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RESEARCH ARTICLE

Estimation of zoomass productivity of epigeic earthworm species *Eudrilus eugeniae* fed with temple flower waste and cow dung mixtures.

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Abstract

Solid waste generation is a major problem in developed and developing countries considering its obnoxious impact on the environment. India is severely affected by improper waste collection at source and mis-management and various cultural and social practices practiced since the time immemorial. Especially in Indian temples various types of pooja offerings generate wastes such as flowers, fruits, clothes, leaves, coconuts and other food wastes. Among all wastes, flower waste predominates inside the temple. While improper disposal of solid waste dumping mostly pollutes the surrounding soil and water, unwanted waste generation and its harmful by products can be controlled using appropriate waste treatment technologies. Vermicomposting is one such biologically driven waste treatment method that was found effective and efficient for organic wastes. The present study deals with analysis of temple flower waste mixed with different ratios of cow dung composted by the earthworm *Eudrilus eugenia* to assess their growth rate and zoomass gain. The highest increase in the zoomass was found in the reactors with 100% cow dung, while 25% flower waste + 75 % cow dung appears to be the best option for the temples.

Introduction:-

Thirunallar is situated in Karaikal, a coastal city and a part of Puducherry, a Union Territory of India. The city is famous for Saneeswaran temple located in Thirunallar town. Concomitant with increase in the number of religious tourists, the Municipal Solid Waste (MSW) generated in the temple is on the increase. Temple wastes in India generally consist of large amounts of organic matter and biomass (Kumar et al., 2013; Gurav and Pathade., 2011; Edwards et al., 2010; Isha et.al., 2015; Kundu et al., 2015). Every day huge quantum of flowers, fruits, coconuts, coconut, oil, and ghee and cloths are used for worship in the temple. Flower wastes accounts for the higher fraction. Especially lotus (*Nelumbo nucifera*) and blue lotus (*Clitoria ternatea*) flowers are important offerings to Saneeswara Bhagavan (In Vedic astrology the planet Saturn is called Shanaiswara and Bhagavan rerfers to God) , which finally find their way to the dumping site without treatment or recycling. Devotees consider offering flowers as an important part of the ritual. The waste management system followed in Thirunallar temple is a traditional method of dumping the waste in landfills and water bodies. The solid waste dumps/dump sites are known to generate global warming gasses like methane and nitrous oxide besides polluting the water table through the percolation of its leachate into the soil /groundwater.

The offering of flowers and other solid organics to the deities is found throughout the Indian subcontinent. Proper disposal of the floral offerings is a major problem due to shortage of dumping grounds and stringent environmental laws. Improper decomposition of such organic wastes that finally end up in water bodies emit a foul odour, affecting aquatic life and pose environmental and public health risks (Singh et al., 2011). Because of these difficulties, tons of floral offerings generated daily are generally disposed off in open dumps or is released in the adjoining rivers, generating foul odour as well as act as breeding sites for disease causing microorganisms and their vectors (Tiwari and Juneja., 2016). In view of the hazardous impacts of the improper disposal of wastes on the environment, emphasis should be given on aerobic composting, which converts waste into organic manure rich in plant nutrients and humus (Singh and Sharma, 2002; Sarma et al., 2010; Fernández-Gómez et al., 2010). Degradation of floral waste is a very slow process as compared to that of kitchen waste (Jadhav et al., 2013). Fortunately, there are several appropriate methods for treating the organic waste fraction among the temple wastes- particularly flower wastes, and most important among them is vermicomposting (Kohli and Hussain., 2016; Gurav and Pathade., 2011, Kapoor, et al ,.2015). Conversion of organic wastes into Vermi composting has therefore gained importance recently because of the safe, accelerated breakdown of organic wastes through microorganisms and earthworms in mesophilic conditions (Dominguez, 2004).

The present study was carried out the to assess the use of different ratios of flower waste and cow dung using epigeic earthworm species *Eudrilus eugeniae* as bio agent for its decomposition. The study was carried out for a period of 60 days (during January-March, 2016)

Vermicomposting of temple wastes:-
vermicomposting is better than mere composting , as the nutrients retained in the composting contains essential hormone like substances necessary for the germination of seeds and early growth of the plant (Gajalakshmi et al., 2004; Shah et al., 2015). The term vermicomposting is coined from the Latin word 'Vermis' meaning to the 'worms'. Vermicomposting technology is one of the best options available for the treatment of organics-rich solid wastes (Kohli and Hussain, 2016; Kapoor et al., 2015).

