Comparative study on assessment of compost stability through C/N ratio by different composting techniques

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***Abstract*— Immature and poorly stabilized compost may pose a number of problems related to their various applications and land disposal. Poorly stabilized compost may lead to production of various toxic compounds which may change soil chemistry and contaminate the ground water sources on land disposal. Present study focuses on Comparative study on assessment of compost maturity through carbon, nitrogen C/N ratio obtained in different phases of rotary drum composting and vermicomposting technique. Industrial sludge in the present study was collected from Common Effluent Treatment Plant (CETP) Bhiwadi in state of Rajasthan India. CETP Bhiwadi treating the waste water from large cluster of different small scale industries (SSI). The end product obtained in the study had lower C/N Ratio than initial value in both rotary drum composting and vermicomposting techniques and decrease in C/N ratios shows the organic matter breakdown, compost maturity and stabilization achieved.**

Keywords: Composting, vermicomposting, C/N Ratio, Sludge, Common Effluent Treatment Plant

1. INTRODUCTION:

The huge amount of hazardous sludge generated from the Common Effluent Treatment Plants (CETPs) is now a major environment management challenge due to its no usages, toxicity and confined area for disposal. Sludge generated from the CETPs are classified as hazardous waste as per Hazardous Waste (Management and Handling) Rules, 1989. Improper disposal of thsese type of waste causes serious environmental problems. Land-filling of sludge creates many problems in nearby soil by destroying soil fertility and changing in soil chemistry, land degradation, contaminate surface and ground water, and also affect public health. Industries produce huge quantities of liquid and solid wastes and their treatment results into the generation of huge quantity of sludge. Uncontrolled disposal of this hazardous sludge causes significant environmental risk and also adverse impact on health, community, peoples and aesthetics. So economical and ecologically acceptable disposal of industrial sludge is becoming a great challenge to industries due to high cost of sludge stabilization reactors, dehydration systems and transportation of sludge to disposal site. The huge quantity of hazardous sludge produced per day and there is no use of hazardous sludge produced in common effluent treatment plant due to presence of heavy metals, high COD and BOD, low pH, high TDS and TSS. It can only disposed in landfills. Maintenance of landfills also requires additional cost. Landfill creates many problems in nearby soil by destroying soil fertility and changing in soil chemistry, land degradation, contaminate surface and ground water, and also affect public health. So composting and vermicomposting are economic and environmentally safe options for a sustainable waste management of industrial sludge.

Composting and vermicomposting are the reliable technologies for production of stabilized organic matter or compost that is suitable for agriculture and can be applied on soil, but this process should be carefully monitored with appropriate indices. Quality of compost is important from maturity and stability viewpoint, but in most compost factories there is no proper monitoring and operation. This study was designed to evaluate the Carbon nitrogen ratio (C/N ratio) the major stability parameter in the composting and vermicomposting of sludge (Produced from Common Effluent Treatment Plant). The composting by rotary drum composting method, for selecting the best index in quality monitoring of the waste during the whole composting period. Similarly, Vermicomposting is an environmental sound technology for conversion of various kinds of organic wastes into vermicompost. There are several literatures available on vermicomposting of sewage sludge and different industrial sludge like textile mill sludge, pulp and paper mill sludge, food industry sludge and distillery sludge using different earthworm species. But there is not much literature is available on vermicomposting of common effluent treatment plant (CETP) sludge. So the main objective of this study is to stabilize CETP sludge mixed with cow dung and saw dust in different proportion using Eudrilus eugeniae earthworm species and compare it with the rotary composting process by observing the C/N ratio, the major stability and maturity parameter of the prepered compost.

2. MATERIALS AND METHODS:

2.1 Materials in Composting:

The main material used in the study included a Rotary drum composter, sludge of Common Effluent Treatment Plant (CETP) sludge, cow-dung and sawdust. A brief description of each of these is presented in the following sections.

