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Vermiremdiation of Sugar Industry Waste using Earthworms *Eudrilus eugeniae, Perionyx excavatus* and *Eisenia fetida*

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ABSTRACT

Bagasse at different concentrations 100, 200, 400, 600 and 800 g/kg, were subjected to composting for first 60 days and subsequently vermicomposted for 60 days. The experiment was terminated on 120th day. Earthworm species chosen for the present study were E. eugeniae, P. excavatus and E. fetida. Earthworm was harvested and their weights and net reproductive rate (nrr) were evaluated. Compost and vermicomposted SIW were physico-chemically analyzed. No significant change in body weight of the earthworms was observed between the treated and untreated ones. Nrr of all the three species of earthworm were not affected on exposure SIW. Macro and micronutrients elevated both composted and vermicomposted of SIW. Further, heavy metals like Cr, Pb and Hg declined after composting and vermicomposting of SIW. This study demonstrates that vermicomposting technology could be an alternate strategy to convert the SIW bagasse into an agro beneficial product.

Keywords: *Eudrilus eugeniae, Perionyx excavatus, Eisenia fetida.* SIW**,** nrr

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INTRODUCTION

Although industrial development in our nation has played a vital role in boosting the economy, has it led to sustainable development is questionable. Impact of these industries on the environment is a threat to the biota. Reduction in the pollution load and innovative alternate technology to convert the industrial wastes into ecologically useful product is the need of the hour. Apart from sugar and alcohol as primary products, sugar industries and fermentation units also produce many by-products such as press mud, bagasse, distillery waste, and boiler ash and fermentation yeast sludge. All these wastes serve as an excellent source of nutrients. Earthworms are able to convert these wastes into fine mucus coated faecal pellets, popularly known as vermicompost. This is quality organic manure rich in beneficial micro flora and plant promoter substance along with major and micro nutrients necessary for plant growth in water soluble form so that they are immediately available for plant use [1,2]. Thus, earthworms are the natural fertilizer factories, which serve as bio-catalytic agents to enhance the soil fertility through physical, chemical and biological processes. Bagasse is the fibrous residue remaining after sugarcane or sorghum stalks are crushed to extract their juice. It is currently used as a biofuel and as a renewable resource in the manufacture of pulp and paper products and building materials. Agave bagasse is a similar material which consists of the tissue of the blue agave after extraction of the sap.

For each 10 tones of sugarcane crushed, a sugar factory produces nearly 3 tones of wet bagasse. Since bagasse is a by-product of the cane sugar industry, the quantity of production in each country is in line with the quantity of sugarcane produced. With this view, the present study was initiated to gain insight into the usage of SIW, bagasse as agro beneficial product. The present investigation was initiated with the following objectives: to profile the physicochemical characteristics of sugar industry waste; to observe the survivability of the earthworms *Perionyx excavatus, Eudrilus eugeniae* and *Eisenia fetida* on exposure to SIW; to compare the composted and vermicomposted product of SIW and to assess the best suitable species of earthworm in vermicomposting SIW.

MATERIALS AND METHODS

Sugar industry waste used in this study was collected from Kothari Sugar and Chemicals Ltd., Tamilnadu. Young non - clitellated specimen of *Eudrilus eugeniae, Eisenia fetida* and *Perionyx excavatus*, of 10 worms each were randomly picked from stock cultures containing 500 to 2000 earthworms each maintained in the garden with cow dung as culturing material. Weight of worms *Eudrilus eugeniae, Eisenia fetida and Perionyx excavatus*, were in the range of 0.52g to 2.36g, 0.05g to 0.25g and 0.07g to 0.77g, respectively. Preliminary study was conducted to examine the survivability of three species of earthworm *Eudrilus eugeniae, Eiseniae fetida* and *Perionyx excavatus* in the sugar industry waste inoculated vermibed. Sugar industry waste was mixed with cow dung and garden soil in different proportions as shown in table- 1. Control worms (not exposed to sugar industry waste) were maintained simultaneously. Bedding was kept moist throughout the experiment by regular watering. After 15 days of experimental period, survivability of the worms in different treatments was assessed.

