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Study on Aerobic In-vessel composting of Food Waste

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Abstract

This study is about the management of food waste by means of aerobic In-vessel composting that has been carried out in laboratory scale with the primary objective pertaining to on site composting of food waste generated in hotels, markets and thus making it as a source of revenue. Three trials have been carried out with different mix ratios, bulking agents and starting cultures. The process has been monitored based on parameters like pH, Height (volume reduction), Organic Matter, organic carbon, Moisture content, Dry matter, Ash content and finally the compost is mixed with soil to check the plant growth and its yield. According to the findings the best suitable ratios will suggested to be implemented in large scale.

Keywords: Composting, Food waste, In-vessel system, Mix ratios, Bulking Agents, yield.

Introduction

Municipal Solid Waste (MSW) is defined as droppings or detritus that is thrown away after consumption of the desired or useful material; it includes packing materials, backyard trimmings or garden wastes, food scraps, broken or unused furniture, newspapers, home appliances, waste clothes, construction and demolition wastes, empty bottles and tins. The main sources of these wastes are residential units, educational institutions, hospitals commercial complexes[1]. Food waste is one of the single largest constituent of municipal solid waste stream. The proportion of food waste in MSW is approximately (20 to 40%). Above 35 million tons of food is wasted and is let in to landfills or it is incinerated annually as per the statistics of United States Environmental Protection Agency that is 40 percent of the entire country's food consumption. Residential units of United Kingdom waste around 8 million tons of food annually[2]. As per statistics taken in 2013 India wastes around 44000 crore worth food every year, Due to lack of storage facilities about 30 per cent of the country's fruits and vegetables are let out as wastes[3]. As a result of improper management of food production 15 to 20 percent of food is wasted at wedding, parties and restaurants. The above mentioned statistics indicates that excessive amount food is wasted all over the world. The amount of food waste present in the municipal solid waste stream is increasing gradually so a proper food waste management system has to be implemented for the safe disposal of food waste. These wastes are good energy sources which when disposed in landfills leads to emission of green house gases in to the atmosphere. Since the food waste contains higher amount of sodium slats, moisture content and in addition, due to mixing of food waste with other wastes the treatment of food waste has become critical. These wastes are generated mainly from residential units, hotels, cafeterias, food processing industries etc. hence the food wastes has to treated separately instead of disposing it into landfills or incinerators which will help to resolve environmental crises like climate change, pollution of air, water and soil. This will also let us to generate revenue, to offer employment opportunities and to generate renewable energy from food waste[2].

Composting: It is one of the fast growing treatment methodologies adopted to treat the organic wastes such as food waste etc. The process of collection of organic wastes such as food wastes and back yard trimmings and enable them to breakdown in to simpler substances naturally under suitable conditions is known as composting. The end product (i.e) compost can be used as organic manure[4]. The main components required for composting are nitrogen: which helps to build the cell structure, carbon: acts as an energy source, moisture and oxygen: helps for the survival of bacteria and insects.

In-Vessel Composting: It is one of the composting methodologies that contain a chamber or vessel equipped with facilities to provide proper mixing, aeration and moisture to the feed stock present in it[5]. All the environmental conditions are maintained properly in order to quicker the composting process. In the process of composting; the feed stock is homogenized by turning and mixing it frequently and to ensure transfer of oxygen quickly[5]. In vessel systems, when operated properly produces lesser or no lechate and odours. This system can decompose up to 2.5lakhs tonnes of waste per year.

Advantages of In-vessel composting: Composting process can be controlled easily and it also helps in rapid decomposition, it gives a good quality end product, adverse effects on climate change and environmental pollution can be avoided. It requires less man power and the working persons are will have less exposure towards the feed stock, this process can be done on site thus reducing transportation and collection costs, it requires

lesser land area, collection and treatment of process air and lechate can be done easily, it is suitable for all kinds organic wastes and any amount of wastes can be treated my this method. This method is the one which will be accepted by the public easily due to above mentioned advantages[6].

