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**ORIGINAL ARTICLE**

# *Lampito mauritii* (Kinberg) – A POTENTIAL INDIGENOUS EARTHWORM FOR VERMICOMPOSTING LIGNOCELLULOSIC WASTE RESOURCES

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**ABSTRACT**

In India, the cashew tree play a major role in the socio-economic scenario of the country by means of its plantation, giving employment opportunities to peoples and 32250 US$ annual turnover. On the contrary, approximately 25-30kg of leaf litter is fall on the ground per annum per plant. These are not properly managed and or utilized, thereby causing environmental pollution problems. Normal decomposition of these litter takes about 8-9 months due to its wide lignin-cellulose-hemicellulose chemical structural complexity. Hence these potential organic lignocellulosic waste resources could be used as an organic fertilizer through vermitechnology, in addition to mechanical way of treatments.In the present study, we aimed to recycle and reuse the enormously available unutilized lignocellulosic organic waste resources, cashew leaf litter (CLL) with various animal dung- cowdung (CD), sheepdung (SD) and horsedung (HD) by using indigenous earthworm, *Lampito mauritii* (Kinberg) and produce value added vermicompost. Four different combinations of each [100% dung alone, 3:1(75%dung + 25% CLL), 2:2(50%dung + 50% CLL) and 1:3 (25% dung + 75% CLL)] vermibeds were prepared for vermicomposting process under laboratory conditions. After 60 days, the worm worked vermicompost and worm unworked normal compost were harvested and characterized by means of quantifying physico-chemical and biological parameters. The growth (biomass), reproductive performance of earthworm-cocoon production, hatchling number and recovery of vermicompost were also studied. The obtained results clearly showed that vermicompost from 2:2 ratio of CLL admixed with CD had lower pH, OC, C-N ratio, C-P ratio, lignin, cellulose, hemicellulose and phenol content, and higher N, P, K, dehydrogenase and humic acid content than the raw substrates and worm unworked normal compost. Also pronounced and better growth and reproductive performance of earthworm and vermicompost recovery were found in the above vermibed combination. Therefore, these vermiresources have vast and diversified potential for sustainable agricultural activity by means of producing bio-organic fertilizer through vermitechnology.

**Keywords:** Lignocellulosic wastes, *Lampito mauritii*, vermicomposting, cashew leaf litter, animal dungs, vermicompost, agricultural activity

## 1.INTRODUCTION

At present, the problem of efficient disposal and management of organic solid wastes has become more vigorous due to rapidly increasing population, urbanization, intensive agriculture and industrialization. Production of large quantities of organic waste all over the world poses major environmental (odour problems, contamination of ground water and soil) and disposal problems. So it is significant nowadays to opt an efficient disposal and management method (Edwards and Bohlen, 1996) of shorter duration and cost-effectiveness suitable to Indian conditions; where large quantities of necessary plant nutrients contained in domestic wastes and agricultural byproducts are wasted that are deficient in tropical soils (Bhiday, 1994). Worldwide approximately 38 billion metric tons of organic wastes and in India 3000million metric tons of organic wastes are produced (Statista, 2017). In overall, the predominant mode of waste disposal is open dumping (94%) and only 5% is composted (Waste Atlas Report, 2017). The natural decomposition of organic wastes is inefficient because the complex structural

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composition of organic wastes resist the breakdown, so the decomposition process become slow resulting in the accumulation and lead to environmental pollution problems. Various studies have shown that vermicomposting of organic wastes accelerates organic matter stabilization (Parthasarathi *et al.*, 2016) and gives a product rich in chelating and phytohormonal elements (Tomati *et al.*, 1995; Parthasarathi, 2010) which has a high content of stabilized humic substances (Edwards and Bohlen, 1996; Ranganathan, 2006; Patidar *et al*., 2012; Prashija and Parthasarathi, 2016).

Lignocellulose which mainly composed of a mixture of cellulose (ca.40%), hemicellulose (ca.20-30%), and lignin (ca.20-30%) (Sjostrom, 2013), is a renewable organic material and since it accounts for major part of biomass in nature, its degradation is essential for the operation of the global carbon cycle (Menon and Rao, 2012). Annually more than 200 million tons of lignocellulosic biomass is estimated to be produced worldwide and in relation to residues from 27 food crops, the world annual production is estimated at about 4 billion tons, and non-use of these materials constitutes a loss of potentially valuable materials besides the environmental pollution caused by their accumulation (Michelin *et al*., 2013). Cashew tree is grown in an area of 10.27 lakh hectares with a total production of 7.25 lakh MT of raw nuts and unit area productivity of 706kg/ha in India (in Tamilnadu - 478 Kg/Ha/Year) and is the largest producer of raw cashew nut contributing 20% of total global production, the major exporter of cashew kernels to earn a foreign exchange of Rs 5500 crores per annum, and provides sustainable employment opportunities to 1.5 million people in processing and agrarian sector, especially women, thereby contributing substantially to rural economy (DCCD, 2017). But in the negative way, approximately 25-30 Kg of leaf litter is fall on the ground per annum per plant, which is not properly managed and or utilized causing environmental pollution problems (Isaac and Nair, 2005; Parthasarathi *et al*., 2016). When the leaves are burnt to keep the area clean, all plant nutrients are become lost and soil become infertile (Sannigrahi, 2009). Cashew leaf litter can be composted to be used as fertilizer or soil conditioner, but due to the presence of higher amount of lignin (134g/Kg) and phenol (48g/Kg)contents the normal decomposition process takes about 8-9 months (Isaac and Nair, 2005). Therefore, the present study deals with vermicomposting of lignocellulosic wastes cashew leaf litter with various animal dung amendments by using indigenous anecic earthworm,*Lampito mauritii* to produce quality vermicompost and, also testing their activities in these vermicomposting processes.

## 2.MATERIALS AND METHODS

### Collection of earthworm, animal dung and cashew leaf litter

Earthworm, *L. mauritii* (Kinberg) were obtained from the breeding stocks, Department of Zoology, Annamalai University, Annamalainagar, Tamilnadu, India. Cowdung (CD) and Sheepdung (SD) were obtained from Agricultural Experimental Farm of Annamalai University, Annamalainagar and Horsedung (HD) was obtained from Vandayar Horse Farm, Chidambaram, Tamilnadu, India. Cashew leaf litters (CLL) were collected from cashew forest, Mutlur, Cuddalore district, Tamilnadu, India. The chemical composition of these experimental raw substrates are given in table 1.