Table- 1 Survivability of the earthworms exposed to SIW

Treatments	SIW(g)	Garden Soil (g)	Cow dung (g)	Total Weight (kg)	Mortality (%)		
					Eudrilus eugeniae	*Eiseniae fetida*	*Perionyx excavatus*
T_1	100	450	450	1	0	0	0
T_2	200	400	400	1	0	0	0
T_3	400	300	300	1	0	20	0
T_4	600	200	200	1	0	0	0
T_5	800	100	100	1	0	0	0
T_6	1000	-	-	1	40	30	30
Control	0	500	500	1	0	0	0

T-Treatment

I. *Eudrilus eugeniae*

100% survivability was detected in T_1, T_2, T_3, T_4, T_5 treatments and control. On the other hand, T_6 treatment elicited 60% survivability. In the present investigation, SIW at 100g/kg, 200g/kg, 400g/kg, 600g/kg and 800g/kg were chosen for vermicomposting employing *Eudrilus eugeniae* (Table 1).

II. *Eisenia fetida*

100% survivability was detected in T_1, T_2, T_4, T_5 exposed to SIW and control. On the other hand, T_3 and T_6 treatments elicited 80% and 70% survivability, respectively. In the present investigation SIW at 100g/kg, 200g/kg, 400g/kg, 600g/kg and 800g/kg were chosen for vermicomposting employing *Eisenia fetida* (Table 1).

Table- 2 Experimental design to evaluate the potentiality of the earthworms *Eudrilus eugeniae, Eisenia fetida* and *Perionyx excavatus* to vermicompost SIW

Treatments	SIW (g)	Garden Soil (g)	Cow dung (g)	Total Weight (kg)
T_1 x 3	100	450	450	1
T_2 x 3	200	400	400	1
T_3 x 3	400	300	300	1
T_4 x 3	600	200	200	1
T_5 x 3	800	100	100	1
Control	0	500	500	1

T- Treatment

III. *Perionyx excavatus*

100% survivability was detected in T_1, T_2, T_3, T_4, T_5 exposed to SIW and control. On the other hand, T_6 treatment elicited 70% survivability. In the present investigation, SIW at 100g/kg, 200g/kg, 400g/kg, 600g/kg and 800g/kg were chosen for vermicomposting using *Perionyx excavatus* (Table 1).

Inoculation of earthworms

Ten worms were inoculated in each pot. Weight of the worms (biomass in wet weight) was determined before the animals were inoculated using electronic balance. Composting of the SIW was carried out for 60 days and subsequently vermicomposted for 60 days. Reproductive parameters like number of hatchlings were counted by hand sorting. For the present study, five concentrations of the SIW were selected for vermicomposting. The experiments were performed in triplicates (Table 2).

Determination of growth and reproductive performance of worms

Weight of the earthworm was measured using monopan digital balance.

Reproductive performance

This was determined as the Net Reproductive Rate (nrr) and was computed following Dynes [3].

Physicochemical analysis of the vermicompost and PMS

A representative sample was taken from the homogenized garden soil, PMS and vermicompost for the sequential extraction of heavy metals and other analysis. pH was measured using Hanna pH meter 210. Electrical conductivity (EC) was determined using aqueous extract of air dried sample by Systronics Conductivity meter 304.