Materials and Methods

Reactor Setup: A simple open cylindrical composting reactor made out of an acrylic fibre with the following dimensions; Diameter: 300mm, Height: 410mm, Working Volume: 15.88Litres. feed stock was placed over the stainless steel grid of 8mm square mesh which at the distance of 90mm from the base of the reactor. Feed stock was aerated by means of an electric fan of 2800 rpm, 230 V, 12" and 30.5 cm in size. Mixing was done manually on daily basis with the help of shovel.

Feed stocks and their ratios: In this study three different trials were carried out with different mix ratios, different feed stocks and manures, bulking agents and starting cultures. All the details are furnished below.

Table-1
Feed stock details of trial 1

Feed stock materials	Weight in kg
Vegetable Waste	02
Rice	0.5 =3.5 Kg
Tea	01
Poultry manure	01
Starting culture	0.5
Ratio	70:20:10

Table-2
Feed stock details of trial 2

Feed stock materials	Weight in kg
Vegetable Waste	2.3
Rice	1.5 =6 Kg
Tea	2.2
Poultry manure	0.5
Cow Dung	0.5
Saw Dust	0.5
Ratio	80:6.7:6.7:6.7

Table-3
Feed stock details of trial 3

Feed stock materials	Weight in kg
Vegetable Waste	03
Rice	1.5 =7.5 Kg
Tea	03
Cow Dung	01
Starting culture	0.5
Rice husk	0.5
Ratio	76:12:6:6

The vegetable and food wastes were collected from a nearby Hotel. The poultry manure and cow dung were collected from a small farm located at palladam. The vegetable wastes were cut in to small pieces and the mixed with other wastes such as rice tea waste and manure according to mix ratio and then fed in to the reactor.

Experimental Methodologies: During the process of composting parameters such as pH, Organic matter, moisture content, dry matter, ash content, and height were monitored at the interval of 5 days for the time period of 30 days. All the observations made are shown in Table-4 to 7.

Results and Discussion

pH: The amount of acidity (or alkalinity), or the activity of hydrogen ion in soil or compost (on a logarithmic scale) is known as pH. It has a scale ranging from 0 to 14, with a value of 7 that refers to neutral pH. A 10-fold increase or decrease of acidity is indicated by pH change of 1 unit. Mostly the pH of a compost lies within 6 to 8[7]. Initially for all the three trials pH was 5.79, 5.82, 5.15 respectively, due to the production of organic acids[8] on the second and third day pH dropped down to the range of 4. The pH may also be lowered due to the production of secondary acidic metabolites because of the presence of excessive organic components and microbial activities that occurs within the food waste compost[8]. From the day 5 it gradually started to increase which may be due to the microbial activities, degradation of proteins, annihilation of carbon dioxide and ammonification process may also help in increasing pH[8] (i.e) In case of trial 1 the pH increased from 5.79 to 7.88 gradually.

For the trial 2 and trial 3 pH increased gradually to 8.12 and 8.00 on 15th and 20th days respectively and then came down to neutral range of 7.36 and 7.57 respectively. The graphical representation of duration vs pH for all the trials is shown in Figure-1.

Table-4
Observations of Trial 1

Day	pH	Moisture content (%)	Dry Matter (%)	Organic Matter (%)	Organic carbon (%)	Ash content (%)	Height (cm)
0	5.79	83.1	16.9	86	49.88	14	9
5	5.95	82.8	17.2	82	47.56	18	8
10	6.05	81.15	18.85	80	46.40	20	7.8
15	6.88	80.75	19.24	79.24	45.56	20.76	6.5
20	7.15	77.70	22.30	78	45.24	22	4.8
25	7.30	68.70	31.30	64	37.12	36	3.6
30	7.88	59.40	40.60	58	33.64	42	2.2

