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RESEARCH ARTICLE

VERMIREMEDIATION OF FILTERMUD WASTE MIXED WITH ANIMAL DUNGS INTO VALUABLE MANURE USING EARTHWORM *Eudrilus eugeniae* (KINBERG)

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ABSTRACT

Problem statement: Filter mud has significant fertilizer value but due to prohibitive cost of sludge disposal, it is dumped in open where it adversely affects the ambient environment .Conversion of industrial wastes in to beneficial vermicompost not only solves solid waste accumulation but also yield highly nutritive organic manure.
Approach: The management and nutrient recovery from filtermud has been attempted by vermicomposting after mixing it with organic nutrient in appropriate quantities. The final products were nutrient rich, odour free, more mature and stabilized. The results showed that carbon content was decreased during the process and nitrogen content was enhanced. The C: N ratio decreased with time in all the feed mixtures indicating a stabilization of the waste.
Results: Bioconversion of filter mud waste using animal wastes like Goat dung, Buffalo dung, Sheep dung and Cow dung lead into nutrients rich manure by using the earthworm *Eudrilus eugeniae.* The results suggest that the filter mud supplementary animal wastes promote the activity of earthworm and produce highly nutritive vermicompost. The chemical composition of the compost prepared by different types of composting using filter mud showed that the level of nitrogen, phosphorus, potassium, Calcium and metals like Mg, S, Cu and Zn showed and increasing trend during end of the vermicomposting.
Conclusion: The present study recommends filtermud mixed with animal wastes for vermicomposting to enhance the functioning of the earthworm and to increase fertilizer value of vermicompost. In the present study also macronutrient and micronutrient content increased significantly in vermicompost prepared from filtermud waste due to the supplementation of goat dung. This is practical significance if adopted by urban farmers as a result of soil health and in turn the productivity of soil can be maintained for further agriculture.

INTRODUCTION

The industrial units produce a huge quantity of both hazardous and non hazardous solid/liquid wastes, and safe management of such waste has become most challenging issue for the society. The majority of the wastes generated from industrial units are disposed in environmentally unsafe manner which leads to unhealthy urban environment. [1]. Filtermud as it is commonly known is one of the important by-products of the sugar industry. Filter mud is a soft, spongy, amorphous and dark brown to brownish white material containing sugar, fibre, and coagulated colloids including cane wax, albuminoids, inorganic salts and soil particles. It is readily converted to a repository of macro and micro nutrients besides being a very effective soil ameliorant through vermicomposting. Filter mud mounts as it is accumulated at a stocking point, It undergoes self combustion and adds to pollution to the environment besides causing an eye sore [2, 3] do not advocate the direct application of pressmud to the soil due to its 8-15% wax content and prefer that it be composted before use. According to [4] approximately 12 million tones of press mud is produced in India annually. Due to the prohibitive cost of sludge disposal, it is either dumped in open or along roadsides or railway tracks or stored in the sugar mill premises where it causes adverse impacts on the ambient environment. Apart from this, such practices entail wastage of organic and inorganic nutrients present in the sludge that might be put to good use [5]. The compost so obtained has less nutritive value and more compactness. Therefore, appropriate pressmud management technology is desired which not only protect and conserve the environment and land resources but also to recover the nutrients present in it. However, industrial sludge cannot be used without dilutions for earthworm feed because it contains several hazardous chemicals, which directly harm inoculated earthworms in vermibed. A suitable amendment substance is needed for successful vermicomposting operation [6] used the saw dust and Cow dung as bulky agents for vermicomposting trials of guar gum industrial wastes. He suggested that 60:20:20 ratio of industrial waste, cow dung and saw dust are ideal combination to achieve the maximum biopotential of earthworms. [7] suggested that substrate containing 40% textile mill sludge + 60% biogas plant slurry as a suitable combination for better mineralization and earthworm production during process. Animal wastes conversion into vermicompost enhances the macro and micronutrients.

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MATERIALS AND METHODS

Earthworm Cultures

Eudrilus eugeniae was obtained from a vermicomposting unit of Kalapavirusam in Tenkasi, Tamilnadu, India. The stock culture of the earthworm was maintained in plastic containers using partially decomposed bio-waste and Cow dung as growth medium in laboratory condition. This was further used in the vermicomposting experiment

Animal Dung

Animal manures commonly available in this region of Tirunelveli (Tamilnadu) are of Goat, Buffalo, Sheep and Cow dung. Urine free animal dung's were collected separately in quantities sundried and powdered.