**Table1. Characteristic features of the lignocellulosic wastes used for experiment (n=6)**

| Parameters | CD | HD | SD | CLL |
|---|---|---|---|---|
| pH | 8.03 | 8.08 | 8.05 | 6.13 |
| OC (%) | 27.9 | 26.7 | 26.2 | 42.79 |
| N (%) | 1.09 | 1.05 | 1.03 | 1.07 |
| P (%) | 0.50 | 0.46 | 0.44 | 0.37 |
| K (%) | 0.82 | 0.76 | 0.73 | 0.28 |
| C:N ratio | 26:1 | 25:1 | 25:1 | 40:1 |
| C:P ratio | 56:1 | 58:1 | 60:1 | 116:1 |
| Total microbial population ($CFUx10^6g^{-1}$) | 264 | 248 | 227 | 88 |
| Dehydrogenase* | 4.35 | 3.92 | 3.86 | 1.32 |
| Lignin (g/kg) | 22 | 3.88 | 3.77 | 193 |
| Cellulose (g/kg) | 86 | 79 | 76 | 459 |
| Hemicellulose (g/kg) | 14 | 12 | 11 | 46 |
| Phenol (g/kg) | 29 | 24 | 23 | 68 |
| Humic acid (mg/g) | 6.06 | 5.82 | 5.76 | 0.42 |

CD– Cowdung, HD – Hoursedung, SD – Sheepdung, CLL – Cashew leaf litter, * -µlH/5 g substrate

### Preparation of experimental substrates

Three different animal dung (AD) alone and each mixed with different proportion of CLL in total of 12 treatments were prepared in the following manner: cowdung (100%) (1000g), cowdung + leaf litter (75+25%) (750+250g), cowdung + leaf litter (50+50%) (500+500g), cowdung + leaf litter (25+75%) (250+750g), horse dung (100%) (1000g), horse dung + leaf litter, (75+25%) (750+250g), horse dung + leaf litter (50+50%) (500+500g), horse dung + leaf litter (25+75%) (250+750g), sheep dung (100%) (1000g), sheep dung + leaf litter (75+25%) (750+250g), sheep dung + leaf litter (50+50%) (500+500g) and sheep dung + leaf litter (25+75%) (250+750g). The finely powdered AD and chopped CLL (3-5cm) were weighed (dry weight) in the above said proportions, taken in 12 plastic troughs (40cm diameter and 15cm height) and mix well. The sides and bottom of the each trough was perforated to facilitate free aeration and to avoid water logging in the trough. The substrates were made into 65-70% moisture content by sprinkling of normal tap water in each vermibed and maintained at 31 ± 2°C and 65% relative humidity (Thermo-Hygrometer, Germany). After seven days of initial natural decomposition, earthworms are added to each vermibeds and controls were maintained without worms. The trough were covered with nylon mesh and maintained in the laboratory at aforementioned conditions for 60 days. For making 65-70% moisture content of substrates by adding required ml of normal tap water from each per kg of the substrates in all vermibeds. Experimental bedding was kept in triplicate for each treatment and same another triplicate for each treatment without earthworms served as the experimental control.

### Earthworm inoculation and their activity in the vermibeds

Approximately 15 g of sexually immature preclitellate *L.mauritii* (22-25 numbers, 30-32 days old) were inoculated into each plastic trough separately. The worms were not fed with additional substrates in the duration of the experiments (60 days). The mortality of the worms was observed on

every day in each vermibed up to 60 days. The growth of the worms (biomass in wet weight) was determined before the animals were inoculated into each of the vermibeds and thereafter 60th day of experiment by an electronic balance. The reproductive parameters like number of cocoon produced and number of hatchlings were counted on the 60th day by hand sorting method (Parthasarathi, 2007a). The vermicompost was collected on the 60th day by hand sorting method (Parthasarathi, 2004), weighed, shade dried and used for determining various quality parameters. At the end of the experiment, worms, cocoons and hatchlings were taken out and put back in stock culture.

**Quality analysis of vermicompost**

The nutrient contents of the substrates- initial (0-day), worm unworked normal compost and worm worked vermicompost were analysed by using standard methods: pH (ISI Bulletin, 1982), Organic carbon (Walkley and Black, 1934), total Nitrogen (Jackson, 1962), phosphorus (Olsen *et al.*, 1954), potassium (Standford and English, 1949), total microbial population (Baron *et al*., 1994), dehydrogenase activity (Pepper *et al*., 1995), lignin, cellulose, hemicellulose (Ververis*et al*., 2007), phenol (Dolatto *et al*., 2012) and humic acid content (HA) (Valdrighi *et al*., 1996). The C/N ratio was calculated by dividing the percentage of carbon in the substrates by the percentage of nitrogen in the same substrates. The C/P ratio was calculated by dividing the percentage of carbon in the substrates by the percentage of phosphorus in the same substrates.

**Statistical analysis**

Two-way ANOVA procedures were applied to the data to determine significant differences. Duncan's multiple – ranged test was also performed to identify the homogenous type of the treatments for the various assessment variables (NPRS Statistical package, Version 9/98).

## 3.RESULTS

The nutrient quality of the initial feed substrates from 12 different vermibeds of lignocellulosic wastes, worm unworked natural compost and worm worked vermicompost are given in the tables (2 & 3). From the observations, it is understood that vermicomposting process significantly modified the various physico-chemical and biological properties in all vermibeds. The earthworm activity in terms of growth, cocoon production, hatchling number and recovery of vermicompost by *L.mauritii* from all vermibeds up to 60 days are given in the table 4. During the 60 days vermicomposting period, no mortality of worm is found. As summarized in thetable 4 the rate of growth (biomass), reproduction (cocoon production and hatchlings) and recovery of vermicompost of *L.mauritii* were highest in 100%CD, 100%HD and 100% SD vermibeds and each AD admixed with CLL (50:50%) vermibed than the values obtained from other vermibeds.In general, regarding vermicomposting of CLL admixed with various AD, growth, reproduction and recovery of vermicompost of *L. mauritii* had increased significantly in all vermibeds.