The worms consume the organic debris, digest them and the excreted end product is called Vermicompost. This process of breaking down of organic waste into nutrients rich fertilizer using worms is called Vermicomposting. The casting obtained is also very rich in nitrogen, calcium, phosphorous and magnesium which are important micro nutrients for plant growth. It also exceeds the nutrient quality of normal topsoil as it contains five times the available nitrogen, seven times the available nitrogen, and 1 ½ times more calcium than that found in topsoil (Adhikary, 2012 ; Baffour., 2009). Research and analysis on Vermicompost have brought some distinguishing results which show that it promotes excellent aeration, porosity, structure and moisture-holding capacity of the soil. The burrowing action of worms also significantly contributes to the permeability of water present in the soil. Castings have shown to hold nine times their weight in water, further enriching the fertility of the soil (Girde et al., 2016).

Material and Methods:-

Earthworms:-
Earthworms belong to phylum- Annelida, subclass- Oligochaeta. In this study the well known epigeic species of earthworm *Eudrilus eugeniae* was used for vermicomposting- one of the best earthworm species known for the treatment of the municipal solid waste (Kaushik and Garg, 2003; Chaudhari et al., 2011).

Vermicomposting reactors:-
Plastic tubs of size 25 X 15 cm and of 2 kg capacity have been used for vermicomposting experiments. Each plastic (in triplicate) tub was filled with 1 kg of substrate; it consisted of flower waste and cow dung in selected proportions. The flower waste was pre-composted to remove the aromatic compounds that might harm the survival of the earthworms as suggested by Singh et al., (2011). The activity of the earthworms and increase in their zoomass exposed to selected substrates were investigated as suggested by several workers (Ponmani et al., 2014; Karthikeyan et al., 2014). The Flower Waste (FW) was mixed with Cow Dung (CD) in various ratios such as 100%CD, 100%FW, FW75%+CD25%, FW50%+CD50 and FW25%+CD75. The vermicomposting study was carried out for a period of 60 days covering February to March 2016. Each of the five treatments consisted of three reactors and each were loaded with 20 earthworms and 1 kg of substrate combination as given above. Jute bags (0.2mm thickness) were used as bedding to retain the moisture content and natural environment for earthworms. The standard retention time (SRT) was 10 days for each run. At the time of harvesting, earthworms were removed. The vermicast was separated from the undigested matter and quantified. The juveniles and cocoons that have been produced were separated and kept in the culture. The parent earthworms from which reactors had been started were returned to the reactors and the new run was started having every parameter same as of the previous run (Edwards et al., 2010).

Statistical analysis:-

One way ANOVA was carried out using SPSS version 16 to compare the differences between the different treatments of flower waste mixed with cow dung.

Result and Discussion:-

The flower wastes are generated from different sources such as hotels, marriage gardens, besides temples and various cultural and religious activities. The waste contains more of the organic friction, while just falling on the ground or depositing in the landfills causes it to decompose anaerobically thus contributing to the emission of harmful green house gases like methane which has global warming potential of 25 or 34 times more when compared to carbon dioxide taken as 1 (McKeown and Garner, 2008). Depositing of the MSW in the landfills and other known dumping sites are practices in the urban areas only, but people in the rural areas are mostly illiterate (Agunwamba,1998) and they even donot know how and where to dump the MSW and their environmental and health implications. The majority of flower waste is generated from the temple containing mainly Pooja offerings of coconut, flower, lemon, plastic, paper cups, plates, leaf plates, palm leaf plates, food waste, and eat and throw waste. Table 1 shows the amount of solid waste generation inside the Saneeswaran Bhagavan main temple in Thirunallar temple town that indicates that that the major fraction of temple waste is derived from flower waste.

The reactors with 100 % of the CD with no flower waste had shown rigorous activity with corresponding increase in the zoomass at the start of the experiment .The earthworms in reactors with 75% of the CD and 25% of the FW and 50% of CD and 50% FW had shown more or less similar activity, i,e in both the combinations earthworms had displayed more or less similar behavior. In all the three types of reactors the earthworms fed voraciously. There was a considerable increase in the zoomass with concomitant production of the vermicast. This will be discussed in the subsequent research paper. We have also assessed the reactors loaded with 25% CD and 75% FW and the reactors with 100% of FW. In both these reactors, the earthworms became sluggish and mostly shown delinquent behavior. This might be because the C: N ratio was not appropriate for the earthworms to proliferate and grow with concomitant increase in their body size (Edwards and Bohlen, 1996).

