EXPERIMENTAL STUDY ON BIODEGRADATION OF KITCHEN REFUSE BY VERMICOMPOSTING

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Abstract - *In this study, kitchen refuse from hostel messes and Non Resident Student Canteen (NRSC) of Government College of Technology campus could be collected and refuse generation rate is estimated. The sample refuse collected is preprocessed through various processes like segregation, size reduction and removal of other contaminants. Then the preprocessed refuse is feeded in the prepared vermi compost trial pits along with the manure of various proportions. The sampling was done once in five days and the samples were analysed for various parameters like pH, moisture content, temperature, organic carbon, nitrogen, phosphorous, potassium, total solids, volatile solids and chemical oxygen demand. After the completion of maturation period the compost and earthworms are recovered from the each trial pits. The recovered composts were dried, sieved through 2.5mm sieve and then analysed for the final characteristics. Finally the compost can be used as a manure and earthworms were used for the next cyclic processes.*

Key Words: Kitchen refuse, Vermicomposting, Earthworms, Mix proportions, Carbon/Nitrogen ratio and Compost.

1. INTRODUCTION

India and many other countries are suffering from the problems of urbanization. Solid waste is its major contributor. The problems associated with the management of solid waste in today's society are complex because of the quantity and diverse nature of the waste. The per capita of MSW generated daily, in India ranges from about 150 g in small towns to 600 g in large towns. Under the circumstances, it would be advisable to recover the resources from the MSW by the energy recovery techniques rather than go for half-hearted treatment measures.

1.1. Vermicomposting

Vermicomposting is the process of converting the organic waste into vermicompost through the action of earthworm species. Microbial decomposition of biodegradable organic matter occurs through extra cellular enzymatic activities. It is the easiest way to recycle food wastes. It allows the worms to do all the work with no pile turning, no smell and fast compost production. The level of nutrients in compost depends upon the source of the raw material and the species of earthworm.

Earthworms are also known as "Friends of the Farmer" as they decompose organic waste material present in the soil and make the soil fertile for agricultural use. There are nearly 3600 types of earthworm species are available. The earthworm species most often used are red wigglers (*Eisenia fetida* or *Eisenia Andrei)*, though European night crawlers (*Eisenia hortensis* or *Dendrobaena veneta)* could also be used. Red wigglers are recommended by most vermicomposting experts, as they have some of the best appetites and breed very quickly.

2. MATERIAL

In India nearly 30 to 40% of solid waste generated is kitchen refuse, which is the left – over organic matter from kitchens of restaurants, hotels and households. Tons of kitchen refuse are produced daily in highly populated areas. Kitchen refuse comprises of vegetable and fruit remains and peelings, egg shells and coffee sediments, tea and coffee filter bags, tainted food, non – liquid cooked food waste etc.,

Kitchen refuse entering the mixed municipal waste system are difficult to process by standard means such as incineration due to the high moisture content. Furthermore, organic matter can be transformed into useful fertilizer and biofuel. Kitchen refuse is a nutrient rich, or eutrophic environment containing high levels of carbohydrates, lipids, proteins and other organic molecules which can support abundant populations of microorganisms.


Fig -1: Kitchen Refuse

3. METHODOLOGY

3.1. Kitchen Refuse Generation Rate

The waste was collected every day and weighed from NRSC and hostel mess. The population was also noted by taking survey from the workers of the canteen and hostel incharge. From that percapita generation of waste was calculated and tabulated in the tables.

