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Soil Amendment with Flyash through Vermicomposting by the Action of Epigeic Earthworm

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ABSTRACT

The coal based industries are key sources of huge production of Fly Ash (FA). According to the current scenario about 87% of FA are utilized globally but the continuous production and over production is still constant. An effective recycling is the major solution for sustainable utilization of FA. It has ability to increase the soil nutrition due to contain oxides of heavy metals for the purpose of agricultural practice. A subsequent quantity is required for soil amendment by adding various proportion of FA. Vermicomposting (VC) is a dynamic involvement of microbes with vermis or worms especially earthworms to convert the waste into organic manure in form of vermicasts. The present study was experimented out by taking various proportions of FA such as 20%, 40%, 60%, 80% and 100% including soil+ cow dung (Organic Manure-OM) as control. Each of proportions adding with the rest amount of OM to make it 1kg for the purpose of amendment. All proportions were under the process of vermicomposting by the action of Eudriluseugeniae after it's inoculation. This paper was focused on to find out the suitable proportion of FA can be able to the amendment for crop yielding by estimating through different physico-chemical parameters that obtained during vermicomposting.

Keywords
Fly Ash (FA), Vermicomposting (VC), Organic Manure, proportion of FA, physico-chemical parameters, Eudrilus is the pillar eugeniae

INTRODUCTION

Electricity is the pillar of industrialisation and urbanization for whole global production. The huge supply of electricity to run various industries is possible due to power generation from Thermal Power Plants (TPPs). Generally TPPs are responsible for production of huge amount of Fly Ash (FA) as by-product due to the combustion of coal or lignite during generation of power. Now a day heap of FA is surrounding the production area as well as effects miles away from it causes various environmental issues and health hazards. FA is a finest, greyish, powdered oxides of heavy metals (silica, aluminium and oxides of iron, calcium, magnesium, arsenic, chromium, lead, zinc and other toxic metals (Petrlik, 2017). As a source of environment pollution it is contaminating ground water, soil and causes of landfills due to over disposed. The production of FA in India raised to approximately 130 mts. in 2019-20 (CEA, 2020). Recycling of this industrial waste has been carried out for various productive utility. The major implementation of FA is focused by number of scientists for amendment with soil to enhance plant nutrition for agriculture production (Bhattacharya et al., 2012; Gupta et al., 2005).

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Vermitechnology is an effective low cost treatment for amendment of FA with an accuracy to convert into vermicompost (Edwards, 1992) by the action of earthworms (EWs) and microbes (Aira et al. 2008). There are certain varieties of EWs are found such as *Eiseniafoetida*, *Eudriluseugeniae* ,*Lampitomauritii and Perionyxexcavates etc.* (Bhattacharya et al., 2006)which only applicable for the purpose of vermicomposting on waste material for rapid conversion (Singh et al., 1997). The activity of earthworms are significantly modifies the physical and chemical properties of wastes as in form of vermicasts and enhance the soil fertility after application. Microorganism also play major role along with earthworm during vermicomposting for releasing cast from organism's gut composed of mineral (Elvira et al., 1998).The conversion of wastes into manure depends on the action of organism which correlates with the physico-chemical parameters such as temperature, pH, salinity and proper moisture that suitable for the process.

In the present experiment the inorganic waste FA was collected from IB Thermal industries of Jharsuguda, Odisha and carried out in the laboratory of Zoology Department of CenturionUniversity of Technology & Management, Odishaunder observation of vermicomposting. It was conducted to convert FA into organic manure with proper physico-chemical environment. The analysis of the entire procedure was experimented out to find out the rapid conversion rate with respect to various proportion of FA.

