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Sugar Industry Waste Recycling through Vermicompost by *Eisenia Foetida* (Savigny)

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ABSTRACT

The present study is the capability of epigeic earthworm, *Eisenia foetida* to convert sugar mill filter mud like pressmud mixed by cow excrement into value added and gaining popularity. The ten different ratio combination of sugar industry waste, Pressmud (PM) and Cow dung (CD) to compare with control Vc_1, Vc_2, Vc_3, Vc_4, Vc_5, Vc_6, Vc_7, Vc_8, Vc_9 and Vc_{10} were reprocessed for vermicompost experiments. The *E. foetida* growth, development, cocoon production then the number of hatchling were observed in a range of ten different ratio of feed mixture for 14 weeks in the research laboratory under controlled suitable environmental condition. The extreme growth as well as reproduction was obtained in Vc_4 (70%CD+30%PM), but worm growth and reproduced favorably in Vc_3 (80%CD+20%PM) and Vc_2 (90%CD+10%PM) also. Addition of filter cake (Pressmud) residues had adverse effect on growth as well as reproduction of earthworm. Vermicomposting resulted in significant decrease in C/N ratio as well as increase major and minor nutrients after 98 days of worm activity in all the mixture. The end of result vermicompost can be a cheapest technology for the management of sugar mill pressmud, if mixed with cow dung in appropriate quantities.

Keywords : *Eisenia foetida*, Filter Cake, Cow Dung, Sugar Mill, Vermicompost, Waste Management

I. INTRODUCTION

India harvests an average of two hundred seventy million tons of sugarcane per year. Roughly one hundred thirty four million tons of sugarcane crushed, four million tons of pressmud are generated (Zeyer *et al.* 2004; Yadav 1995). Vermicomposts are manufactured from organic wastes through interacted between earthworms and microorganisms. Wormcompost can be utilized as Plant growing mass media and soil improvements. During vermicomposting, moisture and temperature can performance synergistically (Edwards and Arancon, 2004; Gunadi *et al*. 2003). Unproductive management and clearance of waste is an obvious cause of pollution to the environment in most cities of the succeeding world. Aerobic composting was a substitute innovative method and it means that composting with air. (Sriakilam *et al* 2016). As a result, emphasis is currently on aerobic composting, that concerts wastes mad about organic fertilizer rich in humus and plant nutrients, by product of sugarcane processing are best substrates for breeding of earthworm (Singh and sharma 2002; Parmanik *et al*.2007, Manna *et al*.2003) and provide a product rich in gelatin and phyto-hormonal elements with a high microbial contented and steadied humus substances. The pace of decay can be raised by treating that wastes initially with certain efficient microflora (Atiyeh et al.2001; Singh and sharma 2002). Apart from this, such practices necessitate wastage of inorganic and organic nutrients extant in the sludge that powerfulness be put to good use (Elvira et al.1985). Vermicomposting was used for the managing of industrial waste (Elvira *et al*.1997). The Benefit of using sugarcane pressmud for soil use is its little cost, slower relief of nutrients, presence of trace element, high water stock capacity and protecting properties. (Shankaranand *et al*.1993).

Earthworm are the main constituents of the soil fauna in a wide-ranging variety of soil temperatures and are involved directly or indirectly in organic material decomposition and equilibrium, nutrient revenue and amendment of soil physical properties. A lot of these rigorous effects are connected with the relationships among earthworms and microorganisms which mainly occur in earthworm gut, casts, burrows and middens. Casting has a main importance considering the high rate on which casts are created, which range among 36 and 108 mg $ha^{-1}year^{-1}$ in temperate zones in addition stout amendments in biochemical properties with respect to an ingested material. Vermicomposting is usually accepter that microbial biomass also respiration are greater in earthworm casts than in the parent soil (Edwards and Bohlen 1996; Lavelle and Spain 2001; Scheu 1987; Aira et al.2003; Tiunov and Scheu 2000a; Zhang and Hendrix 1995). However, microbes may constitute a critical function of the intake of worms, which can feedstuff on them selectively. Microorganisms are mostly answerable for the biochemical degraded of organic matter, worms performance a significant part in the progression by fragmenting and conditioning the substrates, increasing surface area for growth of microorganisms, also altering its biological bustle (Moody et al. 1995; Edwards 2004; Dominguez 2004; Dominguez and Edwards 2004).

II. METHODS AND MATERIAL

2.1. Collection of Earthworm

Eisenia foetida collected from "The Sakthi agricultural farm", Erode District, Tamil Nadu, India. Young, healthy unclitellated earthworms of *Eisenia foetida* weighing 180 to 200 mg live weight, were indiscriminately picked stock culture. Stock culture was prepared in a cement tank (2.5x1x1.5ft) for earthworms to make easily available to them for vermicomposting in pots.