**Table 2. Chemical composition of compost and vermicompost obtained from lignocellulosic wastes (n=6)**

| Parameters | Vermibeds | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100% CD | 75%CD + 25%CLL | 50%CD + 50%CLL | 25%CD + 75%CLL | 100% HD | 75%HD + 25%CLL | 50%HD + 50%CLL | 25%HD + 75%CLL | 100% SD | 75%SD + 25%CLL | 50%SD + 50%CLL | 25%SD + 75%CLL |
| **pH** | | | | | | | | | | | | |
| OD | 8.03$^{ab}$ | 10.17$^{abc}$ | 10.52$^{ab}$ | 11.61$^{ab}$ | 8.08$^{ab}$ | 10.06$^{ab}$ | 10.49$^{ab}$ | 11.56$^{a}$ | 8.05$^{ab}$ | 10.10$^{cd}$ | 10.55$^{a}$ | 11.60$^{ab}$ |
| WU | 7.64$^{ba}$ | 9.72$^{c}$ | 9.68$^{bc}$ | 9.86$^{bc}$ | 7.71$^{bc}$ | 9.76$^{a}$ | 9.57$^{a}$ | 9.90$^{ab}$ | 7.74$^{bc}$ | 9.83$^{abc}$ | 9.86$^{bc}$ | 9.98$^{a}$ |
| WW | 7.02$^{ab}$ | 7.11$^{ab}$ | 7.00$^{bc}$ | 7.16$^{bc}$ | 7.06$^{ab}$ | 7.14$^{ab}$ | 7.21$^{bc}$ | 7.25$^{abc}$ | 7.08$^{ab}$ | 7.16$^{abc}$ | 7.21$^{bc}$ | 7.28$^{ab}$ |
| **Organic carbon (%** | | | | | | | | | | | | |
| OD | 27.9$^{ab}$ | 30.6$^{bc}$ | 38.8$^{cd}$ | 40.6$^{abc}$ | 26.7$^{ab}$ | 29.4$^{bc}$ | 35.5$^{a}$ | 38.7$^{bc}$ | 26.2$^{bc}$ | 28.7$^{ab}$ | 31.1$^{ab}$ | 34.8b$^{c}$ |
| WU | 21.2$^{abc}$ | 27.7$^{abc}$ | 29.3$^{bc}$ | 36.5$^{bcd}$ | 23.5$^{a}$ | 27.2$^{ab}$ | 32.4$^{b}$ | 36.2$^{ab}$ | 24.0$^{a}$ | 24.4$^{bc}$ | 28.3$^{bc}$ | 32.6$^{ab}$ |
| WW | 16.0$^{abc}$ | 20.1$^{de}$ | 18.2$^{a}$ | 22.6$^{a}$ | 16.8$^{a}$ | 22.1$^{ab}$ | 19.2$^{abc}$ | 24.3$^{abc}$ | 17.3$^{a}$ | 21.7$^{abc}$ | 20.5$^{abc}$ | 27.2$^{e}$ |
| **Nitrogen (%)** | | | | | | | | | | | | |
| OD | 1.09$^{cde}$ | 1.42$^{abc}$ | 1.58$^{a}$ | 1.34$^{b}$ | 1.05$^{ab}$ | 1.28$^{bc}$ | 1.33$^{ab}$ | 1.18$^{b}$ | 1.03$^{b}$ | 1.21$^{bc}$ | 1.26$^{ab}$ | 1.15$^{d}$ |
| WU | 1.27$^{ab}$ | 1.51$^{bc}$ | 1.81$^{b}$ | 1.46$^{ab}$ | 1.19$^{bc}$ | 1.34$^{ab}$ | 1.46$^{b}$ | 1.32$^{c}$ | 1.14$^{c}$ | 1.31$^{abc}$ | 1.38$^{bc}$ | 1.29$^{b}$ |
| WW | 1.93$^{a}$ | 2.26$^{a}$ | 2.55$^{d}$ | 2.13$^{bc}$ | 1.72$^{bcd}$ | 1.95$^{ab}$ | 2.11$^{ab}$ | 1.80$^{abc}$ | 1.65$^{abc}$ | 1.88a$^{bc}$ | 2.05$^{bc}$ | 1.77$^{de}$ |
| **Phosphorus (%)** | | | | | | | | | | | | |
| OD | 0.50$^{bc}$ | 0.61$^{bc}$ | 0.76$^{ab}$ | 0.58$^{cde}$ | 0.46$^{abc}$ | 0.54$^{ab}$ | 0.65$^{bc}$ | 0.49$^{a}$ | 0.44$^{a}$ | 0.51$^{ab}$ | 0.62$^{abc}$ | 0.46$^{ef}$ |
| WU | 0.78$^{b}$ | 0.85$^{ad}$ | 1.16$^{ac}$ | 0.82$^{bc}$ | 0.54$^{bc}$ | 0.78$^{abc}$ | 0.97$^{ab}$ | 0.71$^{b}$ | 0.51$^{b}$ | 0.72$^{bc}$ | 0.80$^{bc}$ | 0.58$^{ab}$ |
| WW | 1.12$^{ced}$ | 1.33$^{de}$ | 1.56$^{cde}$ | 1.26$^{bcd}$ | 0.96$^{bc}$ | 1.18$^{ab}$ | 1.36$^{bc}$ | 1.12$^{bc}$ | 0.90$^{abc}$ | 1.14$^{bc}$ | 1.25$^{b}$ | 1.01$^{a}$ |
| **Potassium (%)** | | | | | | | | | | | | |
| OD | 0.82$^{abc}$ | 0.71$^{ab}$ | 0.64$^{abc}$ | 0.51$^{bc}$ | 0.76$^{a}$ | 0.62$^{b}$ | 0.44$^{ab}$ | 0.31$^{ab}$ | 0.73$^{bc}$ | 0.56$^{a}$ | 0.41$^{a}$ | 0.28$^{bc}$ |
| WU | 0.91$^{ab}$ | 0.88$^{a}$ | 0.79$^{bc}$ | 0.65$^{a}$ | 0.82$^{ab}$ | 0.74$^{a}$ | 0.52$^{a}$ | 0.43$^{abc}$ | 0.78$^{a}$ | 0.67$^{bc}$ | 0.50$^{ab}$ | 0.35$^{a}$ |
| WW | 1.10$^{a}$ | 1.18$^{bc}$ | 1.31$^{abc}$ | 1.15$^{ab}$ | 0.90$^{abc}$ | 1.12$^{bc}$ | 1.21$^{ab}$ | 1.05$^{ab}$ | 0.86$^{a}$ | 0.93$^{ac}$ | 0.98$^{ab}$ | 0.91$^{ab}$ |
| **C:N ratio** | | | | | | | | | | | | |
| OD | 26:1$^{bc}$ | 22:1$^{ab}$ | 25:1$^{ab}$ | 30:1$^{bc}$ | 25:1$^{ab}$ | 23:1$^{cd}$ | 27:1$^{bc}$ | 33:1$^{b}$ | 25:1$^{bc}$ | 24:1$^{ab}$ | 26:1$^{bc}$ | 30:1$^{ab}$ |
| WU | 17:1$^{a}$ | 18:1$^{bc}$ | 16:1$^{bc}$ | 25:1$^{a}$ | 20:1$^{b}$ | 20:1$^{ab}$ | 22:1$^{abc}$ | 27:1$^{ab}$ | 21:1$^{abc}$ | 19:1$^{bc}$ | 21:1$^{abc}$ | 25:1$^{abc}$ |
| WW | 8:1$^{a}$ | 9:1$^{bc}$ | 7:1$^{b}$ | 11:1$^{b}$ | 10:1$^{bc}$ | 11:1$^{ab}$ | 9:1$^{bc}$ | 14:1$^{b}$ | 10:1$^{bc}$ | 12:1$^{c}$ | 10:1$^{abc}$ | 15:1$^{bc}$ |
| **C:P ratio** | | | | | | | | | | | | |
| OD | 56:1$^{ab}$ | 50:1$^{ab}$ | 51:1$^{ab}$ | 70:1$^{a}$ | 58:1$^{ab}$ | 54:1$^{abc}$ | 55:1$^{ab}$ | 79:1$^{ab}$ | 60:1$^{abc}$ | 56:1$^{a}$ | 53:1$^{a}$ | 76:1$^{ab}$ |
| WU | 27:1$^{ba}$ | 33:1$^{bc}$ | 25:1$^{ac}$ | 46:1$^{ab}$ | 44:1$^{abc}$ | 35:1$^{cd}$ | 33:1$^{b}$ | 51:1$^{bc}$ | 47:1$^{de}$ | 34:1$^{bc}$ | 35:1$^{bc}$ | 56:1$^{abc}$ |
| WW | 14:1$^{ad}$ | 15:1$^{bc}$ | 12:1$^{cde}$ | 18:1$^{ab}$ | 18:1$^{a}$ | 19:1$^{ab}$ | 14:1$^{a}$ | 22:1$^{ab}$ | 19:1$^{a}$ | 19:1$^{bc}$ | 16:1$^{d}$ | 28:1$^{e}$ |