Table -1: Estimation of Refuse Generation Rate in NRSC

S.No.	Day	Quantity Generated (kg)	Population (Approx.)	Per Capita Generation (kg)
1	Day 1	9.560	180	0.053
2	Day 2	7.280	150	0.049
3	Day 3	9.970	190	0.052
4	Day 4	8.680	170	0.051
5	Day 5	8.230	170	0.048

Table -2: Estimation of Refuse Generation Rate in Hostel

S.No.	Day	Quantity Generated (kg)	Population (Approx.)	Per Capita Generation (kg)
1	Day 1	446.50	2350	0.190
2	Day 2	430.05	2350	0.183
3	Day 3	451.20	2350	0.192
4	Day 4	437.10	2350	0.186
5	Day 5	415.95	2350	0.177

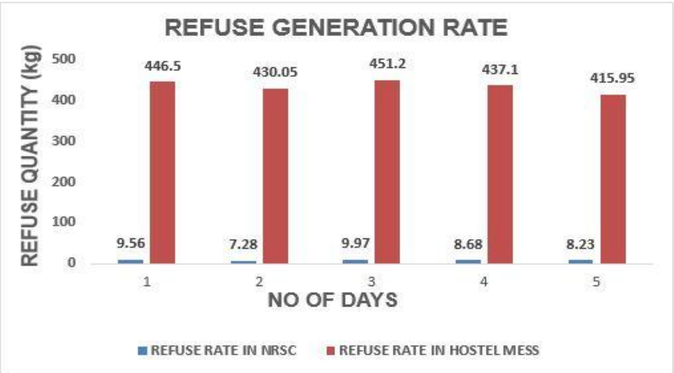

Chart -1: Refuse Generation Rate

3.2. Collection of Kitchen Refuse Sample

Separate bins were provided at the NRSC and hostel mess for dumping organic waste (kitchen and vegetable waste) and inorganic waste (plastic). The refuse collected in the bin for organic wastes containing kitchen and vegetable waste was collected and removed every day as a cycle for 2 weeks. Surveys were conducted to the workers regarding the quantity of food cooked every day, quantity of vegetables used for cooking per day and the days of the week when the waste generation was at peak.

3.3. Segregation of the Collected Refuse

The workers in the canteen and hostel mess were educated about the need for segregating organic and inorganic wastes so as to contribute to fit compost. It was found that sometimes traces of inorganic wastes were found in the bin for organic waste. The workers were reinstructed about the potential harm caused to the compost by accidental or careless mixing of organic and organic wastes in the bin. Any inorganic particles found in the organic waste mixture was found and immediately removed. The efficiency of segregation was examined and strict implementation measures were taken.

3.4. Preprocessing of the Collected Refuse

The optimal particle size is typically in the range of 2 to 8 mm to provide a high volume to surface ratio. This process is done either manually or mechanically, mechanical shredders are available for size reduction.

Contaminants include light materials such as film plastic and textiles, dense materials such as glass, ferrous and non-ferrous materials. This can done by manual means only and the efficiency must be high.

The feedstock should be optimum so a mixture of leave trimmings and coir pith were added and have a water content in the range of 55 to 60 percent and a ratio of available carbon to nitrogen (C:N) of 30 to 40. Food waste and sludge are high in nitrogen. It is also essential that the materials be thoroughly mixed and wetted.

3.5. Characterization of the Collected Refuse

Temperature

The temperature was measured directly using thermometer at the sampling site.

Moisture Content

The dish containing sample W_1 was kept in moisture analyzer at 105ºC for 1 hour. Finally the heated dish is cooled in a desiccator and weighted W_2

$$\text{Moisture content in \%} = \frac{(W_1 - W_2)}{W_1} \times 100$$

pH

1:100 ratio sample solution was prepared by taking 1g of waste sample in 100 ml of deionized water. The solution was shaken for 1 hour using a mechanical shaker at regular intervals. After calibration of the pH meter, reading was noted.

Chemical Oxygen Demand

The chemical oxygen demand was measured by using Spectroquant TR 420. The diluted samples of 3 ml were taken up in the glass test tube. Add 2.5 ml and 1.5 ml of COD solution A and B and place it in the COD digester for 2 hours at 148°C. After 2 hours the sample was cooled for 1hour and then the sample is place it in the Spectroquant Move 100 display meter to display COD value for the sample.

Total Organic Carbon

The total organic carbon was measured by using TOC analyzer. After washing, the sample solution is injected into the analyzer which utilizes a combustion technique (upto 720°C). The CO_2 generated by oxidation process is measured with Non – Dispersive Infra-Red sensor. The detector determines the concentration of organic carbon in the sample solution.

