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Full Length Research Paper

Impact of quantity of paper mill wastes on vermi-conversion time and quality of product

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ABSTRACT

Vermi-conversion experiment was conducted for comparison the difference of vermicomposting carried out in small scale at research laboratories or at home with vermicomposting usually carried out medium to large scale for commercial purposes. The experimental raw material (substrate) was made by mixing 30 kg dry and powered Paper Mill solid Wastes (PMW) with 15 kg dry saw dust (SD) and 15 kg dry grinded cow dung (CD). Treatment beds were made in triplicate by using 2 kg, 5 kg and 10 kg of this amended paper mill wastes for vermicomposting. The experiment was carried out following initial aerobic decomposition for 14 days and thereafter vermicomposting using *Eisenia fetida* earthworms. Quality of vermicomposting and composting time did not differ much on change in quantity of substrate since same composition of raw materials were taken and same vermi-conversion procedure was followed. The results clearly indicate that the quality of vermicompost (on an average pH-7.08, organic carbon-16.28%, total nitrogen1.10%, total phosphorus-0.16%, total potassium-0.15%, total calcium-7.66% and total sulphur-0.19%) does not vary with quantity of substrate used either in large scale commercial production or in small scale research experiments in laboratory. The vermicompost from PMW was, however, found quite low in total content of phosphorus, potassium and sulphur. The content of heavy metals was also reduced significantly during vermicomposting in comparison to their amount recorded in paper mill wastes. The bioassay study with bean seeds (*Phaseolus vulgaris*) showed that there was no significant difference in data on germination of seeds, number of leaves, number of branches, shoots length, etc., confirming no difference in quality of vermicompost prepared from different quantity of paper mill wastes.

Keywords: Commercial vermicompost production, *Eisenia fetida*, Paper mill wastes, Vermi-conversion technique, Vermicompost quality

INTRODUCTION

About 100 kg of solid wastes is generated per ton of raw materials used in paper mill as biomass processing residuals, boiler and furnace ash, lime mud, lime slaker grits, scrubber sludge and wastewater treatment sludge (Pokhrel and Viraraghavan, 2004). Disposal of these solid wastes cause environmental problems because of chlorinated organic materials, pathogens, ash and trace amount of heavy metal content (Monte et al., 2009). Karn and Chakrabarti (2015) mentioned that out of four major modes of sludge disposal (incineration, sea discharge, landfill and land application), most of paper mill industries preferred disposing the sludge by land application only. Several researchers (Butt, 1993; Elvira et al., 1998; Wang et al., 2013, Karn and Chakraborti, 2015; Mohapatra et al., 2017) showed that the environmental problem caused due to this loading of huge quantity paper mill wastes (PMW) on land mass could easily be solved by converting that waste into valuable organic manure using vermicomposting technology. Mohapatra et al., (2018) converted easily Emami Paper mill wastes after its mixing with half quantity of saw dust and half quantity of cow dung and using *Eisenia fetida* earthworms at the rate of 10 earthworms per kg of waste. Vermi-conversion is generally carried out in small scale by taking 5 kg or less substrate at houses and in research laboratories while in large scale (50 kg or more substrate at a time) in vermicomposting yards, mainly for commercial purposes. Researchers and post graduate/Ph.D students usually carry out different vermicomposting experiments using less quantity of waste materials due to mainly lack of space and required infrastructure facility at laboratory level. Review showed that Ponmani et al., (2014) used 150 kg substrate materials per bed for vermicomposting of paper mill solid waste, Sonowal et al. (2014) prepared beds using only 1.5 kg substrates for vermicomposting of solid Pulp and paper mill sludge while many researchers (Natarajan and Gajendran, 2014; Gurav and Pathade, 2011; Shouche et al., 2011, Mohapatra et al., 2017), used only 2 kg substrates for making vermi-beds at different research experiments. But in commercial vermicomposting, beds are made by using large quantity of raw material for earning more profit in less time. This experiment was, therefore, conducted to study the impact of three different quantities of amended Paper Mill wastes on rate of vermicomposting as well as the quality of vermicompost assessed through their chemical analysis as well as their bioassay by growing beans plants in earthen pots.