MATERIALS AND METHOD

Preparation of Vermicomposting

Vermicomposting is the biotechnological process of involvement of "verms" or worms to produce compost converting from organic wastes. Worm casting is one of the major physical parameters to observe the formation of vermicompost along with various activity of earthworm (Rogyan, 2010)

2.1 Collection of materials

The required materials such as industrial waste (Fly Ash), soils, cow dung were collected from some Industrial sectors and Centurion University of Technology and Management (CUTM) of Odisha, India for experimental set up of vermicompostingaccording to the objective of present work**.** The experiment was carried out in the laboratory of Department of Zoology, CUTM, Odisha, India.

2.1.1 Collection of substrates:

The coal combustion fine residue industrial waste Fly Ash (FA) was collected from IB Thermal Power station, Jharsuguda, Odisha as major substrate. The sample materials was brought to the Laboratory through plastic bag package. The next substrate dried cow dung of atleast 4-5 days old was collected in a large plastic container from cattle-shed of CUTM campus. Similarly soil was collected from different parts of the garden area of campus. All the collected soil materials were thoroughly mixed to use as sample.

2.1.2 Collection of Vermicomposting species:

The vermicomposting species earthworms were collected from vermiculture centre of CUTM campus. The collected earthworm species were *Eudrilluseugeniae* shifted to laboratory condition and maintained at room temperature with proper nutrition of cow dung at laboratory of Zoology

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department, CUTM campus Bhubaneswar, Odisha. Plastic containers were selected and brought for vermibed preparation having 42cm heights,18cm breadth and about11cm height depth.

2.1.2 Collection of Drying and sieving materials:

The randomly collected soil samples were mixed properly to make standard and it was also followed for cow dung then allowed for air drying under bright sun. The samples were allowed to dry for 7-10 days. During drying the large pieces of soil and cow dung were chopped into smaller one and extra wastes along with these were removed. After drying the materials were collected and sieved through a sieve having diameter 2.3 mm to separate the unwanted particles. The sieved materials were allowed for weighing and collected in polythene bags.

2.3 Preparation for vermicomposting

The completely dried and sieved cow dung, soil along with Fly Ash were brought into weighing site. This present experiment was prepared by using dried substrates in various proportions in laboratory conditions. There are 6 different proportions such as C for Control (1:1), fa1 (4:1), fa2 (3:2), fa3 (2:3), fa4 (1:4), E (100%) as experimental were prepared by taking different measurement of all substrates cow dung (CD), soil (S) and FA. Six labelled plastic containers were taken to prepare a complete set of experiment. Various percentage such as 20%,40%,60%,80%,100% of major substrate Fly Ash (FA) were prepared adding with rest percentage of soil and cow dung. Control (C) was only prepared for 100% having equivalent ratio of soil and cow dung. To avoid variability soil were collected from different places of inside campus, CUTM, Odisha, India. Similarly cow dung collected from the stocks of 2days before from diary unit to minimize the methane amount. After measurement all the proportions were put in their 6 respective labelled containers. All proportions were properly mixed at dry stage and then allowed to add water by sprinkling upto reach a well moisture content. All the proportions were kept for precompostingupto 10-15 days. The mixtures were kept through windrow compost method in laboratory where composting material was not covered and ventilation was not supplied by pipes. All proportion mixtures were regularly monitored and agitated for proper aeration to reach upto maturation (Nares.1992).

2.4 Experimental Design –

The experimental design was carried out with the following proportion by taking 6 containers labelled as

Control = C= (S+ Cd) (50%+50%) = (1:1)
Treatment-1-T1 =fa1 =(S + Cd) + fa (20%) = (4:1)
Treatment-2-T2 =fa2 =(S + Cd) + fa (40%) = (3:2)
Treatment-3-T3 =fa3 =(S + Cd) + fa(60%) = (2:3)
Treatment-4-T4 =fa4= (S + Cd) + fa (80%) = (1:4)
Experimental= E = (fa-100%)

The various proportion of mixture about 3kg in triplicate were taken in their labelled containers as C, T1, T2, T3, T4 and E that kept in laboratory conditions. Control was taken Sprinkling of water was done daily upto 10–15 days to maintain moisture content and proper composition.
N: B- fa-Fly Ash, S-Soil, Cd-Cow Dung, (S+Cd) is taken as standard with equal proportion.