2.2 Reactor:

Rotary drum composter design

In order to study the compost dynamics, a rotary drum composter of 250 L capacity was used (Figure 5). The main unit of the composter, i.e., the drum, is of 1.0 m in length and 0.9 m in diameter, made up of a 4 mm thick metal sheet. The inner side of the drum is covered by anti-corrosive red oxide coating and outside of drum is covered by green paint. The drum is mounted on four metal rollers and a chain attached to a metal stand with wheels (Stand length= 1.28m, stand width=1.18m and stand height = 1.02m) and the drum is rotated manually. In order to provide the appropriate mixing of wastes, 40 mm angles are welded longitudinally inside the drum. The sludge, cow-dung and sawdust mixture is loaded into the drum by the means of a metal container and it can be filled up to 50 % of the total volume, but capacity of filling volume can be further increased up to 70%. Aerobic conditions are maintained by opening up both half side doors of the drum after a certain period of rotation which ensures proper mixing and aeration.

Fig. 1 : Rotary Drum Reactor set up in old hydraulics lab MNIT Jaipur

Fig. 2: Sludge from CETP Bhiwadi

2.3 Feedstock material

We have taken sludge from CETP Bhiwadi District Alwar Rajasthan. In CETP Bhiwadi the effluent from 55 different types of industries comes. The bulking agent saw dust collected from a wood shop and cow dung collected from the H-Quarters at MNIT Jaipur.

Table 1. Run 1: C/N Ratio 25.1037 (In winter season, from 01Jan to 30 Jan)

Ingredient	% Moisture	% Carbon	% Nitrogen	Mass (kg or lbs.)
Sludge	73.3	24.9	1.3	91.00
Cow Dung	55.8	43.8	1.6	20.00
Saw Dust	16.8	47.0	0.9	9.00
			Calculated mixture moisture content:	**66.1**
			Calculated mixture C/N ratio:	**25.2**

Table 2. Run 2: C/N Ratio 30.1 (In Summer season, 25 Mar to 25 Apr)

Ingredient	% Moisture	% Carbon	% Nitrogen	Mass (kg or lbs.)
Sludge	73.3	24.9	1.3	60.00
Cow Dung	55.8	43.8	1.6	40.00
Saw Dust	16.8	47.0	0.9	20.00
			Calculated mixture moisture content:	**58.0**
			Calculated mixture C/N ratio:	**30.1**

2.4 Detail of materials in Vermireactors:

The experimental work was carried out with different percentage of compost material i.e. CETP sludge, cow dung and saw dust using earthworm species *Eudrilus Eugenia*. The table given below indicates the percentage content in initial feed mixer.

Table 3: Vermireactors with different feed mixture percentage:

R1: Vermicomposting of Sludge with Cow dung (CD) and Saw dust (SD) (80:20:0)

R2: Vermicomposting of Sludge with Cow dung (CD) and Saw dust (SD) (50:50:0)

R3: Vermicomposting of Sludge with Cow dung (CD) and Saw dust (SD) (50:25:25)

R4: Vermicomposting of Sludge with Cow dung (CD) and Saw dust (SD) (70:30:0)

R5: Vermicomposting of Sludge with Cow dung (CD) and Saw dust (SD) (40:40:20)

R6: Vermicomposting of Sludge with Cow dung (CD) and Saw dust (SD) (30:30:40)

Each Reactor contained a Control (i.e. CR)

Fig.3 Vermicompost reactors used in the experiment

3. METHODOLOGY OF ANALYSIS

The present study was carried out to analyze the initial characteristic of sludge, cow dung and saw dust and after that continuous monitoring of C/N ratio till the maturation of compost. For this the biological and physico-chemical analysis of the compost sample collected from the drum composter were carried out in PHE laboratory Civil Engineering department MNIT and Agricultural Research laboratory Durgapura Jaipur. The physico-chemical and Biological parameters were analyzed, by the methods described in the Standard Methods for the examination of wastewater (APHA.AWWA.WEF, 1999).