Filtermud

The filter mud was collected from the Dharani Sugar Factory near Vasudevanallur, Tirunelveli. Fresh filter mud was kept in shade for 2-3 weeks before using for the vermicomposting process. The partially degraded filter mud (FM) was then blended with nutrient supplement animal manures like Goat dung (T_1), Buffalo dung (T_2), Sheep dung (T_3) and Cow dung (T_4) in 1:1 ratio.

Experimental Design

The vermibed were prepared using filter mud in plastic containers and watering was done regularly to moist the medium. Four treatments were taken for vermicomposting of FM materials; For filter mud the feed ratios introduced into the vermibed (in triplicates) are 100% Cow dung (C) control; Filter mud:Goat dung (T_1) ; Filtermud: Buffalo dung (T_2); Filter mud: Sheep dung (T_3); Filtermud: Cow dung (T_4). Experimental beddings were kept in triplicate for each treatment in perforated cylindrical plastic containers, Control consisted of 100% Cow dung (T_0) All waste mixtures were turned over manually for 15 days in order to pre-compost it so that it becomes palatable to earthworms. After 15 days of pre-composting 20 adult epigeic earthworms *E.eugeniae* species having individual live weight (350-400mg) were inoculated in each vermicompost. All the vermicompost were operated in dark at a laboratory temperature of (26 ± 1ºC). The moisture content was maintained at 65 ± 5% by periodic sprinkling of distilled water. During the experimental period no extra waste mixture was added at any stage in any vermicompost. All the vermicomposters were maintained in triplicate with earthworm density of twenty in each container. Control and treatments was triplicate. At the end of experiment, worms, cocoons and hatchlings were removed and so produced vermicompost was air dried at room temperature and packed in airtight plastic bottles for further physico-chemical and nutrient content analysis. The vermicompost was harvested after appearance of black granular structure on the surface of the composting medium. Watering of the composting medium was discontinued four days before the harvesting. Vermicompost output from each treatment was calculated on dry weight basis.

Compost Analysis

About 110g of homogenized wet samples (free from earthworms, hatchlings and cocoons) were taken out at1st and 60th day of composting period. Triplicate samples were collected and stored at 4ºC for stability parameters, The pH and EC were determined using a double distilled water suspension of each waste in the ratio of 1:10 (w/v) that had been agitated mechanically for 30 min and filtered through Whatman No.1 filter paper. Total organic carbon (TOC) was measured using the method of [8]. Total Nitrogen (TN) was determined after digesting the sample with concentrated H_2SO_4 and concentrated $HClO_4$ (9:1, v/v) according to [9] procedure. Total available phosphorus (TAP) was analyzed using the colorimetric method with molybdenum in sulphuric acid. Total potassium (TK) was determined after digesting the sample in diacid mixture (concentrated HNO_3: concentrated $HClO_4$, 4:1, v/v), by flame photometer. [10]. Heavy metals' content in the vermicompost was determined by using diacid digest of the sample. Analysis was done using atomic absorption spectrophotometer (AAS). Standard solutions were prepared by using the nitrate salts of the estimated heavy metals.

RESULTS AND DISCUSSION

Physico-chemical Changes in filtermud waste mixture during vermicomposting

The earthworm processed waste mixture was more stabilized, odor-free, dark brown and nutrient rich material. During the process physio-chemical properties of waste mixtures is changed drastically and end material is rich in soil nutrients. Hence it is essential to specify various physico-chemical characteristics, such as pH, electrical conductivity, total organic carbon, total nitrogen, total available phosphorus, total potassium, metal content etc., to quantify the dynamics of vermicomposting process. Physico-chemical characteristics of the initial feed mixtures and vermicompost are given in Table 1.

pH

pH is an important parameter in the vermicompost for promoting plant growth [11]. In the present study (Table 1), pH in the filter mud and filtermud supplemented with Goat dung, Buffalo dung, Sheep dung and Cow dung showed an alkaline trend above neutral (pH-7) at 1st day of vermicompost. After 60th days a shift from the initial alkaline status to neutral condition was observed. In all the reactors (T_0-T_4) the pH was in the range, 7.13-8.46. In goat dung treated filter mud the pH was 7.13, in buffalo dung treatment the pH level was above 7.64 (Table 1). The change in pH after vermicomposting must be due to mineralization of nitrogen and phosphorus into nitrites/nitrates and orthophosphates and bioconversion of the organic material into intermediate species of organic acids [12,13,14] had reported that pH shift is dynamic and substrate dependent. The pH for all the reactors varied significantly ($P<0.05$) on 60th days.

Electrical Conductivity (EC)

Electrical conductivity in the reactors T_0-T_4 varied in relation to vermicomposting period and supplement addition (Table 1).The prolongation of vermicomposting from 1 day to 60 days elevated the EC rate significantly in all the reactors. The increase in EC was due to the loss of weight of organic matter and release of different mineral salts in available forms (such as phosphate, potassium and Ammonia) as, reported by earlier workers [6] [15],[29].