2.4 Process of vermicomposting

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The Fly Ash mixtures of various proportions were collected and shifted to another same set of labelled containers after completion of precomposting. The mixture of all proportions were thoroughly mixed and used to form vermibed by applying in layers adding with slurry in between. The whole proportion kept in laboratory for the purpose of vermicomposting by using windrow compost method. The selected Earthworm species *Eudrilluseugeniae*of two in numberwith a range of 7 cm to 11 cm of length were used for inoculationinto each composting bin (Singh et al., 2004). The next step was followed with regular monitoring of vermicomposting bins with an interval of 2-3 days. The monitoring process was conducted for proper feeding of cow dung slurry and sprinkling of water to earthworms for their survival. In initial stage it was highly necessary to sprinkle water into each vermicomposting bin till these got proper moisture content and then it was maintained in a gap of 5-6 days. A systematic monitoring procedure was carried out till the indication of maturation appear with black granular soil on upper surface of vermicomposting bins. The completion of FA vermicomposting was carried out within 60-80 days.

2.5 Methodology

2.5.1 Measuring of physico-chemical parameter:

The vermicomposting of FA was designed in triplicate form and followed with various analytical methods for different physico-chemical parameters such as pH, temperature, electro-conductivity and moisture content etc during the entire process. The measurement of all parameters were recorded by applying various instrumental methods conducted in the laboratory of Zoology department, CUTM, Odisha. Estimation of pH was observed by digital pH meter (Labtronic), electrical conductivity by LT-16 conductivity meter using 1:20 (w/v), moisture content was determined by ASTM D1762-84 with weighing balance (ACZET CY224) for calculating the difference of moisture content in % from dry mixture to wet mixture for each container. Temperature was measured by Chemiline technologies for vermicompost. Within an interval of 15 days all the parameters were recorded of entire process till obtaining of humus vermicompost.

RESULT AND DISCUSSION

The present experiment was estimated through instrumental analysis for various physico-chemical parameters of obtained vermicompost manure. The result was also focused on the population study and index of excretion. Each proportion was primarily observed with respect to electro conductivity, PH, temperature and moisture content. The pH value of all proportional mixtures were ranged from 6.5 to 7.3 during vermicomposting whereas the acidity of soil (pH=6.5) reduced due to the action of microorganism that produced organic acid and CO2 (Elvira et al., 1998; Haimi et al., 1900 and 1986) may due to amendment with cow dung and FA (pH=7.9). The pH of T1> T2>T3 was maintained the pH with a mean difference of 0.23-0.25 from final to initial value whereas in T 4 and E was reduced from high alkalinity pH value to low (approx. 0.4 value of mean difference) with a delay performance. Hence the pH range significantly maintained as 7.1-7.3 might have caused due to action of nitrification process of microorganism (Eklind et al., 2000) as well as the activity of earthworm during the process of precomposting and vermicomposting. The pH range was normal which suitable indicator for survival of Earthworm (EW) and growth of crop [Jain, 2016] shown on (Table-I & Fig.1). The electro conductivity (EC) was maintained and shown in Table-2 and Fig.1. The range of EC was showing 0.83 dS m^{-1} to 1.5 dS m^{-1} for all proportional treatments of FA. The initial value was increased suddenly and then reduced at the end of the vermicomposting maintained with normal

