mishra (Eds.), pp.66-68. Five Star Printing Press, Burla.

Lee, K. E. 1985. Earthworms: Their Ecology and Relationships with Soils and Land Use. Academic Press, London, 411 p.

Lindwist, 1941. Investigation of the importance of some earthworms for decomposition of broad leaf litter and for the structure of mull. Abs. Biol., 62-70.

Manna, M. C., Singh, M., Kundu, S. and Tripathi, A. K. 1994. Decomposition of waste organic materials of farm and city as influenced by vermiculture extended summaries. National Seminar on Developments in Soil Science on Nov. 28 - Dec. 1, 1994 at Indian Agricultural Research Institute, New Delhi 110 012.

Mitchell, M. J., Mulligan, R. M., Hatenstein, R. and Neuhauser, E. F. 1977. Conversion of sludges into 'top soils' by earthworms. Compost Science, 18 (4): 28-32.

Mitchell, M. L., Hornor, S. G. and Abrans, B. L. 1980. Decomposition of sewage sludge in drying beds and the potential role of the earthworm, *Eisenia foetida*. J. Environ. Qual., 9: 373-378.

Modena, A. C. 1978. Earthworm makes fertilizer. Sugar News, Phillipines, 54: 228-241.

Needham, A. E. 1957. Components of the nitrogenous excreta in the earthworms *Lubricus terrestris* and *Eisenia foetida* (Savigny). J. of Exp. Bio., 34: 425-446.

Reinecke, A. J., Viljoen, S. A. and Saayman, R. J. 1992. The suitability of *Eudrilus eugeniae, Perionyx excavatus* and *Eisenia foetida* (Oligochaeta) for vermicomposting in Southern Africa in terms of their temperature requirements. Soil Biol. And Biochem., 24: 1295-1307.

Riffalda, R. and Leviminzi, R. 1983. Preliminary observations on the role of *Eisenia foetida* in manure decomposition. Agrochimica, 27 (2-3): 271-274.

Rosset, P. and Benjamin, M. 1993. Soil conservation: A key to the new model. In: Two Steps Backward One Step Forward. Cuba's Nationwide Experiment with Organic Agriculture, 67, p., Global Exchange, San Francisco.

Satchel, J. E. (Ed.) 1983. Earthworm Ecology: From Darwin to Vermiculture, Chapman and Hall, London.

Senapti, B. K., Dash, M. C., Rana, A. K. and Panda, B. K. 1980. Observation on the effect of earthworm in the decomposition process of soil under laboratory condition. Comp. Physiol. Ecol., 5: 140-142.

Talukdar, M. C. and Goswami, B. 1995. Effect of urban wastes on quality of vermicompost. Int. Workshop on Urban Agriculture and Sustainable Environ., Dec. 8-10. Calcutta.

Vimal, O. P. and Talshilkar, S. 1983. Recycling of wastes in Agriculture: Looking ahead to 2000 A.D. J. Scientific and Industrial Research, 42: 115-127.

Wallwork, 1983. Earthworm Biology, Edward Arnold Limited, London, pp. 58.

Waugh, J. M. and Mitchel, M. J. 1981. Effect of the earthworm, *Eisenia foetida* on sulphur speciation and decomposition in sewage sludge. Pedobiologia, 22: 268-275.

Environment News

150 million children suffer malnutrition, says UNICEF

While "spectacular gains" have been made against some nutritional deficiencies, one-third of children in the developing world are malnourished, according to a report released on Wednesday.

The report by the United Nations Children's Fund (UNICEF) found that child malnutrition in the developing world had fallen from 32 per cent to 28 per cent, or about 150 million children in all. But nearly half the children in South Asia and less than one-third in sub-Saharan Africa were malnourished, it said.

"The familiar symbol of the visibly starving child misrepresents the problem. In reality, most malnutrition is totally invisible," according to the report 'Malnutrition: The News'.

Frequent illness, not a lack of food, is the major factor in malnutrition, the report said. The overwhelming majority of malnourished children live in homes with enough food, according to the study. Illness can cause a lack of appetite, calories are used up fighting infections and vomiting and diarrhoea drain away vital nutrients.

The vast majority of malnourished children develop the condition in the first three years of life – a critical period for brain and body growth.

"The greatest tragedy of malnutrition is that it prevents children reaching their full potential," said former James Bond actor Roger Moore, a UNICEF goodwill ambassador.

On the up side, the report said 18 countries – including China, Mexico, Indonesia, Bangladesh and Vietnam – reduced child malnutrition by 25 per cent or more.

More than 70 per cent of the developing world's households now use iodized salt a rise of 50 per cent – protecting an estimated 12 million children a year from suffering brain damaged as a result of iodine deficiency.

Vitamin 'A' supplements now reach half the world's children, saving about 333,000 lives a year, the report said. And the decline in breast-feeding – key to good nutrition – appears to have ended.

The study was conducted in more than 100 countries. Its figures were compiled from the largest ever data collection on infant well being and the first released in a decade.

COLA-WATER WAR: Kerala villagers cross swords with Coke over indiscriminate groundwater use

Even as Coca-Cola draws a generic link with all things cool in its latest ad, the soft-drink giant is feeling the heat of a two-month-long agitation by local villagers against its bottling plant in Palakkad district of Kerala. Their grievance: excessive groundwater extraction by Hindustan Coca-Cola Beverages Private Limited (HCBL), a local unit of the multinational company.

Double indemnity: Death by DDT

Despite the ban on Dichlorodiphenyltrichloroethane (DDT) by most developed countries in the 1970s, India sprayed 7,000 tonnes of DDT in 2001-2002. Ignoring the widely accepted fact that DDT induces alarmingly high levels of toxicity and possible carcinogenicity, India has continued to consume 3,50,000 tonnes of DDT since 1985, mainly for agricultural and public health purposes. Studies reveal Indians have one of the highest body DDT concentrations. Now, intensive use of DDT has made mosquitoes resistant to the insecticide.

(Compiled from various newspapers and newsletters)