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Vermicomposting of Distillery sludge with different wastes by using *Eisenia fetida*

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ABSTRACT

The aim of the study is to utilize distillery sludge with different types of waste i.e. agricultural waste, municipal waste and poultry waste through vermicomposting by using Eisenia fetida. The experiments were conducted in circular plastic containers. The containers were filled with three different combinations of distillery sludge and different wastes in 1:1 (distillery sludge + different waste), 1:3 (distillery sludge + different waste), and 3:1 (distillery sludge + different waste) were prepared. In the experimental period (60 days), different chemical parameters were analyzed within a time interval of 15 days. The Total Kjeldahl Nitrogen (%), Available Phosphorus (%) and Total Potassium (%) – increased at the end of the process, while the % Organic Carbon decreased as the vermicomposting processes progressed.

Key words: distillery sludge, agricultural waste, poultry waste, municipal solid waste vermicomposting, *Eisenia fetida.*

INTRODUCTION

A rapidly increasing population and high rate of industrialization has increased the problem of solid waste management [1]. It is well known that the disposal of a large amount of waste water and sludge produced by anthropogenic sources is becoming a serious problem [2]. The sludge generated in enormous quantity creates the problem of safe disposal. Sludge is an inevitable, hazardous and odorous by-product from conventional water and waste-water treatment plants which eventually requires safe disposal either in landfills or by incineration incurring heavy cost [3]. Beside it we are facing the major problem with the wastes like municipal solid waste, agricultural waste and poultry waste because these are highly organic in nature and pollute our water, air and soil environment. Thus vermicomposting has become an appropriate alternative for the safe hygienic and cost effective disposal of these wastes. Vermicomposting, through earthworms, is an eco-biotechnological process that transforms energy rich and complex organic substances in to stabilized vermicompost [4]. The promising technique that can be applied to treat the industrial sludge is vermicomposting by a specific composting worm. The use of earthworms in sludge management has been termed as vermistabilization [5]. Some epigeic earthworms: *Lumbricus terrestris, Eisenia fetida, E. andrei, Eudrilus eugeniae* and *Perionyx excavatus* have been appeared as key sources to combat the problem of organic waste disposal on a low-input basis [6-8]. The epigeic *Eisenia fetida* earthworm well suitable for vermicomposting and its product quality better than traditional composting [9].

Hence, the aim of present study was to determine the effect of different wastes and distillery sludge in different combinations by using *Eisenia fetida* and its utilization into natural fertilizer.

MATERIALS AND METHODS

Collection of earthworms: *Eisenia fetida* species were collected from Devsanskriti Vishwavidyalaya Campus (Dehradun-Rishikesh road) 10 km. from the Kanya Gurukul Campus, Haridwar, (Uttarakhand).

Collection of waste: Agricultural waste was collected from the agricultural fields of Devsanskriti Vishwavidyalaya, Haridwar and municipal solid waste from the dumping site of Chandi Ghat situated in Haridwar city. Poultry waste was collected from the local poultry farm of Roorkee, situated 27 Kms far from the Haridwar city. All of the these three wastes were left for pre decomposition for 15 days prior to study for removing the various harmful organisms and noxious gases.

Collection of Sludge: Distillery sludge was collected from Doon Valley Distillery, Doiwala, Dehradun. (Uttarakhand, India) and was pre decomposed with cow dung for one month prior to study for reducing the toxicity and high temperature because both may be lethal for the earthworms.

Experimental set up: The experiments for vermicomposting were conducted in circular plastic pots. In each pot different combinations of distillery sludge (DS) and different wastes (DW) i.e., (agricultural, municipal solid waste and poultry waste) in three proportions viz., 1:1 (T_1), 1:3 (T_2), 3:1 (T_3) were prepared. 15 adult worms were introduced in each mixture. A set of control in each combination was also maintained without the earthworms.

Chemical parameters: The total nitrogen (%N), available phosphorus (%P), total potassium (%K) and organic carbon (%OC) were analysed [10].

RESULTS AND DISCUSSION

The nutrient value of vermicompost depends on several factors viz., nature of feed substrate, aeration, moisture, temperature and earthworm species used in the process [11].

The performance of vermireactors with distillery sludge and different wastes in terms of macronutrients during the study period is summarized in Table-1, 2 and 3. Results revealed a considerable increased amount of macronutrients at the end of 60th day.

