Iran. J. Environ. Health. Sci. Eng., 2007, Vol. 4, No. 3, pp. 147-156

INFLUENCE OF MOISTURE ON THE ACTIVITY OF PERIONYX EXCAVATUS (PERRIER) AND MICROBIAL–NUTRIENT DYNAMICS OF PRESSMUD VERMICOMPOST

K. Parthasarathi

Division of Vermibiotechnology, Department of Zoology, Annamalai University, Annamalainagar-608002, India

Received 30 May 2007; revised 14 June 2007; accepted 30 June 2007

ABSTRACT

Moisture play a crucial role in vermicomposting of pressmud (filter cake) (P). Five levels of moisture contents of pressmud (55-57%, 60-62%, 65-67%, 70-72% and 75-77%) at 31±2°C on earthworm activities (growth, reproduction and recovery rate of vermicompost) of Perionyx excavatus (Perrier)-an indigenous species and total microbial population, activity and nitrogen, phosphorous, potassium contents in the P vermicompost, over 60 days at an interval of 15, 30, 45 and 60 days have been studied. More and better worm biomass, cocoon production, hatchling number and rate of compost recovery were found in the 65-67% moisture. Besides this level, 70-72% and 60-62% moisture were adequate. On the other hand, 55-57% and 75-77% moisture did not have the desired effects on the growth and reproduction of earthworms and on vermicompost production. Enhanced microbial population and activity and nitrogen, phosphorous, potassium contents were found in fresh vermicomposts from 65-67% moisture than other moisture levels due to the ideal moisture of P for better multiplication of microbial population while passing through the worm gut with more activity, thereby enhancing the mineralization process resulting enhancement of nitrogen, phosphorous, potassium contents, whereas these decreased with decline in moisture content, immobilization and inactivation of microorganisms and/or increase in time (aging).

Key words: Moisture content, pressmud, Perionyx excavatus, reproduction, vermicomposts, microbial activity, nutrient contents

INTRODUCTION

India's agro-industrial sector contributes huge potential resource of plant nutrients in the form of wastes, which is either thrown away or buried or burnt causing environmental pollution. Pressmud (filter cake), a major-by product of sugarcane processing is produced 12 million tones annually. It is a spongy and dark brown material, contains sugar, fibre, cane wax, inorganic salts, soil particles and rich micro and macro nutrients, enzymes and microbes (Yadav, 1995; Parthasarathi and Ranganathan, 1999). Because of its bad smell, costs involved in transports and fear that its application might lead to crust formation, pH variation, pollution problems, farmers are reluctant to apply it to their land. Conventional composting of this pressmud takes about six months, does not remove the bad smell completely, has less nutritive value and is compacted. We had already vermicomposted this pressmud by using *Lampito mauritii, Eudrilus eugeniae, Perionyx excavatus and Eisenia fetida* into an eco-friendly organic fertilizer/soil amendment and had found that this pressmud vermicompost shows rich enzymatic-microbial activities and nutrient contents in available form facilitating the easy uptake by the plants (Parthasarathi and Ranganathan, 1999; 2000; 2002).

Vermicomposting being a biological process depends on worm and microbial activity which in turn is dependent on temperature, moisture, O_2 supply and availability of degradable organic wastes as feed substrate for earthworms (Edwards and Bohlen, 1996). During vermicomposting process, the temperature and moisture can act synergistically (Gunadi *et al*., 2003). The moisture content of organic wastes used in vermicomposting

*Corresponding author-Email: *kpsarathi_2000@rediffmail.com*
Tel: +91 4144 238259(329), Fax: +91 4144 238080

is an important factor influencing the growth and reproduction of earthworms and also the recovery rate of vermicomposts. It is due to 75–90% of water constituting the body of earthworm (Grant, 1955) and prevention of water loss is a major factor in the survival of earthworm. Various authors have reported better growth, reproduction and survival of earthworm and rate of recovery of vermicompost at different temperatures and moisture levels: *E.fetida* in horse manure and activated sludge at 20-30°C and 75-90% moisture (Edwards, 1988); in cattle and pig manure at 25°C and 75% moisture (Gunadi *et al*., 2003); *E.fetida* and *L.mauritii* in a mixture of biogas slurry, leaf litter, cowdung, wheat straw, saw dust and kitchen wastes at 25°C and 75% moisture (Tripathi and Bhardwaj, 2004 a and b, 2005); *E.eugeniae* in cattle manure at 25°C and 70-80% moisture (Viljoen and Reinecke, 1994) and *E. fetida, P. excavatus, E.eugeniae and L. mauritii* in trash bagasse-pressmud mixture at 30°C and 60-70% moisture (Manivannan *et al*., 2004). In optimal moisture condition the microorganisms and earthworms act symbiotically to accelerate and enhance the decomposition of organic matter, mineralization and humification take place resulting in the availability of nutrients to plants (Edwards and Bohlen, 1996). Vermicomposts have been shown to exhibit more microbial-enzyme activities and nitrogen, phosphorous, potassium (NPK) enrichments (Parthasarathi and Ranganathan, 1999). Our knowledge on the influence of moisture level, during vermicomposting process of agro-industrial waste especially by using indigenous species on the earthworm activity such as growth, reproduction and vermicompost production and microbial activity and nutrient content of the vermicomposts is incomplete. Hence the present paper deals with our attempts at understanding the influence of different moisture levels on the activity of the widely used indigenous, commercial earthworm, *Perionyx excavatus* (Perrier) and microbial activity and NPK contents in the vermicomposts produced by it out of pressmud.

