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Bioremediation of dye industrial sludge by the epigeic earthworm *Eudrilus eugeniae*

Murali. M[1*] and Umamaheswari. S[2]

[1]P.G. Department of Biotechnology, Krishna Arts and Science College, Krishnagiri, India.
[2]P.G and Research Department of Zoology, Periyar EVR College, Tiruchirappalli, India.
*Corresponding Author E-mail: dpimurali2523@gmail.com

Abstract

The influx of textile waste effluents into waterways poses threat to the flora and fauna inhabiting the aquatic habitat and general health of the public residing in that area. This study was an attempt to convert the DIS (Dye industrial sludge) into vermicompost, which in turn could be used to improve the physical, chemical and biological properties of the soil. Resultantly, could also enhance the plant growth yield. DIS at 5 g/kg, 10 g/kg, 20 g/kg, 30 g/kg and 40 g/kg concentrations were subjected to composting using *Eudrilus eugeniae.* The physico-chemical analyses of the vermitreated DIS reveal significant enhancement in the N and Fe in all the treated groups when compared to the control. On the other hand, significant elevation in K, Ca, Mg, Pb and Mn was evinced at 40g / kg vermicompost of DIS when compared the control and other treated groups. Significant elevation in phenol content of vermitreated DIS was evident at 40 g/kg and 30 g/kg when compared to the control and other treated groups. DIS at 40 g/kg 30 g/kg and 10 g/kg exhibited significant elevation in the phosphorus content on vermitreatment with *Eudrilus eugeniae* when compared to the control and other treated groups. pH of DIS shifted towards acidity on composting with *Eudrilus eugeniae*.

Keywords: Physico-chemical, Dye industrial sludge, Vermicompost.

Introduction

The disposal and management of solid wastes generated by textile industries is a burden to the industries. Although, land filling practises and incineration are quite a few options for management of these wastes, cost-effective, time-effective and eco-friendly method has to be devised. These dye wastes are known to contain high organic matter, N, P, K, micronutrients, salt, acids, alkalis and heavy metals (Balan and Monteiro, 2001; Marian *et al*., 2005). Textile industries have been placed

in the category of the most polluting industries by the Ministry of Environment and Forests, Government of India (Garg and Kaushik, 2004). In recent years, earthworms have been widely used in the breakdown of a wide range of organic residues including sewage sludge, animal wastes, microbe residues and industrial refuse in producing vermicompost (Dominguez and Edwards, 1997). Some epigeic earthworm: *Lumbricus terrestris, Eisenia fetida, E.andrei, Eudrilus eugeniae* and *Perionyx excavatus* have appeared as sources to combat the problems of organic waste disposal on a low input basis (Kale *et al*., 1992; Butt 1993; Elvira *et al*., 1998; Dominguez *et al*., 2001; Garg and Kaushik, 2005). *Eudrilus eugeniae* is popularly called as "African Night Crawler" originally oriented in Africa, present found distributed in most parts of the world. In India since 1930's *Eudrilus eugeniae* is reportedly distributed in Travancore, Pune and North konkan. This species is recommended for vermiculture in India. The present study aimed to study the efficiency of *Eudrilus eugeniae* to convert dye industrial sludge into agro beneficial products.

Materials and Methods

Sample collection and Survivability of *Eudrilus eugeniae* exposed to DIS

Earthworm**,** *Eudrilus eugeniae* was chosen as the experimental animal. The dye industrial sludge were collected from textile dye industry located at Tirupur, Tamil Nadu, India. Preliminary study was conducted to examine the survivability of the earthworm *Eudrilus eugeniae* on exposure to this dye waste. They were cultured in dye industrial sludge which was mixed with cow dung, garden soil and dye sludge in different proportions as shown in Table 1. Control earthworms (not exposed to DIS) were maintained simultaneously.

After 14 days of experimental period, survivability of the earthworm in different treatments were assessed. 100 % survivability was detected in the control and treatment T1 to T5. On the other hand, T6 to T9 exhibited survivability in the range of 80 % to 90 %. For the present experiment, five concentration of the DIS were selected for vermicomposting of DIS. The experiments were performed in triplicates (Table 2). The experiment was terminated on the 45^{th} day. A control was maintained simultaneously which was not exposed to DIS.