Similary in Vermicomposting about 150 g of homogenized wet samples of the feedstock was analyzed before the start of the experiment referred as zero day then samples were analyzed for C/N ratio after every 6 days interval. The zero day refers to the substrate taken out before earthworm inoculation. Sample analysis was carried out at PHE Lab, civil engineering department MNIT Jaipur and Agricultural Research lab Durgapura Jaipur. The physico-chemical and Biological parameters were analyzed, by the methods described in the Standard Methods for the examination of wastewater (APHA.AWWA.WEF, 1999).

4. RESULTS AND DISCUSSION:

It deals with composting of sludge with saw dust and cow dung with different combinations according to C/N ratios. Different combination of ingredients as per calculated by online calculator in Cornell University website [12]. The study was conducted in two runs:

Run 1: C/N Ratio 25.1037 (In winter season)

Run 2: C/N Ratio 30.1 (In Summer season)

Similarly the vermicomposting of CETP Sludge with different combinations of various wastes by using earthworm species Edurilus eugenia. The experiment was conducted in plastic container of capacity 20 L. 20 holes along the circumference and 15 holes (0.5 cm diameter) at the bottom of the container were drilled for aeration and drainage. The study was carried out about the performance of vermireactors in terms of quality and stability of compost.

A good composting process requires that the temperature, oxygen and moisture levels be maintained uniform throughout the compost period. Therefore, having the side doors of the drum closed, two rotations are provided manually on a daily basis, whereas the doors are kept open the rest of the time for aeration. There are two distinct stages in the composting system: the active stabilization phase and the maturation period. In this study both the phases were undertaken in the rotary drum by adjusting aeration by means of the rotation process. With regard to the composting process, the key function of the rotation is to expose the material to air, provide oxygen and release the heat and gaseous products of decomposition.. In warm, moist environments with good amount of oxygen and organic material available, aerobic microbes multiply, grow and decompose the waste in a very fast rate.

4.1 Stability Parameter: C/N Ratio in Rotary drum composting:

The end product obtained in the study had lower C/N Ratio than initial value [21] suggested that the decrease in C/N ratios shows the organic matter breakdown and stabilization achieved during composting. The decomposition of organic matter is brought about by microorganism, which utilizes carbon as a source of energy and nitrogen for building cellular components. If the C/N ratio of the compost is higher, the excess carbon tends to utilize nitrogen in the soil to build cellular structure. This results in a loss of nitrogen from the soil and is known as the robbing of nitrogen in the soil. On the other hand, if the C/N ratio is too low the compost does not help in improving the of soil texture.

To adjust C/N ratio, different combination of ingredients as per calculated by online calculator in Cornell University website [12]. In Run 1 the composting started with C/N ratio of 25.1037 and during initial three days C/N ratio decreased to 20.7062. From three to twenty days the C/N ratio dropped to 12.2296. In this period some fluctuations was observed .After twenty days C/N ratio gradually decreased and stabilized and final C/N ratio of 7.4658 was observed in Run 1.It indicates the maturity of the compost.

In Run 2 the composting started with C/N ratio of 30.1(Ideal for composting) and during initial three days C/N ratio decreased sharply to 20.443. From three to twelve days the

C/N ratio dropped to 13.8409. In this period also some fluctuations was observed .After twelve days C/N ratio gradually decreased up to twenty seven days and then stabilized and final C/N ratio of 8.2857 was observed in Run 2.It indicates the maturity and stability of the compost. (Inbar, Hadar and Chen 1993) reported a similar pattern in which C/N ratio decreased from 27.1 to 8.1 during the composting process [20].