Total Nitrogen

The total nitrogen content was also measured by TOC analyzer. After washing, the sample solution is injected into the analyzer which utilizes a chemi – luminescence reaction. The sample solution is combusted to NO and NO_2. Chemi – luminescence detector determines the concentration of total nitrogen present in the sample solution.

Total Solids

Take a crucible dried in a hot air oven for 1 hour about 105°C and weighed as W_1. Take 20 ml of sample solution and pour into the crucible and dried in a hot oven air and then the crucible were cooled in a desiccator and weighed as W_2.

$$\text{Total Solids in } {}^{mg}/_{l} = \frac{(W_2 - W_1)}{\text{Volume of the sample}} \times 1000$$

Volatile Solids

Take a crucible dried in a hot air oven for 1 hour about 105°C and weighed as W_1. Take 20 ml of sample solution and pour into the crucible and dried in a muffle furnace at a temperature of 550°C for atleast 4 hours. Then the crucible was cooled in a desiccator and weighed as W_2.

$$\text{Volatile Solids in } \% = \frac{(W_1 - W_2)}{W_1} \times 100$$

Total Phosphorus

Standard samples was prepared and the colour intensity was measured for the determination of total phosphorus using a spectrophotometer at 690nm. The concentration of total phosphorus as PO_4^{3-} P mg/L in the aliquots was determined using the standard graph.

Potassium

The potassium level in the sample is measured using flame photometer. The standard solutions were aspirated into the flame and the instrument was calibrated. The sample was aspirated into the flame and the concentration of potassium present in the sample was determined.

3.6. Preparation of Vermi Compost Trial Pit

Vermi compost trial pit was made by using plastic bin in the form of an open rectangular box with the size 60cm x 15cm x 15cm. 3 separate bins were used for different mix proportions. First 5cm of the bin is filled with fine grained soil and the next 5cm is layered with the feedstock and earthworms. Finally 3 cm is filled with manure like coir pith and leave trimmings and 2 cm is kept as freeboard. The bins were provided with wire like holes at bottom for drainage and on periphery for better ventilation.

It should be kept in the shade and covered with a wire mesh or plastic mosquito net to prevent houseflies from laying eggs and the formation of maggots. Water was added for providing the optimum moisture content of 60% along the maturation period. So that microbial activity is high and food matter is easy to feed upon. The temperature should be maintained between 20°C to 30°C. Temperature affects metabolism, growth and reproduction of worms. Compost pit exposed to the sun loses moisture content from the waste quickly and are devoid of earthworms.

The carbon – nitrogen (C:N) ratio is the critical factor that limits earthworm population. When the C:N ratio of the feed material increases it becomes difficult to extract enough nitrogen for tissue production. Worms find it difficult to survive when the organic carbon content of the soil is low. C:N ratio in the range of 15 – 35:1 is considered to be suitable. Worms are sensitive to changes in pH. They prefer neutral condition. The processed waste pH in the range 5 – 9, appears not significantly affect the growth and reproduction of worms. The lowered pH hampers the normal activities of the worms, leading to weight loss and decline in population.

Fig -2: Trial Pits for Vermicomposting

Trial I was carried out with 2kg of vegetable waste and 1kg of food waste (2:1) and trial II has 1.5kg of vegetable waste and 1.5kg of food waste (1.5:1.5) and finally trial III has 1kg of vegetable waste and 2kg of food waste (1:2). Nearly 100 worms per bin were employed for the bio-degradation process. The refuse was initially characterized before fed into the trial pit. The process of composting was monitored with great attention. The sampling was done once in five days and the samples were characterized.

4. RESULTS AND DISCUSSION

A range of physical and chemical parameters like pH, moisture content, temperature, organic carbon, nitrogen, phosphorous, potassium, chemical oxygen demand, total solids and volatile solids were assessed in regular intervals for understanding the biodegradability of the waste.