MATERIALS AND METHODS

Collection and Chemical nature of Raw Materials

Paper Mill waste (PMW) was dried and powdered after collection from Waste paper based Balasore Emami Paper Mill. Saw dust from Remuna Saw Mill and cow dung from a farmer's house were also collected for conducting vermi-conversion experiment during 2nd week of November to 2nd week of December 2016 in round plastic tubs of capacity 2 kg, 5 kg and 10 kg. The PMW was found almost neutral in reaction (pH 7.65) with 3.0 dS/m electrical conductivity (EC) and rich in total nitrogen (1.14%), potassium (0.65%), calcium (12.0%) and sodium (0.19%) but low in total phosphorus (0.24%) and sulphur (0.15%). Considerable content of total cromium (22.1 mg/kg), lead (15.7 mg/kg) and zinc (1.32 mg/kg) were also recorded in PMW. Sawdust analysis recorded pH and EC as 7.49 and 0.4 dS/m, respectively with total nutrient contents as 0.89% nitrogen, 0.48% phosphorus, 0.54% potassium, 2.4% calcium, 0.02% sulphur and 0.04% sodium. Cow dung analysis, on the other hand, showed 7.23 pH, 0.8 dS/m EC, 0.35% total nitrogen, 0.29% total phosphorus and 0.38% total potassium.

Vermi-Conversion Technique Followed

Thirty kg powdered paper mill wastes, 15 kg saw dust and 15 kg cow dung were mixed together for making uniform quality of experimental substrate. Nine beds (3 for each treatment) were prepared using 2 kg, 5 kg and 10 kg of this substrate mixture and kept inside the laboratory following randomised block design. Beds were made moist by adding required quantity of deionised water and covered each tray with black plastic sheet. Turning of substrate in all trays were carried out twice on 7th and 14th day for facilitating uniform aerobic decomposition. After second turning healthy *Eisenia fetida* earthworms were added on top of each bed at the rate of 10 earthworms per kg substrates (i.e., 20 earthworms for each bed of T_1, 50 earthworms for each bed of T_2 and 100 earthworms for each bed of T_3). Trays were covered with moist hessian cloths for facilitating better moisture and sufficient aeration to earthworms. Precaution was taken to avoid any anaerobic condition in each tray. After complete conversion to black loose granular tea powder type vermicompost, the bed materials were spread tray-wise separately for partial air drying inside well ventilated room. After removal of all earthworms following heap making and hand sorting method, the cocoons were also collected and then vermicompost of each bed was sieved separately using 2 mm sieve. Approximately 1 kg each sample was kept in ember coloured glass bottles for further analysis. The composted and non composted portions were weighed separately. Total collected earthworms were first washed in deionised water after putting in a conical flask and then wiped out extra water by putting them on blotting paper. Total weight of earthworms was measured by weighing on electric balance after putting in pre-weighed beaker.

Chemical Analysis and Bioassay of Sample

The pH and electrical conductivity of all prepared vermicompost samples were determined from suspension made by mixing 10 g vermicompost sample with 20 ml distilled water using Systronics pH meter and Conductivity meter respectively. Total moisture content was determined from weight difference measured before and after heating vermicompost samples in oven for overnight at 105°C. Total dissolved solids (TDS) of each vermicompost sample was measured gravimetrically from filtered water suspension prepared during pH measurement by evaporating 10 ml liquid solvent in pre-weighed platinum crucible and measuring the mass of residue left. Chemical analysis were also carried out for oxydizable Organic carbon (Wakley and Black titration method) and total nitrogen (Kjeldahl digestion and distillation method) following standard methods mentioned by Tandon (2013). Diacid (9:4 mixtures of Nitric acid and Perchloric acid) digestion extracts of all samples were analyzed for total phosphorous (Vanado-molybdate yellow colour method), total sulphur (Turbidimetry method), total calcium (EDTA method), total potassium and sodium (Flame photometric method) and heavy metals like Cromium, Lead and Zinc (Atomic Adsorption Spectrophotometric method). All data were calculated on oven dry basis and statistically analysed for standard deviation.

The efficacy of all vermicompost samples on growth of Beans was studied in 5 kg capacity earthen pots. Nine vermicompost (vc) samples of 3 treatments (200 g each) were added in triplicate in total 27 pots containing 2 kg soils of paddy field each for making 9 replications of each treatment (PT_1 to PT_3). Three control treatments were made in triplicate by taking 200 g PMW mixed in 2 kg soil per pot (PT_4), 2 kg PMW per pot (PT_5) and only 2 kg soil per pot (PT_6). All treatments with their replications were arranged in complete randomised design. Five healthy bean seeds (*Phaseolus vulgaris*) were placed on each pot and water was sprinkled for making the beds moist. Germination of seeds was noted in each pot at 5 days interval up to 15 days while number of leaves, number of branches, shoots length, etc. were recorded from each plant of each pot at 10 days interval thrice from 15 days onwards. Plants from each pot were uprooted on 35th day, washed in water and soak on blotting papers to wipe out excess of water attached to plants. Shoots length, roots length, number of flowers appeared, number of bean pods developed and fresh weight of plants, etc. were measured. Plants were oven dried for overnight keeping oven temperature at 100°C and dry plant weight was recorded after cooling the samples.