Total nitrogen was measured by following micro kjeldahl method [4].Extractable phosphorous was determined by following Olsen's sodium-bicarbonate extraction method using Tecator Model Enviroflow-50k autonalyser [5]. Exchangable elements (K,Ca and Mg) were determined after extracting the sample using ammonium acetate extractable method [6] and analysed by Perkin-Elmer model 3110 double beam Atomic Absorption Spectrophotometer (AAS). Heavy metals were determined by DTPA (diethylenetriaminepentaacetatic acid) extraction method. A Total of 10 gm of air-dried soil was taken in a 50ml conical flask and 20ml of the DTPA – extracting solution was added to it. The solution was extracted on a horizontal shaker for 2h. After exactly 2h of shaking, suspension was filtered by gravity through whatmann No.42 filter paper. The filtrate was analysed by the method adopted by Surindra Suthar [7] for Fe, Zn, Cu, Pb, Cr and Mn using AAS. The phenol is alkaline medium, combines with 4 amino antipyrine and potassium ferricyanide to form a red antipyrine dye which can be measured spectrophotometrically at 460 nm.

RESULTS

Impact of Bagasse on the worm growth parameters:-

No significant difference in body weight and nrr of SIW treated and untreated worms were observed, irrespective of the species (table 3 and 4).

Table – 3 Variation in the weight of the earthworm *Eudrilus eugeniae*, *Perionyx excavatus* and *Eisenia fetida* on exposure to SIW

Treatments	Weight (g)		
	Eudrilus eugeniae	***Perionyx excavatus***	***Eisenia fetida***
Control	1.0700^{a}	0.4300^{b}	0.3400^{a}
T_1	1.1800^{a}	0.7933^{ab}	0.6500^{a}
T_2	1.2100^{a}	0.9033^{a}	0.3200^{a}
T_3	1.2233^{a}	0.6500^{ab}	0.4133^{a}
T_4	1.1933^{a}	0.7833^{ab}	0.3500^{a}
T_5	1.1800^{a}	0.6833^{ab}	0.4867^{a}
F	0.781^{NS}	1.910^{NS}	0.821^{NS}

T- Treatment

****Significant at P < 0.001; n =3; NS- not significant; values are Mean; In a column, figures having dissimilar letters differ significantly according to Duncan New Multiple Range Test (DMRT)*

Table – 4 Variation in nrr of the earthworm *Eudrilus eugeniae* and *Perionyx excavatus* and *Eisenia fetida* on exposure to SIW

Treatments	nrr		
	Eudrilus eugeniae	*Perionyx excavatus*	*Eisenia fetida*
Control	0.1267^{b}	0.1700^{b}	0.1733^{b}
T_1	0.2800^{ab}	0.3000^{ab}	0.4333^{a}
T_2	0.4033^{a}	0.3800^{ab}	0.3300^{ab}
T_3	0.2233^{ab}	0.3033^{ab}	0.4100^{a}
T_4	0.3233^{ab}	0.3900^{ab}	0.3800^{ab}
T_5	0.3400^{ab}	0.4533^{a}	0.3000^{ab}
F	1.917^{NS}	2.056^{NS}	2.122^{NS}

T-Treatment

****Significant at P < 0.001; n =3; NS- not significant; values are Mean; In a column, figures having dissimilar letters differ significantly according to Duncan New Multiple Range Test (DMRT)*

Table – 5 Physico – chemical characteristics of SIW

S.No.	Name of the Parameters	SIW
1.	pH	7.65
2.	Electrical conductivity (dsm^{-1})	3.65
3.	Total Nitrogen (%)	2.36
4.	Total Phosphorus (%)	1.25
5.	Total Potassium (%)	2.63
6.	Total calcium (%)	4.53
7.	Total magnesium (%)	2.58
8.	Total Zinc (ppm)	1.26
9.	Total Copper (ppm)	1.63
10.	Total Iron (ppm)	56.36
11.	Total Manganese (ppm)	8.76
12.	Total Chromium (ppm)	0.53
13.	Total lead (ppm)	0.26
14.	Total phenols (mg kg^{-1})	2.34

SIW: Sugar Industry Waste

Physico chemical Characteristics of Bagasse (SIW)

pH of SIW was slightly alkaline (7.65). Electrical Conductivity was 3.65 dsm $^{-1.}$ Total nitrogen, phosphorus, Potassium, calcium and magnesium were found to be 2.36%., 1.25 %, 2.63 %, 4.53 % and 2.58 %, respectively. Heavy metals like total Zinc, Cu, Fe, Mn, Cr and Pb constituted 1.26 ppm, 1.63 ppm, 56.36, ppm, 8.76ppm, 0.53 ppm and 0.26ppm, respectively. Total phenol content was 2.34 mg kg^{-1}(Table 5).

