Vermicomposting of Textile Industries' Dyeing Sludge by Using *Eisenia foetida*

Kunwar D. Yadav, Dayanand Sharma

***Abstract*—**Surat City in India is famous for textile and dyeing industries which generate textile sludge in huge quantity. Textile sludge contains harmful chemicals which are poisonous and carcinogenic. The safe disposal and reuse of textile dyeing sludge are challenging for owner of textile industries and government of the state. The aim of present study was the vermicomposting of textile industries dyeing sludge with cow dung and *Eisenia foetida* as earthworm spices. The vermicompost reactor of 0.3 m^3 capacity was used for vermicomposting. Textile dyeing sludge was mixed with cow dung in different proportion, i.e., 0:100 (C1), 10:90 (C2), 20:80 (C3), 30:70 (C4). Vermicomposting duration was 120 days. All the combinations of the feed mixture, the pH was increased to a range 7.45-7.78, percentage of total organic carbon was decreased to a range of 31-33.3%, total nitrogen was decreased to a range of 1.15-1.32%, total phosphorus was increased in the range of 6.2-7.9 (g/kg).

***Keywords*—**Cow dung, *Eisenia foetida,* textile sludge, vermicompost.

I. Introduction

SURAT is situated on the bank of river Tapti which is famous for textile and dyeing industries in India. In India, the presence textile and dyeing and textile finishing industries are 25000 and 4135. The textile industries produce huge quantities of textile sludge which contains hazardous organic and inorganic chemical. These sludges are mostly dumped into the agricultural land, near the railway track, riverside and road side or landfilling sites which pollutes the ground water and surrounding environment. Therefore, to solve the sludge problem the industrialist and municipalities are in search of sustainable and suitable technologies. Vermicomposting is widely used technology in all over the world to solve this problem and convert the hazardous sludge into nutrient enriched vermicompost.

The vermicomposting is used by previous researcher for the conversion of industrial sludge into vermicompost such as Gajalakshmi et al. [1] used paper mill sludge, Bansal and Kapoor [2] used agricultural waste, Sinha et al. [3] used domestic kitchen waste, Elvira et al. [4] used paper mill sludge, Kaushik and Garg [5] used sewage sludge. The previous literature shows that the vermicomposting of industrial sludge by using *Eisenia foetida* was useful for the utilization of industrial sludge as vermicompost for agricultural purposes.

The aim of present study was vermicomposting of textile dyeing industries sludge using *Eisenia foetida* earthworm species to convert into usable manure, obtain an optimum composition of the industrial sludge and cow dung which can produce a mature and stable product of vermicompost, study the earthworm growth and their multiplicity for various different compositions of feed materials and study the variation in physico-chemical parameters and macro-nutrients for different compositions of feed mixture.

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II. Material and Methods

Fresh solid sludge from textile dyeing industry was obtained from the common effluent treatment plant of Palsana Evniro Protection Ltd. located near Haripura, Surat, India. Fresh cow dung was procured from the cow shed, near Ichchhanath Circle, Surat, India. The vermicomposting reactor is made up of PVC material which is water resistant. It is of the shape of frustum with top diameter of 250 mm, bottom diameter of 180 mm and height of 10 mm, providing exposed top surface area of 49100 mm^2. The volumetric capacity of the reactor is 1.5 L. After adding the required quantities of industrial sludge and cow dung in a reactor, the feed mixture is thoroughly mixed for uniformity. For each combination, 14 identical reactors were prepared, so that a set of two identical reactors for a particular combination would be available for analysis on the planned day. After the precomposting phase, 50 adult *Eisenia foetida* earthworms from the culture prepared in the laboratory itself were introduced in each reactor. The average weight of the adult earthworm is between 0.4 - 0.5 g. The top surface of the reactors exposed to atmosphere was closed with gunny bags and were kept at dark place in controlled temperature of 25 °C. Each combination of the feed material was planned to be analysed on 0^{th}, 15^{th}, 30^{th}, 45^{th}, 60^{th}, 75^{th}, and 90^{th} day after the precomposting phase. The next day of the precomposting phase was considered as the 0^{th} day. On the 0^{th} day, earthworms were introduced into the reactors.

Keeping 0^{th} day as the starting event of the vermicomposting process, subsequent days of analysis were planned. Table I gives the detail of quantities in different combinations of textile dyeing sludge and cow dung mixture.