Table: 1 Pattern of nutrient changes during the vermicomposting of distillery sludge with different wastes using *Eisenia fetida*
Treatment-[T_1] (DS+DW) -1:1

Elements	Control and experimental unit	Initial day	15th day	30th day	45th day	60th day	% increase and decrease
%N	T_1 C	1.60±.03	1.66±.05	1.84±.04	1.92±.05	1.94±.04	+21.25
	T_1 E		1.73±.04	1.66±.04	1.93±.04	2.08±.19	+30.00
%P	T_1 C	0.77±.04	0.82±.05	0.93±.03	1.15±.14	1.25±.03	+62.33
	T_1 E		0.84±.05	0.95±.03	1.26±.01	1.31±.06	+17.12
%K	T_1 C	0.35±.04	0.44±.04	0.42±.06	0.55±.04	0.62±.03	+77.14
	T_1 E		0.54±.05	0.57±.06	0.71±.03	0.79±.09	+125.71
%OC	T_1 C	24.35±.60	20.31±.96	18.77±.86	17.33±.38	16.40±.40	–32.64
	T_1 E		18.60±1.1	16.25±.47	15.43±.59	14.46±.28	–40.61

Mean ± SD of 3 observations, C-Control without earthworm, E-Experiment with earthworm

ANOVA: One way factor (SPSS 12.0)

Analysis of Variation	SS	df	MS	F	Sig.
%N Between Groups	.637	8	.080	3.363	.000
Within Groups	.426	18	.024		
%P Between Groups	1.063	8	.135	33.886	.000
Within Groups	1.072	18	.004		
%K Between Groups	0.472	8	.0599	21.195	.000
Within Groups	.052	18	.003		
%OC Between Groups	215.458	8	26.932	56.456	.000
Within Groups	8.587	18	.477		

Sig. Indicates the significance level of the F- test. [$p \leq 0.05$]
p-significance level at 95%

The total nitrogen (N) content of T_1 (control) showed 21.25% increase from the initial day while T_1 (experiment) has 30.0% increase in N content from the initial day. Likewise the T_2 (control) showed 76.68% increase while T_2 (experiment) showed 90.79% increase from the initial day. In the same manner in T_3 the % increase in N change was more in T_3 (experimental) unit which was 20.66% than that of T_3 (control) 18.66%. The higher % of N was found in T_2 as compared to the T_1 and T_3 which may be due to mineralization of organic matter. The final content of nitrogen in vermicomposting is dependent on initial nitrogen present in the waste and the extent of decomposition.

Earthworm activity enriches the nitrogen profile of the vermicompost through microbial mediated nitrogen transformation, addition of mucus and nitrogenous waste secreted by earthworms [12-15].

Table: 2 Pattern of nutrient changes during the vermicomposting of distillery sludge with different wastes using *Eisenia fetida*
Treatment- [T_2] (DS+DW) - 1:3

Elements	Control and experimental unit	Initial day	15th day	30th day	45th day	60th day	% increase and decrease
%N	T_2 C	1.63±.03	1.72±.04	1.81±.02	1.96±.06	2.88±.04	+76.68
	T_2 E		1.77±.06	1.93±.04	2.28±.20	3.11±.12	+90.79
%P	T_2 C	0.84±.04	0.94±.03	0.97±.02	1.54±.04	1.56±.08	+84.71
	T_2 E		1.07±.15	1.24±.04	1.70±.04	1.81±.06	+115.47
%K	T_2 C	0.44±.03	0.56±.05	0.67±.05	0.77±.02	0.82±.06	+86.36
	T_2 E		0.68±.06	0.77±.02	0.87±.04	0.94±.04	+113.63
%OC	T_2 C	19.50±.25	17.81±.35	16.28±.20	14.65±.31	12.91±.52	–33.79
	T_2 E		16.58±.38	14.54±.31	12.67±.34	11.75±.66	–39.74

Mean ± SD of 3 observations, C-Control without earthworm, E-Experiment with earthworm

ANOVA: One way factor (SPSS 12.0)