Physico chemical analysis of composted SIW

pH of the composed SIW was slightly alkaline (7.09). Electrical conductivity was 1.05dsm^{-1}. Total nitrogen, phosphorus, potassium, calcium and magnesium were 3.59%, 1.94 %, 3.59 %, 4.58 % and 2.41 %, respectively. Heavy metals included zinc (1.63 ppm), copper (1.91 ppm), Fe (25.3 ppm), Mn (8.43), Cr (0.07ppm) and lead (0.01 ppm). Total phenol content was found to be 0.57 mg kg^{-1}.

Table – 6 Physico – chemical Characteristics of Composted SIW

S.No.	Parameters	Composted SIW
1.	pH	7.09
2.	Electrical conductivity (dsm^{-1})	1.05
3.	Total Nitrogen (%)	3.59
4.	Total Phosphorus (%)	1.94
5.	Total Potassium (%)	3.59
6.	Total calcium (%)	4.58
7.	Total magnesium (%)	2.41
8.	Total Zinc (ppm)	1.63
9.	Total Copper (ppm)	1.91
10.	Total Iron (ppm)	25.3
11.	Total Manganese (ppm)	8.43
12.	Total Chromium (ppm)	0.07
13.	Total lead (ppm)	0.1
14.	Total phenols (mg kg^{-1})	0.57

SIW: Sugar Industry Waste

Table – 7 Two way ANOVA showing variation in the physico- chemical parameters of vermitreated SIW

Species	Parameters													
	pH	EC (dsm^{-1})	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Zn (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)	Cr (ppm)	Pb (ppm)	Phenol (mg kg^{-1})
Eudrilus eugeniae	7.68^a	2.43^a	2.53^c	1.38^c	2.77^c	4.53^a	1.57^c	1.39^c	1.60^a	45.00^a	7.61^b	0.38^a	0.16^a	1.82^a
Perionyx excavatus	7.43^b	1.47^b	3.11^b	1.57^a	3.17^b	4.55^a	1.94^b	1.59^b	1.70^a	37.57^b	7.58^b	0.23^b	0.09^b	1.26^b
Eisenia fetida	7.17^c	1.13^c	3.41^a	1.67^a	3.69^a	4.51^a	2.36^a	1.92^a	1.63^a	29.75^c	8.45^a	0.12^c	0.03^c	0.77^c
F	49.623 ***	146.429 ***	72.506 ***	8.053 ***	17.101 ***	0.251 NS	116.211 ***	137.006 ***	1.683 NS	82.694 ***	45.467 ***	114.582 ***	96.691 ***	55.775 ***

Treatments	Parameters													
	pH	EC (dsm^{-1})	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Zn (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)	Cr (ppm)	Pb (ppm)	Phenol (mg kg^{-1})
Control	7.41^a	1.61^a	3.09^a	1.56^a	3.14^a	4.52^a	2.00^a	1.66^a	1.61^a	35.57^a	7.88^a	0.24^a	0.08^a	1.12^a
T_1	7.47^a	1.76^a	2.96^a	1.50^a	3.12^a	4.46^a	1.90^a	1.62^a	1.63^a	38.79^a	7.89^a	0.27^a	0.08^a	1.37^a
T_2	7.45^a	1.72^a	3.00^a	1.58^a	3.18^a	4.52^a	1.92^a	1.60^a	1.68^a	38.31^a	7.91^a	0.25^a	0.11^a	1.37^a
T_3	7.48^a	1.73^a	3.01^a	1.56^a	3.49^a	4.55^a	1.94^a	1.61^a	1.70^a	38.04^a	7.99^a	0.22^a	0.09^a	1.34^a
T_4	7.42^a	1.67^a	3.04^a	1.53^a	3.15^a	4.58^a	1.99^a	1.66^a	1.70^a	37.50^a	7.85^a	0.25^a	0.08^a	1.25^a
T_5	7.35^a	1.58^a	3.02^a	1.50^a	3.19^a	4.55^a	1.99^a	1.65^a	1.54^a	36.46^a	7.74^a	0.24^a	0.10^a	1.24^a
F	0.806 N.S	0.828 NS	0.366 NS	0.239 NS	0.758 NS	0.359 NS	0.731 NS	0.743 NS	1.252^{NS}	1.049 NS	0.619 NS	0.802 NS	1.608 NS	0.986^{NS}