A. Analysis of Physicochemical Parameters

The important physicochemical parameters were analyzed for the study are pH, electrical conductivity, total nitrogen, total organic carbon, C/N ratio, Na^+, K^+, phosphorus and carbon dioxide evolution rate. The fresh sample was used for the analysis of pH and electrical conductivity determination. After monitoring the moisture content, the oven dried sample was grinded and sieved through 0.1-mm sieve size. This sieved sample was used for the analysis of total nitrogen, total organic carbon, Na^+, K^+, phosphorus and calculation of C/N ratio.

TABLE I
COMBINATION OF FEEDSTOCK MATERIAL INTO VERMIREACTOR

Combination	Textile Dyeing Sludge (STDS)			Cow Dung (CD)		
	Percentage (%)	Dry weight (g)	Wet weight (g)	Percentage (%)	Dry weight (g)	Wet weight (g)
C1	0	0	0	100	500	2865
C2	10	50	94	90	450	2579
C3	20	100	189	80	400	2292
C4	30	150	283	70	350	2006

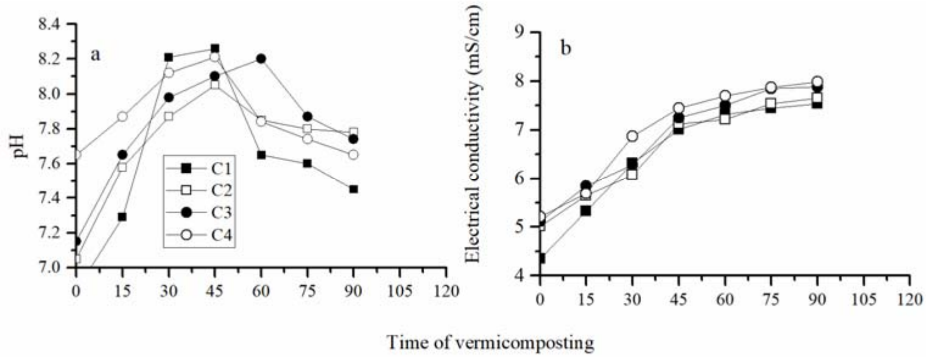

Fig. 1 Variation of pH and electrical conductivity during the vermicomposting process

III. RESULTS AND DISCUSSION

A. pH and Electrical Conductivity (EC)

pH is very important parameter which influences the vermicomposting process. The variation in the pH of the system affects the microbial activity on the organic waste. There should be a good control, and maintenance of pH in optimum range is necessary for the effective composting process. The initial values of pH for the combination C1, C2, C3 and C4 were 6.87, 7.05, 7.15, and 7.19 respectively which was increased from 7.45, 7.78, 7.74 and 7.65. The reasons for increase in pH were due to turning of and joint action of earthworm. The nitrogen is transformed into NH_3 or NH_4^+ during ammonification which was responsible for increasing the pH of the compost [6].

Electrical conductivity was used for maturity of vermicompost which shows the presence of salinity into the vermicompost [7]. Initially electrical conductivity into the combinations C1, C2, C3 and C4 was 4.35, 5.01, 5.12 and 5.21 mS/cm^{-1} which was increased to 7.54, 7.65, 7.88 and 7.98, respectively during final days of vermicomposting process. Similar increasing trends of electrical conductivity were observed during vermicomposting of industrial sludge by Yadav and Garg [8]. The degradation of sludge releases the mineral salts such as ammonium, phosphate, thus increasing the electrical conductivity.

B. Total Organic Carbon (TOC), Total Nitrogen (TN), C:N Ratio and CO_2 Evolution Rate

Total organic carbon is the important parameters for the metabolism of the microbes. The microbes utilize the carbon as the source of energy and some part of carbon was lost as CO_2 during the composting process. Initial the presence of total organic into combinations C1, C2, C3 and C4 was 38.19, 37.97, 37.88, 35.79%, which was decreased to 32.13, 33.16, 33.33, and 31.02%. The rate of reduction of total organic carbon was similar to Yadav and Garg [8] during the vermicomposting of industrial sludges. The reduction in total organic carbon was due to the combined action of earthworms and microorganisms bring TOC loss from the substrates in the form of CO_2.

Fig. 2 (c) shows the decreasing trends of the C:N ratio. C/N ratio is the very important parameter which influences the microbial activity. Proper ratio of carbon to nitrogen should be maintained for the active microbial degradation process. For the combinations C1, C2, C3, and C4 the initial C/N ratios was recorded as 54, 63, 54, and 57 which was reduced to 24, 23, 26, and 27 at the end of vermicomposting periods. The nitrogen content is very important parameter and shows the maturity of vermicompost in the composting practices. The nitrogen content is utilized by the microorganisms for building the cell structure and for the synthesis of cellular matter, amino acids and proteins.

