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Arya Alok
Thinking Fox Academic Science Lab, Bhoisahi, Balasore, Odisha, India

Sushree Sangita Mohapatra
Department of Zoology, North Orissa University, Takatpur, Odisha, India

Enhancement of productivity and quality of vermicompost using pond sediments for structural application of paper mill wastes along with various organic residues

Arya Alok and Sushree Sangita Mohapatra

Abstract
Pond sediment (PS) is full of organic composition derived from detritus of aquatic plants, animals and microbes; hence this has to be nutritious for the earthworm *Eisenia fetida* and it has high CN content also. This work reveals the effectiveness of pond sediment on productivity timing and better quality of the Vermicompost using various organic wastes mixed along with paper mill wastes (PMW). Although using PMW for vermicomposting and using PS for agriculture directly has been done by many previous researchers, but the combination of both gave this research a new direction and fruitful results. Since PS are usually anaerobically settled for a long time hence it needed to be aired out before using and then when added to the pre-compost it enhanced the humification and degradation of composting matters; temperature, NH3 emission, cocoon formation and structural change in compost beads were the signs of optimised rate of vermicomposting. The amendment of PMW and PS with cow-dung and sawdust in 1:1:0.5:0.5 resulted adequate amount of vermicompost. The two-stage composting process with addition of PS certainly enhanced the production quality and rate, resulted a matured vermicompost in just 30-35 days rather than in 90-270 days in normal composting. Further the quality was ensured with Pot-seedling method as it produced an early germination, root development and growth of onion plants in lab conditions.

Keywords: Sediments, Vermicompost, cocoon, siltation, C/N ratio

1. Introduction
Pond sediments are those elements, which are mainly the benthic or lower most layer a lentic water body like pond, lakes and ephemerals etc. In this case, the sediments of ponds of rural area, which are devoid of industrial pollutants has taken into consideration assuming the absence of heavy metals. Earlier studies reveal the bad impact of heavy metals on earthworm growth, though it can tolerate upto a certain limit of them, hence the ponds of the rural area of Jaleswar, Balasore, Odisha were chosen. Basically, PS are composed of dead or living aquatic flora, fauna and microbes.

On the other hand, Paper mill wastes (PMW) is generated from pulp paper industries that use old papers to prepare new papers. It consists of high molecule complex fibers used during paper making produced and residuals of pulping of raw materials, paper sludge, calcium carbonate, ink particles, clays and other compounds used in de-inking of old papers. The production process of the industries varies along with their basic chemical usage which causes various quality and quantity of residuals. The nutrient values of these wastes also differ as a result of the production technique and chemical. Study done already shows the higher level of heavy metals and high C/ N ratio in the PMW. The high C/N ration affects the plant growth negatively and makes the soil nitrogen immobilization due to large molecules and low break down of those. Mill wastes are not easy material to compost and normally need both structural and nitrogen amendments to compost well (Tucker, 2005) [15]. Some researchers have successfully done vermicomposting of different PMW after its amendment with sawdust (Thyagarajan *et al*., 2010) [14], food processing industry's wastes (Quintern, 2011), mixture of Pig wastes, water hyacinth and cowdung (Natarajan and Gajendran, 2014) [7], or Leaf litter and cowdung mixture (Ponmani *et al*., 2014) [9] with a mixture of Agricultural,

Correspondence
Arya Alok
Thinking Fox Academic Science Lab, Bhoisahi, Balasore, Odisha, India

municipal solid wastes and poultry wastes (Yadav and Madan, 2013) [17], fruit and vegetable wastes (Tucker, 2005) [15] etc.

Vermicomposting is stabilization of organic waste materials with the help of epigeic earthworms and microorganisms. During vermicomposting, nutrients are converted into soluble and available forms required for growth of plants. This is a work that not only tried for a new combination but also applied two thoughts into one concept, because this works helps promote the resolving siltation of water reservoirs and promoting the use of silts along with another waste material (PMW) to make fruitful manure by the help of earthworms.