*T- Treatment ***Significant at $P < 0.001$; $n = 3$; NS- not significant; values are Mean; In a column, figures having dissimilar letters differ significantly according to Duncan New Multiple Range Test (DMRT)*

Physico-chemical analysis of the vermicomposted SIW

The data presented in table 7, reveal significant difference ($F = 49.623$, $P < 0.001$) in the pH of the vermicomposted SIW among the species. *Eudrilus eugeniae* registered maximum pH of 7.68 followed by *P. excavatus* (7.43) and *E. fetida* (7.17). No such significant difference in the mean pH was evident among the different treatments and the control (table 7). Similar trend was exhibited among the species with regard to Electrical conductivity. Significantly ($F = 146.429$ $P < 0.001$) higher electrical conductivity was recorded by *Eudrilus eugeniae* (2.43 dsm^{-1}) when compared to other species (*Perionyx excavatus* : 1.47 dsm^{-1}; *E. fetida* 1.13 dsm^{-1}). On the other hand, no significant difference in electrical conductivity was noticed among the different treatments and untreated ones. The data pertaining to mean total Nitrogen reveal significant ($F = 72.506$, $P < 0.001$) difference among the earthworm species exposed to SIW. Maximum mean total nitrogen was elicited *E. fetida* (3.41 %), followed by *Perionyx excavatus* (3.11%) and *E. eugeniae* (2.53%). No such significant difference in mean total nitrogen was evident between the treatments and the control. Mean total phosphorus content of the vermicompost varied significantly ($F = 8.053$, $P < 0.001$) among the species. Maximum mean total phosphorus content was recorded by *E. fetida* (1.67 %) and *P. excavatus* (1.57 %) followed by *E. eugneiae* (1.38%) (Table7). On the other hand, the different concentration of SIW did not elicit any significant change in the mean total phosphorus content of the vermicompost. From table 7, it is evident that there is no significant difference in the mean total potassium among the different treatments. Mean total potassium content significantly varied ($F = 17.101$, $P < 0.001$) among the different species. Maximum potassium content was registered by *E. fetida* (3.69 %) followed by *P. excavatus* (3.17 %) and *E. eugeniae (*2.77%).

Mean total calcium content did not very significantly among the different species, as well as among the different concentrations of the SIW treated and the untreated ones. The data presented in table 7, reveal significant ($F = 116.211$, $P < 0.001$) difference in the mean total magnesium content among the different species tested. Maximum mean total magnesium was recorded by *E. fetida* (2.36 %) followed by *P. excavatus* (1.94 %) and *E. eugeniae* (1.57 %). Mean total Zinc content was found to significantly ($F = 137.006$, $P < 0.001$) vary among the different species tested. Maximum mean total Zinc content was registered by *E. fetida* (1.92 ppm) followed by *P. excavatus* (1.59 ppm) and *E eugeniae* (1.39 ppm). On the other hand, no such significant difference was noticed among the different concentrations of SIW and the control groups.