CD – Cowdung, HD – Hoursedung, SD – Sheepdung, CLL – Cashew leaf litter, Mean value followed by different letters is statistically different (ANOVA; Duncan multiple - ranged test, OD – chemical composition of raw materials used in different vermibed (initial 0-day); WU – chemical composition of compost proceed without earthworm (normal compost); WW – chemical composition of compost proceed with *L. mauritii* (vermicompost).

**Table 3. Biological composition of compost and vermicompost obtained from lignocellulosic wastes (n=6)**

| Parameters | Vermibeds | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total microbial population ($CFUx10^6g^{-1}$)** | **100% CD** | **75%CD + 25%CLL** | **50%CD+ 50%CLL** | **25%CD + 75%CLL** | **100% HD** | **75%HD + 25%CLL** | **50%HD + 50%CLL** | **25%HD + 75%CLL** | **100% SD** | **75%SD + 25%CLL** | **50%SD+ 50%CLL** | **25%SD + 75%CLL** |
| OD | $264^{ab}$ | $282^{a}$ | $291^{ab}$ | $162^{ab}$ | $248^{ab}$ | $256^{a}$ | $264^{ab}$ | $127^{a}$ | $227^{ab}$ | $238^{ab}$ | $241^{ab}$ | $116^{a}$ |
| WU | $316^{a}$ | $355^{bc}$ | $386^{a}$ | $204^{a}$ | $296^{bc}$ | $341^{ab}$ | $365^{a}$ | $186^{bc}$ | $268^{abc}$ | $326^{bc}$ | $348^{bc}$ | $174^{bc}$ |
| WW | $461^{a}$ | $485^{cd}$ | $501^{abc}$ | $388^{abc}$ | $428^{cde}$ | $444^{a}$ | $467^{ab}$ | $356^{a}$ | $402^{bc}$ | $424^{bc}$ | $435^{bc}$ | $331^{ab}$ |
| **Dehydrogenase*** | | | | | | | | | | | | |
| OD | $4.35^{b}$ | $4.86^{abc}$ | $5.13^{ab}$ | $3.58^{ab}$ | $3.92^{b}$ | $4.48^{ab}$ | $4.35^{abc}$ | $3.18^{ab}$ | $3.86^{ab}$ | $4.31^{abc}$ | $4.17^{a}$ | $3.06^{a}$ |
| WU | $5.10^{cd}$ | $5.64^{ab}$ | $6.02^{b}$ | $4.42^{a}$ | $4.74^{a}$ | $5.22^{bc}$ | $5.36^{bc}$ | $4.06^{bc}$ | $4.42^{bc}$ | $4.98^{ab}$ | $4.76^{bc}$ | $3.84^{bc}$ |
| WW | $6.45^{ab}$ | $6.96^{abc}$ | $7.28^{ab}$ | $6.12^{abc}$ | $6.16^{a}$ | $6.37^{bc}$ | $7.06^{bc}$ | $5.78^{bc}$ | $5.86^{bc}$ | $6.21^{a}$ | $6.66^{cd}$ | $5.41^{a}$ |
| **Lignin (mg/g)** | | | | | | | | | | | | |
| OD | $22.0^{abc}$ | $48.3^{bc}$ | $95.5^{bc}$ | $126.3^{ab}$ | $19.3^{ab}$ | $43.2^{ab}$ | $86.7^{ab}$ | $117.5^{a}$ | $18.6^{ab}$ | $41.5^{ab}$ | $84.6^{ab}$ | $114.3^{bc}$ |
| WU | $19.5^{bc}$ | $42.8^{a}$ | $92.3^{a}$ | $123.6^{b}$ | $17.6^{a}$ | $39.9^{bc}$ | $81.9^{bc}$ | $113.8^{bc}$ | $16.8^{c}$ | $38.6^{bc}$ | $80.8^{abc}$ | $108.6^{ab}$ |
| WW | $9.51^{ef}$ | $24.3^{a}$ | $66.3^{a}$ | $90.2^{ab}$ | $10.5^{a}$ | $23.6^{ab}$ | $69.2^{bc}$ | $92.5^{bc}$ | $11.3^{cd}$ | $28.4^{bc}$ | $67.5^{bc}$ | $98.6^{bc}$ |
| **Cellulose (mg/g)** | | | | | | | | | | | | |
| OD | $86.0^{ab}$ | $171.6^{bc}$ | $256.5^{bc}$ | $323.3^{abc}$ | $79.0^{ab}$ | $158.5^{a}$ | $208.6^{ab}$ | $309.7^{a}$ | $74.0^{ab}$ | $151.2^{a}$ | $182.4^{a}$ | $301.6^{a}$ |
| WU | $78.0^{bc}$ | $162.2^{abc}$ | $237.6^{ab}$ | $296.5^{bc}$ | $67.0^{a}$ | $144.3^{ab}$ | $184.6^{a}$ | $277.4^{ab}$ | $63.0^{bc}$ | $138.2^{ab}$ | $169.3^{bc}$ | $284.6^{ab}$ |
| WW | $58.2^{a}$ | $126.5^{de}$ | $155.2^{c}$ | $232.3^{ab}$ | $48.2^{cd}$ | $104.3^{bc}$ | $114.5^{a}$ | $212.6^{a}$ | $48.6^{bc}$ | $97.3^{a}$ | $112.8^{ab}$ | $216.7^{ab}$ |
| **Hemicellulose (mg/g)** | | | | | | | | | | | | |
| OD | $14.0^{bc}$ | $15.6^{ef}$ | $28.2^{de}$ | $23.3^{ab}$ | $12.0^{ef}$ | $14.8^{a}$ | $24.5^{ab}$ | $20.6^{ab}$ | $10.4^{a}$ | $12.6^{ab}$ | $22.8^{ab}$ | $18.7^{abc}$ |
| WU | $11.8^{abc}$ | $12.7^{cd}$ | $24.5^{ab}$ | $20.6^{a}$ | $9.7^{ab}$ | $11.6^{ab}$ | $21.8^{cd}$ | $17.7^{ac}$ | $8.5^{bc}$ | $10.7^{bc}$ | $19.5^{abc}$ | $15.3^{bc}$ |
| WW | $7.9^{a}$ | $9.2^{bc}$ | $11.6^{cd}$ | $15.8^{a}$ | $5.9^{ab}$ | $7.8^{a}$ | $14.2^{bc}$ | $10.3^{a}$ | $5.0^{b}$ | $5.9^{bc}$ | $11.8^{b}$ | $9.2^{ab}$ |
| **Phenol (mg/100g)** | | | | | | | | | | | | |
| OD | $29.0^{abc}$ | $39.5^{abc}$ | $49.1^{a}$ | $56.1^{ab}$ | $24.0^{a}$ | $36.2^{a}$ | $45.5^{a}$ | $54.4^{ab}$ | $21.8^{cd}$ | $32.3^{ab}$ | $43.6^{cd}$ | $53.6^{a}$ |
| WU | $24.2^{cde}$ | $35.5^{bc}$ | $41.7^{abc}$ | $50.3^{ab}$ | $19.6^{bc}$ | $30.6^{abc}$ | $40.4^{bc}$ | $49.2^{bc}$ | $17.8^{e}$ | $28.1^{ab}$ | $38.3^{ab}$ | $47.4^{bc}$ |
| WW | $17.2^{ab}$ | $26.3^{ef}$ | $24.6^{de}$ | $36.4^{a}$ | $13.8^{a}$ | $20.1^{a}$ | $22.3^{a}$ | $33.6^{bc}$ | $11.6^{cd}$ | $18.21^{ab}$ | $25.3^{de}$ | $36.6^{ab}$ |
| **Humic acid (mg/5g)** | | | | | | | | | | | | |
| OD | $6.06^{d}$ | $4.16^{ab}$ | $3.68^{ab}$ | $1.72^{bc}$ | $5.82^{ab}$ | $4.01^{bc}$ | $3.45^{ab}$ | $1.59^{def}$ | $5.76^{ab}$ | $3.90^{bc}$ | $2.75^{b}$ | $1.37^{a}$ |
| WU | $7.15^{a}$ | $5.21^{bc}$ | $4.42^{de}$ | $2.61^{ab}$ | $6.63^{a}$ | $5.06^{ab}$ | $4.05^{a}$ | $2.36^{ef}$ | $6.42^{bc}$ | $4.73^{abc}$ | $3.82^{ab}$ | $2.12^{bc}$ |
| WW | $9.12^{bc}$ | $6.64^{ef}$ | $6.04^{a}$ | $3.71^{ab}$ | $7.38^{a}$ | $6.36^{b}$ | $5.22^{bc}$ | $3.55^{ab}$ | $7.21^{bc}$ | $5.92^{bc}$ | $4.76^{a}$ | $3.3\ 8^{ab}$ |