MATERIALS AND METHODS

Earthworm collection and preparation of different moisture levels pressmud

P. excavatus was obtained from stock culture of our Vermibiotechnology division, Department of Zoology, Annamalai university. Pressmud (P) was procured from E.I.D Parry sugar factory, Nellikuppam near Cuddalore, Tamilnadu, India. Two months old and cured P free of foul smell was used as feed substrate for *P.excavatus* with different moisture levels: 55-57% (55-57% M), 60-62% (60-62%M), 65-67% (65-67%M), 70-72% (70-72%M) and 75-77 (75-77%M). The moisture level of P was maintained by sprinkling with required quantities of water. For making 55-57% M pressmud (55-57% MP) 660 mL of water per kg of P was added, 60-62% M pressmud (60-62% MP) by adding 730 mL of water per kg of P, 65-67% M pressmud (65-67% MP) by adding 980 mL of water per kg of P, 70-72% M pressmud (70-72% MP) by adding 1130 mL of water per kg of P and 75-77% M pressmud (75-77% MP) by adding 1320 mL of water per kg of P. The different moisture levels of P was maintained constantly and the percentage of moisture in each substrate were determined once in 2 days upto 60 days by ordinary Dry-Base method. In this method, the P was weighed initially and then kept in a hot air oven at 105°C for 4 hours. After 4 hours, weighed the same P (%MP) (Parthasarathi and Ranganathan, 2000). The P with different moisture levels was left for 48 hours to stabilize before the experimental animals were inoculated into them. One kg of 48 hours stabilized P were taken in a plastic trough (32cm diameter and 20cm height), replicated six times at 31±2°C and 65% relative humidity (Thermo-hygrometer, Germany). The sides and bottom of the each trough was perforated to facilitate free aeration and to avoid water logging in the trough. The troughs were covered with nylon mesh and maintained in the laboratory at aforementioned conditions for 60 days.

Inoculation of earthworms

15 g of sexually immature preclitellate *P. excavatus* (36 numbers, 15-18 days old) were inoculated into each plastic trough. The worms were not fed with additional P in the duration of the experiment (60 days). The growth of the worms (biomass in wet weight) were determined before the animals were inoculated into each of the moisture level P and there after every 15 days

upto 60 days. The worm biomasses (g) were weighed in an electronic balance. The reproductive parameters like number of cocoon production and number of hatchlings were counted once in 15 days by hand sorting (Parthasarathi, 2007). The vermicompost was collected once in 15 days upto 60 days for determining total microbial population, microbial activity and NPK content. The moisture content of vermicomposts from each trough was also determined by adopting above mentioned method.

Determination of total microbial population and activity

One gram of each of the substrates (55-57% MP, 60-62% MP, 65-67% MP, 70-72% MP, 75-77% MP and respective vermicomposts samples on 15,30,45 and 60 days were collected) was suspended in 1 mL sterile saline (lg NaCl in 100 mL distilled water) in a sterile test tube and was shaken thoroughly in a vortex mixer and used as inoculum for enumeration of total microbial population (fungi+bacteria+actinomycetes) from the substrates. Using standard platinum loop, 0.01 mL of the inoculum was inoculated into nutrient agar and MacConkey agar plates for bacterial growth, Sabouraud's dextrose agar plates for fungal growth and Actinomycetes agar plates for actionmycetes growth and incubated at 30°C and 37° C for 18-24 hours for bacteria, 30°C and 37°C for 5-7 days for fungi and 30°C and 37°C for 10-12 days for actinomycetes, respectively. The different colony forming units (CFU) developing on the media were estimated according to the method of Baron *et al*., (1994) and expressed as CFU×10^4/g (for fungi), CFU×10^6/g (for bacteria), CFU×10^5/g (for actionmycetes) and CFU×106/g (for total microbial population-fungi+bacteria +actinomycetes). The microbial activity (in terms of estimating dehyrogenase activity) in the substrates was determined according to the method of Stevenson (1959) and the activity was expressed in terms of µlH/5g substrates.

Determination of NPK content

The total N content of substrates was analysed according to the method of Tandon (1993) by macro Kjeldhal method and phosphorus (Olsen *et al*., 1954) and potassium (Standford and English, 1949) were determined by colorimetrically and flame photometer methods, respectively.

