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Poultry Waste Management using Earthworms *E. eugeniae, E. foetida* and *P. excavates*

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ABSTRACT

In this study, biodegradation efficiacy of three different earthworms (*E. eugeniae, E. foetida* and *P. excavates*) on poultry waste was studied. Earthworms were exposed to various concentrations of poultry waste to identify the median lethal concentration, for 72 hrs. Macronutrient and micronutrients analysis of Poultry waste showed varied results in earthworm degrading samples than compared to control. Among the three earthworm species, *E. eugeniae* showed high efficiency of biodegrading poultry waste into an organic manure. This study identified the efficient earthworm with high biodegrading efficiency which helps to reduce the environmental pollution developed by poultry waste.

Key words: Biodegradation, Earthworm, Heavy metal, Poultry waste.

INTRODUCTION

Around 1961 and 1980s, the annual estimation of value of poultry and poultry products were 0.65 and 8 billion rupees respectively and it was increased as 35 billion rupees in 2000. India ranked fifth in the world egg and broilers production (FAO 1998). Storing chicken waste also adversely affect the natural environment (Schmidt and Bicudo, 2000), generally in one ton of chicken manure contains 27kg of nitrogen and P_2O_5. Along with these compounds, ammonia, carbon dioxide and sulphur hydrogen were also released. High concentration of these gases has a negative effect on the health of humans and animals (Kirchman and Lundvall, 1998; McGinn and Janzen 1998).

In India, nearly 2000 million tons (MT) of animal wastes, 300 MT of crop wastes, as well as huge amount of agro-industrial, domestic sewage wastes were produced annually (Ramaswamy 1998; Mishra 2001). Extensive utilization of poultry manure for agricultural purposes has serious consequences for the natural environment by causing nutrient leaching, ground water contamination, eutrophication of fresh water systems, pose a serious threat to the aquatic organisms (Aubert, 2001). To overcome this problem aroused from organic fertilizer vermicomposting poultry waste can be used which is also an effective, simplest and low cost ecofriendly process by biodegrading organic materials.

E. foetida and *P. excavates* are the common earthworm species (Akilan and Nanthakumar, 2017) which showed increased vermicompost production (Sarma *et al*., 2012). Vermifertilizer enhances the soil porous nature with improved sustainable agriculture (Sudhakar *et al*., 2002). Various researchers also suggested that utilization of earthworms for organic waste degradation is an important developmental progress in biological sciences (Graff, 1981; Edwards *et al*., 1998; Giraddi 2000; Chaudhuri *et al*., 2001; Reddy and Ohkura, 2004). *E. eugeniae, E. foetida* and *P. excavatus* were the extensively used earthworms species in vermicomposting process across the world. This study was focussed to identify the biodegrading efficiacy of three different earthworms on poultry waste.

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MATERIALS AND METHODS

Collection and processing of worms and waste

The earthworm *E. eugeniae E. foetida* and *P. excavatus* were bought from a vermiculture farm situiated in Vallum, Tanjore (10° 48' 0"N, 79° 9' 0"E), Tamil Nadu (India). The earthworms were reared in garden soil and garden waste vermibed (4×2×4/4 feet) with controlled moisture (35-45%) and temperature (26-28°C). Nylon net was used to cover the bed to prevent the entry of predators. Adequate watering was done daily to maintain optimum moisture conditions in the bed (Merel 2012). After acclimatization for a period of 15 days, the worms selected for the present work were maintained under proper condition (Yadav and Garg, 2011). The earthworms were hand-sorted and the species were identified by morphological observations. The raw materials, poultry waste collected in Cheyyar and transported to the laboratory. Cowdung (CD) procured from the Srinivasa cowshed, Tiruchirapalli, Tamil Nadu (India) served as feed. Chemical parameters such as Total solids, pH, Total Organic Carbon (TOC), Total Nitrogen (TN) and Carbon Nitrogen ratio

(C: N) were quantified. C.N ratio was calculated by dividing the percentage of carbon estimated with the percentage of nitrogen estimated for the same sample.

Preparation of pre-compost substrate

From various collection points, the environment and industrial wastes dumped in and around Cheyyar, Tamil Nadu (India) were collected. The waste material for the present work was prepared by mixing appropriate environmental waste, soil and cowdung in combinatorial composition through which the optimum growth concentration and the lethal concentration (LC_{50}) and Chemical parameters were determined.

Design of bioreactor

Bioreactors (30 cm diameter, 18 cm depth) were filled with feed mixture (on dry weight basis) containing different percentages of Environmental waste, Cow dung and/or soil. Every 24 h the mixtures were manually stirred to eliminate volatile toxic substances. After 15 days, all containers were maintained at controlled environmental temperature (26-28°C), with 10 earthworms in each container. 40-45% moisture content was maintained throughout the study.

