A Term Project Report

On

Composting of Biodegradable Solid Waste

Submitted by

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1. INTRODUCTION

The expanding urbanization with the arrival of science has surely brought fortune for the people but not for the nature. In today's ever- expanding world with rapidly growing population, solid waste management (SWM) has become a serious problem. A common citizen from a developed nation generates close to 500 kg of waste every year and this huge generation of solid waste is a major concern throughout the world. Approximately 1.3 billion metric tons of solid waste is generated throughout the world out of which India alone generates more than tenth of world's waste (277 million tonnes according to 2016 estimate) and is expected to produce 543.3 million tonnes as per 2050 estimated by World Bank. With the growing development and urbanization around the world, SWM becomes more challenging and crucial day by day. Therefore, using techniques specifically through biological means which are economically feasible will help in managing the solid waste and it will in turn help in maintaining an ecological balance which is quite essential in the current times.

Composting is one of the most efficient and efficacious treatment methods that can be employed for the removal of organic fraction of solid waste. It is an economically feasible and environmentally sustain- able technique that can be used for the effective treatment of solid waste around the world. The main purpose of composting is to convert solid organic wastes into nutrient rich soil conditioner and organic fertilizer which results in reduction of odour, phytotoxic chemicals, weed seeds and pathogens. Outdated waste management systems based on collection and transportation of waste to disposal sites are still utilized in many countries. Treatment by composting process can be done at the household itself with the utilization of composting bin which makes the composting technique a best alternative to replace the outdated waste management systems. Composting process is being more widely adopted and accepted for SWM throughout the world recently. Sustainable management of waste along with the circular economy is a wide area of re- search currently being explored by scientists and researchers across the globe. Both developing and under-developed countries lack the facility of systematic segregation and removal of garbage, including organic wastes. Environmentalists consider SWM as the second most important problem after wastewater treatment. Hence to control and break off the solid waste generation cycle at its source itself, composting is the essential way.

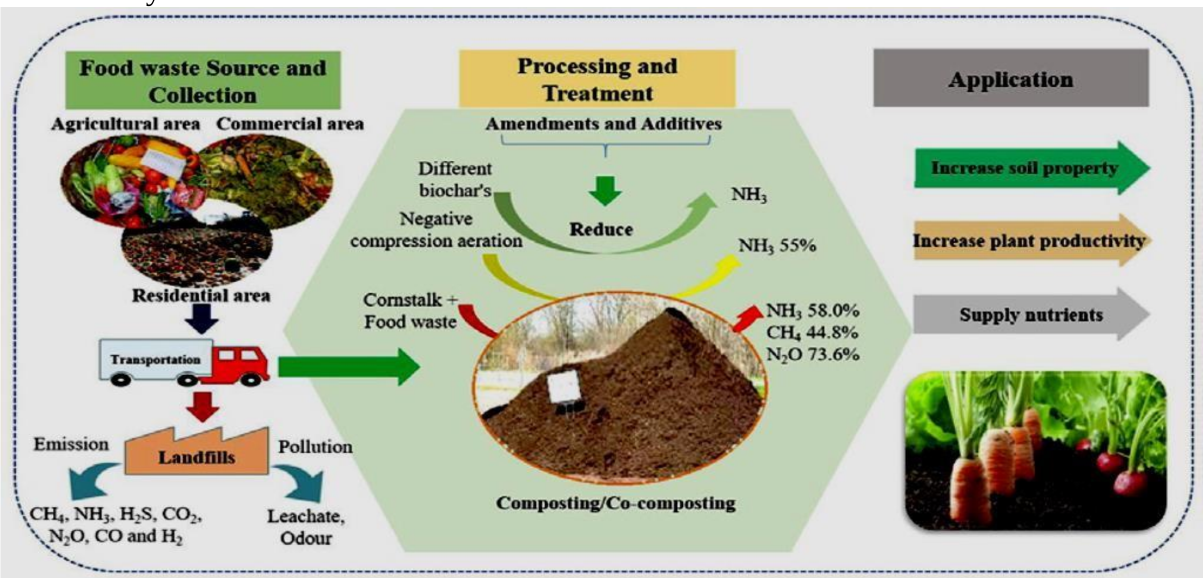

Figure1: Composting Process

An efficient and promising technique in decentralised composting is the rotary drum composter. It is an excellent concept for smaller communities or in the case of projects that require a rapid and an enclosed pathogen killing process. The composting time is drastically reduced to 2–3 weeks. There are two main aspects in the speeding up of the composting process. The first is that the material is constant motion, ensuring that the total organic waste is in constant contact with oxygen. The second is that the material which is freshly added to the drum is aerated with warm ammonia laden air.