The results were statistically analyzed at 0.05 levels using two way analysis of variance (ANOVA) (SPSS Package, Version 12).

RESULTS

The effect of different moisture levels of P during its composting by *P. excavatus* on the biomass of worms, rate of production of cocoons, rate of hatchability, rate of recovery (formation) of vermicomposts, on the total microbial population and activity (dehydrogenase) and on the content of N, P, K on the 15, 30, 45 and 60th days of composting are tabulated in the Tables 1-9. It is seen that the worm could grow in a sustained manner and gain a maximum weight only when the moisture level of feed substrate, P had 65-67%. In the other levels of moisture ie., 70-72% and 60-62% the gain in the body weight was slightly lesser than 65-67% level but in lower (55-57%) and higher (75-77%) levels of moisture the worm could gain little weight (Table 1).

Table 1: Influence of different moisture levels on the worm biomass (g) during vermicomposting of pressmud (P<0.05)

Pressmud (P)	Vermicomposting days				
	Initial(0)	15	30	45	60
55-57% M	15±0.08	15.1±0.05	15.4±0.03	16.1±0.05	16.3±0.01
60-62% M	15±0.08	16.0±0.03	17.2±0.05	21.6±0.01	25.5±0.05
65-67% M	15±0.08	17.6±0.07	19.2±0.03	25.5±0.03	28.8±0.04
70-72% M	15±0.08	16.4±0.02	18.8±0.02	22.7±0.07	26.6±0.02
75-77% M	15±0.08	15.3±0.01	16.5±0.04	18.6±0.02	19.7±0.06
ANOVA					
Analysis of variance		Sum of square		Mean of square	F - value
Rows		101.8656		25.4664	6.25940
Columns		244.1576		61.0394	19.26313

%M - Percentage of moisture $\bar{X}$ ±SE of six observations Initial (0) - worm unworked P

Higher rate of production of cocoons could obtain only in the P of 65-67% moisture level. The rate of production of cocoon was slightly lower in the other moisture levels of P than 65-67% but very low rate of production of cocoon was obtained in lower and higher moisture level of P (Table 2). Similar to biomass and cocoon production, more number of hatchlings could obtained only in the 65-67% moisture level of P. Next to 65-67% moisture, higher rate of cocoons were obtained in the 70-72% and 60-62% moisture level of P. Low rate of cocoon production were obtained in the lower and higher moisture level of P (Table 3). Like growth and reproduction, significantly higher recovery rate of vermicomposts could obtained in the 65-67% moisture level of P, which were followed in the 70-72 and 60-62 % moisture level of P. Insignificant recovery rate of vermicomposts could obtained in the higher and lower moisture level of P (Table 4).

Table 2: Influence of different moisture levels on the rate of cocoon production (number) during vermicomposting of pressmud (P<0.05)

Pressmud (P)	Initial(0)	Vermicomposting days 15	30	45	60	Total
55-57% M	-	2.2±0.02	0.98±0.06	12.5±0.03	17.2±0.07	32.88±0.05
60-62% M	-	7.2±0.03	24.5±0.07	32.7±0.02	36.4±0.05	100.8±0.03
65-67% M	-	10.6±0.08	36.7±0.05	66.8±0.06	89.3±0.02	203.4±0.02
70-72% M	-	8.4±0.04	30.3±0.02	48.6±0.07	61.3±0.01	148.6±0.06
75-77% M	-	5.8±0.01	20.8±0.06	27.6±0.03	30.5±0.02	84.7±0.09
ANOVA						
Analysis of variance		Sum of square		Mean of square		F - value
Rows		3086.52		771.6306		5.233431
Columns		7897.37		1974.343		13.39058

%M - Percentage of moisture $\bar{X}$ ±SE of six observations Initial (0) - worm unworked P

Table 3: Influence of different moisture levels on the rate of hatching (number) during vermicomposting of pressmud (P<0.05)

Pressmud (P)	Initial(0)	Vermicomposting days 15	30	45	60	Total
55-57% M	-	-	11.1±0.09	17.5±0.05	22.2±0.02	50.8±0.10
60-62% M	-	-	20.8±0.06	36.6±0.08	44.5±0.06	101.9±0.15
65-67% M	-	-	40.5±0.02	88.5±0.12	104.7±0.18	233.7±0.26
70-72% M	-	-	27.5±0.05	54.3±0.08	71.4±0.01	153.2±0.14
75-77% M	-	-	15.8±0.06	21.6±0.04	29.5±0.03	66.9±0.09
ANOVA						
Analysis of variance		Sum of square		Mean of square		F - value
Rows		4391.468		1097.867		4.335308
Columns		12341.52		085.379		12.18369