Table-5
Observations of Trial 2

Day	pH	Moisture content (%)	Dry Matter (%)	Organic Matter (%)	Organic Carbon (%)	Ash Content (%)	Height (cm)
0	5.82	83.85	16.15	92.20	53.48	7.8	18.5
5	6.98	72.70	27.30	88.56	51.36	11.44	11.2
10	7.45	62.85	37.15	85.11	49.37	14.89	9.70
15	8.12	59.37	40.63	80.60	46.75	19.40	6.40
20	8.04	56.89	43.11	76	24	44.08	4.80
25	7.98	47.41	52.59	67.40	32.60	39.09	2.60
30	7.36	43.25	56.75	62	38	35.96	1.80

Table-6
Observations of Trial 3

Day	pH	Moisture Content (%)	Dry Matter (%)	Organic Matter (%)	Organic Carbon (%)	Ash Content (%)	Height (cm)
0	5.15	80	20	87.62	50.83	12.38	22.00
5	5.70	73.57	26.43	80.87	46.90	19.13	16.30
10	6.33	69.45	30.55	74.10	42.98	25.90	13.80
15	7.38	64.42	35.58	65.48	37.98	34.52	9.20
20	8.00	59.11	40.89	60	34.80	40	6.40
25	7.64	54.65	45.35	57.40	33.29	42.60	3.20
30	7.57	47.40	52.60	55.68	32.47	44.32	2.40

Moisture Content: The amount or quantity of water present in the compost is known as moisture content which is expressed in terms of percentage of total weight. The moisture content affects the handling and transportation of compost due to the changes in its bulk density. A compost with higher moisture content (55 to 60%) will be bulky and clumpy which will make the application of compost to be a difficult task and also increase the cost of delivery while excessively dried composts (less than or equal to 35%) will be very powdery and difficult to apply, Finished compost should have a moisture content of about 40 to 50%[7]. Initially moisture content of all the 3 trials were around 80% (i.e) 83.10%, 83.85% and 80% respectively It was around 50 to 70% till 20th day which was mainly due to hydration of feed stock, reduction of moisture content mainly depends on aeration[9] . Finally gradually decreased to 59.40%, 43.25%, and 47.40% respectively. The graphical representation of duration vs moisture content is shown in Figure-2.

Table-7
Weight and C/N Ratios of compost

Trial No	Initial Weight Kg	Final Weight Kg	C/N Ratio (Initial)	C/N Ratio (final)
1	5	1.25	25.45	12.53
2	7.5	1.5	27	14.30
3	9.5	1.72	30	15.56