2. Materials and Methods

The pond sediment (PS) was collected by deep excavation of an old pond situated in rural area. The Ps is then aired out and shed dried in lab with daily mixing up by hand. After that the pH, EC, C/N ratio, Total N%, total P%, total K% were analysed and found to be 7.36, 3.8 dS/m, 34.4, 92%, 0.28%, 0.70% respectively. Similarly the collection of PMW was done from the dump yard of Waste paper based Paper Mill at Balasore and then it was dried in sheds and powdered for conducting experiment. Chemical analysis has shown that this PMW is almost neutral in reaction (pH 7.65) with electrical conductivity 3.1 dS/m and C/N ratio 28.1. It contained 1.19% total N, 0.26% total P, 0.73% total K. Sawdust is collected from Ganesh Saw Mill at Balasore. Its pH (1:2) and EC are 7.49 and 0.4 dS/m, respectively while total N, P & K were 0.89%, 0.48%, 0.54% respectively. Different ratios of these materials are mixed with PMW for making experimental vermicompost beddings of 3kg each (Table-1). The compost bed was formed in layers rather than complete mixing to check the solo reactions of earthworms to different layers. Sufficient water is added to make the beds moist to get the initial moisture level at 90% initially. Each treatment was made in triplicate following a randomized block design under the shade after covering each tray with jute cloths. The bedding materials of all the trays are thoroughly mixed thrice at 7 days interval and covered every time. 20 healthy adult *Eisenia fetida* earthworms were released after 15 days on top of each bed and covered again with moist jute cloths. Moisture level was maintained at 70 to 80 % moisture by spraying deionized water as and when required. When loosely granular structure as beads of compost emerged from the lower layers of the bed it confirmed the process of vermicomposting. Hence the compost beads were separated and collected from the bed by using hand brush (figure: 3) & near to the end of the experiment the bed materials were dried at room temperature for partial air drying. Earthworms were separated by hand sorting. Sieving of vermicompost of each replication was separately done through 2mm sieve (Fig: 3) and stored in plastic zipper bags. To determine the nutrient status different chemical analysis of these collected Vermicomposts are done following standard methods mentioned by Bhargava and Raghupati (1993) [1].

Fig 1: (Layers of vermicomposting bed in the tray)

Fig 2: (Triplicates of each treatment on racks in lab)

Fig 3: (Process of sieving of compost beads and cocoons from the post-compost bed)

For the pot seeding test onion plants were considered as it needs sandy soil for better growth. Again the test and comparison of root growth in lab condition is technically easy to work out along with onion due to its clear, bunchy roots. For this experiment, 50 gram water washed & sterilised sand was mixed with 5 gram of collected compost varieties in each plastic cup. 10 ml of water was poured and then a healthy onion was placed on each cup. The root growth and germination of onion leaves were observed after 10 days to conclude the result. The longest root length and total weight of root bunch were measured for each plantation (Fig: 6). Similarly by taking 100 ml of water and 5 gm. ratio of different vermicompost varieties in different culture bottles (Fig: 7), the length of longest root and total root weight were also observed to check the effect of vermicomposts in aqua-spray culture, where plant roots are sprayed only with nutrient reach water for growth.

3. Results and discussions

Table-1 shows the combinations and results of different treatments done during the experiemnts and also shows the percentage of harvested compost along with the survival rate of earthworms. As expected due to toxic elements and high heavy metal content Vermicomposting was not completed in Paper Mill waste alone (Control treatment). It was due to the dying of majority of earthworms and also less food intake of earthworms. PMW alone was not palatable to *Eisenia fetida*. During investigation on paper mill sludge collected from the National Cellulose Company Ltd. in Spain as a feedstock for vermiculture, Elvira and Dominguez (1995) [3] found that the worms suffered weight loss when it was their sole diet. Cow dung itself is a good feed for the earthworm and when it is mixed with saw dust it enhances the degradation of organic matters. Though the pond sediment contains coarse sand particles but it certainly contains a lot of organic debris hence after mixing with saw dust and cow dung it gets degraded quickly. This is the earliest bed to be ready at the precomposting stage before the introduction of earthworms. The bed of combination of 1 kg PMW + 0.5 kg SD + 0.5 kg CD + 1 kg PS was ready within as early as 7 days and the final composting was finished at 30 days which is the first to finish. The survival and growth rate of earthworms were found to be the highest among all treatments. Hence this was found to be the best combination for the amendment of PMW with organic residues. Total NPK value was also at good level that indicates high fertility manure.

Fig 4: (Collected vermicompost along with earthworm juveniles),

Fig 5: (Erath worm cocoons on petri plate)

Table 1: Comparison of vermicomposting days, compost produced, % of non-composted portion and harvested earthworm in different treatments