%M - Percentage of moisture $\bar{X}$ ±SE of six observations Initial (0) - worm unworked P

Table 4: Influence of different moisture levels on the recovery rate of vermicompost (dry weight) (g) during vermicomposting of pressmud (P<0.05)

Pressmud (P)	Initial(0)	Vermicomposting days 15 (± 44 - 46%M)	30 (± 43 - 45%M)	45 (± 37 - 39%M)	60 (± 33 - 35%M)	Total
55-57% M	-	80±1.07	120±2.07	60±1.77	24±0.28	284±1.09
60-62% M	-	108±0.79	295±0.96	102±0.54	58±1.14	563±1.03
65-67% M	-	137±1.08	345±0.96	125±1.13	81±0.79	688±1.74
70-72% M	-	113±1.63	318±1.52	116±1.10	61±0.79	608±1.50
75-77% M	-	105±1.26	205±1.54	80±1.09	56±2.51	446±1.15
ANOVA						
Analysis of variance		Sum of square		Mean of square		F - value
Rows		61698		15424.5		3.586976
Columns		10057.4		182011.5		42.326

%M - Percentage of moisture $\bar{X}$ ±SE of six observations Initial (0) - worm unworked P

Higher total microbial population and activity were found only in the vermicompost obtained from 65-67% moisture level P, which was followed by 60-62% and 70-72% moisture level of P. Low level of microbial population and activity could found in the vermicomposts from lower and higher moisture contents. Significantly enhanced total microbial population and activity could found only in the freshly formed vermicompost i.e., 15th day. A declined total microbial population and activity could found in the 30, 45 and 60th day vermicompost (Tables 5 and 6).

Table 5: Influence of different moisture levels on the total microbial population* of pressmud vermicompost (P<0.05)

Pressmud (P)	Initial(0)	Vermicomposting days 15 (± 44 - 46%M)	30 (± 43 - 45%M)	45 (± 37 - 39%M)	60 (± 33 - 35%M)
55-57% M	213±0.19	881±0.17	856±0.44	830±0.12	805±0.15
60-62% M	183±0.23	1516±0.25	1492±0.51	1436±0.14	1402±0.18
65-67% M	515±0.44	2110±0.81	2007±0.45	1885±0.13	1814±0.12
70-72% M	465±0.25	1886±0.33	1790±0.28	1689±0.17	1610±0.17
75-77% M	282±0.19	1218±0.35	1180±0.33	1089±0.26	1018±0.10
ANOVA					
Analysis of variance		Sum of square	Mean of square		F - value
Rows		2967104	741776		32.89875
Columns		4552735	1138184		50.47997

%M - Percentage of moisture $\bar{X}$ ±SE of six observations Initial (0) - worm unworked P * CFU×10^6/g

Table 6: Influence of different moisture levels on the dehydrogenase* activity of pressmud vermicompost (P<0.05)

Pressmud (P)	Initial(0)	Vermicomposting days 15 (± 44 - 46%M)	30 (± 43 - 45%M)	45 (± 37 - 39%M)	60 (± 33 - 35%M)
55-57% M	4.58±0.08	10.79±0.12	10.44±0.26	10.32±0.55	10.05±0.42
60-62% M	6.52±0.12	22.13±0.15	23.43±0.22	21.25±0.27	21.08±0.66
65-67% M	7.79±0.07	31.15±0.16	30.85±0.41	30.67±0.18	30.28±0.38
70-72% M	7.18±0.01	26.40±0.13	25.95±0.52	25.32±0.16	25.02±0.21
75-77% M	5.43±0.14	18.72±0.11	18.02±0.24	17.27±0.17	17.26±0.50
ANOVA					
Analysis of variance		Sum of square	Mean of square		F - value
Rows		825.2358	206.309		24.89687
Columns		898.4668	224.6167		27.10621

%M - Percentage of moisture $\bar{X}$ ±SE of six observations Initial (0) - worm unworked P * µ1H/g substrates

Like microbial population and activity, higher NPK contents could found only in the vermicompost obtained from 65-67% moisture level of P, which was followed by 60-62 and 70-72 % moisture level of P. A low level of NPK contents could found in the vermicompost obtained from the higher and lower moisture level of P. The enhanced NPK contents were found in the freshly formed vermicompost i.e., 15th day from different moisture level of P, whereas it was reduced in the 30, 45 and 60th day formed vermicompost (Tables 7 and 9).