Physico – chemical analysis of the garden soil, dye sludge and vermicompost

A representative sample was taken from the homogenised garden soil, DIS and vermicompost for 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 (Jackson, 1973). Extractable phosphorous was determined by following Olsen's sodium-biocarbonate extraction method using Tecator Model Enviroflow-50 k autoanalyser (Olsen, 1954). Exchangeable elements Potassium (K), Calcium (Ca) and Magnesium (Mg) were determined after extracting the sample using ammonium acetate extractable method, analysed by Perking-Elmer model 3110 double beam Atomic Absorption Spectrophotometer (AAS) (Simrad, 1993).

Heavy metals were determined by DTPA (diethylene triamine pentaacetic acid) extraction method. A total of 10 g of air-dried soil was taken in a 50 ml conical flask and 20 ml of the DTPA- extracting solution was added to it .The solution was extracted on a horizontal shaker for 2 hours. After exactly 2 hours of shaking, suspension was filtered by gravity through Whatmann No.42 filter paper. The filtrate was analysed by the method adopted by Surindra Suthar (2008) for Iron (Fe), Zinc (Zn), Copper (Cu), Mercury (Hg), Chromium (Cr), and Manganese (Mn) using AAS. The phenol in alkaline medium combines with 4 amino antipytine and potassium ferricyanide to form a red antipyrine dye which can be measured spectrophotometrically at 460 nm.

Statistical Analysis

The results were statistically analyzed using one way analysis of variance (SPSS Package version 16).

Result

Physico-chemical analysis of the Dye industrial Sludge

The data pertaining to the physico-chemical nature of industrial dye sludge is presented in Table 3. The pH of the sludge was slightly alkaline (8.46). Electrical conductivity, total nitrogen, total phosphorus, total potassium, total calcium and total magnesium content were 2.59 dsm^{-1}, 1.12%, 0.26%, 2.06%, 4.98%, and 2.06%, respectively. The heavy metals like total copper (0.58 ppm), total iron (10.26 ppm), total manganese (2.48 ppm), total chromium (0.87 ppm), total lead (0.22 ppm) and total mercury (0.26 ppm) were quantified in the industrial dye sludge. Total phenols content of the sludge was 0.12 mg/ kg. The data pertaining to garden soil reveal pH and electrical conductivity of 8.16 and 0.45 dsm^{-1}, respectively (Table **3**). The total N, P, K, Ca and Mg were found to be 0.42%, 0.16%, 0.39%, 2.19% and 1.08%, respectively. The heavy metal constituents were Cu (0.86 ppm), Iron (16.79 ppm) and Hg (8.48 ppm).

Physico-chemical changes during vermicomposting process

As presented in Table 4, the mean pH of the dye sludge vermicompost of *Eudrilus eugeniae* significantly ($F = 25.924$, $P < 0.001$) decreased in all the treated groups (40 g/kg: 7.8267; 5g/kg: 7.7100; 30g/kg: 7.6800; 20g/kg: 7.6333: 10 g/kg 7.6600) when compared to the control ones (8.2600). The vermitreated DIS employing *Eudrilus eugeniae* exhibited significant ($F = 32.860$, $P < 0.001$) increase in the mean electrical conductivity (5 g/kg: 0.4200 dsm^{-1};10 g/kg 0.3967 dsm^{-1}; 30 g/kg: 0.3867 dsm^{-1}; 20g/kg: 0.3167 dsm^{-1} and 40 g/kg 0.2967 dsm^{-1}) when compared to control (0.1600 dsm^{-1}). Statistically significant ($F = 68.126$, $P < 0.001$) elevation in the mean total nitrogen of *Eudrilus eugeniae* vermicomposted of DIS was evident at all concentrations of DIS (40 g/kg: 1.0933% followed by 30 g/kg: 0.9400%; 20 g/kg: 0.9233%; 10 g/kg: 0.8733%; 5 g/kg: 0.6933%) when compared untreated one (0.5400%). Significant ($F = 3.823$, $P < 0.05$) increase in the mean total Phosphorous content of the vermicompost dye sludge was registered at 30 g/kg (0.5567%), 40 g/kg (0.5500%) and 10 g/kg (0.4067%) when compared to the control (0.2900%) and other treatments (20 g/kg: 0.3267% and 5 g/kg: 0.3033%). Mean potassium content of the dye sludge vermicompost with *Eudrilus eugeniae* revealed no significant increase at 40 g/kg concentration (0.7333%), when compared to the control (0.7200%), 30 g/kg (0.6533%), 10 g/kg (0.6200%), 5g/kg (0.5733%) and 20 g/kg (0.5800%).