RESULTS AND DISCUSSION

The quantity of vermicomposts prepared, percentage of non-composted portion and period of vermicomposting are presented in Table 1. Among the three treatments since both substrate as well as number of earthworm released per kg substrate were same, only the quantity of substrate per treatment was different, the time duration in vermicompost production was found same. Even the quantity of vermicompost as well as non composted portion proportionately recorded similar percentage in case of larger quantity of substrate. The huge number of earthworm population was marked in each treatment. Although in T_1 the amount of bed material was 2 kg but the amount of earthworm population including cocoon number was too good. In T_2 and T_3 earthworm numbers, weight and cocoon numbers were found very high and could not be possible to count all. More food materials and comparatively bigger favourable space helped in growing more juvenile earthworms.

Data on chemical analysis as presented in Table 2 showed that different parameters except TDS did not differ much. The pH of vermicomposts varied from 7.01 to 7.18, electrical conductivity (EC) from 1.23 to 1.36 dS/m, moisture percentage from 49.23 to 52.65 percent and oxidizable Organic Carbon from 15.85 to 16.65 %. Slight variation might be due to earthworm activity only since composition of substrate was same in all treatments. The TDS was comparatively higher in T_3 followed by T_2 and then T_1 which was obvious since presence of more PMW provided more concentration of salt which could not leached out from beds (Plastic trays). Total macronutrient (Nitrogen, Phosphorus and Potassium) status as shown in Table 3 did not vary considerably among treatments since the composition of substrates was same in all treatments. Secondary nutrients like total calcium (7.46 to 8.6 %), total sulphur (0.18 to 0.20%) and total sodium (0.08 to 0.10%) also recorded similar trends. Similar range of results was also earlier reported by Thyagarajan et al., 2010; Yadav and Madan. 2013; Mohapatra et al., 2017; Mohapatra et al., 2018 during vermicomposting of paper mill wastes amended with saw dust and cow dung.

In case of heavy metal little variation was marked in data recorded for total chromium (Cr) (5.34 to 6.86 mg/kg), total lead (Pb) (5.40 to 6.90 mg/kg) and total zinc (Zn) (0.01mg/kg) due to no change in substrate composition or earthworm population (Table 4). But there was a considerable reduction in content of chromium, lead and

Table 1. Vermicompost production and earthworm reproduction with variation in substrate quantity.

Treatment No.	Quantity of substrate mixture (kg)	Vermi-conversion time (days)	Vermi compost production (kg) (Mean ± SD)	Non-composted portion (%) (Mean ± SD)	Earthworm numbers	Earthworm total weight (g)	Cocoon numbers
T_1	2 kg	35	0.99 ± 0.11	15.00 ± 3.00	320	78	220
T_2	5kg	35	3.13 ± 0.28	17.00 ± 2.65	more than 450	185	More than 400
T_3	10kg	35	6.39 ± 0.72	13.33 ± 3.22	more than 600	350	More than 500

Table 2. pH, EC, TDS, Oxidizable organic carbon and Moisture content of vermicomposts produced under different quantity of wastes.

Treatments	Substrate mixture used	pH (1:2)	EC(ms/cm)	Moisture (%)	Total Dissolved Solids (ppm)	Oxidizable organic Carbon (%)
T_1	2 kg	7.01+0.05	1.26+0.06	52.65+6.05	432.00+26.44	16.33+1.82
T_2	5 kg	7.04+0.07	1.23+0.06	49.23+4.49	465.00+31.34	16.65+1.26
T_3	10 kg	7.18+0.03	1.36+0.12	50.87+1.52	585.66+19.61	15.85+2.44

Table 3. Nutrient analysis of vermicomposts.