Table 7: Influence of different moisture levels on the nitrogen content (%) of pressmud vermicompost (P<0.05)

Pressmud (P)	Initial(0)	Vermicomposting days 15 (± 44 - 46%M)	30 (± 43 - 45%M)	45 (± 37 - 39%M)	60 (± 33 - 35%M)
55-57% M	2.12±0.13	3.01±0.32	2.96±0.11	2.87±0.62	2.81±0.16
60-62% M	2.21±0.47	3.85±0.35	3.77±0.26	3.69±0.37	3.64±0.27
65-67% M	2.34±0.45	3.96±0.01	3.90±0.37	3.82±0.21	3.79±0.20
70-72% M	2.29±0.43	3.89±0.10	3.82±0.36	3.77±0.30	3.71±0.18
75-77% M	2.17±0.36	3.31±0.14	3.26±0.27	3.23±0.26	3.18±0.24
ANOVA					
Analysis of variance		Sum of square	Mean of square		F - value
Rows		2.372777	0.395463		31.08403
Columns		9.855103	2.463776		193.6568

%M - Percentage of moisture $\bar{X}$ ±SE of six observations Initial (0) - worm unworked P

Table 8: Influence of different moisture levels on the phosphorus content (%) of pressmud vermicompost (P<0.05)

Pressmud (P)	Initial(0)	Vermicomposting days 15 (± 44 - 46%M)	30 (± 43 - 45%M)	45 (± 37 - 39%M)	60 (± 33 - 35%M)
55-57% M	1.06±0.28	1.70±0.21	1.63±0.41	1.58±0.23	1.55±0.16
60-62% M	1.23±0.21	1.92±0.26	1.84±0.37	1.77±0.21	1.74±0.13
65-67% M	1.35±0.22	2.09±0.27	2.02±0.25	1.97±0.10	1.94±0.26
70-72% M	1.30±0.16	2.01±0.24	1.96±0.18	1.89±0.08	1.84±0.33
75-77% M	1.16±0.18	1.85±0.20	1.81±0.19	1.75±0.15	1.71±0.15
ANOVA					
Analysis of variance		Sum of square	Mean of square		F - value
Rows		0.443297	0.073883		97.18384
Columns		2.349674	0.587419		772.6771

%M - Percentage of moisture $\bar{X}$ ±SE of six observations Initial (0) - worm unworked P

Table 9: Influence of different moisture levels on the potassium content (%) of pressmud vermicompost (P<0.05)

Pressmud (P)	Initial(0)	Vermicomposting days 15 (± 44 - 46%M)	30 (± 43 - 45%M)	45 (± 37 - 39%M)	60 (± 33 - 35%M)
55-57% M	0.70±0.15	1.41±0.40	1.36±0.31	1.32±0.61	1.28±0.26
60-62% M	0.88±0.20	1.67±0.21	1.61±0.35	1.58±0.66	1.52±0.28
65-67% M	1.05±0.27	1.89±0.29	1.82±0.42	1.78±0.65	1.75±0.31
70-72% M	0.92±0.31	1.76±0.41	1.72±0.45	1.67±0.71	1.63±0.44
75-77% M	0.75±0.36	1.55±0.28	1.51±0.47	1.46±0.10	1.42±0.26
ANOVA					
Analysis of variance		Sum of square	Mean of square		F - value
Rows		0.132737	0.022123		48.49478
Columns		0.229131	0.057283		125.5678

%M - Percentage of moisture $\bar{X}$ ±SE of six observations Initial (0) - worm unworked P

DISCUSSION

The success of the vermicomposting is dependent upon the quality of the organic waste provided as food for the earthworms and also on moisture content, temperature, pH and aeration are important factors influencing composting. Earthworms have no protective wall against changes in moisture and temperature. About 75-90% of the weight of the body is constituted by water and hence can survive only when there is sufficient moisture. There is a direct relationship between the moisture content and the growth rate of earthworms. The biomasses of *E. eugeniae* were more significant at 25°C and 82% moisture content of cattle solid waste than at 15, 20 and 30°C. (Dominguez *et al.*, 2001). Kaushik and Garg (2003) reported *E. fetida* to gain more biomass during vermicomposting of mixed solid textile mill sludges and cowdung at 25°C and 70% moisture. Tripathi and Bhardwaj (2004 a and b, 2005) found the optimal temperature, pH and moisture to be 25 and 30°C; 6.5 and 7.5 and 70 % and 60 %, respectively for better growth of *E. fetida* and *L. mauritii* during vermicomposting of mixed biogas slurry, cow dung, wheat straw, leaf litters, sawdust and kitchen wastes. Cattle manure at 26-30°C and 80% moisture provides a more nutritious and friendly environment to *E. fetida* for their better growth and reproductive performance than goat manure (Loh *et al.*, 2005). Falling in line with these findings, in the present study too, it is found that 65-67% MP was found to be ideal in supporting pronounced biomass in *P. excavatus* followed by 60-62% MP, 70-72% MP, 75-77% MP and 50-52% MP. Already, Ranganathan and Parthasarathi (1999) and Parthasarathi and Ranganathan (2000 a and b) reported that P at the ideal condition of 29±1°C and 60-70% moisture could support

growth, development and biomass production in *L.mauritii* and *E. eugeniae*.