CD – Cowdung, HD – Hoursedung, SD – Sheepdung, CLL – Cashew leaf litter, Mean value followed by different letters is statistically different (ANOVA; Duncan multiple - ranged test, P<0.05), OD – chemical composition of raw materials used in different vermibed (initial 0-day); WU – chemical composition of compost proceed without earthworm (normal compost); WW – chemical composition of compost proceed with *L. mauritii* (vermicompost); * - µl H/ 5g substrate.

**Table 4. Earthworm (*L. mauritii*) activity during vermicomposting of lignocellulosic wastes (n=6)**

| Vermibeds | Biomass (g) | | Cocoon production (number) | | Hatchling number | | Vermicompost recovery (g) | |
|---|---|---|---|---|---|---|---|---|
| | **Initial (0-day)** | **Final (after 60 day)** | **Initial (0-day)** | **Final (after 60 day)** | **Initial (0-day)** | **Final (after 60 day)** | **Initial (0-day)** | **Final (after 60 day)** |
| 100% CD | $15.7^{a}$ | $45.2^{a}$ | 0 | $31.8^{ab}$ | 0 | $58.7^{a}$ | 0 | $680.2^{a}$ |
| 75% CD +25% CLL | $15.5^{ab}$ | $41.5^{b}$ | 0 | $28.6^{b}$ | 0 | $54.1^{b}$ | 0 | $677.6^{b}$ |
| 50 % CD+ 50% CLL | $15.2^{ab}$ | $44.0^{a}$ | 0 | $30.5^{a}$ | 0 | $56.2^{ab}$ | 0 | $678.5^{ab}$ |
| 25% CD +75% CLL | $15.5^{ab}$ | $39.7^{b}$ | 0 | $27.2^{a}$ | 0 | $50.3^{a}$ | 0 | $662.3^{ab}$ |
| 100% HD | $15.7^{ab}$ | $43.6^{b}$ | 0 | $29.5^{ab}$ | 0 | $55.2^{ab}$ | 0 | $670.6^{ab}$ |
| 75% HD +25% CLL | $15.3^{a}$ | $40.3^{a}$ | 0 | $26.5^{a}$ | 0 | $51.6^{b}$ | 0 | $652.7^{ab}$ |
| 50 % HD +50% CLL | $15.7^{a}$ | $42.5^{ab}$ | 0 | $28.2^{b}$ | 0 | $53.3^{ab}$ | 0 | $660.3^{a}$ |
| 25% HD +75% CLL | $15.2^{a}$ | $38.2^{ab}$ | 0 | $25.4^{ab}$ | 0 | $49.6^{ab}$ | 0 | $645.8^{b}$ |
| 100% SD | $15.6^{ab}$ | $42.5^{ab}$ | 0 | $27.2^{ab}$ | 0 | $53.3^{ab}$ | 0 | $651.5^{a}$ |
| 75% SD +25% CLL | $15.3^{ab}$ | $39.2^{ab}$ | 0 | $23.6^{b}$ | 0 | $48.2^{ab}$ | 0 | $628.3^{ab}$ |
| 50 % SD +50% CLL | $15.1^{a}$ | $40.8^{ab}$ | 0 | $25.5^{a}$ | 0 | $50.6^{a}$ | 0 | $644.6^{ab}$ |
| 25% SD +75% CLL | $15.6^{a}$ | $37.6^{a}$ | 0 | $21.8^{a}$ | 0 | $45.5^{b}$ | 0 | $618.6^{ab}$ |

CD – Cowdung, HD – Hoursedung, SD – Sheepdung, CLL – Cashew leaf litter,

Mean value followed by different letters is statistically different (ANOVA; Duncan multiple - ranged test, P<0.05)

As summarized in tables 2 and 3 after 60 days of experimentation, the chemistry and biochemical levels of compost and vermicompost in the vermibeds changed significantly. As compared to initial substrates and worm unworked compost values, vermicompost showed significantly more reduction in pH, OC, C:N ratio, C:P ratio, lignin, cellulose, hemicellulose and phenol values in all vermibeds, more being in the 50%CD + 50%CLL followed by 50%HD + 50%CLL and 50%SD + 50%CLL vermibeds than other vermibeds. At the end of the experiment, N, P, K, total microbial population, dehydrogenase activity and HA contents in the vermicompost were significantly higher than that in the initial substrate and normal compost. Comparatively, the maximum increase in these values occurred in 50%CD + 50%CLL vermibed followed by 50% HD + 50% CLL and 50% SD + 50% CLL vermibed than other vermibeds. Finally, in the present experimental observation, 50%CD+50%CLL vermibed alone was found to show prolonged and sustainable earthworm activity and nutrient quality of vermicompost; even though better growth, reproduction and more recovery of vermicompost, and nutrient quality of vermicompost i.e., increased N, P, K, total microbial population, dehydrogenase activity and HA content and reduced pH, OC, C:N ratio, C:P ratio, lignin, cellulose, hemicellulose and phenol were found in the other vermibeds.