Table 1: Characterization of the temple waste *

SL.NO	Waste type	Waste composition (in one Kg temples waste (%)	Total organic waste (%)
1	**Flower waste**	38	77.8
2	**Paper waste**	4.5	
73	**Banana waste**	21.6	
4	**Coconut waste**	3.6	
5	**Akalvilaku**	6.7	
6	**Cloth waste**	3.4	
7	**Plastic**	4.5	
8	**Mixed other waste**	17.8	

Waste Characterization was performed on a sample of 10kg waste obtained from the temple on a Saturday- an auspicious day for the presiding deity. The sample was taken at primary dumping site inside the Thirunallar temple. A total of 50 kg waste was collected randomly at five places of the site and a composite sample of 10 kg was obtained, in turn the 10 kg sample was then segregated into different categories of the waste such as flower, paper, banana, coconut, cloth, akalvilaku, plastic and other mixed waste as suggested by Gawaikar and Deshpande., (2006).

Flower waste constituted the bulk -38%, followed by banana waste 21.6%, cloth waste of about 3.4%, paper waste 4.5%. Akalvilaku (mud lamp used in Pooja) comprised of about 6.7%, while coconut waste of about 3.6%. Non degradable waste like plastic constituted about 4.5%, miscellaneous waste contributed to 17.8%. A large proportion of temple waste was found to be composed of biodegradable organic matter (77.8%) possessing greater potential for recycling and hence the scope for sustainable solid waste management is greater. It is because of this high organic content of the flower waste, the present study was carried out for assessing the feasibility of using vermicomposting technology. According to Singh and Gupta, (2011) management of solid waste by composting is the best option and composting techniques has decreased the waste transportation and their disposition in landfills. Vermicomposting and biomethanation were the eco-friendly management methods for temple waste (Gurav and Pathadez, 2011). Vermicomposting of the temple waste is the most appropriate eco technology for the secure, hygienic and cost effective disposal (Chakole and Jasutkar, 2014). Vermicompost is suitable for the seed germination and earlier plant growth and vermicomposting of temple waste is an excellent and eco-friendly method for its management too, the biodegaradable waste may be anaerobically decomposed in the open thus generating harmful green house gases. (Kohli and Hussain, 2016) that can be prevented by composting.

Table 2 compares the growth rate of earthworm *Eudrilus eugenia* subjected to various treatments. The initial average weight of the earthworms selected for the study was 33g ± (0.12) and after 10 days there was a gradual increase in the zoomass. The moisture, pH and temperature were properly maintained throughout the study period. The moisture content was maintained at 60 to 80%,pH close to or neutral (7) and the temperature was maintained between 24-28c^0,suitable for the *Eudrilus eugenia* as recommended by Gurav and Pathade (2011).

It was observed that the zoomass increased at different ratio of flower waste mixed with cow dung. According to Vasanthi *et al*., (2013) the earthworm growth rate was increased due to the high physiological activity in the most favorable temperature with 26±1^{0}C. A very high increase in zoomass was observed in the reactors with 25% flower waste + 75% cow dung (1.82%) and least increase was seen in the reactors with 100% of flower waste. By and large, the reactors with greater % of cow dung showed more increase in zoomass (2.52%) as the pre-composted cow dung seem to be the best feed for earthworms (Kaushik and Garg, 2003; Mujeebunisa et al., 2013). A similar trend has been observed in all the reactors.

At the beginning the increase in the zoomass was very much low (100% CD -0.18%; 100% FW 0.10%; FW75%+CD25% -0.14%; FW50%+CD50 -0.14%; FW25%+CD75% -0.17%). This might be ascribed to the exposure of earthworm to the new feed (CD/CD FW mixture), along with optimum temperature, moisture, and pH (acidity-alkalinity). All these factors influenced the earthworm growth, reproduction, and health as reported by several earlier workers (Sherman, 2003; Sarabpal Kaur et al., 2014; Alexandar, 2007). But as soon as the earthworms got acclaimatized to the new feed and the environment as whole, the increase in the zoomass got accelerated and showed an increasing trend till 5th run (each run for 10 days). In the last run there was a little decrease in zoomass, the reason being ageing of the earthworms, as suggested by some earlier workers (Aira, and Domínguez, 2011; Tiwari and Juneja, 2016). The flower waste was used as the nitrogen, potassium biofertilizer (which is a rich source of nutrients necessary for the earlier growth of plants and the germination of seeds) when it was degraded by microbes and earthworm .It has high values of N, P and K (Jadhav et al., 2013; Ponmani et al., 2014). The results of the Zomass increase are presented in the Table 2.