Determination of Lethal concentration (LC_{50})

LC_{50} is the concentration of the substance, which kills 50% of the sample population during the test period. Ten healthy worms in the soil medium are exposed to varying concentrations of poultry waste *viz.* 50, 60, 70, 80 and 100. Mortality is recorded for each of the concentration for an exposure period of 72 hours. Procedures used were based on those described by Heimbach (1984) as modified by Ahmed *et al.* (1991).

Soil nutrient and heavy metal analysis

The pH was measured using pH 6.15 digital pH meter in 1/10 (w/v) aqueous solution. Total Organic carbon (TOC) was determined by the partial-oxidation method (Walkley and Black, 1974). Total nitrogen (TN) was measured by micro Kjeldahl method (Jackson, 1975). C: N ratio was calculated from the measured value of C and N. Total extractable phosphorous (TP) was determined by using Olson's sodium bicarbonate extraction method (Olsen *et al.*, 1954). Potassium concentration determined by flame photometric method, Ca and Mg were determined as described by Tandon (1993) using acid digestion method and the samples were analyzed by Perkin Elmer AA-6300, double beam atomic absorption spectrophotometer (AAS). Presence of heavy metals in the soil before and after the treatment of earthworms were analyzed by Soil Testing Institute, Govt. of Tamil Nadu, Tiruchirappalli, Tamil nadu (India) by Tandon (1993), Chopra and Kanwar (1991) methods and the results were tabulated.

Statistical analysis of data

The data obtained from study were analyzed statistically and all values are presented as Mean±SD. The values of increase/decrease of physico-chemical parameters in the tested and non tested (control) were subjected to ANOVA using the Computer Software (SPSS, Version 16).

RESULTS AND DISCUSSION

Lethal concentration

The LC_{50} was determined by the wide dosage and found the waste to be lethal at the concentration between 55 and 60 and presented in Table 1 and Fig 1.

Physical-chemical changes during Vermicompost

Treatment of *E. eugeniae, E. foetida* and *P. excavatus* on Poultry waste (PW) showed a significant reduction in the pH whereas the control pH found as 8.55±0.16 and reduced into 7.4±0.28 after treating with *E. eugeniae*. A similar trend was followed with *E. foetida* and *P. excavatus* treated soil as 7.41±0.38 and 6.88±1.82 respectively. TOC levels was decreased from 454.69±23.94 into 209.86±8.45 in the experimental group treating with *E. eugeniae*, 232.39±1.94 in the EF and 231.02±66.06 treating with PE (Table 2). There was a significant improvement in the Nitrogen availability in the soil. The Nitrogen content of the control soil was found to be 5.71±0.25, whereas the Nitrogen content was 8.80±8.45, 17.71±1.08, 12.70±5.43 for EE, EF and PE respectively. When compared to control, decreased C:N ratio found in all the treated groups. Our results were evidenced by C:N ratio which narrowed down substantially over normal control compost (Gaur, 1991; Manna *et al*., 2003; Bansal and Kapoor, 2000).

Similarly, TP, TK, TCa and TMg were increased and provide greater bioavailability in the soil (Table 2). This shows that the vermitechnology has the potency to convert the PW into valuable feedstock for the crops. Enhanced calcium and potassium content in vermicompost by the end of the experiment were observed in various studies (Delgado *et al*., 1995; Manna *et al*., 2003; Suthat 2007) due to the microbes in gut of earthworms and their metabolic process (Lee 1992).

The chromium content in the PW after inoculated with *E. eugeniae* was reduced to 0.44±0.21.There was a decreased level found in the Zn content in the soil, the Zinc content of the control soil was found to be 2.50±0.30 whereas the Zinc content was 1.73±0.15, 1.75±0.13, 1.70±0.07for EE, EF and PE respectively. The same trend was observed in the Cu Mn, Ni, Co and Cd and provides lower bioavailability in the soil (Table 2). This shows that the

Table 1: Determination of LC_{50} for *E. eugeniae, E. foetida* and P. excavatus for various dosages of Poultry waste.

No of worms	Dosage	Mortality		
		E. eugeniae	E. foetida	P.excavatus
10	40	0	0	0
10	45	2	3	1
10	50	3	4	5
10	55	4	5	7
10	60	5	7	8

vermitechnology has the potency to decrease the Micronutrient level in the soil.

Earthworm gut is an effective tubular bioreactor, which accelerates various enzymes like acid and alkaline phosphatases, nitrate reductase, etc. These enzymes secreted in the gut are responsible for the breaking down the food which contains plant matters and decompose. The remains of the soil which is essential for the formation of vermicomposting (Prabha *et al*., 2007). The vermicompost technology employed in this study reveals the enrichment of Poultry waste with nitrogen, phosphorus, potassium, calcium and magnesium.