2.2. Collection of Solid sugar mill waste (SSMW)

Solid sugar mill waste, Fresh pressmud was collected from the E.I.D Parrys sugar mill Ltd, Nellikuppam, Cuddalore District, Tamilnadu, India. The Main physio-chemical character and Composition of pressmud were pH (1:10) 7.75±0.03, EC, Total Organic Carbon (TOC) 190.84±0.81/kg, Total nitrogen (TN) 17.68±0.15g/kg, Total Phosphorus (TP) 7.12±0.10 g/kg. etc.,.

2.3. Collection of Cow dung

The fresh cow dung (CD) was collected in the semi solid form from the Cattle Farm, Department of Agriculture, Annamalai University, Annamalai nagar, India. The main Physio-chemical Characters of CD were pH (1:10) 8.70±0.20, Total Organic Carbon (TOC) 231.43±2.72/kg, Total nitrogen (TN) 10.68±0.52g/kg, Total Phosphorus (TP) 3.29±0.29 g/kg, etc., Cow dung is one of the most universally used livestock for earthworms as it contains higher nitrogen content is used with C/N ratio exceeding 12:1, it is advisable to add nitrogen additions to ensure active decomposition.

2.4. Physicochemical Features of the pressmud, cow dung and vermicompost

The initial Physico-chemical characteristics of pressmud and cow dung are summarized in Table 1. The different Physico-chemical parameters weighing 500mg, were inoculated in each container. Three replicates for each container were maintained. All containers were preserved in dark at temperature 25±1ºC. Biomass gain and cocoon growth were recorded weekly for 14 weeks. The feed mixes in the container was turn out and earthworms, cocoons were separated from the feed by hand sorting, after which they were counted, examined for cocoon development and weighed after washing with water and drying them by paper towels. The Potential of Hydrogen (pH) and electrical conductivity (EC) the method of Jackson (1973) were determination using a water suspension each waste in the ratio 1:10 (w/v) that be necessary agitated mechanically for 30min and filtered done Whatman filter paper No 1. The total organic carbon (TOC) was measured using the method of Nelson & Sommers (1982). The moisture content and humus of the soil was determinates by the standards of (Thorex et al. 2008). Organic carbon, Phosphate, nitrogen and potassium in the soil sample were analyzed by using a soil analysis kit (Jyoti Scientific, India). OC was estimated by chromic acid wet digestion method of Walkley and Black (1934). The levels of total nitrogen (TN) present in the samples were estimated using of Jackson (1973). The levels of total phosphorous (TP) present in the organic samples were estimated using ammonium phospho-molybdate method of Pemberton (1945). The levels of total potassium (TK) present in the organic samples were estimated by using Flame photometry method of Stanford and English (1949). The ratio of the percentage of carbon to that of nitrogen (C/N ratio) was arrived at by dividing the percentage of carbon with the percentage of nitrogen estimated in the given organic sample. The levels of micronutrients such as manganese (Mn), zinc (Zn), copper (Cu) and iron (Fe) present in the organic samples were estimated by Atomic Absorption Spectrophotometry method of Lindsay and Norwell (1978).

2.5. Experimental design

Ten different vermicompost (Vc) unit were established having different content of Pressmud and Cow dung. Control Vc_1 (100% CD) without pressmud, Vc_2 (90% CD + 10% PM), Vc_3 (80% CD + 20% PM), Vc_4 (70% CD + 30% PM), Vc_5 (60% CD + 40% PM), Vc_6 (50% CD + 50% PM), Vc_7 (40% CD + 60% PM), Vc_8 (30% CD + 70% PM), Vc_9 (20% CD + 80% PM) and Vc_{10} (10% CD + 90% PM). Ten Different concentrations, c control Vc_1, Vc_2, Vc_3, Vc_4, Vc_5, Vc_6, Vc_7, Vc_8, Vc_9 and Vc_{10} were Prepared having different content of the PM and CD. Each feed mixture was filled in a big cement tank (2.5 x 1 x 1.5 Ft) on dry weight basis. Each concentration was established triplicate. All feed mixtures were turned over manually every day for 15 days in order to remove volatile toxic substances. All the concentration was kept in the dark at a laboratory temperature of 25-29°C. The Moisture content was maintained at 70±10 % by periodic sprinkling of distilled water throughout the study period and by covering the pot by jute clothes. To assess the rate of cocoon Production in the seed mixtures, 10 to 15 adult earthworm of *Eisenia foetida* were inoculated into each pot.