Analysis of Variation	SS	df	MS	F	Sig.
%N Between Groups	6.792	8	.849	108.167	.000
Within Groups	.141	18	.008		
%P Between Groups	3.156	8	.394	82.625	.000
Within Groups	.086	18	.005		
%K Between Groups	.568	8	.071	32.841	.000
Within Groups	.039	18	.002		
% OC Between Groups	157.797	8	19.725	133.585	.000
Within Groups	2.658	18	.148		

Sig. Indicates the significance level of the F- test. [$p \leq 0.05$]
p- significance level at 95%

Table: 3 Pattern of nutrient changes during the vermicomposting of distillery sludge with different wastes using *Eisenia fetida*
Treatment- [T_3] (DS+DW) - 3:1

Elements	Control and experimental unit	Initial day	15th day	30th day	45th day	60th day	% increase and decrease
%N	T_3 C	1.50±.02	1.56±.03	1.59±.04	1.71±.03	1.78±.02	+18.66
	T_3 E		1.65±.04	1.71±.03	1.73±.06	1.81±.03	+20.66
%P	T_3 C	0.63±.04	0.65±.04	0.69±.04	0.74±.06	0.92±.05	+46.63
	T_3 E		0.74±.03	0.82±.03	0.92±.03	1.04±.13	+65.07
%K	T_3 C	0.30±.03	0.34±.05	0.41±.04	0.49±.02	0.51±.31	+70.00
	T_3 E		0.44±.04	052±.04	0.60±.02	0.65±.04	+116.66
%OC	T_3 C	17.70±.18	16.01±.68	14.26±.3	12.91±.17	11.82±.04	–33.22
	T_3 E		14.28±.20	12.88±.08	11.62±.10	9.91±.17	–44.01

Mean ± SD of 3 observations, C-Control without earthworm, E-Experiment with earthworm

ANOVA: One way factor (SPSS 12.0)

Analysis of Variation	SS	df	MS	F	Sig.
%N Between Groups	.264	8	.033	20.174	.000
Within Groups	.029	18	.002		
%P Between Groups	.483	8	.060	16.726	.000
Within Groups	.065	18	.004		
%K Between Groups	.314	8	.039	26.736	.000
Within Groups	.026	18	.011		
%OC Between Groups	135.251	8	16.906	19 6.484	.000
Within Groups	1.549	18	.086		

Sig. Indicates the significance level of the F- test. [$p \leq 0.05$]
p- significance level at 95%

The available phosphorus (P) content of T_1 (control) showed 62.33% increase from the initial day whereas T_1 (experiment) has 17.12% increase in P content from the initial day. Similarly the T_2 (control) showed 84.71% increase and T_2 (experiment) shows 115.47% increase from the initial day. In the same manner T_3 (control) showed 46.63% increment and T_3 (experiment) 65.07% increase from its initial day. The highest increase was found in T_2 as compared to T_1 and T_3 which may be due to mineralization and mobilization of phosphorus as a result of bacterial and faecal phosphatase activity of earthworms [16].

The % increase in the Total potassium (K) content was 77.14% in T_1 (control) and 125.71% in T_1 (experiment) units. The similar trend was found in the T_2 and T_3. In T_2 control % increase was 86.36% and in T_2 (experiment) 113.63% from its initial mixture. Likewise in T_3 (control) % increase was 70% and in T_3 (experiment) the % increase was found to be 116 % from its initial day. The % increase was higher in T_2 as compared to the T_1 and T_3 treatments at the 60th day. In the case of vermicomposting the enhanced number of micro flora present in the gut of earthworms plays an important role in this process resulting in increased potassium over the control [17].

The organic carbon % decreased in all the treatment units including control and experimental units. The % organic carbon content decreased as the decomposition progress [18]. The % decrease in carbon (OC) content of T_1 (control) was 32.64 % and in T_1 (experiment) was 40.61%. Similarly % decrease in T_2 (control) was 33.79% and T_2 (experiment) 39.74%. In the same manner in T_3 (control) this % decrease was 33.22% and T_3 (experiment) was 44.01%.

CONCLUSION

From the above study it has been concluded that 1:3 (distillery sludge + different waste) was more efficient in bioconversion of distillery sludge and different wastes into nutrient rich vermicompost produced by *Eisenia fetida* than that of 1:1 and 3:1 because in these ratios mineralization could be decreased due to more concentration of distillery sludge and have higher proportion of heavy metals which exerts toxicity and higher concentrations of distillery sludge affected the population of microbes and microbial enzymes.

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