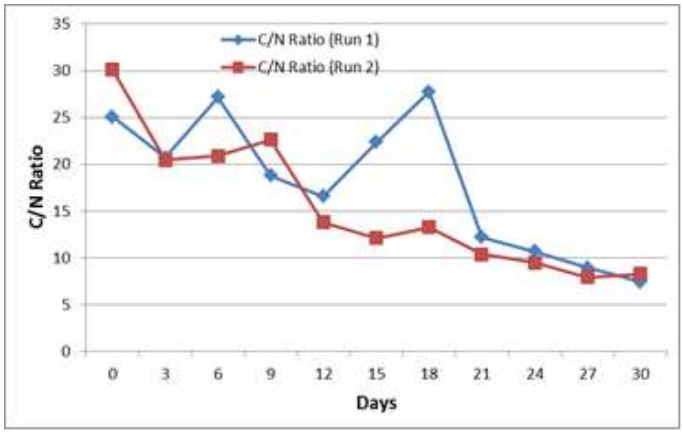


Fig.4 : Variation in C/N ratio observed during composting period

4.2 C: N Ratio in Vermicomposting

Similarly in vermicomposting also the decrease in C/N ratios shows the organic matter breakdown and stabilization achieved during composting [21]. The decomposition of organic matter is brought about by microorganism earthworms which utilize carbon as a source of energy and nitrogen for building cellular components. The variation of C/N in vermireactor and their controls showed in graphs 19 and 20. In the start of vermicomposting C/N ratio were 29.96, 19.11, 35.84, 30.62, 20.92, and 23.01 in vermireactor R1, R2, R3, R4, R5 and R6 respectively. After 24 day of vermicomposting there is reduction in the C/N were 19.82, 9.91, 8.93, 16.12, 9.63 and 13.06 in in vermireactor R1, R2, R3, R4, R5 and R6 respectively. In controls C/N ratio vary from 9.87 to 17.16 after 24 day of composting showed in graph 20. The reduction in C/N ratio was higher in vermireactors as compare to their controls.

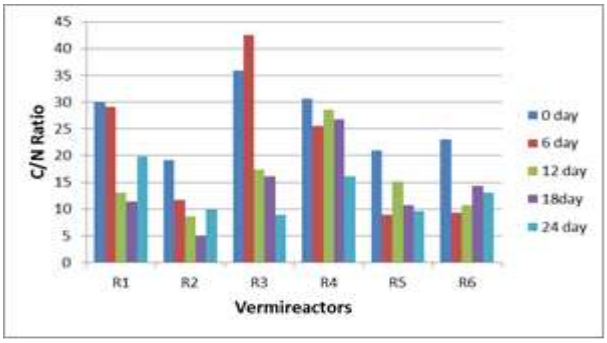
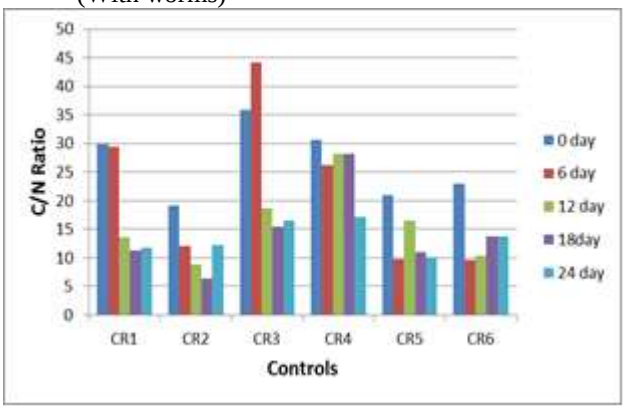


Fig. 5: Variation of C/N Ratio in vermireactors (With worms)



Variation of C/N Ratio in controls (Without worms)

5. Conclusion:

Rotary drum Composting process was performed in two different runs started at different C/N ratio and it was found that final C/N ratio decrease to 7.46 and 8.28 in both runs. Vermicomposting was performed in six different vermireactor started at six different C/N ratio and there is average reduction of C/N ratio to 12.91. In vermicomposting the final C/N ratio of compost varies from 8.93 to 19.82.. The reduction in C/N ratio was higher in rotary drum composting as compared to vermicomposting in case of composting of hazardous sludge of CETPs. In the duration of rotary drum composting and vermicomposting some fluctuations were observed in C/N ratio but final compost indicate maturity and stability as decrease in C/N ratios shows the organic matter breakdown and stabilization achieved during composting.

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