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EC to medium range of EC. Out of all proportion control and experimental was reached to 1.5-1.3 dS m^{-1} and 0.53-0.11dS m^{-1} respectively whereas T1, T2, T3, T4 overall reached to an optimum from 0.79 – 1.9 dS m^{-1} range in EC due to wriggling action of earthworm and microbes for addition of salt concentration into respective proportion (Table-II & Fig.2). The obtained range from precomposting to vermicomposting for EC as compared C>T1<T2>T3>T4>E was an indicator from Normal to Medium range for crop yielding (D.H. Patel et. al., 2014). The temperature ranges in each container 33-25^0C approximately from initial to final stage of vermicomposting. The temperature was initially ranges at 28^0C which increased to 33-36^0C and finally decrease to approximately 25^0C after ending of vermicomposting shown in (Table-III & Fig.3). Beyond the temperature 35^0C the earthworms cannot survive (Taiwo and Oso, 2004) as they are photosensitive and thermo sensitive organisms. The moisture content was figured out from initial weight of each proportion taken as 5gm and allowed these for hot dry oven method at 110^0C for finding final weight after and before vermicomposting (Table-IV & Fig.4. The observed data was equivalent to the study of Nagar et.al. , 2017. The moisture content was estimated as % for each proportion by using the formula below:

$$\% \text{ of moisture} = \frac{\text{Wt. of wet sample-wt. of dry sample}}{\text{Wt. of moisture}}$$

N.B:- Wt. -weight

The population of earthworm was studied from the mean difference of earthworm numbers that inoculated at initial stage of vermicomposting with final number was found at the end in the triplicate containers (Nath et al., 2014). It was presented in (Table-V & Fig.5).

The formation of vermicompost was studied from the excretion index and biomass. The upper surface of containers was observed with granular substances scattered initially few in mass after 20-22nd days of initiation of vermicomposting that marked as excretion index (Prakash*et. al*., 2010) .Later almost after 65-70 days around the whole surface was covered with granular excreta called vermicompost (Table-2 & Fig.2). The first appearance was found in order of treatments as T2->T1->C->T3->T4. In T3 and T4 the vermicompost was formed in 70-80 days. But the appearance was negligible in experimental. The vermicompost is more suitable in T2->T1->T3 due to all favourable condition was obtained by all parameters. From the result it was studied that the physico chemical parameters are effected on population growth and formation of vermicompost which was equivalently proposed by the mentioned authors.

TABULATION-I Measurement of Electro-conductivity of various proportions of Fly Ash (FA) during Vermicomposting

Sl. No.	Observations	Experimental set up	Electro-conductivity(dS m^{-1}) during vermicomposting		
			Initial reading	**Final reading**	**Difference**
1	C	S+Cd(1:1)	1.56±0.006	1.32±0.01	0.24±0.045
2	T1	fa1 (4:1)	0.79±0.04	0.94 ±.0.08	0.15±0.04
3	T2	fa2 (3:2)	0.96±0.06	1.61±.0.09	0.75±0.03
4	T3	fa3 (2:3)	1.03±0.07	1.86±.0.11	0.83±0.04
5	T4	fa4 (1:4)	1.18±0.004	1.91±0.005	0.73±0.001
6	Expt.-100%	E- (whole)	0.53±0.04	1.12.±0.07	0.59±0.03

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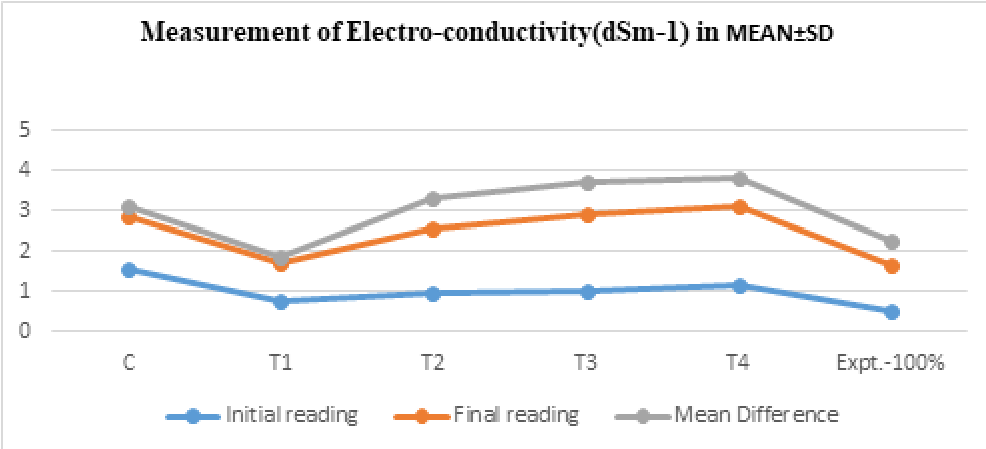