Earthworm fecundity is often expressed in various ways-rate of cocoon production, hatchling success of cocoons and number of offsprings emerging from each cocoon (Banu *et al.,* 2005). One factor that seems to be important for the fecundity of earthworms is moisture (Evans and Guild, 1948). The fecundity characteristics of cocoons, incubation period and hatching success were studied in *E.eugeniae* and *L. mauritii* fed on P at 27±2°C and 70-80% moisture by Ranganathan and Parthasarathi (1999). Recently Parthasarathi (2007) reported higher rate of cocoon production and hatchling in *L. mauritii* and *E. eugeniae* when reared on P at 65-70% moisture and 30±2°C than in cowdung and soil. According to Viljoen and Reinecke (1994) *E. eugeniae* deposit more cocoons between 79 and 80% moisture. *E. fetida* was also found to prefer same moisture range for deposition of cocoons (Reinecke and Venter, 1987). Earlier studies of Manivannan *et al*., (2004) revealed maximum cocoon production in *L. mauritii, E. eugeniae, E. fetida* and *P. excavatus* during vermicomposting of trash-bagasse and pressmud mixture at 30±2°C and 60-70% moisture.

Also in the present study on *P.excavatus* cultured on different moisture levels P, 65-67% P was found to support higher number of cocoon deposition than other moisture levels (60-62% MP, 70-72% MP, 75-77% MP and 55-57% MP). This finding was supported by Elvira *et al*., (1998) and Loh *et al*., (2005) who reported more mean number of cocoon production in *E.anderi* and *E.fetida* during vermiprocessing of sludges from paper-dairy industrial wastes at 25°C and 80-85% moisture and cattle-goat manure at 26-33°C and 80% moisture. Apart from temperature and moisture the nutrient content of the organic material used as the feed material for vermicomposting seems to be the important factor. Hatchability rates of different species of earthworms cultured on different organic wastes show wide fluctuations: 2.7 in *E.fetida* on cattle manure at 75% moisture and 25°C (Venter and Reinecke, 1988), 2.2 in *E.eugeniae* on cattle manure at 70-80% moisture and 25±2°C (Viljoen and Reinecke, 1994), 2.63 and 3.15 in *E.eugeniae* and *L.mauritii* on P at 70-80% moisture and 27±2°C (Ranganathan and Parthasarathi, 1999), 1.4,1.3 and 0.2 hatchlings/ cocoon in *E.eugeniae, E.fetida and P.excavatus*, respectively on rubber leaf litters at 70-80% moisture and 30.5±0.29°C (Chaudhuri *et al*., 2003), 2.45 and 1.37 in *P.excavatus* on cowdung and kitchen wastes at 70-80% moisture and 27-30±2°C (Chaudhuri and Bhattacharjee, 2002), 2.3, 3.2, 1.6 and 1.8 hatchlings/cocoon in *E. eugeniae, P. excavatus, E. fetida* and *L.mauritii*, respectively, on trash-bagasse-pressmud mixture at 60-70% moisture and 30±2°C (Manivannan *et al*., 2004). Falling in line with these findings in the present study too, number of hatchlings (1.16±0.13 hatchlings/cocoons of *P. excavatus*) was obtained at 65-67% MP than at 60-62, 70-72, 75-77 and 50-52% MP (restricted to 60 days). This falls in line with the findings of Hallatt *et al*., (1992) on the same species of earthworm cultured in cattle manure at 80% moisture and 25°C. Dominguez and Edwards (1997) also arrived to the same conclusion from their studies on *E. anderi* cultured in pig manure at 85% moisture and 20°C. Casting activity of earthworm, however, is known to be influenced directly or indirectly by variations in soil/ substrate temperature and moisture (Evans and Guild, 1948; Edwards and Bohlen, 1996). During vermicomposting processes earthworms become adapted to feed the given organic matter, consume 2-5 times their body weight and after utilizing 10% of the food materials for their own body growth and reproduction, excrete the mucus coated matter as worm casts (Lee, 1985). Dresser and McKee (1980) found that moisture contents between 50 and 80% are the most appropriate for vermicomposting processes.

The rate of recovery of vermicompost in the present study was more at 65-67 % moisture level of the feed. The organic matter that passes through earthworm gut results in increased level of microbial population, microbial activity, microbial respiration, enzymatic activity and micro and macro nutrients in vermicomposts (Edwards and