From the experimental results, significant increase ($F = 89.481$, $P < 0.001$) in the mean calcium content of the dye sludge vermicompost of *Eudrilus eugeniae* was observed at 40g/kg treatment (3.8233%) when compared to the control (3.1400%) and other treatments (30 g/kg: 2.5233%; 20 g/kg: 2.3767%; 10 g/kg: 2.3233%; 5 g/kg: 2.2533%). Mean total copper content of the vermicompost significantly ($F = 55.257$, $P < 0.001$) increased at all concentrations of DIS vermitreated with *Eudrilus eugeniae* (40 g/kg: 1.8100 ppm; 30g/kg: 1.7033 ppm; 20 g/kg 1.6167 ppm; 10 g/kg: 1.3200 ppm; 5g/kg: 1.3500) when compared to the control (1.0500 ppm).

Significant ($F = 484.532$, $P < 0.001$) increase in the mean total Fe content of the vermicompost was observed at all concentrations of DIS vermitreated with the *E. eugeniae* (40g/kg: 54.3533 ppm; 30 g/kg 54.3533 ppm; 20 g/kg: 54.3533 ppm; 10 g/kg: 53.4167 ppm and 5g/kg: 52.8533 ppm) when compared the control (35.4500 ppm). Significant ($F = 4.064$, $P < 0.05$) elevation in the mean total magnesium content of the dye sludge vermicomposted with *Eudrilus eugeniae* at 40 g/kg (1.8067%), 5g/kg (1.7167%) and 10 g/kg (1.5967%) was observed when compared to the control

(1.2400%) and other treated group 30 g/kg (1.3733 %) and 20 g/kg (1.1933%). Mean total of lead content of DIS subjected to vermicomposting with *Eudrilus eugeniae* was significantly ($F = 17.160$, $P < 0.001$) elevated at DIS of 40 g/kg (0.5700 ppm), 30 g/kg (0.4033 ppm) and 20 g/kg (0.2700 ppm) when compared to lower concentration (10g/kg: 0.2100 ppm; 5 g/kg 0.1500 ppm) and control (0.1200 ppm). Mean total chromium content of dye sludge vermicomposted with *Eudrilus eugeniae* significantly ($F = 32.8400$, $P < 0.001$) increased in all the treated groups (40g/kg: 0.6067 ppm; 30 g/kg: 0.4367 ppm; 20 g/kg: 0.3867 ppm; 10 g/kg: 0.2833 ppm) except at 5 g/kg concentration (0.1433 ppm) when compared to control (0.0600 ppm). Significantly ($F = 24.428$, $P < 0.001$) higher total manganese content of the dye sludge vermicompost of *Eudrilus eugeniae* was observed at 40 g/kg (13.8633 ppm), 30 g/kg (12.2867 ppm) and 20 g/kg: (11.1167 ppm) when compared to control (10.7200 ppm). Minimum total manganese content was registered at 5 g/kg: 10.4433 ppm and 10 g/kg: 10.100 ppm. 30 g/kg concentration of DIS vermicomposted with *Eudrilus eugeniae* exhibited significant ($F = 3.372$, $P < 0.05$) increase in mean total phenol (0.1133 mg/kg) followed by 40 g/kg: (0.1067 mg/kg) when compared to the control (0.0800 mg/kg) and other treated groups (5g/kg: 0.0833; 10 g/kg: 0.0733; 20 g: 0.0800 g/kg).

Table-1 Survivability of *Eudrilus eugeniae* exposed to DIS

Treatment	DIS (g)	Garden soil (g)	Cow dung (g)	Total (kg)	Survivability of earthworms (%)
Control	-	500	500	1	100%
T1	5	497.5	497.5	1	100%
T2	10	495	495	1	100%
T3	20	490	490	1	100%
T4	30	485	485	1	100%
T5	40	490	490	1	100%
T6	50	480	480	1	80%
T7	60	470	470	1	90%
T8	70	465	465	1	90%
T9	80	460	460	1	90%
T10	90	455	455	1	0
T11	100	450	450	1	0

DIS - Dye Industrial Sludge; T-Treatment; - nil

Table-2 Experimental design to evaluate the potential of the earthworm *Eudrilus eugeniae* to vermicompost DIS

Treatment	DIS (g)	Garden soil (g)	Cow dung (g)	Total (kg)
Control	-	500	500	1
T1×3	5	497.5	497.5	1
T2×3	10	495	495	1
T3×3	20	490	490	1
T4×3	30	485	485	1
T5×3	40	490	490	1