Table -3: Performance Analysis of Trial I

DAYS	pH	Temp (°C)	Moisture content (%)	Total solids (%)	Volatile solids (%)	Carbon (%)	Nitrogen (%)	C/N ratio	Phosphorus (%)	Potassium (%)	COD (mg/l)
1	6.89	27	41.87	59.10	78.99	11.50	0.73	15.75	1.26	0.91	904.30
5	7.00	28	41.80	59.00	77.28	11.49	0.75	15.32	1.37	1.04	868.24
10	7.08	27	41.72	56.30	73.48	11.48	0.78	14.71	1.49	1.16	752.80
15	7.17	26	41.57	55.12	72.91	11.46	0.78	14.69	1.67	1.29	744.60
20	7.20	27	41.27	51.33	69.98	11.43	0.80	14.28	1.74	1.36	714.80
25	7.36	27	41.14	50.11	65.72	11.42	0.82	13.92	1.81	1.42	710.52
30	7.38	27	41.01	48.60	64.94	11.40	0.87	13.10	1.88	1.59	698.78
35	7.42	28	40.94	47.70	61.53	11.38	0.90	12.64	1.95	1.68	668.90
40	7.49	27	40.87	45.35	58.60	11.35	0.94	12.07	1.99	1.82	624.85
45	7.53	28	40.66	44.56	51.16	11.28	0.98	11.51	2.08	1.90	598.26
50	7.55	28	40.50	44.21	56.70	11.24	1.20	9.37	2.14	2.03	584.14
55	7.81	27	40.32	43.65	54.20	11.20	1.30	8.62	2.20	2.16	560.52
60	7.89	27	40.16	42.33	53.38	11.16	1.37	8.14	2.28	2.34	544.76

Table -4: Performance Analysis of Trial II

DAYS	pH	Temp (°C)	Moisture content (%)	Total solids (%)	Volatile solids (%)	Carbon (%)	Nitrogen (%)	C/N ratio	Phosphorus (%)	Potassium (%)	COD (mg/l)
1	6.63	27	45.70	56.85	70.58	11.45	0.74	15.47	0.96	0.74	720.54
5	6.81	26	45.34	55.95	67.01	11.40	0.85	13.41	0.98	0.76	752.80
10	7.06	26	45.08	55.14	65.52	11.42	0.94	12.14	1.06	0.79	672.62
15	7.07	25	44.87	54.21	58.71	11.38	0.94	12.10	1.14	0.85	648.78
20	7.18	25	44.62	53.25	57.22	11.32	0.98	11.55	1.21	0.86	632.45
25	7.20	25	44.31	52.10	57.04	11.30	1.03	10.97	1.27	0.89	616.89
30	7.23	27	44.18	51.15	56.18	11.24	1.08	10.40	1.30	0.91	608.12
35	7.36	28	44.03	49.60	56.70	11.20	1.10	10.18	1.36	0.95	529.32
40	7.39	27	43.86	48.27	54.36	11.18	1.36	8.22	1.42	0.97	584.64
45	7.45	28	43.52	46.35	52.10	11.12	1.42	7.83	1.49	1.03	560.93
50	7.48	27	43.22	45.15	51.56	11.09	1.56	7.10	1.52	1.07	528.10
55	7.48	27	43.14	42.58	40.64	11.05	1.63	6.78	1.56	1.14	496.24
60	7.54	28	43.02	41.25	35.62	11.03	1.74	6.34	1.59	1.28	480.60