Treatments	Quantity of mixed raw materials in beds	Period of vermicomposting (days)	Vermi Compost produced (kg)	Non-Composted portion (%)	Earthworms at harvesting	
					No. (Matured + juveniles)	Weight (gm)
T1	3 kg Pond Sediment (PS)	40	1.78 ± 0.08	38.6	20+ 14	15
T2	3 kg Paper Mill Waste (PMW)	Not fully completed	0.32 ± 0.10	87.2	5+0	1.6
T3	2 kg Paper mill waste (PMW) + 1 kg pond sediment (PS)	Not fully completed	1.15 ± 0.10	46.7	15 + 0	4
T4	1.5 kg PMW + 0.5 kg cow dung (CD) + 1 kg PS	50	2.27 ± 0.05	21.3	18 + 30	15
T5	1 kg PMW + 1 kg CD + 1 kg PS	45	1.93 ± 0.04	34.6	20 + 60	45
T6	0.5 kg PMW + 1.5 kg CD + 1 kg PS	40	2.53 ± 0.07	14.4	17 + 120	41
T7	1 kg PMW + 0.5 kg SD + 0.5 kg CD + 1 kg PS	30	2.85 ± 0.08	6.5	32 + 310	81
T8	1 kg PMW + 1 kg Saw dust (SD) + 1 kg PS	45	2.64 ±0.08	10.9	28 + 100	62

Table 2: (physical parameters): Analysis of pH, EC and Moisture content of different treatments

Treatments	Quantity of mixed raw materials in beds	pH (1: 2)	EC (dS/m)	Moisture content (%)
T1	3 kg Pond Sediment (PS)	7.36 ± 0.03	3.80 ± 0.24	32.8 ± 2.2
T2	3 kg Paper Mill Waste (PMW)	7.30 ± 0.20	3.06 ± 0.13	47.8 ± 8.5
T3	2 kg Paper mill waste (PMW) + 1 kg pond sediment (PS)	7.48 ± 0.10	3.30 ± 0.24	51.5 ± 6.8
T4	1.5 kg PMW + 0.5 kg cow dung (CD) + 1 kg PS	7.54 ± 0.35	2.95 ± 0.12	57.2 ± 4.2
T5	1 kg PMW + 1 kg CD + 1 kg PS	8.04 ± 0.10	3.90 ± 0.10	45.8 ± 1.2
T6	0.5 kg PMW + 1.5 kg CD + 1 kg PS	7.43 ± 0.21	4.27 ± 0.23	37.8 ± 6.5

T7	1 kg PMW + 0.5 kg SD + 0.5 kg CD + 1 kg PS	7.22 ± 0.10	4.8 ± 0.10	34.8 ± 1.2
T8	1 kg PMW + 1 kg Saw dust (SD) + 1 kg PS	7.10 ± 0.25	4.67 ± 0.22	41.4 ± 13.6

Table 3: (chemical analysis): Analysis of total nitrogen, total phosphorous and total potassium in different treatments

Treatments	Quantity of mixed raw materials in beds	Total Nitrogen (% N)	Total Phosphorus (% P)	Total Potassium (% K)
T1	3 kg Pond Sediment (PS)	0.55 + 0.06	0.27 + 0.58	0.48 + 0.01
T2	3 kg Paper Mill Waste (PMW)	0.93 + 0.03	0.27 + 0.01	0.34 + 0.03
T3	2 kg Paper mill waste (PMW) + 1 kg pond sediment (PS)	0.95 + 0.09	0.22 + 0.04	0.64 + 0.02
T4	1.5 kg PMW + 0.5 kg cow dung (CD) + 1 kg PS	0.86 + 0.02	0.21 + 0.02	1.02 + 0.07
T5	1 kg PMW + 1 kg CD + 1 kg PS	0.57 + 0.25	0.27 + 0.06	0.41 + 0.01
T6	0.5 kg PMW + 1.5 kg CD + 1 kg PS	1.13 + 0.25	0.34 + 0.03	0.87 + 0.06
T7	1 kg PMW + 0.5 kg SD + 0.5 kg CD + 1 kg PS	1.11 + 0.01	0.21 + 0.02	1.38 + 0.01
T8	1 kg PMW + 1 kg Saw dust (SD) + 1 kg PS	0.96 + 0.24	0.28 + 0.02	0.94 + 0.01

Fig 6: (Early development of roots in onions in vermicompost treated sand).

Fig 7: (quick growth of onion root in vermicompost treated water)

4. Conclusion
In rural areas, pond sediment or silted layer of the water reservoir is directly used as manure in the paddy fields. PMW cannot be used directly for plant growth. But in combination with residual and industrial materials like PMW it is an advance scientific treatment to use highly organic PS for vermicomposting. The processing time, resulting manure quality and root development ensures this strategy of utilization of PMW for manure purpose indirectly. Again one more positive outcome is that we often come across the siltation problems (causing high BOD and COD) in water reservoirs whether that might be man-made or natural, but during this exercise we can also solve that problem by periodic removal of silts from the reservoirs and use them along with the PMW for vermicomposting. And since this variety of compost is reach in NPK value, hence it is proved to be good manure for farmers. Certainly this practice is much more useful & fruitful than the use of PMW or PS only for land filling.

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