No significant difference between the mean total copper content was noticed among the different treatment and the control group. Similarly, there was no significant difference in the mean copper content among the different species tested. From table 7, it is revealed that significantly ($F = 82.694$, $P < 0.001$) higher mean total iron content was registered by *E. eugeniae* (45.00 ppm), followed by *P. excavatus* (37.57 ppm) and *E. fetida* (29.75 ppm). No significant difference in the mean manganese content was observed among the treatments and control group. Mean total manganese content of the vermicompost varied significantly (F = 45.467 P < 0.001) among the species. *E. fetida* registered maximum value of (8.45 ppm), followed by *E. eugeniae* (7.61 ppm) and *P. excavatus* (7.56 ppm), whereas, no such significant differences were elicited among the different treatments and the control. From table 7, its evident that *E. eugeniae* registered significantly (F = 114.582, P< 0.001) higher mean total chromium content of 0.38 ppm, followed by *P. excavatus* (0.23 ppm) and *E. fetida* (0.12 ppm). On the other hand, no such significant difference was noticed among the different concentration of the SIW and the untreated ones. The data displayed in table 7, revealed significant (F = 96.691, P < 0.001) increase in the mean total lead by *E. eugeniae* (0.16 ppm) followed by *P. excavatus* (0.09 ppm) and *E. eugeniae* (0.03 ppm). Different experimental groups did not vary significantly with regard to the mean total lead content. Significantly (F = 55.775, P < 0.005) higher mean total phenol content was recorded by *E. eugeniae* (1.82 mg kg^{-1}), followed by *P. excavatus* (1.26 mg kg^{-1}) and *E. fetida* (0.77 mg kg^{-1}). On the other hand, no such significant difference in the mean total phenol content was noticed among the different treatments and the control group.

DISCUSSION

Food requirements play an important role in the growth and reproduction of earthworm *(E. Andrei*)[8]. Earthworm population depends on both physical and chemical properties of the soil, such as soil temperature, moisture, pH, salts, aeration and texture, as well as available food, and the ability of the species to reproduce and disperse. The net reproductive rate of the various species was not affected by SIW. Munnoli and Saroj Bhosle [9] have reported that optimum proportion of soil + cow dung (1:3) for culturing of earthworms has shown highest number earthworm hand sorted in three earthworms (*E. fetida*:20; *E. eugeniae* : 35; *M. megaseolex*:32) after 32 days. This observation lies in line with the present findings. Net reproductive rate of the earthworms were not affected by SIW. This observation is well supported by Umamaheswari et al., [10] who have also reported that there was no significant increase in the number of worms harvested and the net reproductive rate of *E. eugeniae* exposed to PMS (paper mill sludge).

Sangwan et al., [11] have recorded maximum growth of *Eisenia fetida* grown in 100% cow dung. Further, they have observed that earthworms grew and reproduced favorable up to 1:1 press mud and cow dung feed composition earthworms are sensitive to pH. Thus pH of soil or waste is sometimes a factor that limits the distribution, numbers and species of earthworms. Little information is available on effect of substrate pH during vermicomposting. Sugar industrial waste exhibited slightly alkaline pH of 7.65 in the present study. But several researchers have stated that most species of earthworms prefer a pH of about 7 [12,13,14,15]. However, *Lumbricus terrestris* occurs in soils with pH 5.4 in Ohio, USA[16]. Satchell [17] reported that *Bimastos eiseni, Dendrobaena octaedra* and *Dendrobaena rubida* were acid tolerant species, and *Allolobophora caliginosa*, *Allolobophora nocturna*, and *Allolobophora longa* were acid intolerant ones. Further, he has reported that *Lumbricus terrestris* was not very sensitive to pH. Composted and vermicomposted SIW showed a decline in pH when compared to raw SIW. This result is well supported by Edwards [18] who have reported a wide range of pH 5-0 to 9.0 for maximising the productivity of earthworms in the waste management. Furthermore, Bhawalkar [19] has suggested for neutral pH for substrates to be used in vermicomposting. Singh et al., [20] revealed that earthworms play a significant role in the processing of substrates having different initial pH. Among the three species tested, *Eudrilus eugenia* exhibited low pH. This could be attributed due to conversion of complex compounds into simpler forms during the log and stabilization phases of microbial action leading to formation of weak acids, which become predominant in comparison to formation of basic compounds and / or hydroxides. Decline in pH was also observed during the study of changes in biochemical properties of cow manure by earthworms *(Eisenia andrei Bouche*) [21].This finding is further supported by the observation that pH values of cow manure exhibited slight changes in pH with and without earthworms (*E.andrei*). In contrast to the present observation, pH value of the manure increased and moved towards neutrality during decomposition without earthworms. Gajalakshmi and Abbasi [22] have opined that soil pH sometimes limits the distribution, number and species of earthworms that live in a particular soil. Most species prefer soils with a pH close to 7 [23]. pH of all agro-industrial wastes was slightly deviated from the neutral pH [24]. Further, they have registered pH of 6.7 for bagasse. In this study, pH of Bagasse was 7.65. Electrical conductivity of the raw SIW declined after subjecting it to composting and vermicomposting. Kitturmath et al.,[24] have reported that the electrical conductivity of different agro-industrial wastes ranged from 0.76 dsm^{-1} (coir waste) to 1.15 dsm^{-1} (press mud). Further, they observed electrical conductivity of 0.82 dsm^{-1} for Bagasse, which is quite low when compared to the present study (3.65dsm^{-1}).