III. RESULT

3.1. Growth and reproduction of the Earthworm

The changes in earthworm biomass for all the studies of feed mixtures over the observation period is given in table no: 2. There is no mortality was observed in all the treatments during initial 3 weeks. Increasing proportion of solid sugar mill waste (SSMW) in the feed mix supported a decrease in biomass of *E. foetida*. The positive result was observed in control Vc_1, Vc_2, Vc_3, Vc_4, Vc_5, and Vc6. After 30 Days which was reduced to in Vc_7, Vc_8, Vc_9 and Vc_{10} of SSMW feed mixture.

During the experimental period of 14^{th} weeks earthworm growth in some vermicomposts and no mortality was observed in biomass and fecundity rate was lower in those vermicomposts, which have a greater percentage of SSMW. Table no 2 encapsulates the growth pattern of *E. foetida* in different ratio with time. The maximum worm biomass were observed in Vc_4 followed by Vc_3 and Vc_2, Vc_5. The minimum earthworm biomass were recorded in Vc_{10}, followed by Vc_9, however biomass gain by earthworm in Vc_6 was insignificant with Vc_5 and Vc_7.

Among the various experimental conditions such as control Vc_1, Vc_2, Vc_3, Vc_4, Vc_5, Vc_6, Vc_7, Vc_8, Vc_9 and $Vc_{10,}$ the maximum worm biomass was observed in (30%PM+70%CD) bedding material, i.e. in Vc_4 (1091.58±0.582), the least growth was observed in Vc_{10} (779.51±0.596) and the maximum net biomass achieved in the Vc_4 (947.78±1.014 mg/g) ratios, among the all treatment the lowest net biomass is Vc_{10} (651.19±0.540 mg/g). Table 2 summarizes the cocoon and hatchling production by *E. foetida* in different treatment. The cocoon development started from 4^{th} week in control and first four treatments. However, it started from 5^{th} week in vermicompost Vc_5 and Vc_6. Earthworm showed the maximum cocoon production in Vc_4 followed by Vc_3, Vc_2, Control ($P \leq 0.05$) for all. Although, the reproduction rate (Cocoon $worm^{-1}$ day^{-1}) ranged between 0.150±0.035 (Vc_{10}) and 0.80±0.017 (Vc_4), among different treatment. Cocoon and hatchling production were significantly higher in pot 4: Vc_4 (0.800±0.017 and 75.27±0.877) than in the other mixture. The lowest cocoon and hatchling production were achieved in the pot 10: Vc_{10} (0.150±0.035 and 26.86±1.023).

3.2. Physical and chemical changes in quality of vermicompost

The vermicompost gained from different initial feed mixes was granular and darker in color than originally. The potential of hydrogen (pH) and electrical conductivity (EC) values are the most common parameters used to characterize the vermicompost quality. There was a reduction in pH of all the feed mixes during vermicomposting (Table 3). In all the initial feed mixes pH values were in the range of 7.1±0.40 – 8.6±0.37. The finale of the process pH was in the range of 6.4±0.60 – 7.5±0.06 in the final vermicompost. EC value were in the range of 1.63±0.05 – 2.6±0.04 in the initial feed mixtures. EC was increased significantly in ending vermicompost and was in the range of 2.1±0.02 – 3.2±0.8. The EC values in Vc_4 (30%PM+70%CD), Vc_2 (10%PM+90%CD) and Vc_3 (20%PM+80%CD) were not significantly different from the EC values in control (Vc_1) (100%CD) ($P<0.05$). As compared to the initial feed mixtures, TOC of the ending vermicompost was extraordinarily reduced at the end of the experiment (Table 4). Data exposed that TOC loss was highest in control Vc_1 (100%CD; 22.19±0.20g kg^{-1}). Comparatively, organic C loss from vermicompost was the maximum for Vc_1, followed by the Vc_4 (22.16±0.13), Vc_3 (21.99±0.15). The decrease of TOC after vermicompost designates net organic matter equilibrium in the substrate due to combined action of earthworms and microbes. The initial TN (Table 4) content of feed mixtures was in the value of 8.41±0.15 – 11.20±0.04 gkg^{-1} and in the ending vermicompost, it increased to 15.73±0.14 – 20.18±0.06 gkg^{-1} in different vermicompost, in the final values. In our experiment, the increase in TN content was significant in control i.e. 100%CD, but the changes in the TN content of the vermicompost gained from Vc_2 – Vc_7 was not significant ($P<0.05$). This shows that the percentage (%) of PM up to 50% addition in the initial feed mixture have no impact on the final TN contented of the vermicompost. The early TK content in the feed mixture was in the range of 6.21±0.05 – 8.74±0.08. The final TK contented in all the vermicompost was higher than initial and was in the range of 12.68±0.07 – 16.78±0.09. Data revealed that the TK contented in the final vermicompost for Vc_1 – Vc_7 was significantly different from each other ($P<0.05$), inferring that up to adding of Vc_4 (30%PM) did not affected the TK contented in vermicompost as compared to (Vc_1) control.