Bohlen, 1996). Scheu (1987); Mulongy and Bedoret (1989); Parthasarathi and Ranganathan (1999) and Kalam *et al*., (2004) have shown enhanced microbial population and activity and NPK contents in the vermicomposts. Earlier studies of Parthasarathi and Ranganathan (1999), Vinotha *et al*., (2000) and Parthasarathi *et al*., (2007) have shown that NPK content, cellulolytic, amylolytic, proteolytic, phosphate solubilizing enzyme activities and population of nitrifying microbes and microbial activity were enhanced found in the vermicasts of pressmud compared to uningested pressmud. In the present studys, similar to the above report, enhanced microbial population and activity and NPK contents in the freshly collected vermicompost (15th days) of *P.excavatus* was observed. This observation is supported by Parthasarathi and Ranganathan (1999) and Parthasarathi *et al*., (2007) who reported enhanced microbial population, microbial activity and NPK content in the vermicompost at 31^{o}C and 60-70% moisture during vermicomposting of sugar industrial wastes. Stability of vermicompost depends considerably on their age, their microbial population and activity and the organic matter content (Ge *et al*., 2001). Microbial biomass, microbial activity and N P K content was found to be decreased in aged vermicasts (Scheu, 1987; Parthasarathi and Ranganathan, 1999). A slight reduction of microbial population and activity and NPK contents in the older P vermicompost of 30, 45 and 60th day was mainly due to reduced moisture/low microbial growth and enzyme synthesis by microorganisms/leaching and the immobilization and inactivation of micro-organism (Mulongy and Bedoret, 1989; Parthasarathi, 2006). The 65-67% moisture level P support better growth, reproduction and more recovery rate of vermicomposts with enhanced microbial population, activity and NPK contents. 65-67% moisture level pressmud is ideal and optimal for vermiculture and vermicomposting.

ACKNOWLEDGEMENTS

Author thanks to the authorities of Annamalai University for providing facilities and is highly indebted to the Ministry of Science and Technology, Department of Science and Technology, Government of India for the financial assistance under SERC Fast Track- Young Scientist Scheme (2004-2007).

REFERENCES

Banu, J., Esakkiraj, S., Naendran, R., Logakanthi, S., (2005). Biomanagement of petrochemical sludge using an exotic earthworm, Eudrilus eugeniae. J. Environ. Biol **26** (1): 43-47.

Baron, J. E., Peterson, R. L., Finegold, M. S., (1994). Cultivation and isolation of viable pathogens In*: Diagnostic Microbiology*, 9th Ed. Mosby, London. pp. 79-96.

Chaudhuri, P. S., Bhattacharjee, G., (2002). Capacity of various experimental diets to support biomass and reproduction of *Perionyx excavatus*. Bioresource. Technol., **82**: 147-150.

Chaudhuri, P. S., Pal, T. K., Bhattacharjee, G., Dey, S. K., (2003). Rubber leaf litters (Hevea brasiliensis, Var RRIM 600) as vermiculture substrate for epigeic earthworms, Perionyx excavatus, Eudrilus eugeniae and Eisenia fetida. Pedobiologia., **47**: 796-800.

Dominguez, J., Edwards, C. A., (1997). Effect of stocking rate and moisture content on the growth and maturation of *Eisenia andrei* (Oligochaeta) in pig manure. Soil. Biol. Biochem., **29**: 743-746.

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

Dresser, V., McKee, I., (1980). Compendium on solid waste management by vermicomposting. Prepared for the Municipal Environmental Research Laboratory Office of Research and Development. Environment Protection Agency, Cincinnati

Edwards, C. A., (1988). Breakdown of animal, vegetable and industrial organic wastes by earthworms In : Earthworms in waste and environmental management. (Eds : C.A. Edwards. and E.F. Neuhauser), SPB Academic Publishing, The Hague, pp 21-31.

Edwards, C. A., Bohlen, P. J., (1996). Biology and ecology of earthworms, 3rd Ed. Chapman and Hall, London .

Elvira, C., Sampedro, L., Beritez, E., Nogales, R., (1998). Vermicomposting of sludge from paper mill and dairy industries with *Eisenia andrei* : A pilot scale study. Bioresource. Technol., **63**: 211-218.

Evans, A. C., Mc, W. J., Guild, L., (1948). Studies on the relationship between earthworms and soil fertility. IV on the life cycles of some British Lumbricidae. Ann. Appl. Biol., **35**: 471-484 .

Ge, F., Shuster D. W., Edwards, C. A., Parmelee, R. W., Subler, S., (2001). Water stability of earthworm casts in

manure and inorganic fertilizer amended agro ecosystems influenced age and deapth. Pedobiologia., **45**: 12-26 .

Grant, W. C., (1955). Studies on moisture relationhips in earthworms. Ecology., **36** (3): 400-407.

Gunadi, B., Edwards, C. A., Blount, C., (2003). The influence of different moisture levels on the growth, fecundity and survival of *Eisenia fetida* (Savigny) in cattle and pig manure solids. Eur. J. Soil. Biol., **39**: 19-24.

Hallatt, L., Viljoen, S. A., Reinecke, A. J., (1992). Moisture requirements in the life cycle of *Perionyx excavatus* (Oligochaeta). S. Afr. J. Zool., **25** (1): 41-45.