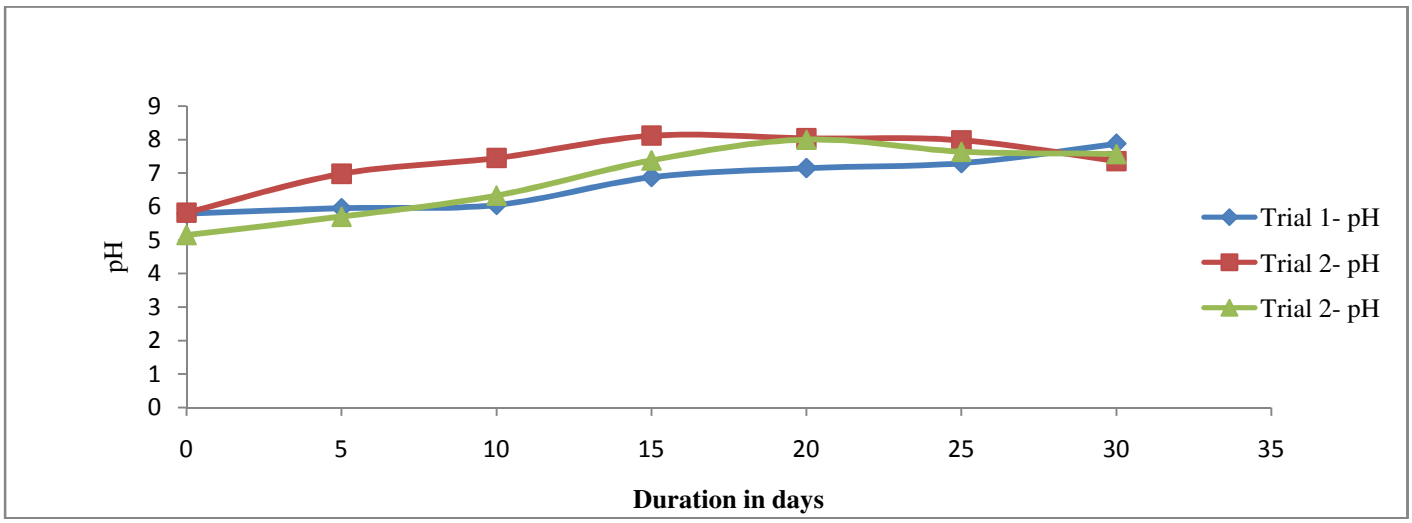

Figure-1
pH profile with respect to time from trial 1, 2 & 3

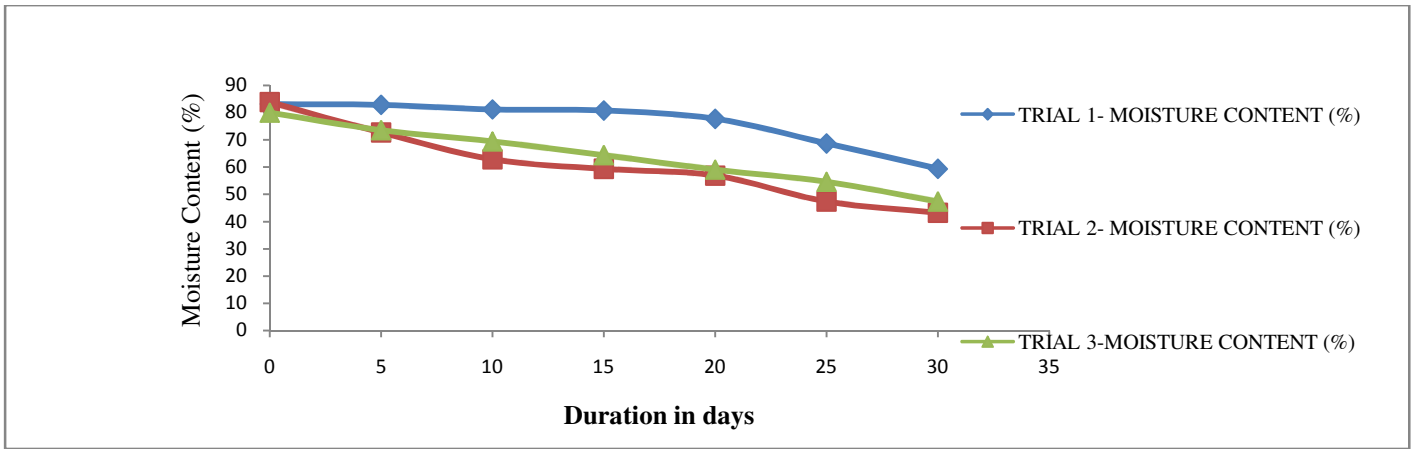

Figure-2
Moisture content profile with respect to time from trial 1, 2 & 3

Organic Matter: The measure of the amount of carbon based materials present in compost is known as organic matter content. It is expressed in terms of percentage of dry weight. It is one most important ingredient present in all the soils and also has significant role in, water holding capacity, availability of nutrients in the soil and in the structure of a soil. Physical properties and maturity of compost can be estimated from the amount of organic matter present in it. Organic matter content present in the compost may be highly essential in order to determine the compost application rates for agricultural crop production and for the establishment of lawns. Test kits are used to determine the allowable application rates of organic matter on to the soils. The application rates are expressed in terms of quantity of organic matter required on per acre basis, hence organic matter content present in the compost should be known in order to determine their allowable application in terms of tons per acre, the organic matter content may vary from 30% to 70%[7]. Food waste usually consists of assailable organic matter in excess which leads to mineralization by means of microbial activities. The organic matters are transformed and stabilized products with the properties of humus materials is obtained as a result of mineralization and humification that occurs during the process of composting, other metabolic products like volatile organic compounds, inorganic elements and biomass are also obtained during the process[8]. In this study initially the organic matter in content in three trials were 86.92.2, and 87.62 percentages respectively and due to the microbial activity it started to decrease as the days passed and finally it was around 58, 62 and 55.62 percentages respectively.