DIS - Dye Industrial Sludge; T-Treatment; - nil

Table-3 Analysis of physico-chemical parameters of dye industrial sludge and soil used in the experiment

Parameters	Dye Sludge	Garden Soil
pH	8.46	8.16
Electrical conductivity (dsm^{-1})	2.59	0.45
Total nitrogen (%)	1.12	0.42
Total Phosphorus (%)	0.26	0.16
Total Potassium (%)	2.06	0.39
Total Calcium (%)	4.98	2.19
Total Magnesium (%)	2.06	1.08
Total Copper (ppm)	0.58	0.86
Total Iron (ppm)	10.26	16.79
Total Manganese(ppm)	2.48	Nil
Total Chromium (ppm)	0.87	Nil
Total Lead (ppm)	0.22	Nil
Total Mercury (ppm)	0.26	8.48
Total Phenols (mg/ kg)	0.12	Nil

Table 4 One way ANOVA showing physico-chemical changes in the Vermicomposted DIS employing *Eudrilus eugeniae*

Treatment	pH	EC dsm^{-1}	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Calcium (%)	Copper (ppm)
Control	8.2600 a	0.1600 c	0.5400 d	0.2900 b	0.7200 ab	3.1400 b	1.0500 d
5 g	7.7100 bc	0.4200a	0.6933 c	0.3033 b	0.5733 c	2.2533 d	1.3500 c
10 g	7.6600 c	0.3967 a	0.8733 b	0.4067 ab	0.6200 abc	2.3233 cd	1.3200 c
20 g	7.6333 c	0.3167 b	0.9233 b	0.3267 b	0.5800 bc	2.3767 cd	1.6167 b
30 g	7.6800 bc	0.3867 a	0.9400 b	0.5567 a	0.6533 abc	2.5233 c	1.7033 ab
40 g	7.8267 b	0.2967 b	1.0933 a	0.5500 a	0.7333 a	3.8233 a	1.8100 a
F	25.924***	32.860***	68.126 ***	3.823^{*}	2.615^{NS}	89.481 ***	55.257***

* Significant at P < 0.05, *** Significant at P < 0.001, EC – Electrical conductivity,

NS-Not Significant.

In a column, figures having similar letter (s) do not differ significantly whereas figures having dissimilar letters differ significantly according to Duncan New Multiple Range test (DMRT).

Table 4a One way ANOVA showing physico-chemical changes in the Vermicomposted DIS employing *Eudrilus eugeniae*

Treatment	Total Iron (ppm)	Total Magnesium (%)	Total lead (ppm)	Total Chromium (ppm)	Manganese (ppm)	Total Phenol (mg/ kg)
Control	35.4500 c	1.2400 c	0.1200 d	0.0600 d	10.7200 cd	0.0800bc
5 g	52.8533 b	1.7167 ab	0.1500 cd	0.1433 d	10.4433 cd	0.0833 bc
10 g	53.4167 ab	1.5967abc	0.2100 cd	0.2833 c	10.1000 d	0.0733 c
20 g	54.3533 a	1.1933 c	0.2700 c	0.3867 bc	11.1167 c	0.0800bc
30 g	54.3533 a	1.3733 bc	0.4033 b	0.4367 b	12.2867 b	0.1133 a
40 g	54.3533 a	1.8067 a	0.5700 a	0.6067 a	13.8633 a	0.1067 ab
F	484.532 ***	4.064^{*}	17.160***	32.840***	24.428***	3.372 *

***Significant at P < 0.001, * Significant at P <0.05

In a column, figures having similar letter (s) do not differ significantly whereas figures having dissimilar letters differ significantly according to Duncan New Multiple Range test (DMRT).

Discussion

In this study, potential of *Eudrilus eugeniae* to transform solid textile mill sludge into vermicompost and the feasibility of vermicomposting in industries for waste management have been investigated. The physico-chemical profiles of the dye sludge were analysed, which revealed that most of the parameters and components of the sludge has crossed the standard permissible limits. Vermicompost samples with and without dye sludge were analysed for their physical and chemical properties. Dye sludge vermicompost of *Eudrilus eugeniae* exhibited significant decrease in pH when compared to the control, which coincides with the findings of Ravindran *et al*., (2008) who have reported that vermicomposting solid waste generated from leather industries using epigeic earthworm *E. fetida* resulted in reduction of pH when compared to the control. The present study is in good accord with Garg *et al*., (2006) who have observed that vermicompost of wastewater sludge from textile mill mixed with aerobically digested biogas plant slurry employing *Eisenia fetida* resulted in pH shift towards acidic. The present observation is in good accord with Vimala *et al*., (2013) who have also demonstrated that vermitreatment of municipal solid waste in combination with textile industry sludge declined at the 60^{th} day and have attributed it to microbial decomposition during the process of vermicomposting (Suthar, 2007). On contrary, decrease in pH of vermitreated (*Eudrilus eugeniae*) CETP (Common Effluent Treatment Plant) mixed with cow dung and crop waste recorded by Parameswari and Udayasooriyan (2013).