Treatments	Macro-nutrient status			Secondary – nutrient status		
	Total Nitrogen (%)	Total Phosphorus (%)	Total Potassium (%)	Total Calcium (%)	Total Sulphur (%)	Total Sodium (%)
T_1	1.07 ± 0.22	0.16 ± 0.02	0.15 ± 0.02	6.93 ± 2.51	0.20 ± 0.06	0.08 ± 0.01
T_2	1.24 ± 0.26	0.17 ± 0.03	0.14 ± 0.03	7.46 ± 1.01	0.18 ± 0.01	0.08 ± 0.01
T_3	1.00 ± 0.14	0.16 ± 0.01	0.16 ± 0.01	8.60 ± 1.53	0.18 ± 0.06	0.10 ± 0.02

zinc present in vermicompost in comparison to those recorded in paper mill waste (22.1 mg/kg Cr, 15.7 mg/kg Pb and 1.32 mg/kg Zn). The decrease in heavy metal content during vermicomposting of Emami paper mill wastes was also earlier reported by Mohapatra et al. (2018). Wang et al. (2013) also recorded the reduction of lead and cadmium concentration after vermicomposting of Paper mill sludge. The quantity of metals present in vermicompost was, however, found within permissible limit for growing crops..

Table 4. Heavy metal analysis of vermicomposts.

Treatment	Vermicompost made from	Total Chromium (mg/kg)	Total Lead (mg/kg)	Total Zinc (%)
T_1	2 kg	6.86 ±1.55	5.40 ± 1.47	0.01 ± 0.00
T_2	5 kg	5.90 ± 0.70	5.70 ± 1.39	0.01 ± 0.00
T_3	10 kg	5.34 ± 0.42	6.90 ± 2.25	0.01 ± 0.00

The influence of vermicomposts(vc) prepared with varying quantities of substrate mixture on growth of bean seeds (*Phaseolus vulgaris*) was studied by measuring shoot and root length, number of plants, number of leaves, number of branches, number of flower and pod formation and germination percentage of seeds. The data presented in Table 5 clearly indicated that initial germination of seeds was delayed in presence of raw PMW whereas addition of vermicompost helped in quick germination. There were not many differences in number of leaves and brunches at initial stage of all treatments, but vermicompost added pots recorded slight higher number of leaves always. But among vermicompost, treatment difference was insignificant.

Both number of branches per plant and shoot length were increased with number of days in all treatments, but both characters were always found more in plants grown in vermicompost added pots than other pots filled up with only PMW, only soil or PMW+Soil shown in Table 6. However, difference among vermicompost treatments in this table was also found negligible.

Similar trend was also observed in other growth parameters like root length, flower numbers, pod number, fresh plant weight and dry plant weight show in Table 7, sowing supremacy of vermicompost added pots than other control pots.

CONCLUSION

The vermin-conversion experiment, therefore, proved that Vermicomposting and the quality of vermicompost did not depend on the quantity of substrate taken for bed preparation so long substrate was same. Paper mill wastes after structural ammendment, if vermicomposted, will take the same time either in small scale at laboratory or in large scale in field.

Table 5. Data on seed germination and per plant leaf production.

Treatment details		Number of seeds germinated on			Number of leaves appeared on		
		5th day	10th day	15th day	15th day	25th day	35th day
PT_1	2 kg Soil+200 g vc of T_1	4	5	5	6	11	19
PT_2	2 kg Soil+200 g vc of T_2	5	5	5	6	11	20
PT_3	2 kg Soil+200 g vc of T_3	4	5	5	6	11	20
PT_4	2 kg Soil+200 g PMW	3	4	5	6	10	17
PT_5	Only 2 kg PMW	2	4	5	5	11	17
PT_6	Only 2 kg Soil	3	4	5	5	10	17

Table 6. Influence of treatments on development of branch and shoots of bean plants.

Treatments	Number of branches per plant			Average shoot length (cm) of bean plant		
	15th day	25th day	35th day	15th day	25th day	35th day
PT_1	2	3	5	8.8	17.5	28.5
PT_2	2	3	6	8.8	17.8	28.7
PT_3	1	3	6	8.5	18.1	29.0
PT_4	2	3	4	6.8	17.2	23.5
PT_5	1	3	4	6.5	16.8	22.3
PT_6	1	3	4	6.8	17.3	24.4

Table 7. Root length, number of flowers and bean pods and plant's fresh weight and dry weight.