Poultry waste can be used as a manure instead of treated as waste (Guru 2003). Waste from the poultry industry includes a mixture of excreta, bedding material, Wood shavings or straw, remaining feed, dead birds, broken eggs and feathers removed from poultry houses. These materials have a high nutritional value and used as an organic fertilizer. Recycling nutrients contain high amount of nitrogen, phosphorous and potassium which has greater importance for plants during growth.

Bitzer and Sims (1998) reported that excessive application of poultry litter in cropping systems could result in nitrate (NO_3) contamination of groundwater. So, these litters were converted into another organic materials which cannot cause harm to the environment. Earthworm digesting the poultry in a great manner which provokes the utilization of degrading organic substances and converting into orgnic manure.

Moreover, *E. eugeniae* appears to participate effectively in biomanagement when compared to *E. foetida* and *P.excavatus.* During vermicomposting process, some degree of metal toxicity was reduced possibly due to the bioaccumulation of some fractions of metals by the inhabiting earthworm's enzymatic milieu. The study provides a resonance source that vermicomposting can be a potential technology to convert the deleterious poultry wastes into nutrient rich, toxic-free value added materials and also provides a new dimensional approach to manage poultry waste biologically.

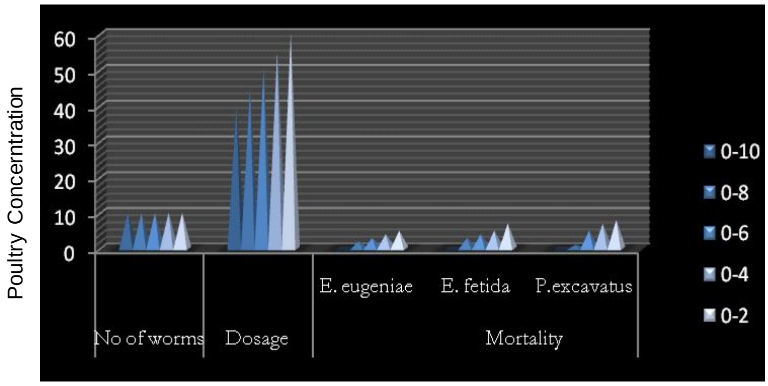

Fig 1: Determination of LC_{50} for *E. eugeniae*, *E. foetida* and *P. excavatus* at various dosages of Poultry waste.

Table 2: Nutrient analysis of Poultry waste before and after treatment with three indegenious earthworms.

Macronutrients and Micronutrients	Control	*E. eugeniae*	*E. foetida*	*P. excavatus*
pH	8.55 ± 0.16	7.43 ± 0.28	7.41 ± 0.38	6.88 ± 1.82
TOC	454.96 ± 23.94	209.86 ± 8.45	232.39 ± 1.94	231.02 ± 66.06
TN	5.71 ± 0.25	8.80 ± 0.31	17.71 ± 1.08	12.70 ± 5.43
C:N	56.80 ± 1.62	44.86 ± 0.77	146.04 ± 2.98	28.11 ± 16.55
TP	9.52 ± 0.30	27.49 ± 0.62	6.95 ± 4.81	10.05 ± 5.08
TK	8.16 ± 0.30	18.67 ± 0.70	14.93 ± 1.33	9.71 ± 5.38
TCa	37.13 ± 2.08	42.73 ± 0.27	41.19 ± 2.47	34.33 ± 10.08
TMg	12.81 ± 1.81	18.30 ± 0.71	16.24 ± 1.61	15.76 ± 4.61
Zn	2.50 ±0.30	1.73 ± 0.15	1.75±0.13	1.70 ± 0.07
Cu	2.83 ±0.50	3.20 ± 0.27	2.43±0.25	2.62 ±0.21
Mn	3.59 ± 034	3.04 ± 0.08	1.71±0.12	1.71 ± 0.14
Cr	0.70 ±0.10	0.44 ± 0.21	2.30±0.16	2.46 ± 0.35
Ni	2.11 ±0.34	0.83 ± 0.13	1.61±0.22	1.01 ± 0.02
Co	1.75 ±0.13	0.26 ± 0.03	1.04±0.02	1.05 ± 0.03
Cd	1.40 ±0.38	0.85 ± 0.08	0.93±0.17	1.06 ± 0.03

Conclusion

In this study, three different earthworms (*E. eugeniae, E. foetida* and *P. excavates*) biodegration efficiacy on poultry waste was studied. LC_{50} analysis helps to fix the experimental dosages. Macronutrient and micronutrient analysis of earthworm degrading samples showed decreased TOC and varied elements than compared to control. Among the three earthworm species, *E. eugeniae* showed high efficiency of biodegrading poultry waste into an organic manure which is an effective way of minimizing environmental dumping of poultry waste.

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