Fig.1 Graphical presentation of Electro-conductivity during vermicomposting

TABULATION-II Measurement of pH of various proportions of Fly Ash (FA) during Vermicomposting

Sl. No.	Observations	Experimental set up		pH during vermicomposting	
			Initial reading	**Final Reading**	**Difference**
1	C	S+Cd(1:1)	6.61±0.042	7.15±0.013	0.54±0.029
2	T1	fa1 (4:1)	6.62±0.11	7.26±0.064	0.64±0.036
3	T2	fa2 (3:2)	7.15±0.23	7.26±0.045	0.11±0.1805
4	T3	fa3 (2:3)	6.85±0.39	7.25±0.017	0.4±0.273
5	T4	fa4 (1:4)	6.58±0.038	7.16±0.013	0.58±0.025
6	Expt.-100%	E- (whole)	6.31±0.127	6.98±0.0128	0.67±0.001

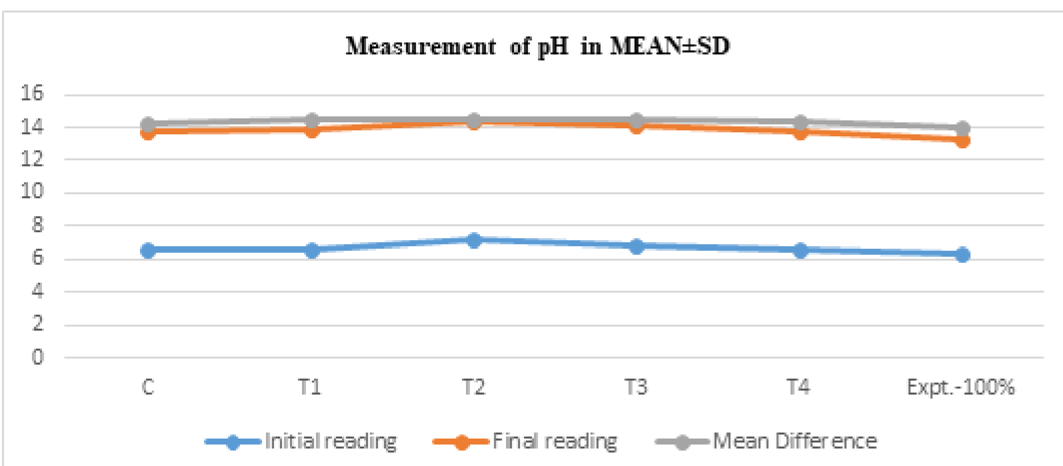

Fig.2 Graphical presentation of pH content during vermicomposting

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TABULATION-III Measurement of temperature of various proportions of Fly Ash (FA) during Vermicomposting

Sl. No.	Observations	Experimental set up	Temperature (before(initial) & after (final) vermicomposting)		
			Initial reading	**Final reading**	**Mean Difference**
1	C	S+Cd (1:1)	31.38±0.67	25.8±0.24	5.58±0.43
2	T1	fa1 (4:1)	33.86±0.44	26.5±0.14	7.36±0.3
3	T2	fa2 (3:2)	34.36±0.73	26.7±0.11	7.66±0.62
4	T3	fa3 (2:3)	36.11±0.56	27.8±0.08	9.31±0.48
5	T4	fa4 (1:4)	34.71±0.44	28.1±0.09	6.61±0.35
6	Expt.-100%	E- (whole)	35.28±0.58	30.8±0.16	5.68±0.42