Therefore, the objective of this study is to investigate the composting process of a mixed organic waste in a rotary drum composter. The study includes the dynamics of composting in terms of temperature, moisture content, Electrical conductivity, pH, nitrogen, phosphorus, potassium.

2. LITERATURE REVIEW

AUTHOR	PUBLICATION	METHODOLOGY	FINDINGS
Sudharsan Varma V, Ajay S. Kalamdhad (2013)	International Journal of Environmental Sciences	• Municipal solid waste was collected from the temporary storage bins located in civil line area of Roorkee city. • Cattle (Buffalo) manure was collected from nearby villages of Guwahati city • maximum particle size was restricted to 1-2 cm • Composting of MSW done with different proportion of cattle manure (1:1.5),(1.5:1),(1:1)	• 1.5:1 gives the higher quality of compost • Total nitrogen (2.16%), final total phosphorus (3.24 g/kg), final TOC (17.04%) and final electrical conductivity (EC) (2.78 dS/m) within 20 days of composting. • Final COD (542 mg/L), BOD (290 mg/L) and final CO2 evolution (1.05 mg CO2/g volatile solids (VS)/day). • Solvita® maturity index of 7
Ajay S. Kalamdhad , A.A. Kazmi(2008)	Chemosphere	• Organic waste (cattle manure, green vegetable and sawdust) shredded to 1 cm. • mixing cattle manure (25 kg), mixed green vegetables (20 kg) and sawdust (10 kg) in 2.5:2:1 ratio • Drum rotated after every 6h, 12h, 18h and 24 h. • The composting period was taken as 15 d and at a time 3 rotation were made.	• It was observed that (24 h turning frequency) caused longer thermophilic phase with a higher rise at temperature 58°C, nutrient rich compost and less loss of nitrogen in gaseous form. • 23% of available carbon was utilized by micro-organisms and the electrical conductivity (1.32 dS m^{-1}) • CO_2 evolution and oxygen uptake rate found to be the lowest(for 24 hr turning frequency)

AUTHOR	PUBLICATIONS	METHEDOLOGY	FINDINGS
Ajay S. Kalamdhada, Yatish K. Singh , Muntjeer Ali , Meena Khwairakpam , A.A. Kazmi(2008)	International Journal of Environment and Waste Management	• Cattle manure, mixed green vegetables and sawdust mixed in a 2.5: 2: 1 ratio • particle size in the mixed waste was restricted to 1 cm	• 5-6 days (mesophilic and thermophilic phase) followed by 6-7 days of maturation phase. Maximum temperature reached 55°C. • Faecal Coliforms and Faecal Streptococci decrease from 7.5×10^8 to 5×10^2 and 1.5×10^7 to 5×10^3 bacteria/g • 2.1% N_T and 3.5% total phosphorus within a period of 20 days • BOD/COD ratio reduced from 0.94 to 0.23
Ajay S. Kalamdhad , Meena Khwairakpam & A. A. Kazmi (2009)	Bioresource Technology	• Hostels green vegetables waste (uncooked), dry tree leaves and cattle (Buffalo) manure, Sawdust collected. • Maturation study of primary stabilized compost was performed in three different seasons. Run 1 (winter, ambient temperature 5–15°C), Run 2 (spring, ambient temperature 10–25°C) and Run 3 (summer, ambient temperature 25–38°C).	• Higher temperature (60–70°C) at inlet zone and (50–60°C) at middle zone were achieved • Total nitrogen (2.6%) and final total phosphorus (6 g/kg) within a week • For maturation, vermicomposting found suitable for primary stabilized compost as is give better quality and fine grained compost • 60–70°C temperature were maintained even in cold weather conditions (ambient temperature 6°C).

AUTHOR	PUBLICATION	METHODOLOGY	REVIEW
V. Sudharsan Varma, Ajay S. Kalamdhad (2014)	Environmental Engineering Research	• Vegetable waste is composted in a 550-L batch scale rotary drum. • Total 150 kg of Vegetable waste (uncooked), cattle (Buffalo) manure, and sawdust, trial A (6:3:1) of C/N 24 and trial B (8:1:1) of C/N 30.	• Maximum of 63.5°C and 61.2°C was observed in trials A and B • Temperature dropped suddenly after the thermophilic stage in trial B, and leachate was observed due to insufficient amount of bulking agent
Ashish Kumar Nayak, Ajay S. Kalamdhad (2014)	Environmental Engineering Research	• Sewage sludge, cattle manure, and sawdust were used for the preparation of different waste mixtures • Sludge was dried in direct sunlight for 4–5 days with periodic turning to bring its moisture content to 70%. • compost material was prepared by mixing different proportions (C/N 15, C/N 20, C/N 25, C/N 30, and control) of the collected waste.	• C/N 30 possesses a higher temperature regime with higher % reduction in moisture content, total organic carbon, soluble BOD and COD; and higher % gain in total nitrogen and phosphorus • CO_2 evolution and oxygen uptake rate decreases • Solvita maturity index of 8