## 4.DISCUSSION

Vermicomposting is a microorganism mediated oxidative decomposition of organic matter under controlled conditions in the presence of earthworms. Edwards and Bohlen (1996) reported that earthworms are very sensitive to pH and in general are neutrophilic in nature. pH of the final product is highly dependent on the physico-chemical characteristics of the raw materials used. In vermicomposting pH usually decreases from alkaline to neutral or acidic (Elvira *et al*., 1998) due to the formation of organic acids (Singh *et al*., 2005) and mineralization of organic nitrogen and phosphorous. Many researchers (Yadav and Garg, 2011; Parthasarathi *et al*., 2016; Prashija and Parthasarathi, 2016) reported decreasing pH level in the vermicompost. Lowering of pH in the present study in the vermicompost from all vermibeds was probably due to mucus secretion by the earthworms that had a 'priming effect' on microbial activity (Trigo *et al*., 1999) and $CO_2$ and organic acids produced during microbial metabolism (Edwards and Bohlen, 1996).

The reduction of OC, C:N and C:P ratios and increase in NPK content in the vermicompost was reported by many earlier investigators(Parthasarathi,2010; Edwards and Bohlen, 1996; Kale, 1998, Lee, 1985). OC content of vermicompost in the present study was reduced from all vermibeds when compared to worm-unworked compost and initial substrates. The obtained reduction in the level of OC in the present study falls in line with the earlier reports. The enhanced levels of NPK in the vermicompost obtained from all vermibeds over initial substrates and natural compost indicated effective decomposition of CLL with different AD by the combined action of earthworm – microbes. Studies revealed that decomposition of organic material by earthworms accelerates the N mineralization process and subsequently changes the N profile of the substrate (Parthasarathi, 2010; Elvira *et al*., 1998). Earthworm gut flora provides enzymes required for P metabolism and these enzyme release phosphorus form ingested waste material (Parthasarathi, 2010; Edwards and Bohlen, 1996; Vinotha *et al*., 2000). Further, release of P may occur by the presence of P-solubilizing microbes in the vermicompost (Parthasarathi *et al*., 2007). The vermicomposting process accelerates the microbial populations in the waste and subsequently enriches the vermicompost with more available forms of plant nutrients. Our present result is also similar to those by Parthasarathi and Ranganathan (1999; 2000), Parthasarathi (2007b; 2010) and Suthar (2009), who reported enhancement of K content in the vermicompost.

Carbon to nitrogen and carbon to phosphorous ratio are the major criteria to assess the rate of decomposition of organic wastes and a reduction in the ratio indicates increased rate of decomposition (Parthasarathi, 2010; Edwards and Bohlen, 1996). The reduction of C:N ratio and C:P ratio recorded in the vermicompost obtained from all vermibeds compared to initial substrates and natural compost reflected the high rate of organic matter decomposition, and mineralization thereby resulting in nutrient rich vermicompost. This result were in accordance with the work of Mba (1983). The reduction in OC and lowering C:N ratio and C:P ratio in the vermicompost could be achieved on one hand by the combustion of carbon or loss of C as $CO_2$ during respiration and worm gut microbial utilization (Edwards and Bohlen, 1996) and on the other hand simultaneous enhancement of higher proportion of total N and ionic protein content in the vermicompost due to loss of dry matter (Viel *et al*., 1987) coupled with the addition of earthworm's activities (i.e., production of mucus, enzymes and nitrogenous excrements) (Curry *et al*., 1995). So from the present finding it can be concluded that the reduction in C:N and C:P ratios of vermicompost indicated enhanced biodegradation process of the organic matter in the different ratios of substrates like CLL and three different AD.

The main component of agricultural waste and the most abundant renewable organic resource in soil, lignocellulose consisting of polymers like cellulose (40%), hemicellulose (20-30%), and lignin (20-30%) (Sjostrom, 2013) which are strongly intermeshed and chemically bonded by non-covalent forces and by covalent cross-linkages (Perez *et al*., 2002). Its complex physical structure and chemical composition make it hard to be degraded during the normal composting process, and there is only few biodegradation studies on lignin, cellulose and phenol content (Hubbe *et al*., 2010; Singh and Nain, 2014). Parthasarathi *et al*. (2016) stated that there is no study available on level of this content in the CLL after the process of vermicomposting. In the present study, the amount of lignin, cellulose, hemicellulose contents were reduced in the vermicompost obtained from all vermibeds when compared to normal compost and initial substrates. Combined action of gut lignocellulolytic microflora and earthworm attribute to this reduction (Parthasarathi *et al*.,2007; Parthasarathi,2010). Loquet *et al*. (1984) reported that combined action of microflora in the gut of worm and inoculated lignocellulolytic fungi might have intensified cellulolysis and lignolysis. Also in the present study the slight reduction of cellulose, hemicellulose, lignin and phenol content in the vermibeds containing either CLL admixed with CD/HD/SD confirmed the fact that it is necessary to inoculate suitable lignocellulolytic microbes and nitrogen rich boosters

for the fast degradation of the lignocellulolytic material like CLL.

In general, increased microbial population and activity and more availability of nutrient content especially nitrogen content that support and stimulate the quick decomposition of organic matter. In the present study, increased nitrogen availability due to the addition of different ratio of AD to CLL in all vermibeds might have enhanced microbial population and activity and earthworm activity in one hand and speed up the decomposition of CLL on the other hand. This conclusion is in accordance with the suggestion of Berg and Matzner (1997) and Manyuchi and Phiri (2013) who stated that increase in nitrogen availability influenced the decomposition rates of plant litter and organic matter.The enhancement of HA in the vermicompost in the present study from all vermibeds could mainly due to the activity of large number of microbes and also due to the gut associated process of earthworm (Parthasarathi, 2010). Mulongoy and Bedoret (1989) and Muscola *et al.* (1999) have also reported that microbial population and their activity play a significant role in HA synthesis and also exhibit positive correlation with HA and FA (Fulvic acid) content.