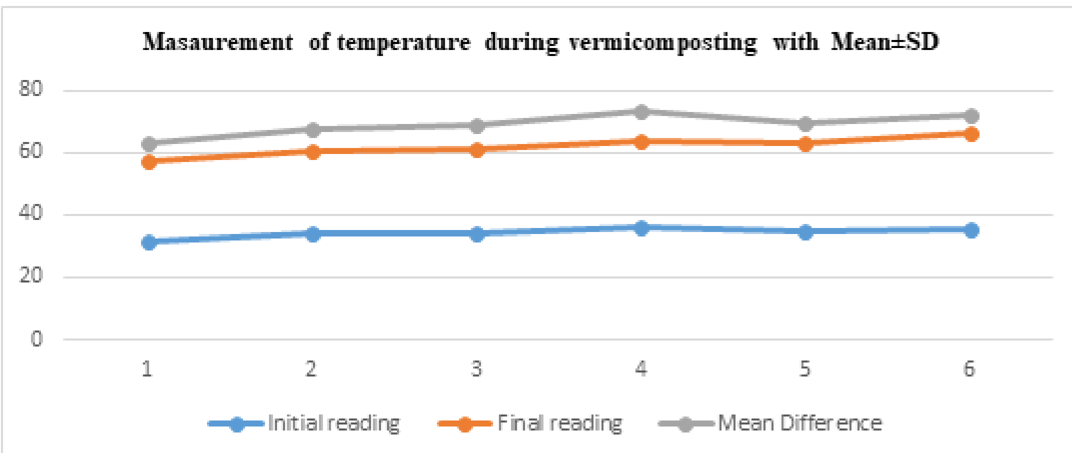

Fig.3 Graphical presentation of Temperature content during vermicomposting

TABULATION-IV Measurement of moisture % of various proportions of Fly Ash (FA) during Vermicomposting

Sl. No.	Observations	Moisture content (during vermicomposting) in gm			
		Initial reading(wet weight)	**Final Reading(oven-dry weight)**	**Difference**	**moisture content in %**
1	C	50	28.35	22.85	80.6
2	T1	50	28.56	21.36	74.8
3	T2	50	27.76	22.24	77.6
4	T3	50	28.63	21.37	74.6
5	T4	50	28.81	21.19	73.5
6	Expt.-100%	50	29.72	20.28	68.2

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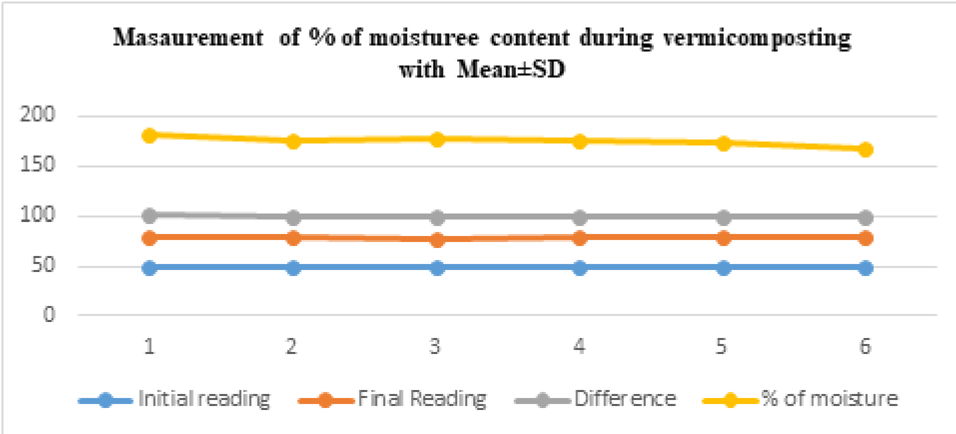