Table -5: Performance Analysis of Trial III

DAYS	pH	Temp (°C)	Moisture content (%)	Total solids (%)	Volatile solids (%)	Carbon (%)	Nitrogen (%)	C/N ratio	Phosphorus (%)	Potassium (%)	COD (mg/l)
1	6.44	25	48.94	54.75	69.58	11.49	0.78	14.73	0.84	0.68	710.34
5	6.75	25	48.58	54.15	68.05	11.46	0.82	13.98	0.92	0.71	640.07
10	7.00	26	48.06	53.65	63.36	11.42	0.94	12.15	0.98	0.75	608.62
15	7.06	27	47.88	53.25	60.80	11.40	1.20	9.50	1.04	0.78	592.00
20	7.13	26	47.62	50.68	58.75	11.24	1.20	9.37	1.09	0.81	568.80
25	7.15	26	47.41	50.10	57.66	11.14	1.24	8.98	1.12	0.84	536.67
30	7.20	27	47.26	49.55	56.90	11.04	1.36	8.12	1.16	0.85	528.12
35	7.23	26	46.93	48.80	55.65	11.01	1.38	7.98	1.19	0.87	504.92
40	7.30	25	46.73	47.35	51.67	10.98	1.43	7.68	1.23	0.88	472.64
45	7.36	25	46.35	46.25	50.88	10.92	1.58	6.91	1.26	0.89	456.67
50	7.40	25	45.98	45.45	49.30	10.84	1.62	6.69	1.28	0.91	448.04
55	7.38	27	45.56	44.00	47.72	10.78	1.68	6.42	1.29	0.92	400.47
60	7.45	28	45.25	42.10	37.89	10.64	1.78	5.98	1.30	0.94	376.50