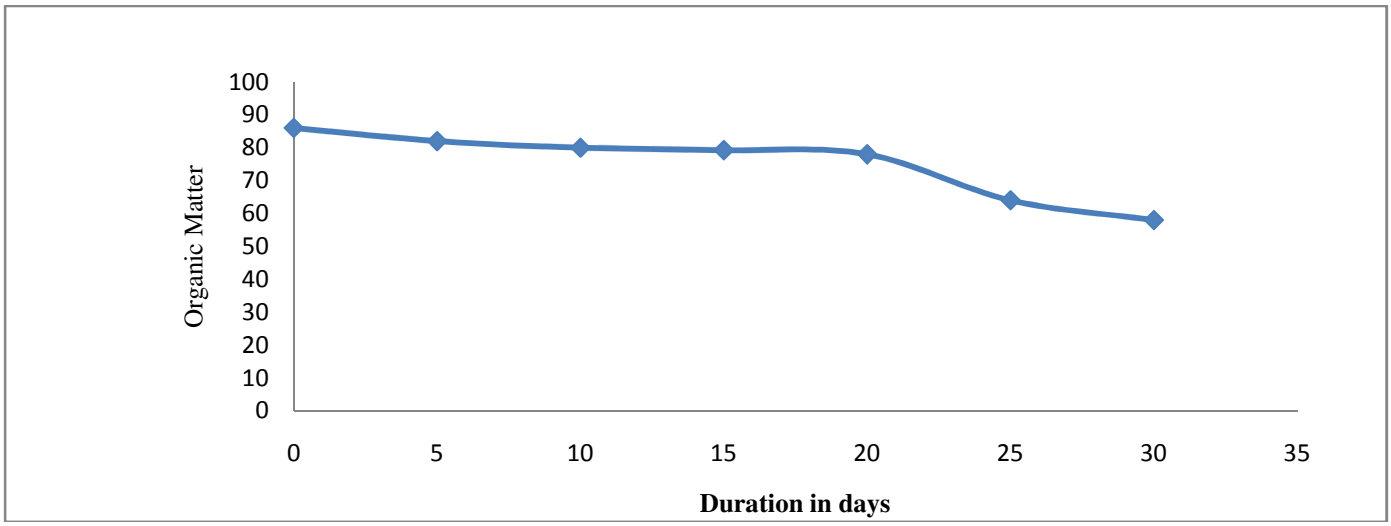

Figure-3
Organic Matter profile with respect to time from trial 1

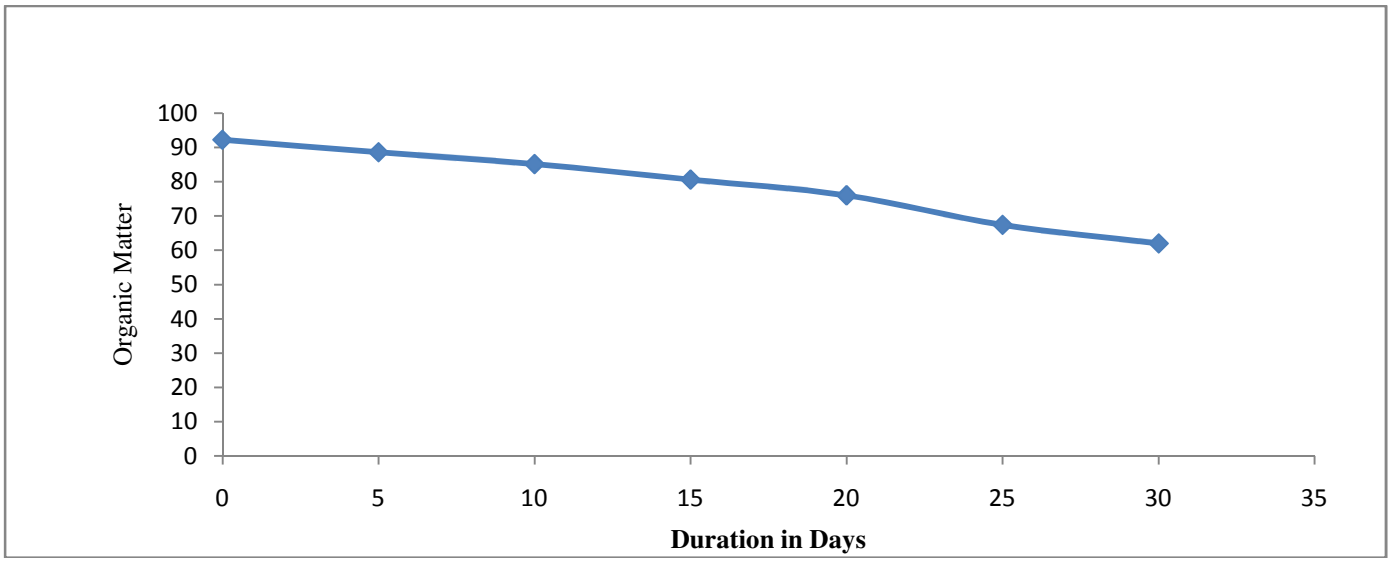

Figure-4
Organic Matter profile with respect to time from trial 2

Ash Content: Ash content test is done in order to know the amount of Inorganic matter or the availability of micro nutrients in the compost sample[10]. In this study initially amount of ash content present in the sample was low (i.e) 14, 7.8 and 12.38 percentages respectively. As the process of composting occurs it increased gradually and finally it was 42, 35.96 and 44.32 percentages respectively.

Effect of Plant growth and its yeild: The NPK values of the three compost trials is tabulated in Table-8.

A comparitive study was made in order to find the variations in above parameters. Four okra (Abelmoschus esculentus L (ladies finger)) seeds were Sowed in 4 different pots; one seed in normal soil and other 3 in the soils mixed with the final compost of 500 grams Obtained from the three trials respectively[11]. The obsevations made are shown in Table-9.

Higher yield was obtained in plant that is planted in soil mixed with trial 2 which may be because of the higher NPK value and the same has been obtained in case of other 2 trials depending on their NPK value.