Composting, a dynamic process depends upon the process executed occur quickly or slowly and the success on the substrates used and the decomposer organism employed (Adegunloye *et al*., 2007). The organic substrate used in the present experiment (CD, HD, SD, and CLL) and the decomposer organism, earthworm (*L.mauritii)* played a crucial role in the process of vermicomposting. The factors related to the growth, reproduction and compost production of earthworms may also be considered in terms of physico-chemical and nutrient characteristics of waste feed stocks (Edwards and Bohlen, 1996). Survival, biomass formation and reproduction of earthworm form a best indicator of an efficient vermireactor (Bhat *et al*., 2015), which are conditional to the type, palatability and nutritional quality of feedstock provided (Azizi *et al*., 2014). The quality of organic amendment play a significant role in the onset and rate of reproduction (Dominguez *et al*., 2001) and recovery rate of vermicompost (Parthasarathi, 2010). Growth and reproduction in earthworms require OC, N and P which are obtained from litter, grit and microbes (Edwards and Bohlen, 1996; Parthasarathi and Ranganathan, 2000a). Major reason for the enhanced growth, reproduction and recovery of vermicompost in all vermibeds in the present study seems to be due to: rich cellulose content, microbial population and activity and enhanced water holding capacity (39-41%) which enable the vermibeds to maintain good and ideal moisture (Parthasarathi *et al*., 2016) since it provides such ideal physico-chemical conditions suitable for better growth and maximum reproduction. Similar enhanced growth, reproduction and vermicompost recovery were reported during vermicomposting of various organic wastes (Parthasarathi and Ranganathan, 1999; Parthasarathi, 2007a & b; Parthasarathi *et al*., 2016; Prashija and Parthasarathi, 2016). The dependency of earthworm on soil moisture for their survival and activity and on organic matter rich in N for growth and reproduction is well known (Edwards and Bohlen, 1996; Parthasarathi, 2010). The physico-chemical and nutrient characteristics of feed stocks for earthworm is considered as limiting factor which directly influence the growth, reproduction and compost production (Edwards and Bohlen, 1996). Parthasarathi (2007a; b; 2010) concluded that growth and reproductive performance of earthworm was directly related to the quality of the feed stock, which is reported to affect the formation of cocoon and hatchling (Bhat *et al*., 2015; Parthasarathi *et al*., 2016; Prashija and Parthasarathi,2016). Our present experimental results are confirmatory of the above hypothesis.

Finally it is concluded that 2:2 ratio of animal dung particularly cowdung and cashew leaf litter could be recommended for vermiculture and production of vermicompost for sustainable agricultural activity, and the indigenous earthworm, *L. mauritii*. is a potential species for managing these lignocellulosic wastes into agronomically valid vermicompost.

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## 6.REFERENCES

Adegunloye, D.V., Adetuyi, F.C., Akinyosoye, F.A. and Doyeni, M.O. 2007.Microbial analysis of compost using cowdung as booster. Pakistan J. Nutr., 6: 506–510.

Azizi, A.B.,Gawi, S.N.A.S.M, Mahmood, N.Z. and Abdullah,N.Vermicomposting of vegetable waste amended with different sources of agro-industrial by-product using *Lumbricus rubellus*. 2014.Polish Journal of Environmental Studies, 23 (5): 1491-1498.

Baron, I.E., Peterson, R.L. and Finegold, M.S. 1994.Cultivation and Isolation of Viable Pathogen in: Diagnostic Microbiology 9$^{th}$ed, Chap 1. 79-96, Mosby, London.

Berg, B. And Matzner, E. 1997. Effect of N deposition on decomposition of plant litter and soil organic matter in forest ecosystem. Environmental Reviews, 5: 1-25.

Bhat, S.A., Singh, J. And Vig, A.P. 2015.Potential utilization of bagasse as feed material for earthworm *Eisenia fetida* and production of vermicompost, springer plus, 4:11, 1-9.

Bhiday, M.R. 1994. Earthworms in agriculture. Indian Farming, 43(12):31-34.

Curry, J.P., Byrne, D. and Boyle, K.E. 1995.The earthworm population in winter cereal field and its effects on soil and nitrogen turnover. Biol. Fertil. Soils,19: 166-172.

DCCD. 2017.Directorate of Cashewnut and Cocoa Development, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India,

Dolatto, R. G., Messerschmidt, I., Pereira, B. F., Silveira, C. A. and Abate, G. 2012.Determination of phenol and o-cresol in soil extracts by flow injection analysis with spectrophotometric detection. Journal of the Brazilian Chemical Society, *23*(5): 970-976.

Dominguez, I., Edwards, C.A. and Ashby, I. 2001.The biology and population dynamics of *Eudrilus eugeniae* (Kinberg) (Oligochaeta) in cattle waste solids. Pedobiologia, 45: 341-353.

Edwards, C.A. and Bohlen, P.J. 1996.Biology and Ecology of Earthworms, 3rd ed., Chapman and Hall, London, UK.

Elvira, C., Sampedro, L., Benitez, E. and Nogales, R.1998. Vermicomposting of sludges from paper mill and dairy industries with *Eisenia andrei*: a pilot-scale study. Bioresource Technology, *63*(3): 205-211.

Hubbe, M.A., Nazhad, M. and Sanchez, C. 2010.Composting as a way to convert cellulosic biomass and organic waste into high-value soil amendments: A Review. BioResources, 5(4): 2808-2854.

Isaac, S. R. and Nair, M. A. 2005.Biodegradation of leaf litter in the warm humid tropics of Kerala, India. Soil Biology and Biochemistry, *37*(9): 1656-1664.

ISI Bulletin. 1982.ManakBahavan, Bhadur Shah Zafar Mark, New Delhi,

Jackson, M.L. 1962.Soil Chemical Analysis. Asia Publishing House, Bombay,

Kale, R.D. 1998.Earthworms: Nature's gift for utilization of organic wastes In: Earthworm Ecology (Eds. CA Edwards). Ankeny, Lowast. Lucie Press, New York. .

Lee, K.E. 198.Earthworms: Their Ecology and Relationship with Soil and Land Use. Academic Press. Sydney, .

Loquet, M., Vinceslas, M. And Rovelle, J. 1984.Cellulosic activity in the gut of *Eisenia foetida.* Appl. Biochem. Biotechnol. 9: 377.

Manyuchi, M.M. and Phiri, A. 2013.Vermicomposting in solid waste management: a review. International Journal of Scientific Engineering and Technology, 2(12): 1234-1242.

Mba, C.C. 1983.Utilization of *Eudrilus eugeniae* for disposal of cassava peel. In: Earthworm Ecology from Darwin to Vermiculture (Satchell, J.E eds), Chapman and Hall, London,

Menon, V. and Rao, M. 2012.Trends in bioconversion of lignocellulose: biofuels, platform chemicals and biorefinery concept. Progress in Energy and Combustion Science, *38*(4): 522-550.

Michelin, M. and Maria de Lourdes, T. M. 2013.Application of Lignocellulosic Residues in the Production of. Fungal enzymes, 31.