The present findings is not in coincidence with the observation of Bhat *et al*., (2013) who have reported elevated pH in the vermicomposted (*Eisenia fetida)* textile mill dyeing sludge and cattle dung for a period of 10 days. As evinced in this study , shift in pH towards acidity from alkaline pH in all the fed mixtures (poultry droppings, Biogas plant slurry and solid textile mill sludge) were recorded by Garg and Kaushik, (2004) and have attributed it to mineralization of nitrogen and phosphorus into nitrites / nitrates and orthophosphates and bioconversion of organic material into intermediate species of organic acids (Ndegwa *et al*., 2001). Electrical conductivity significantly increased in vermitreated DIS when compared to the control. This result coincides with that of Parameswari and Udayasooriyan, (2013) who have also registered increased EC during the process of vermicomposting textile dye sludge spiked with carbonaceous materials and organic manure. On contrary, decline in EC was recorded by Bhat *et al*., (2013), in vermitreated (*Eisenia fetida)* textile mill dyeing sludge spiked with cow dung**.** ***E****udrilus eugeniae* earthworm enhanced the nitrogen

content of the dye sludge vermicompost . This finding coincides with that of Rajesh Banu *et al*., (2008) who have reported many fold increase in nitrogen content of sago-sludge vermicompost of the earthworm *Lampito mauritti*. It also agrees with the findings of Garg *et al*., (2006) who have detected increase in nitrogen content of the vermicompost of *Eisenia fetida* textile mill sludge mixed with anaerobically digested biogas.

As observed in this study Garg and Kaushik (2004) have also noticed elevation in nitrogen content of STMS spiked with cow dung; STMS + poultry droppings and SMST + plant slurry. The elevation of N content of vermitreated DIS gains support from the findings of Parameswari and Udayasooriyan (2013) who have stated that in general, the total N content invariably increased in vermicompost, irrespective of different materials (cow dung, poultry waste and crop waste) mixed with Textile mill dyeing sludge**.** On other hand, significant increase in total phosphorus of the vermicompost employing *E. eugeniae* was exhibited by higher concentrations (30 g/kg and 40 g/kg) of DIS. This observation gains support from Garg *et al*., (2006) who have found that solid textile mill sludge spiked with anaerobically digested biogas plant slurry using *Eisenia fetida* increased the total phosphorus content of the vermicompost. The present result is in parallel to the observations of Garg and Kaushik (2004) who have also the observed that feed mixtures (cow dung, poultry + solid textile mill sludge; Biogas plant slurry + solid textile mill sludge + cow dung) under earthworm treatment exhibited faster increase in TP (Total phosphorus) content than did the feed mixtures without earthworm, which showed the efficacy of earthworms in mineralization of TP in feed mixture. Dye sludge at higher concentrations (40 g/kg) vermicomposted with *E. eugeniae* exhibited significant elevation in total potassium content when compared to untreated worms and other treated worms. Significant decline ($P < 0.05$) in total potassium content of vermicomposted dyeing sludge from textile mill spiked with cattle dung have been demonstrated by Bhat *et al*., (2013) and have attributed it to the use of potassium by earthworm during metabolic activity (Singh *et al*., 2010; Vig *et al*., 2011). Orozco *et al.*, (1996) also attributed the decline in potassium to leaching during vermicomposting. The present findings partially agrees with that of Garg and Kausik (2004), who have evinced TK (Total potassium) concentration in the final vermicompost, which were slightly lower than the initial feed mixture (CD (cow dung) + STMS (Solid Textile Mill Sludge) ; PD (Poultry droppings) + STMS), whereas were higher in the vermicast of feed mixtures STMS+BPS (Biogas plant slurry).