The observed %TN for the combination C1 and C2 on the initial days of the vermicomposting was 0.7 and 0.6%. Then, the reactor showed an increment on % total nitrogen value on the 90th day of vermicomposting and was noted as 1.32 and 1.4% for the reactor C1 and C2. In the plots of combination C3 and C4, it was observed that an increment of % TN on the initial periods of composting and this is because of the presence of nitrogen components such as amino acids, proteins, etc. in the cellular material of the microbes present in the vermireactor [9], [10].

CO_2 evolution is one of the best methods to determine the stability of the compost because it measures carbon derived directly from the compost. CO_2 evolution directly synthesizes to aerobic respiration, which shows the direct measure of respiration and aerobic biological activity [11]. CO_2 evolution rate was decreased with time. The CO_2 evaluation rate was decreased from 0.54, 0.50, 0.5 and 0.48 mg/g VS/day to 0.10, 0.10, 0.04 mg/gVS/day in combination number 1 to 4, respectively (refer Fig. 2 (d)). Similar decreasing trends of CO_2 evolution rate was observed during the vermicomposting of vegetable waste [12].

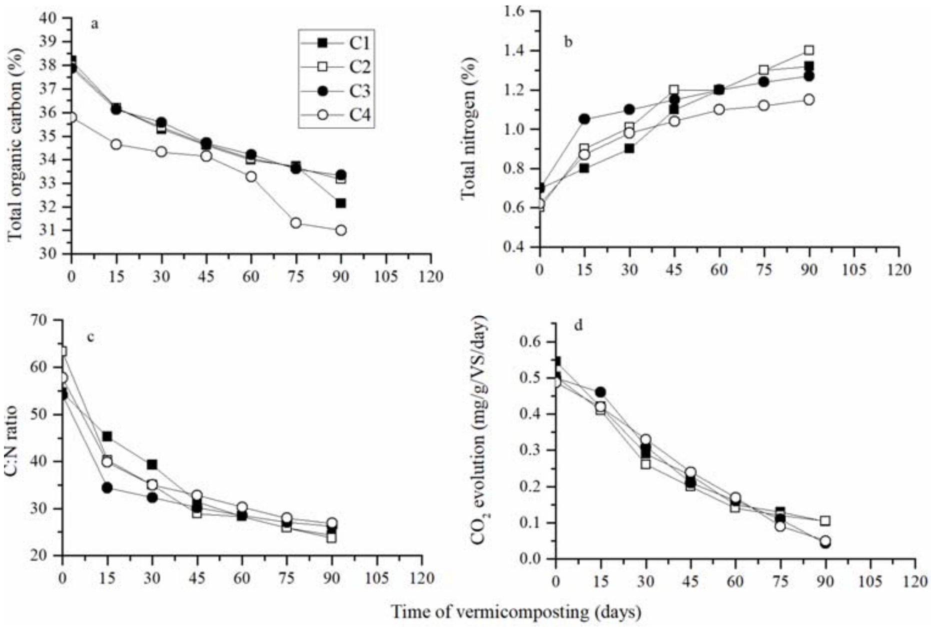

Fig. 2 Variation of total organic carbon, total nitrogen, C:N ratio and CO_2 evolution rate

TABLE II
VARIATION OF SODIUM, CALCIUM, POTASSIUM AND PHOSPHOROUS DURING INITIAL AND FINAL DAY OF VERMICOMPOSTING PROCESS

Parameter	Combinations							
	C1		C2		C3		C4	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Na (g/kg)	9.38	10.26	8.39	9.54	7.65	8.56	6.87	7.89
Ca (g/kg)	8.6	10.98	14.7	17.9	18.5	22.65	26.35	33.54
K (g/kg)	32.66	36.85	27.89	30.21	23.97	26.54	20.69	23.65
P (g/kg)	6.8	7.9	6.05	7.6	5.54	7.05	4.65	6.2