Mulongoy, K. and Bedoret,A. 1989.Properties of wormcasts and surface soils under various plant covers in the humid tropics. Soil Biol. Biochem., 21: 197 - 203.

Muscola, A., Bovalo, F., Gionfriddon, F. And Nardi, S.1999. Earthworm humic matter produces auxin like effects on *DaucusCarota* cells growth and nitrate metabolisms. Soil Biol. Biochem., 31: 1303-1311.

Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L.A.1954. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. USDA, Circ. No. 939.

Parthasarathi, K., Balamurugan, M., Prashija, K.V., Jayanthi, L. and Ameer Basha, S. 2016.Potential of *Perionyx excavatus* (Perrier) in lignocellulosic solid waste management and quality vermifertilizer production for soil health. Int. J. Recycl. Org. Waste Agricult., 5: 65-86

Parthasarathi, K. 2010.Earthworms – Life cycle, Compost and Therapy. Lap Lambert Academic Publishing AG & Co., Germany. .

Parthasarathi, K. 2007a.Life cycle of *Lampito mauritii* (Kinberg) in comparison with *Eudrilus eugeniae* (Kinberg) cultured on different substrates. J. Environ. Biol., 28(4): 803-812.

Parthasarathi, K. 2007b.Influence of moisture on the activity of *Perionyx excavatus* (Perrier) and microbial – nutrient dynamics of pressmud vermicompost. Iran. J. Environ. Health. Sci. Eng., 4(3): 147-156.

Parthasarathi, K. and Ranganathan, L.S. 2000.Aging effect on enzyme activities in pressmud vermicasts of *Lampito mauritii* (Kinberg) and *Eudrilus eugeniae* (Kinberg). Biol. Fertil. Soils, 30: 347-350.

Parthasarathi, K., Ranganathan, L.S, Anandi, V. And Zeyer, J. 2007.Diversity of microflora in the gut and casts of tropical composting earthworms reared on different substrates. J. Environ. Biol., 28(1): 87-97.

Parthasarathi, K. and Ranganathan, L.S. 2000. Influence of pressmud on the development of ovary, oogenesis and the neurosecretory cells of the earthworm, *Eudrilus eugeniae* (Kinberg). African Zoology, 35(2): 281-286.

Parthasarathi, K. and Ranganathan, L.S. 1999.Longivity of microbial and enzyme activity and their influence on NPK content in pressmud vermicasts. Eur. J. Soil Biol., 35: 107-113.

Parthasarathi, K. 2004. Vermicompost produced by four species of earthworms from sugar mill wastes (pressmud). National Journal of Life Sciences, 2004, 1(1): 41-46.

Patidar, A., Gupta, R. and Tiwari, A. 2012.Enhancement of Bio-Degradation of Bio-Solids via Microbial Inoculation in Integrated Composting and Vermicomposting Technology. Open Access Scientific Reports Patidar (Vol. 1),

Pepper, I. L., Gerba, C. P. andBrendecke, J. W.1995. Dehydrogenase activity of soils. Environmental Microbiology: A Laboratory Manual. Academic Press, NewYork,

Pérez, J., Munoz-Dorado, J., de la Rubia, T. D. L. R. and Martinez, J. 2002.Biodegradation and biological treatments of cellulose, hemicellulose and lignin: an overview. International Microbiology, *5*(2): 53-63.

Prashija, K. V. and Parthasarathi, K. 2016.Management of agroindustrial lignocellulosic wastes through vermitechnology and production of agronomic valid vermicompost.International Journal of Biotechnology for Wellness Industries, 5: 153-167.

Ranganathan, L.S. 2006.Vermibiotechnology – From Soil Health to Human Health. Agrobios, Jodhpur, India,

Sannigrahi, A. K. 2009.Biodegradation of leaf litter of tree species in presence of cow dung and earthworms, Indian Journal of Biotechnology, 8:335-338

Singh, N.B., Khare, A.K., Bhargava, D.S. and Bhattacharya, S. 2005.Effect of initial substrate pH on vermicomposting using *Perionyx excavatus* (Perrier, 1872). Appl. Ecol. Environ. Res., 4: 85–97.

Singh, S. and Nain, L. 2014.Microorganisms in the Conversion of Agricultural Wastes to Compost. Proc Indian NatnSciAcad, 80 (2) 473-481.

Sjostrom, E. 2013.Wood Chemistry: Fundamentals and Applications, 2Ed., Academic Press, San Diego, New York.

Standford, D. and English, L. 1949.Use of flame photometer in rapid soil tests of K and Ca. *Agron. J*., 4: 446-447.

Statista. Statistics Portal, Worldwide waste generation per capita, by region 2025 _ Forecast, 2017. https://www.statista.com/statistics/233624/forecast-of-per-capita-waste-generation-worldwide-by-region/

Suthar, S. 2009.Vermistabilization of municipal sewage sludge amended with sugarcane trash using epigeic

*Eisenia fetida* (Oligochaeta), Journal of Hazardous Materials, 163: 199–206.

Tomati, U., Galli, E., Pasetti, L. And Volterra, E. 1995.Bioremediation of olive-mill wastewaters by composting. Waste management & research, 13(5): 509-518.

Trigo, D., Barois, I., Garvin, M.H., Huerta, E., Irisson, S. and Lavelle, P. 1999.Mutualism between earthwroms and microflora. Pedobiologia, 43: 866-873.

Valdrighi, M. M., Pera, A., Agnolucci, M., Frassinetti, S., Lunardi, D. and Vallini, G. 1996.Effects of compost-derived humic acids on vegetable biomass production and microbial growth within a plant (Cichoriumintybus)-soil system: a comparative study. Agriculture, Ecosystems & Environment, 58(2): 133-144.

Ververis, C., Georghiou, K., Danielidis, D., Hatzinikolaou, D. G., Santas, P., Santas, R. And Corleti, V. 2007.Cellulose, hemicelluloses, lignin and ash content of some organic materials and their suitability for use as paper pulp supplements. Bioresource Technology, 98(2): 296-301.

Viel, M., Sayas, D. and Andre, L. 1987.Optimization of agricultural industrial waste management through in-vessel composting in: De Bertoldi, M. (Ed) Compost: Production, Quality and Use. Elsevier Appl. Sci. Essex.,230-237.

Vinotha, S.P., Parthasarathi, K. and Ranganathan, L.S. Enhanced phosphotase activity in earthworm casts is more of microbial origin. Curr. Sci., 2000, 79(9): 1158-1159.

Walkley, A. and Black, I.A. An examination of the Degtjareff method for determining the organic matter and proposed modification of the chromic acid titration method. Soil Sci., 1934, 37: 29-38.

Waste Atlas Report. Waste Atlas - Interactive map with visualized waste management data, 2017. http://www.atlas.d-waste.com/.

Yadav, A. andGarg, V.K. Recycling of organic wastes by employing *Eisenia fetida*. Bioresour. Technol., 2011, 102: 2874–2880.

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