Vermicomposting of solid textile mill sludge mixed with cowdung and agricultural residues resulted in significant increase in total phosphorus (Kaushik and Garg, 2003). Significant elevation in the calcium content of DIS vermicompost at higher concentrations of DIS (40 g/kg) partially agrees with that of Umamaheswari *et al*., (2012) who have reported that calcium content of PMS did not exhibit any significant variation on exposure to *Eudrilus eugeniae* expect at 100 /kg, which exhibited significant decline in mean total calcium content of PMS when compared to control and other treated groups. On other hand, dye sludge vermicomposted with *Eudrilus eugeniae* enhanced the copper content, irrespective of the concentrations of the dye sludge tested.

As evinced in this study, Bhat *et al* ., (2013) have also registered significant elevation in copper content of textile mill dyeing sludge spiked with cattle dung and vermitreated with *Eisenia fetida*. Further, present findings also gains support from the observations of Garg and Kaushik (2004) who have also registered elevation in the copper content of vermicompost (*Eisenia fetida*) CD+STMS feed mixtures. Several studies have reported reduction in copper content of the vermitreated distillery sludge (Suther, 2007), municipal sewage sludge (Suthar and Singh, 2009) and dye industry sludge (Suthar and Singh, 2009), which were found to be contradictory to our present findings. The iron content was found to be significantly elevated in the vermicompost of *Eudrilus eugeniae* exposed to dye sludge at all concentrations when compared to the control.

This findings lies in parallel to the observations of Bhat *et al* (2013) who have also observed significant increase in iron content of vermitreated (*E. fetida*) textile mill dying sludge mixed with cattle dung. On contrary, elevated Fe content was observed with vermitreated (*E. fetida*) STMS spiked with cow dung**.** This elevation in iron content of vermicomposted DIS gains support from the observation of Umamaheswari *et al*., (2012) who have evinced increase in Fe content of vermicomposted PMS with *Eudrilus eugeniae* at all concentrations (500 g/kg , 400 g/kg, 300 g/kg, 200 g/kg) except at 100 g/kg content when compared to the control. Reports suggest that iron content of distillery sludge, municipal sewage sludge, distillery industry sludge reduced after vermitreatment (Suthar and Singh, 2009; Suthar, 2007). Total Magnesium content reflected significant increase at DIS 40 g/kg and 5g/kg when compared to the other dosages and control. This result partially coincides with that Umamaheswari *et al*., (2012) who have reported significant elevation in total Mg content of all the PMS treated vermicompost employing *E. eugeniae* when compared to the control. The lead content of the dye sludge vermicompost using *E. eugeniae* was

found to increase at all the concentrations of the dye sludge when compared to control. This observation is not in good accord with the observations of Suthar and Singh (2009) who have evinced significant reduction in the concentration of lead (4.6-46 %) in the municipal sewage sludge vermitreated with earthworms. In the present study, the chromium content of the dye sludge vermicomposted employing *E. eugeniae* was found to elevate at higher dosages of Dye sludge (40 g/kg, 30 g/kg, 20 g/kg and 10 g/kg) when compared to control and 5 g/ kg of DIS. As evinced in this study, Umamaheswari *et al*., (2012) have also observed significant elevation in the mean total chromium of the vermitreated PMS (Paper Mill sludge) employing *E. eugeniae* at higher dosages when compared to control. Decline in chromium content of vermitreated (*E. fetida*) STMS mixed with cowdung was evinced by Garg and Kaushik (2004). Introduction of the earthworm, *E. eugeniae* to the dye sludge resulted in elevation in Mn content of the vermicompost of DIS at higher concentrations (30 g/kg and 40 g/kg) when compared to the control. Similar increase in Mn content of vermitreated textile mill dyeing sludge mixed with cattle dung was recorded by Bhat (2013).

Our observation partially agrees with that of Umamaheswari *et al*., (2012) who have noticed elevation in the mean total Mn content of PMS vermitreated with *E. eugeniae* when compared to untreated ones. Elevation in the total phenol content of the dye sludge vermicomposted with *E. eugeniae* was observed at higher concentration (40 g/kg and 30 g/kg) of the dye sludge. This elevation in the phenol content of the vermicomposted DIS at higher dosages (30 g/kg and 40 g/kg), which partially falls in line with Umamaheswari *et al*., (2012) who have evinced significant elevation in mean total phenol of *E. eugeniae* treated PMS at higher concentrations when compared to the control.

Conclusion

The results generated in this study signals that DIS sludge vermicomposted with *Eudrilus eugeniae* could enrich the soil micronutrients and macronutrients and also be used for enhancing the plant crop production. This study also reveals that DIS could be pretreated with *Eudrilus eugeniae* before releasing DIS directly into the environment and resultantly reduce the pollution load.

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