Kalam, A. J., Tah, J., Mukherjee, A. K., (2004). Pesticide effects on microbial population and soil enzyme activities during vermicomposting of agricultural waste. J. Environ. Biol., **25** (2): 201-208.

Kaushik, P., Garg, V. K., (2003). Vermicomposting of mixed solid textile mill sludge and cowdung with the epigeic earthworm Eisenia fetida. Bioresource. Technol., **90**: 311-316.

Lee, K. E., (1985). Earthworms : Their biology and relationship with soils and land use. Academic Press. London.

Loh, T. C., Lee, Y. C., Liang. J. B., Tan, D., (2005). Vermicomposting of cattle and goat manures by *Eisenia fetida* and their growth and reproduction performance. Bioresource. Technol., **96**: 111-114.

Manivannan, S., Ramamoorthy, P., Parthasarathi, K., Ranganathan, L. S., (2004). Effect of sugar industrial wastes on the growth and reproduction of earthworms. *J.* Exp. Zool. India., **7**: 29-37.

Mulongy, K., Bedoret, A., (1989). Properties of wormcasts and surface soils under various plant covers in the humid tropics. Soil. Biol. Biochem., **18**: 395-398.

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

Parthasarathi, K., (2006). Aging of pressmud vermicasts of *Lampito mauritii* (Kinberg) and Eudrilus eugeniae (Kinberg) – Reduciton in microbial population and activity. J. Env. Biol., **27** (2): 221-223.

Parthasarathi, K., (2007). Life cycle of Lampito mauritii (Kinberg) in comparison with Eudrilus eugeniae (Kinberg) cultured on different substrates. J. Environ. Biol., **28** (3/4):1-11.

Parthasarathi, K., L.S. Ranganathan, (2000b). Pressmud promotes earlier oocyte development and neurosecretion in *Lampito mauritii* (Kinberg)- A histological study. J. Exp. Zool. India **3(2)**, 247-256 .

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

Parthasarathi, K., Ranganathan, L. S., (1999). Longevity of microbial and enzyme activity and their influence on NPK contents in pressmud vermicasts. Eur. J. Soil. Biol., **35** (3): 107-113.

Parthasarathi, K., 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., (2002). Supplementation of pressmud vermicasts with NPK enhances growth and yield in leguminous crops (Vigna mungo and Arachis hypogaea). J. Curr. Sci., **2**: 35-41.

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

Ranganathan, L. S., Parthasarathi, K., (1999). Precocious development of *Lampito mauritii* and *Eudrilus eugeniae* reared in pressmud. Pedobiologia ., **45**: 904-908.

Reinecke, A. J., Venter, J. M., (1987). Moisture preferences, growth and reproduction of the compost worm *Eisenia fetida* (Oligochaeta). Biol. Fertil. Soils., **3**: 135-141.

Reinecke, A. J., Venter, J. M., (1985). The influence of moisture on the growth and reproduction of the compost worm *Eisenia fetida* (Oligochaeta). Rev. Ecol. De Biol. du Sol., **22**: 473-481.

Scheu, S., (1987). Microbial activity and nutrient dynamics in earthworm casts (Lumbricidae). Biol. Fertil. Soils., **5**: 230-234.

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

Stevenson, I. L., (1959). Dehydrogenase activity in soils. Canadian J. Microbiol., **5**: 229-235.

Tandon, H. K. S., (1993). Method of Analysis of Soils, Plant, Water and Fertilizer. Fertilizer Development and Consultation Organization, New Delhi.

Tripathi, G., Bhardwaj, P., (2004a). Decomposition of kitchen waste amended with cow manure using on epigeic species (*Eisenia fetida*) and an anecic species (*Lampito mauritii*). Bioresource. Technol/., **93**: 215-218.

Tripathi, G., Bhardwaj, P., (2004b). Comparative studies on biomass production, life cycle and composting efficiency of *Eisenia fetida* (Savigny) and *Lampito mauritii* (Kinberg), Bioresource Technol., **92** (3): 275-283.

Tripathi, G., Bhardwaj, P., (2005). Management of organic waste by earthworms *Eisenia fetida* and *Lampito mauritii.* in arid environment. J. Appl. Bio. Sci., **31**(2): 150-159 .

Venter, J. M., Reinecke, A. J., (1988). The life-cycle of the compost worm *Eisenia fetida* (Oligochaete) S. African J. Zool., **23**: 161-165.

Viljoen, S .A., Reinecke, A. J., (1994). The life-cycle and reproduction of *Eudrilus eugeniae* under controlled environmental conditions. Mitt. Hamb. Zool. Mus. Inst., **89** (2): 149-157.

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

Yadav, D. V., (1995). Recycling of sugar factory pressmud in agriculture. In: Tandon, H.L.S. (Eds), Recycling of Crop,

Animal, Human and Industrial Wastes in Agriculture. Fertilizer Development and Consultation Organization, New Delhi, pp.91-108.