Treatments	Root Length (cm)	Number of Flowers	Number of bean pods	Fresh Plant Weight (g)		Dry Plant Weight (g)	
				Shoot weight	Root weight	Shoot weight	Root weight
PT_1	21.8 ± 1.5	3	5	11.4 ± 0.3	1.2 ± 0.0	2.9 ± 0.5	0.8 ± 0.0
PT_2	22.8 ± 1.0	4	4	11.5 ± 0.5	1.0 ± 0.1	2.7 ± 0.7	0.5 ± 0.1
PT_3	22.7 ± 0.4	3	4	12.5 ± 0.9	1.2 ± 0.1	2.0 ± 0.1	0.3 ± 0.0
PT_4	13.5 ± 0.1	2	2	10.2 ± 0.1	0.6 ± 0.1	1.8 ± 0.1	0.1 ± 0.1
PT_5	10.6 ± 0.1	2	2	10.2 ± 0.1	0.5 ± 0.1	1.8 ± 0.1	0.1 ± 0.1
PT_6	14.8 ± 0.1	3	3	9.2 ± 0.1	0.5 ± 0.1	1.6 ± 0.1	0.2 ± 0.1

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REFERNCES

Butt KR (1993). Utilization of solid paper mill sludge and spent brewery yeast as a feed for soil-dwelling earthworms. Bioresource. Tech. 44(2): 105-107.

Elvira C, Sampedro L, Benitez E, Nogales R (1998). Vermicomposting of sludge from paper mill and dairy industries with *Eisenia andrei* : a pilot scale study. Bioresource. Tech. 64(3): 205-211.

Gurav MV, Pathade GR (2011). Production of vermicompost from Temple Waste (Nirmalya): A Case Study, Universal J. Environ. Res. Tech. 1(2): 182-192.

Karn SK, Chakrabarti SK (2015). Simultaneous biodegradation of organic (chlorophenols) and inorganic compounds from secondary sludge of pulp and paper mill by *Eisenia fetida*. Int. J. Recycling Org. Waste Agric. 4(1): 53-62.

Mohapatra D, Sahoo KK, Sannigrahi AK (2017). Impact of structural amendment of paper mill wastes with different organic materials on vermicomposting using Eisenia fetida earthworms. J. Environ. Waste Manag. 4(1): 53-63.

Mohapatra D, Sahoo KK, Sannigrahi AK (2018). Influence of initial aerobic decomposition on vermicomposting of paper mill wastes amended with saw dust and cow dung. Int. J. Waste Resour. 8(1): 325-330.

Monte MC, Fuente E, Blanco A, Negro C (2009). Waste management from pulp and paper production in the European Union. Waste Manag. 29(1): 293-308.

Natarajan N, Gajendran M (2014). Vermiconversion of Paper Mill sludge for recycling the nutrients using earthworm *Eudrilus eugeniae*. IOSR J. Environ. Sci. Toxic. Food Tech. 8(9): 6-11.

Pokhrel D, Viraraghavan T (2004). Treatment of Pulp and Paper mill waste water: A review. Sci. Total Environ. 333(1-3): 37-58.

Ponmani S, Udayasoorian C, Jayabalakrishnan RM, Kumar KV (2014). Vermicomposting of paper mill solid waste using epigeic earthworm *Eudrilus eugeniae*. J. Environ. Biol. 35(4): 617-622.

Shouche S, Pandey A, Bhati P (2011). Study about the changes in physical parameters during vermicomposting of floral wastes. J. Environ. Res. Dev. 6(1): 63-68.

Sonowal P, Khwairakpam M, Kalamdhad AS (2014). Vermicomposting of solid pulp and paper mill sludge using *Eudrilus eugeniae* earthworm. International J. Environ. Sci. 5(3): 502-514.

Tandon HLS (2013). Methods of Analysis of Soils, Plants, Water, Fertilizers and Organic Manures. FDCO Publication, New Delhi.

Thyagarajan LP, Meenambal T, Mangaleshwaran L, Lakshminarasimaiha N, Ramesh N (2010) Recycling of pulp and paper industry sludge with saw dust by aerobic composting method. Nature Environ. Pollution Tech. 9(1): 149-154

Wang L, Zheng Z, Zhang Y, Chao J, Gao Y, Luo X, Zhang J (2013). Biostabilization enhancement of heavy metals during the vermiremediation of sewage sludge with passivant. J. Hazardous. Materials. 244-245C: 1-9.

Yadav A, Madan S (2013) Nutrient status of vermicompost of paper mill sludge with different wastes by using *Eisenia fetida*. Eur. J. Appl. Sci. 5: 62-66.