The earthworm worked initial feed mixes after 14 weeks exhibited increase TP in the ending vermicompost compared with TP Content in initial feed mixes. The initial TP content of the feed mixes was in the range of 8.07±0.16 – 10.27±0.16 gkg^{-1}. While, final TP in vermicompost was in the range of 12.68±0.14 – 19.36±0.09 gkg^{-1}. The drift in C:N ratio as role of time is an important index generally used for the assessment of efficiency of the vermicomposting practice and vermicompost maturity. In our study we found that C/N ratio reduced significantly ($P<0.05$) in all of the feed mixture by the finale of the vermicomposting period. Initial C/N ratio were in the range of 2.72±0.06 – 3.28±0.36. The low C/N ratios of the initial feed mixed can be attributed to the high nitrogen content in them. The final C/N ratios were indicating a decrease value in the range of 1.05±0.01 – 1.17±0.01. Total Ca in the initial feed mixes was in the range of 9.26±0.11 – 11.85±0.07 g kg^{-1}. Finale of the vermicomposting period, total calcium significantly ($p>0.05$) increased from 16.19±0.14 – 20.63±0.25.

The result could be attributed to dissimilarity in the chemical nature of the initial materials. The heavy metal contented in different treatments has been reported. The heavy metals Manganese (Mn), Copper (Cu), Nickel (Ni), Zinc (Zn) content was greater in the vermicompost that the initial feeds. Total sodium, Mn, Cu, Ni, and Zn in the initial feed mixes was in the ranges of 0.46±0.04 – 1.06±0.05, 17.19±0.25 – 19.12±0.22, 5.22±0.20 – 6.52±0.27, 2.57±0.12 – 3.83±0.15, 10.59±0.09 – 11.88±0.04 mg/kg. Finale of the Vermiconvertion period, total Na, Mn, Cu, Ni and Zn significantly ($P>0.05$) increased in the range of 1.73±0.11 – 2.71±0.09, 23.20±0.17 – 26.04±0.19, 7.30±0.18 – 10.41±0.17, 3.28±0.11 – 5.75±0.12, 12.42±0.26 – 17.15±0.13. Our finding showed that total metal concentration were significantly ($P\geq0.05$) greater in the vermicomposts than in the initial feed mixes and statistics obtain were lower than the maximum level allowed for the agronomic soils (Council of the European Commission 1986).

IV. DISCUSSION

In recent times it has been described that along with feed mix quality the microbes biomass and disintegration activities are also important. The answers showed that the value and palatability of food directly affected the natural selection, reproduction potential and increase rate of worms (Tripathi and Bhardwaj, 2004; Gajalakshmi et al.,2005; Suthar, 2006). The variance in cocoon and biomass produced in dissimilar vermicompost can be correlated to the biochemical quality of the feed, which is one of the essential factor in responsible onset of cocoon production. The cocoons and the number of hatchlings were calculated by incubating. The cocoons at 25ºC in glass-dishes in distilled water as described by Flack and Hartenstein, 1984; Venter and Reinecke 1988). The worms are very subtle to salts and for explanatory the fact Mitchell (1997) has reported that E. *fetida* was not capable to live in the cattle solids with a pH of 9.5 and EC of 5.0 dS m-

1. The increase in Ec in due to loss of organic matter and release of dissimilar mineral salts in availbale form such as phosphate (P), ammonium (NH_3), potassium (K) etc. (Kaviraj and sharma, 2003).

The Reduction in earthworm biomass content was saw in all the vermicomposts at 120 days probably because of the exhaustion of food materials. This suggests that both enzyme activities were directly related to *E. fetida* activity and depended on its population (Parthasarathi and Ranganathan, 2000). The increase in the organic carbon of soils is associated with a rise in the number and biomass of earthworms and around exists a strong positive correlation in the middle of earthworm population density and soil organic matter (Ghabbour and Shakir, 1982; Hendrix *et* al., 1992; Ganihar 1996; Auerswald *et al.,* 1996). Tripathi and Bhardwaj (2004) have too saw a less significant reduction in TOC in worm less beds than worm inoculated beds. The TOC losses was not very dissimilar from each other in all the vermicasts. Total nitrogen (TN) was increased in final vermicompost than the initial feed mixes. The contented of organic carbon as well as available NPK increases with increasing rate of application of sulphonation Pressmud. It was additional estimated that carbon percentage of sulphonation pressmud ranges from 26.0% to 43.2% (Tandon,1995).