Table 2: Zoomass increase (%/day) in *Eudrilus eugeniae* up to 60 days (SRT 10) for various ratios of flower waste mixed with cow dung

Runs of days(10)	100% CD	100% FW	75% FW + CD	50% FW +CD	25% FW+ 75% CD
1	0.18	0.10	0.14	0.14	0.17
2	0.22	0.13	0.16	0.19	0.21
3	0.27	0.15	0.21	0.24	0.27
4	0.63	0.15	0.22	0.27	0.30
5	0.65	0.12	0.22	0.32	0.35
6	0.58	0.09	0.22	0.47	0.53
Total increase in zoomass	**2.52**	**0.74**	**1.18**	**1.64**	**1.82**

A one way ANOVA was used to assess how far the five different compost groups such as 100% CD, 100% FW, FW75%+CD25%, FW50%+CD50 and FW25%+CD75% have significant influences on earthworm's growth rate and its zoomass productivity. It was observed that there was a high significant difference (P value less than 0.05) among zoomass in the reactors with the 100% CD, FW50%+CD50 and FW25%+CD75% of the reactors (Table 3). It can be concluded that the zoomass increased in the cow dung mixed with flower waste compost in the ratio of FW50% +CD50 and FW 25%+CD75%. The flower waste mixed biofertilizer 1:1 ratio w/w , promoted higher growth rate of earthworms. This in agreement with the findings of Kumar *et al*,.(2013). In the case of 100% FW and 75% FW (0.15 and 0.13), there was no significant difference in the growth rate of earthworms. Among the five compost groups the two groups such as FW50%+CD50% and FW25%+75%CD were found to have significant impact on the growth of earthworms and its activities that may be due to appropriate C:N ratios available in the substrates for the optimal activity for earthworms. A hypothesis formulated for this study was that the flower compost would have no significant impact on zoomass production and fecundity rate. Our results indicate that there is significant difference due to the application of compost on earthworm zoomass and fecundity rate (P value greater then 0.05). Comparing conventional composting of flower waste on cow dung without earth worms, the results obtained with several other workers have indicated that vermicomposting is preferable for such wastes (Tiwari and Juneja, 2016; Mujeebunisa *et al.*, 2013; Kohli, and Hussain, 2016).

Table 3: One Way ANOVA to assess significant differences in earthworm's growth rate in different ratios of temple flower waste compost over the 60 days period

ANOVA						
Substrates used		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
100% cow dung waste	Between Groups	13.47	5.00	2.69	11.58	**0.00**
	Within Groups	5.58	24.00	0.23		
	Total	19.06	29.00			
100% flower waste	Between Groups	0.15	5.00	0.03	1.81	0.15
	Within Groups	0.39	24.00	0.02		
	Total	0.54	29.00			
75% flower waste+25%cow dung	Between Groups	0.44	5.00	0.09	1.91	0.13
	Within Groups	1.10	24.00	0.05		
	Total	1.53	29.00			
50% flower waste+50%cow dung	Between Groups	3.53	5.00	0.71	13.81	**0.00**
	Within Groups	1.23	24.00	0.05		
	Total	4.76	29.00			
25% flower waste+75%cow dung	Between Groups	6.43	5.00	1.29	18.69	**0.00**
	Within Groups	1.65	24.00	0.07		
	Total	8.08	29.00			

Conclusion:-

In this study we found that the flower waste was voraciously consumed by the earthworms. The reason is the softness and easier digestibility of the flower waste as it has very much less lignocelluloses material on the cell walls. The earthworm zoomass showed an increased trend in all the substrate combinations. The highest increase in the zoomass was found in the reactors with 100% cow dung, while 25% flower waste + 75 % cow dung appears to be the best option for the temples. In the current context of the decreasing livestock population and the scarcity of cow dung, flower waste can act as a potential substitute for cow dung where cow dung can be used as a starter material rather than sole growth medium (Chatterjee, et.al., 2014). In the present study, a very high increase in zoomass was observed in the reactors with 25% flower waste + 75% cow dung (1.82%) and least increase was seen in the reactors with 100% of flower waste. Since there is a paucity of literature where the potential of flower waste was investigated for vermicomposting, our results can be compared only with a few published papers (Mujeebunisa *et al*,. 2013; Tiwari, and Juneja,. 2016) that are in agreement with the findings of our study. Thus, Vermicomposting was found to be a cost effective Eco biotechnology for the treatment and management of the temple flower waste and will be an important component for the emerging concept of "green temples", particularly in India (refer for example http://indianexpress.com/article/world/indians-abroad/worlds-first-green-hindu-temple-opened-in-uk/,http:// www. glazette.com/sripuram-golden-temple-green-temple-in-india-267. html, http://timesofindia. indiatimes. com/home/ environment/pollution/Sabarimala-temple-to-go-green-pilgrims-asked-to-cooperate/articleshow/50508513.cms, http://www. arcworld. org/ downloads/Green%20Hindu% 20Temples% 20 Guide.pdf).

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