Relative to the raw SIW, nutrient composition especially nitrogen, phosphorous and potassium have been elevated during the composting and vermicomposting process in this study. Comparatively, vermicompost has been shown to be richer in many nutrients than compost. Kitturmath et al.,[24] have registered in bagasse N. and K content of 0.70%, 2.01% and 0.82%, respectively. Comparatively, in this study N and K were higher (2.36% and 2.63% when compared to phosphorus (1.25%). Further, they have observed that potassium declined in the vermicompost obtained from bagasse 50% + paddy straw 50% (74%).

The present finding is in good accord with that of Sangawan et al.,[11] who have registered increase in N, P and Ca concentration of pressmud vermicompost employing *Eisenia fetida* and have suggested that vermicomposting could be an alternative technology for the management of pH into useful fertilizer material, if mixed at maximum 50% with cow dung. Micronutrients like Zn content elevated, whereas Fe and Mn declined. No considerable change in the Cu content of the vermicompost was observed. On the other hand, during the composting process, micronutrients like Zn and Cu elevated while that of Iron declined. There was no drastic difference in the manganese content of the SIW before and after composting. In contraction to the present observation, Kihurmath et al.,[24] have recorded copper content (78.32 ppm) with vermicomposting 100% bagasse. Increase in the Zn content of the vermicomposted bagasse gains support from the observation of Kitturmath et al., [24] who have also registered maximum zinc content of 245-61ppm in bagasse (100%) vermicompost.

The present findings are in agreement with the findings of Uthaiah [25]. Jeyabal and Kuppusamy [26], Parthasarathi and Ranganathan [27] and Muthukumarasamy et al., [28] observed increased nutrient contents of vermicompost obtained from press mud, bagasse and coir waste.

Heavy metals like Cr, Pb and Hg declined in the SIW after subjecting to vermicompsting and composting. This indicates the heavy metal bioaccumulation potential of *E. eugeniae, P.excavatus* and *E. fetida.* There was no considerable variation in the copper content of SIW prior to and after vermicomposting. Total phenols also declined after composting and vermicomposting bagasse. As evinced in this study Umar and Sharif [29] have also reported that sugar sludge on vermicomposting with *Darwida nepalensis* and *Remiella bishambari* resulted in high nutrient value (N, P and K) with heavy metal reduction.