The C content and organic material that a productive soil should have ranked from 3-4% and the organic substance contented of vermicompost ranges from nearly 35% to 70% (Dougherty, 1999). The occurrence of enormous number of micro flora in the gut of earthworm potency perform an vital role in increase phosphorus and potassium contented in the practice of vermicomposting (Kaviraj and Sharma 2003). Blair *et al.,* (1997) and Willems *et* al., (1996) reported the demonstrated that earthworms tend to increase the availability of soil N, although it appears that the remaining effects of worm activity can differ with agro-ecosystem management practices. During vermicomposting most of the nutrients such as nitrate-N, ammonium-nitrogen, exchangeable more readily available to plants (Scott *et al*., 1998). The decay of the organic waste during vermicomposting was relaxed compared to that of the pre-decomposition process and might have been due to greater initial N concentration, which powerfulness have increased the microbial activity in the commencement, therefore decreasing the C/N ratio (Eiland *et al*., 2001). Various studies have shown that earthworm utilize micro-organisms in their substrate as a food source and can digest them selectively (Curry and Schmidt, 2006; Subler and Kirsch, 1998).

The increased in worm growth may also be assigned to a low C:N ratio of the pre-decomposed substrate and positive use of bio inoculants used in the present study (Nedgwa and Thompson, 2000). Enhanced organic matter decay in the presence of earthworm has been reported, which results in the let-down of C and N fraction (Kale *et al*., 1982; Edwards, 1988; Talashilkar *et al*., 1999). The lowering of C: N ratio during vermicomposting is attained by the combustion of carbon (C) substrate during inhalation. The loss of carbon as Co_2 in the process of the earthworm respiration and production of mucus and nitrogenous excrements enhance the level of nitrogen which lower the C:N ratio (Senapathi et al. 1980).

The nutrient content of vermicomposts depends on the nature of the organic waste used as a food source for earthworms (Chaudhuri and Bhattacharjee, 1999 and Chaudhuri *et al.,* 2000) increased level of phosphorus during vermicomposting is due to earthworm nut derived phosphatase activity and also increased microbial activity in this cast (Lee 1991). Krishnamoorthy (1990) told that the rise in the level of phosphorus content during vermicomposting is probably due to mineralization and mobilization of phosphorus due to bacterial and fecal phosphatase action of earthworms. Orozoco et al (1996) have reported and increase in TCa, ingestion of coffee pulp waste by earthworms. Gratelly et al (1996) have also reported increases in Total Na, Ca, Mn, Cu and Zn content ratios during the vermicomposting of diary sludge. The higher level of Mn, Zn and Fe in vermicompost indicates accelerated mineralisation with selective feeding by worms on materials containing these metals. The increased level of macro and micronutrients in the vermicomposting was in conformism with the results of earlier works (Kale *et* al,. 1994, Ramalingam 1997 and 2000; Parthasarathi and Ranganathan, 2000). Increased level of macro and micro nutrients in vermicompost were also observed by suthar (2007). The raised level of Zn, Mn and Fe in vermicomposting indicates accelerated mineralization with selective feeding by earthworm on materials containing as an importance of the carbon losses by mineralization during vermicomposting (Dominguez, 2004).The selective action of the gut fluid of earthworms can be a substantial element in the animal nutrition as well as for regulating the steady state of the abdominal microbial community, and modification of microbial communities in soil (Byzov et al., 2007).

V. CONCLUSION

In the current investigation the vermicomposting of Pressmud spiked with cow excrement with E.foetida has been observed for its favorable for growth and reproduction of earthworms and physiochemical parameters. The earthworms didn't feed on raw Pressmud accepted it's as a diet only when cow dung was spiked with it. If Pressmud is mixed with cow excrement up to 40%, the physic-chemical value of the vermicompost is not affected, but a greater percentage of Pressmud in the feed mixes retards the growth and fecundity of earthworms. The result also revealed that earthworm growth was affected negatively by the occurrence of toxic chemical substrates. Mingling of sugar mill waste (Pressmud) up to 90% in Cow excrement not only accelerated the mineralization of nutrients, but also proved as a better growth medium for vermicomposting. The adding of vermicompost in the feed mixture of Vc3: 20%, Vc4: 30% and Vc5: 40% had affirmative effects on earthworm growth.

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Compliance with Ethical Standards
Conflict of interest The authors has nothing to disclose.

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