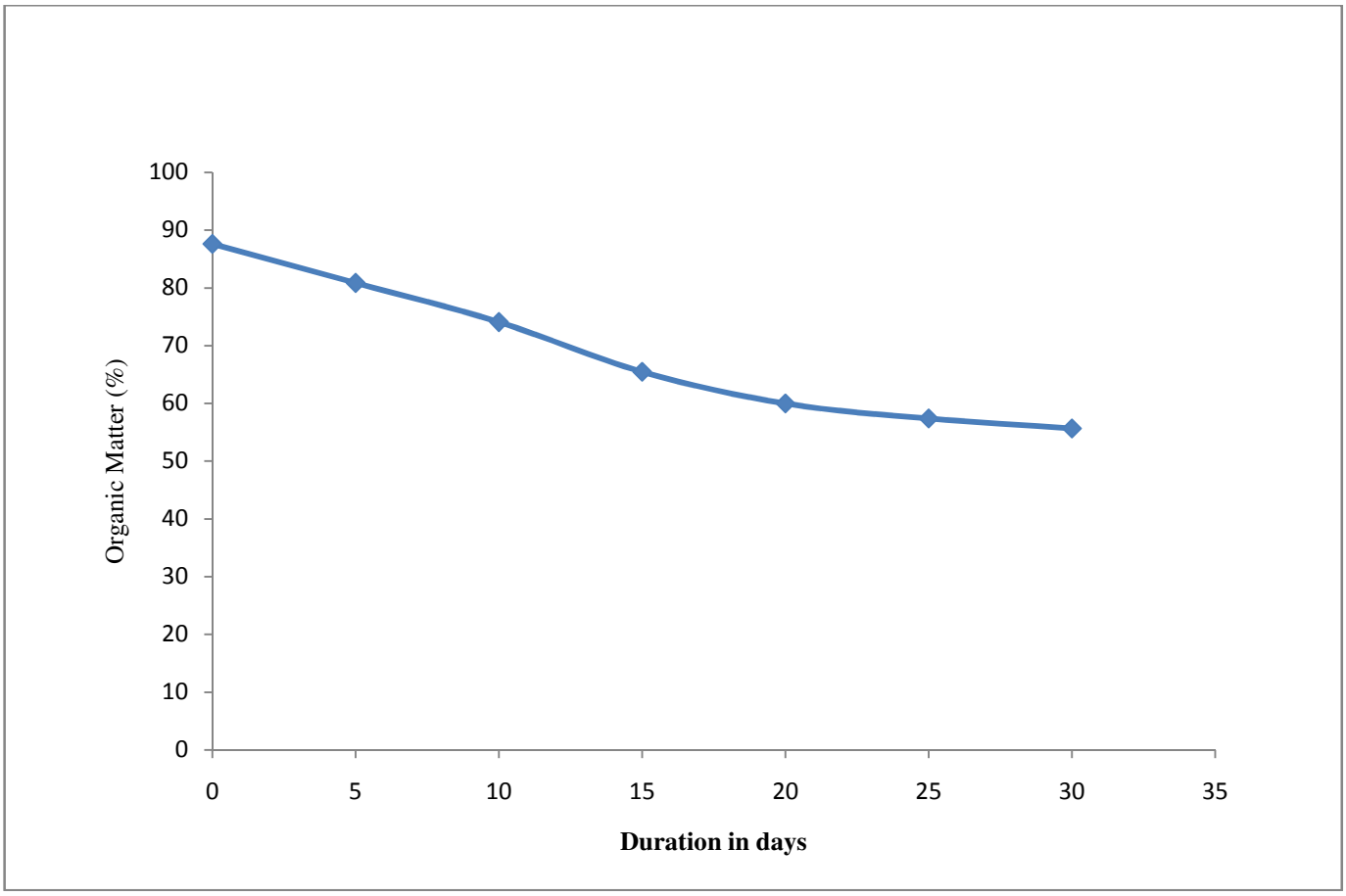

Figure-5
Organic Matter profile with respect to time from trial 3

Table-8
NPK values for compost

Trial no	N (%)	P (%)	K (%)
1	1.21	0.13	1.24
2	4.39	0.62	4
3	1.57	0.25	2.30

Table-9
Plant growth and yield studies

trial no	Germination observed in days	Stem height (cm)			No of okra fruit obtained
		15th day	30th day	45th day	
Normal soil	5th day	9.3	16	23.5	11
Soil + trial 1 compost	4thday	10.1	14.5	25.4	13
Soil + trial 2 compost	3rd day	13	17.7	28.3	17
Soil + trial 3 compost	4th day	12.4	18.2	26.3	14

Figure-6
Plant growth for trial 1

Figure-7
Plant growth for trial 2

Figure-8
Plant growth for trial 3

Conclusion

All the three trials showed nearly same results with a variation approximately of 5 to 10 percentages in the above mentioned parameters. In the case of pH, all the three trials showed a pH of 7 (near neutral). In case of moisture content second and third trials showed the stipulated range of 40 to 50 %, while the first trial showed slightly higher percentage. Higher organic matter and organic carbon reduction was achieved in the order of third, first and second, there is no preferred range for the organic matter to be present in the compost (may vary from 30 to 70%). All the trials can be implemented in large scale particularly the second trail in which a combination of food, vegetable and tea waste with cow dung, poultry manure and saw dust worked well, they can be implemented even in residential units, backyards of hotels etc. In the case of plant growth and yield studies second trial showed higher yield followed by third and first trial which may be due their corresponding NPK value, hence the same can be used for agricultural purposes and it can also be sold out as an organic manure and thus generating a revenue. In the case of volume reduction based on the reduction in height this method works well. Thus it is concluded that this is a good treatment methodology especially for food waste and is also good one in the case of revenue generation from waste.

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