Fig.4 Graphical presentation of %Moisture content during vermicomposting

TABULATION-V Population growth in various proportions of Fly Ash (FA) during Vermicomposting

Sl.No	Observations	Initial population	Final population	After no. of days	% of EWs
1	C	3	79	65	96.2
2	T1	3	82	70	96.4
3	T2	3	95	70	96.8
4	T3	3	67	75	95.5
5	T4	3	34	80	91.1
6	Expt.-100%	3	7	80	57.2

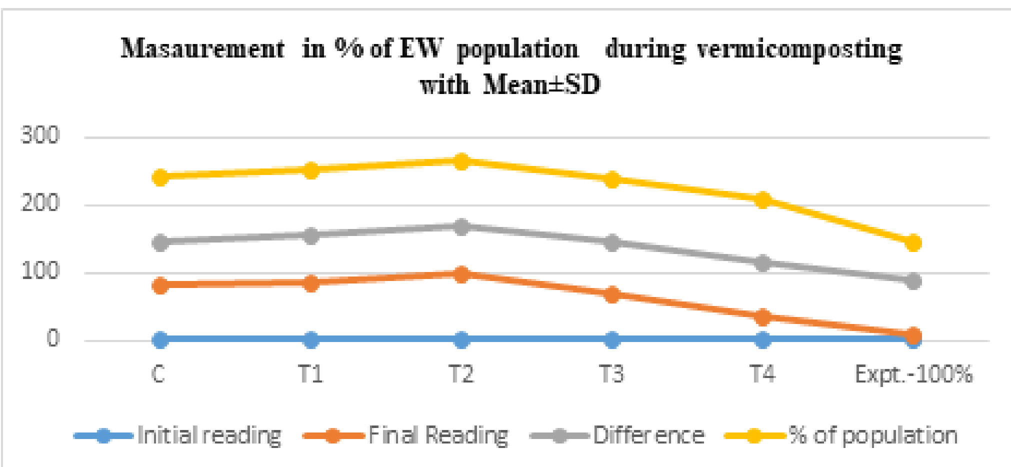

Fig.5 Graphical presentation of population % of EW during vermicomposting

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TABULATION-IV Measurement of excretion index of various proportions of Fly Ash (FA) during Vermicomposting

Sl.No	Observations	Initial reading (excretion Index)	Final reading (excretion Index with size in mm) (Covered on surface)	After no. of days With size in mm
1	C	Scattered	Covered	65-4.0mm
2	T1	Scattered	Covered	70-4.0mm
3	T2	Scattered	Covered	70-4.1mm
4	T3	Scattered	Covered	75-4.1mm
5	T4	Scattered	Covered	80-4.0mm
6	Expt.-100%	Scattered	Covered	80-not found

CONCLUSION

The present work explained about that the application of Fly Ash increases the rate of it's amendment with soil and cow dung due to the activity of earthworm *Eudriluseugeniae*. During the entire period of vermicomposting besides the earthworm activity microbes also enhanced to add the nutritive value for soil fertility. The indication of heavy metal accumulation of FA was determined by the fast production of excreta by EWs. The population growth of EWs is an indicator of conversion of FA into organic manure due to survivability, capable of reproduce the juvenile and production of casting according to suitable physico-chemical parameters. The drawback was considered in 100% of FA and more or less in 80% of FA where the vermicomposting activity was in lower rate due to the compactness and less aeration for EWs. From the present study it can be concluded that the vermitechnology was properly implement in low % of FA like 20% (T1), 40% (T2) and 60%(T3) for production of vermicompost but not have the achievement in higher 100 % of FA. The dynamic conversion of FA into organic manure in a low proportion with amendment procedure of adding soil and cow dung determined by the physico-chemical parameters and accumulation of *Eudriluseugeniae*which aid to improve soil nutrient value for crop production.

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