4.1. GRAPHICAL REPRESENTATION

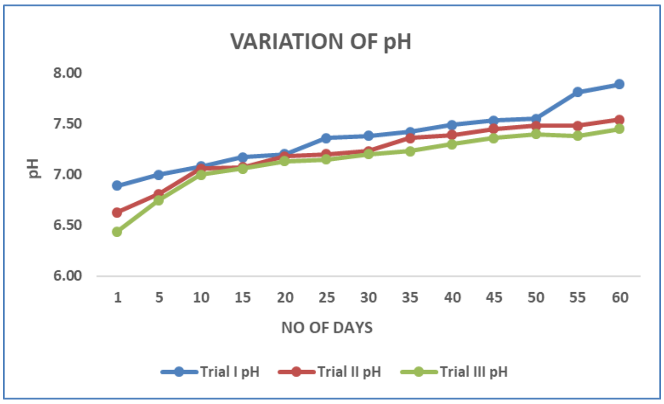

Chart -2: Variation of pH

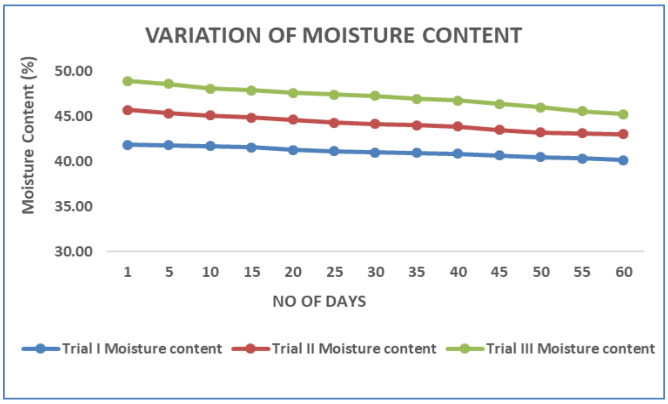

Chart -4: Variation of Moisture Content

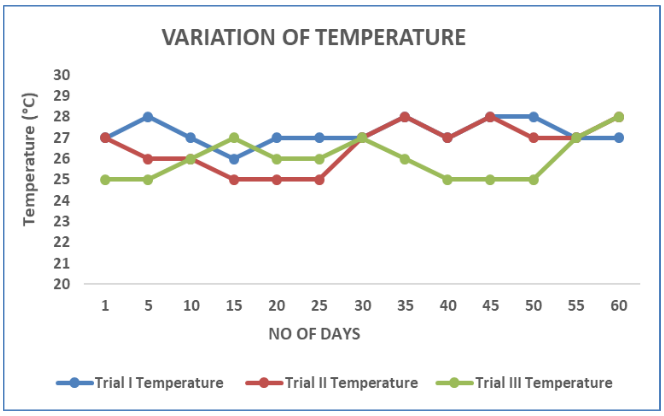

Chart -3: Variation of Temperature

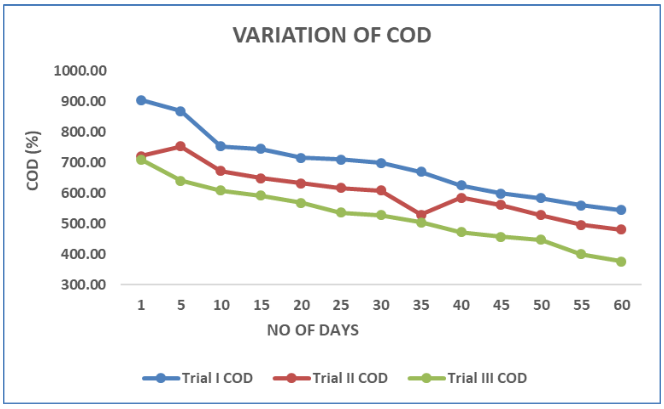

Chart -5: Variation of COD

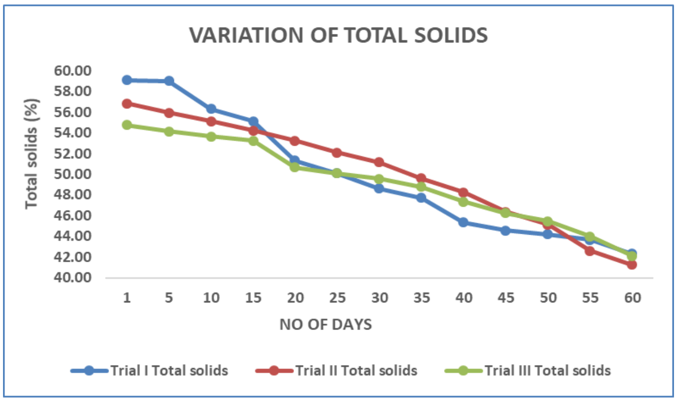

Chart -6: Variation of Total Solids

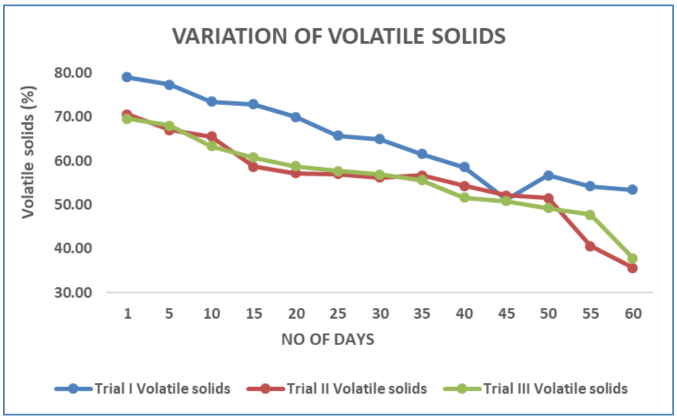

Chart -7: Variation of Volatile Solids

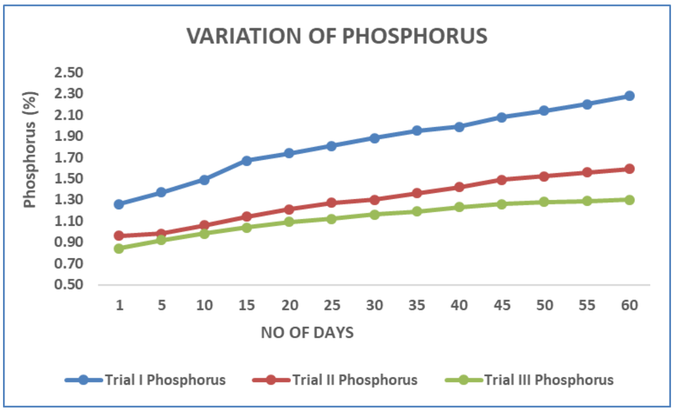

Chart -8: Variation of Phosphorus

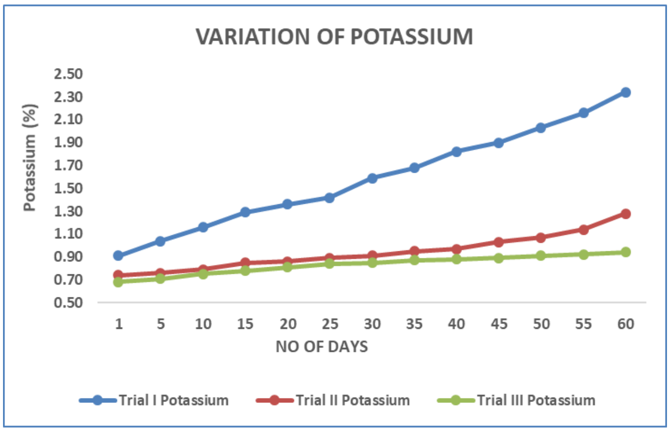

Chart -9: Variation of Potassium

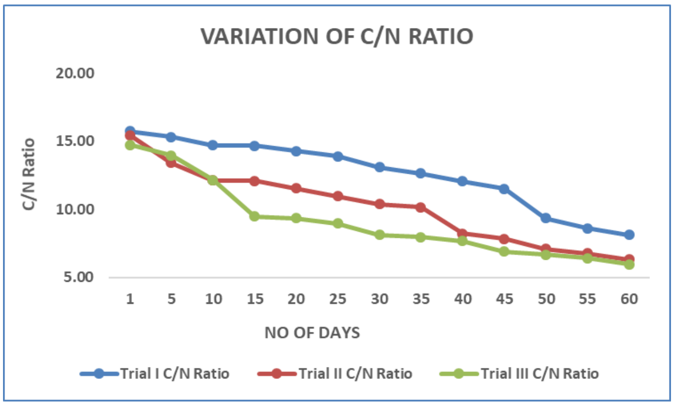

Chart -10: Variation of C/N Ratio

After about 60 days, the volume of the materials has dropped substantially. At this point, the compost and worms were recovered from the each trial pits. The recovered compost were dried, sieved through 2.5mm sieve and then analysed for the final characteristics. Finally the compost can be used as a manure and earthworms were used for the next cyclic processes.

Mix Proportion 2:1 | Mix Proportion 1.5:1.5 | Mix Proportion 1:2

Fig -3: Recovered Compost

5. CONCLUSION

The characteristic values of the compost of various mix proportions are compared with the ideal values of good compost suggested by the Tamilnadu Agricultural University – Organic Farming Department.

Table -6: Ideal Values of Good Compost

S.NO.	Parameters	Ideal Values
1	Moisture Content	40 %
2	pH	5 – 9
3	Organic Carbon	9.5 – 17.98 %
4	Nitrogen	0.5 – 1.5 %
5	Phosphorus	1074 – 1920 mg/kg
6	Potassium	91.85 – 645.55 mg/kg

Based on the ideal values and the results obtained from the study, the following conclusions are drawn.

- The moisture content of compost in trial III has higher value, because of too much quantity of food waste. So the quantity of food waste to be processed plays important role in biodegradation process. Sometimes it may lead to leachate problem also.

- The pH values of the compost in all trials are within the standard limit that is neither acidic nor alkaline.
- C/N ratio of the compost in trial I shows the better results. In trial III the green product (food waste) is too high which will increase nitrogen content but decreases carbon content will results lower C/N ratio.
- Phosphorus and potassium values obtained in trial II and III are sufficient for good compost. In trial I the values obtained is little much more, that will not cause any problem. But prolong application of phosphorus leads to ground water contamination and excess potassium level causes over fertilizing condition.
- From overall results, trial I of 2kg vegetable waste and 1kg food waste will give better results than other two trials.
- The processing time of organic waste by other methods is about more than 100 days but the processing time in this process is a maximum of 60 days.
- There is increasing of worm population which is used for next cycle of the degradation process.
- This process does not result any odour problem.
- It is cost effective and eco – friendly method of waste disposal.

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