C. Sodium, Potassium, Phosphorous and Calcium

Table II shows the increase in concentration of sodium from the initial day of vermicomposting to the final day of vermicomposting. Initially the presences of sodium in combinations C1, C2, C3 and C4 was 9.38, 8.39, 7.65, and 6.87 g/kg which increased at the rate of 7.89 to 10.26 g/kg within the vermicomposting period of 90 days. The concentration Na and Ca gradually increased which indicates the net loss in dry mass due to degradation of organic matter and the release of CO_2, NH_3, and H_2S during vermicomposting process [13]. Initial total potassium content in combination C1 was 32.66 (g/kg) which finally increased to 36.85 (g/kg). In C2, C3, and C4 the initial presence of potassium was 27.89, 23.97 and 20.69 (g/kg) which increased to 30.21, 26.54, and 23.65 (g/kg), respectively at the end of the composting process. The initial concentration of phosphorous content in the combinations C1 to C4 was 6.8, 6.05, 5.54 and 4.65 (g/kg) which was increased to 7.9, 7.6, 7.05 and 6.2 (g/kg) respectively. The increase in potassium and phosphorous concentration in all the combination was partly due to potassium assimilation and immobilization by microbes [14], [15].

D. Growth of Earthworm

The earthworm growth in optimum mixture of waste has been shown in Fig. 3 (a). During the vermicomposting process, the growth of earthworm was very well and mortality of earthworm was observed at the last two weeks. The growth rate of earthworm biomass has been indicator of good growth of earthworm during the vermicomposting process. At the start of experiments the number of earthworm was 50 in all reactors which was changed to 50, 58, 52 and 38 at the 90^{th} day in combinations C1, C2, C3 and C4 respectively. The growth pattern of earthworm biomass shows the combination C2 and C3 was the suitable proportion of earthworm growth which contents nutrients and can be successfully applied as manure for agricultural purposes.

Fig. 3 (b) shows the number of hatchlings growth during the vermicomposting process. The highest growth of hatchling was observed in combinations C3. Similarly, the highest growth of cocoons was observed in combinations C3, which shows the suitability of the waste proportions.

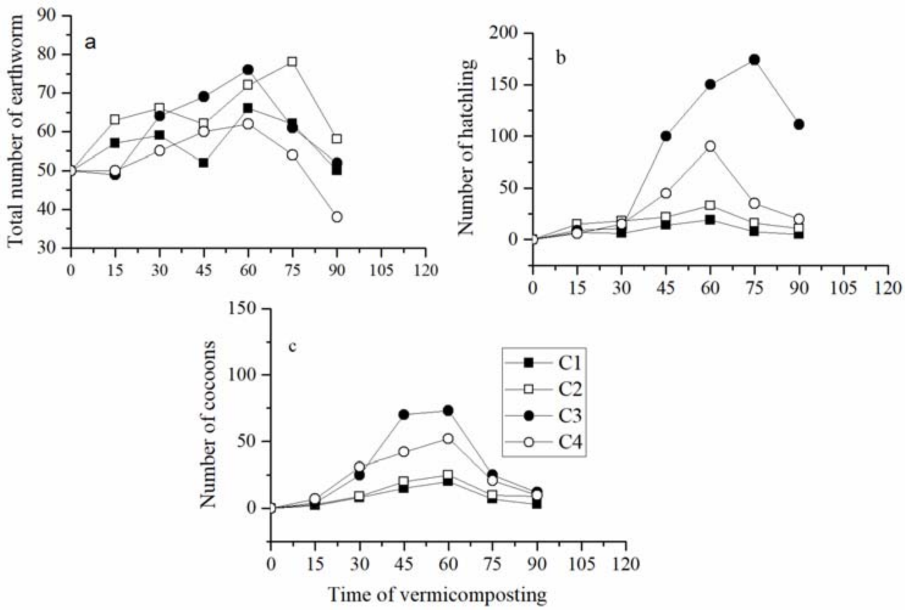

Fig. 3 Variation of growth of earthworm, hatchling, cocoons during the vermicomposting process

IV. Conclusions

Vermicomposting has been reported to be the best methodology for producing quality manure from organic residues. Cow dung is good source of organic matter and plant nutrients, and so, vermicomposting can possibly be used to convert mixture of cow dung and textile dyeing sludge into vermicompost. It was observed that all the combinations can be decomposed by the vermicomposting technique, to generate effective quantity and quality of manure. Due to low toxicity of industrial sludge, the mortality rate of earthworms was not significant. But, there was a considerable decrease in the weight of the adult earthworms for combination 4. The production of hatchlings and cocoons was also observed to be highest for combination 3. The combination C2 and C3 was the suitable proportion for the vermicomposting of textile dyeing industrial sludge.

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