Total Nitrogen (TN)

The total nitrogen content after 1st day and 60th days of *E.eugeniae* action in the different vermibed was estimated. The results were compared with total nitrogen content in pre composted filter mud. In the filter mud the nitrogen content was 1.63±0.0 on 1st day and 1.80±0.05 on the 60th day in control. After supplementing the filter mud with animal wastes the total nitrogen content increased in all the treatments on 1st day except buffalo dung treatment compared with control. But on the 60th day in all the treatments (T_0-T_4) the total nitrogen level increased significantly. More than 2 fold increase in nitrogen content was observed in all treatments. The increase in nitrogen contents during vermicomposting corroborates with the findings of other workers [13][17].

Total Phosphorus (TP)

Total phosphorus in vermicompost contributes the presence of phosphate, an important macronutrient. Phosphate content in the vermicompost must be in an optimal level to promote the vermicompost as a plant nutrient. In the present study total phosphorus was in the range 0.56-1.03 in all the reactors at 1st day. But in the 60th day vermibeds the amount of TP increased in T_1 ,T_3

Table 1. Variation in chemical constituents during vermicomposting of filtermud with animal wastes

Treatments	Days	pH	EC	TN	TP	TK	Organic Carbon %	Calcium%	Magnesium%	Sulphur%	Copper%	Zinc%	C/N ratio
T_0	1st day	8.40±0.05	1.02±0.00	1.63±0.03	0.73±0.03	0.53±0.03	52.46±0.08	1.54±0.01	0.53±0.03	0.53±0.00	1.16±0.03	0.13±0.03	34.73±0.34
	60th day	8.06±0.03	2.36±0.03	1.80±0.05	0.83±0.03	0.60±0.25	38.33±0.33	2.74±0.0	0.87±0.00	0.53±0.03	0.70±0.05	1.10±0.11	28.63±0.03
T_1	1st day	7.86±0.03	1.03±0.01	2.02±0.008	1.03±0.0	0.76±0.03	40.8±0.33	2.13±0.003	1.02±0.00	0.84±0.00	1.56±0.03	1.97±0.00	32.73±0.33
	60th day	7.13±0.00	2.04±0.00	4.07±0.00	2.66±0.04*	1.02±0.03*	26.71±0.01*	4.13±0.0*	2.23±0.01*	1.34±0.0*	2.10±0.005*	3.2±0.011*	14.04±0.01*
T_2	1st day	6.5±0.07	1.28±0.00	0.60±0.05	0.42±0.02	0.45±0.00	40.36±0.35	1.31±0.00*	0.61±0.00	0.39±0.50	0.43±0.03	0.60±0.05	38.56±0.17
	60th day	7.64±0.00	1.35±0.07	1.86±0.02	2.19±0.2*	0.99±0.00*	27.22±0.35*	2.50±0.03	1.91±0.00*	0.43±0.03*	0.87±0.03*	0.87±0.08*	17.42±0.04*
T_3	1st day	8.46±0.03	1.22±0.00	1.84±0.005	0.76±0.03	0.45±0.03	45.44±0.62	1.58±0.0	0.81±0.01	0.73±0.02	0.73±0.03	1.35±0.005	37.53±0.18
	60th day	7.53±0.00	1.90±0.00	4.06±0.00	2.47±0.01	1.10±0.01	31.83±0.62	3.11±0.0	1.5±0.00	1.21±0.00	1.23±0.03	1.70±0.05	14.50±0.11
T_4	1st day	7.83±0.03	1.07±0.00	1.56±0.012	0.66±0.08	0.43±0.033	47.68±0.88	1.58±0.0	0.69±0.00	0.62±0.00	0.56±0.03	1.08±0.00	38.00±0.05
	60th day	7.47±0.00	1.68±0.04	3.69±0.02	2.32±0.04	1.43±0.00	34.71±0.15	3.01±0.01	1.21±0.00	1.18±0.00	1.03±0.08	1.30±0.011	14.27±0.17

$P < 0.05$ - Significant * - non – significant

and T_4 (Table1) In buffalo dung treated filter mud the total phosphorus content was less on 1st and 60th day when compared with other treatments. The increase in TP content for control was in the range of (0.73±0.03). [17] had postulated that the increase in TP content during vermicomposting was through mineralization, release and mobilization of available phosphorus content from organic waste performed partly by earthworm gut phosphates and further release of phosphorus might be due to phosphate solubilizing microorganisms present in worm cast [18]; [19]. According to [20] the increase in phosphorus during vermicomposting was of the direct action of worm gut enzymes (Gut phosphates) and indirectly by stimulation of microflora.