Elevation in nutrient content (N, P and K) in vermicomposted bagasse is in good accord with Manivannan [30] who have reported significant increase in N, P and K after 60 days of processing (BFA(bagasse fly ash) + CD (cow dung) (3:1) and BFA + CD (1:1) for both *E.fetida* and *E. eugeniae.* On contrary to the present finding, they have also observed that *E.fetida* and *E. eugeniae* elevated maximum biomass production, maximum cocoon numbers and hatchling production in the 1:1ratio of BFA + CD (T_2) mixtures as compared to other treatments (BFA + CD 1:3) and control (BFA alone). They have concluded that vermicomposting this earthworms *E. fetida* and *E. eugeniae* could be an alternative technology for the management of BFA if it is amended in 1:1ratio with cow dung. Vasanthi et al., [31] have attempted to recover nutrients from filter mud from sugar factory by vermicomposting using *E. eugeniae* and organic nutrient like Jeevamirtham, Panchagavya, *Azospirillum* and cow dung and convert it to nutrient rich manure. They have observed that these organic nutrients promote the activity of earthworm and produce highly nutritive vermicomposts (elevation in N, P, K). Our findings are in line with Marlin Cynthia and Rajeshkumar [31] who have observed significant elevation in NPK of vermicomposted sugar mill effluent using *Lampito mauritii.*

Padmavathi [33] demonstrated that *E. fetida* efficiently degraded sugar mill waste (press mud) and sago industry waste after a period of 60 days. As evinced in this study, she has also recorded significant elevation in NPK content of the vermicompost. On the other hand, she noticed reduction in organic carbon and have attributed it to the respiratory activity of the earthworms. Bhandarkar et al.,[34] have observed that *E. eugeniea* was capable of converting 50% of organic matter of bagasse waste into vermicompost. They noticed reduction in COD and TOC of bagasse waste by 64% and 75.5%, respectively in 45 days period. They have also noticed buffering of initial acidic pH to neutral and have attributed it to vermicomposting. They have noticed significant increase in Ca, Mg, Na and K and fourfold increase in nitrogen content. In addition, they noticed significant reduction in C/N ratio from 715.71 to 54.44in 45 days period. Furthermore, they have noticed that biomass weight doubled in 45 days period and who weight of bagasse reduced to 53.79% of initial weight.

Vasanthi et al., [35] have supplemented along with filter mud of sugar factory with cow dung and in another vermibed filter mud with jeevamirtham. They observed increase in mean weight of earthworms in the filter mud cow dung vermibed 704.22 ± 59.62 mg (94.26%) but in filter mud-jeevamirtham vermibed the mean weight increase was 803.32 ± 91.40(145.18%). They have concluded that jeevamirtham enhanced the growth of worms. They have also found that jeevamirtham supplementation strengthens the viability of the eggs. In addition, they have noticed that in jeevamirtham mixed vermibed both the cocoons production and hatch ling numbers were significantly higher than the vermibed in which cow dung was applied. In addition they observed elevated level of N, P, K and micronutrients like Ca, Mg and S in jeevamirtham mixed vermicompost. Further, they have noticed that the pH of the vermicompost prepared using jeevamirtham increased from its original value towards neutral. They have concluded that macronutrients and micronutrient content increased significantly in the vermicompost prepared from press mud waste due to the supplementation of jeevamirtham. They have observed that in the jeevamirtham supplemented vermicompost C/N ratio was 55.5% higher than was present in the cow dung added vermicompost.

CONCLUSION

From the literature and the present observation one could conclude that the nature and composition of the agro industrial wastes and substrates used would ultimately influence the level of nutrients present in the vermicompost. Although maximum reproduction rates were achieved in the mixtures of cow dung and SIW, in order to better understand the mechanisms by which the bulking agents influence the growth of *Eisenia fetida, Perionyx excavatus* and *Eudrilus eugeniae,* further studies will be carried out in future. SIW when vermicomposted using earthworms enhanced the macro and micronutrient content of the vermicast. Furthermore, decline in the heavy metal composition of SIW was observed. Compared to composting, vermicomposting of SIW proved to enhance the nutrient content. This study primarily indicates that SIW could be vermicomposted and then utilized for agriculture benefits.

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