Total Potassium (TK)

Potassium is one of the major nutrients essential for plant growth. The optimum presence of TK in a vermicompost elevates its nutritional value for application to crops. The total potassium content in all the vermireactors tested in the present study was in the range 0.43±0.033 - 0.76±0.03 at 1st day. But on the 60th day of vermicomposting the total potassium content level increased , The high concentration of TK in the above mentioned vermibeds (T_1,T_3, and T_4) must be due to higher mineralization rate as a result of enhanced microbial and enzyme activities in the guts of the earthworms as reported earlier [21].

Total Organic Carbon (TOC)

Total organic Carbon in 1st day and 60th day's vermicompost was estimated in filter mud as well as filter mud and animal wastes supplemented vermibeds. Total organic content in 60th day vermicompost was reduced when compared to 1st day old vermicompost. The TOC content in 60th day old vermicompost was in the range 26.71±0.01– 38.33±0.33 where as it was in the range 40.36±0.35 – 52.46±0.08 in 1st days old vermibeds. In all the treatment TOC decreased. The combined action of earthworms and microorganisms were responsible for TOC loss from initial feed [22], [23].

Calcium (Ca)

Calcium content in the vermicompost was higher than initial feed substrates. The increase in Ca level was higher in 60th days treatment than in 1st day treatment. In the 60th days vermicompost the highest Ca level was 4.13% observed in goat dung supplemented filtermud. The lowest level of Ca was noticed in filter mud vermibeds in which buffalo dung was supplemented (2.50±0.03). When compared to control filtermud, the hike in Ca level in (T_1) goat dung mixed filter mud was 87.23% on 60th day. [24] reported that Ca metabolism in earthworm is primarily associated with gut secreted enzymes. He had also reported that in few endogeic and anecic worms the calcium gland is considered to play an important role in calcium secretion.

Metals (Mg, S, Cu, Zn)

Vermicomposting caused significant changes in the metal content. In the present study the Mg, S, Cu, and Zn contents in the substrate was less in 1st days treated vermireactors than the control. In 60th days old vermibeds the Cu, Mg, S and Zn contents level increased. (Table 1 [22] also reported similar increase in vermicompost. [25] reported that there is no direct contribution of earthworm in Mg metabolism. However it is hypothesized that the fungal and micro-algal hyphae, which easily colonize on freshly deposited worm casts contributes to trace level of Mg, S, and Zn are important micronutrients and play an important role in plant physiology. Mineralization of partially digested worm faecal by detritus communities (bacteria and fungi) and their action in the foregut resulted in high level of extractable or available trace elements in vermicompost. [25], [26] stated that earthworm directly influences the availability of Zn in worm casts due to mineralization during passing of substrate through worms gut.

Carbon and Nitrogen Ratio (C/N)

The C/N ratio is traditionally used to establish the maturity degree of compost [27]. The C/N ratio in all the experimental set up including control (T_0-T_4) was in the range 32.73±0.33 to 38.56 ±0.17 at 1^{st} day of vermicomposting. But prolongation of *E.eugeniae* activity on vermibeds had reduced the C/N ratio significantly (Table 1). The C/N ratio was in the range 14.04±0.01 -17.42±0.04 after 60^{th} day vermicomposting. The decrease in C/N ratio was high in filter mud with goat dung (T_1), whereas in other treatments, filter mud supplemented with, goat dung, buffalo dung, sheep dung and Cow dung (T_1-T_4), the C/N ratio on 60^{th} day was reduced when compared to T_0. The C/N ratio is a factor related to the decomposition of the waste material and, even if it is recognized as a factor related negatively with the growth of earthworms and reproduction activities. In the present study, the observed decreasing trend in C/N ratio during vermicomposting is in good agreement with other authors [28], [17].

Conclusion

The present investigation clearly suggests that the incorporation of Goat dung, Sheep dung and Cow dung with filter mud convert this huge waste into highly valuable vermicompost. Due to excellent level of nutrient release into the filter mud by the action of *E. eugeniae*, the vermicompost becomes a good plant growth promoter. The results suggest that the filter mud supplementation with animal wastes promotes the activity of the earthworm and produce highly nutritive vermicompost. The study recommends that filtermud mixed with goat dung wastes is suitable mix for making vermicompost rich in nutrients and microorganisms which can be used as suitable organic soil amendment. The goat dung was suitable to produce a valuable organic soil amendment through vermi-conversion with *Eudrilus eugeniae* within 60 days.

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