3. MATERIALS AND METHODS

3.1 Rotary Drum Composter Design

In order to study the compost dynamics, a rotary drum composter of 250 L capacity was used (Figure 1). The main unit of the composter, i.e., the drum, is of 0.92 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 anticorrosive coating. The drum is mounted on four rubber rollers attached to a metal stand and the drum is rotated manually. In order to provide the appropriate mixing of wastes, 40 mm angles are welded longitudinally inside the drum. In addition to that, two adjacent holes are made on top of the drum to drain excess water. The shredded mixed organic waste is loaded into the drum by the means of a plastic container and filled up to 70% of the total volume. 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.

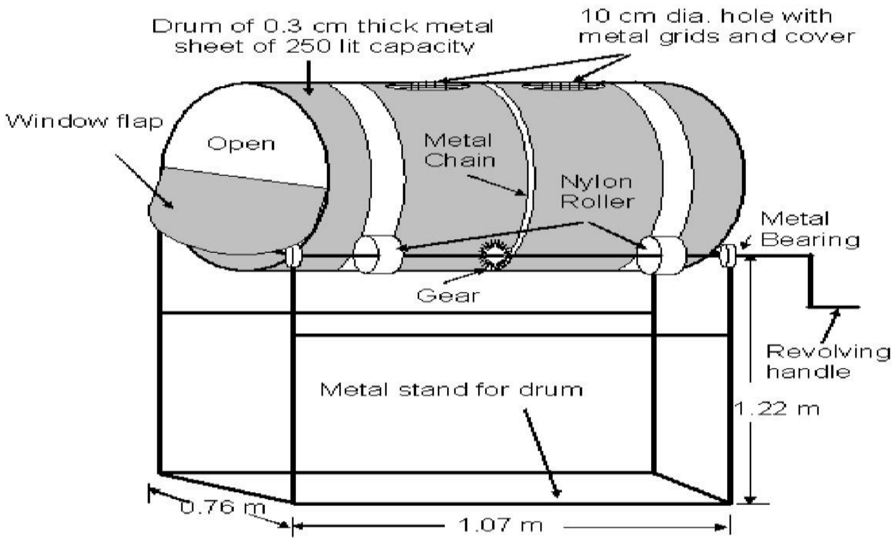

Figure 2 Schematic diagram of rotary drum composter

3.2 Feedstock Materials

A mixture of cattle manure, green vegetables from Siang Hostel and sawdust was selected as the mixed organic waste to be used. Prior to composting, the maximum particle size in the mixed waste was restricted to 1 cm in order to provide better aeration and moisture control. Mixing cattle manure, mixed green vegetables and sawdust in a 5: 4: 1 ratio, on wet mass basis. The vegetable waste is shredded with the help of a shredder. Cattle manure, sawdust and shredded vegetable waste are mixed uniformly.

10 Kg Saw Dust

50 Kg Vegetable Waste

40 Kg Cattle Manure

Figure 3 Substrate for Composting

Figure 4 Shredding of Vegetable Waste

Figure 5 Mixing of Substrate

4. Result and Discussion

A good composting process requires that the temperature, oxygen and moisture levels be maintained uniform throughout the compost matrix. Therefore, having the side doors of the drum closed, four 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 stabilisation 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.
The moisture adjusted composting material is supplied to the rotating drum for fermentation. Inside the drum, the tumbling action mixes and agitates the material inside the drum. In warm, moist environments with ample oxygen and organic material available, aerobic microbes flourish and decompose the waste at a quicker pace.

4.1 Temperature

Composting is essentially a microbiological phenomenon that depends highly on temperature fluctuation within the composting material. The temperature determines the rate at which many of the biological processes take place and plays a selective role on evolution and succession on the microbiological communities. During composting, the average temperature curve within the three mixtures showed three classic phases i.e. mesophilic, thermophilic and cooling phase. Maximum temperature observed was 53^0C at 3^{rd} day.

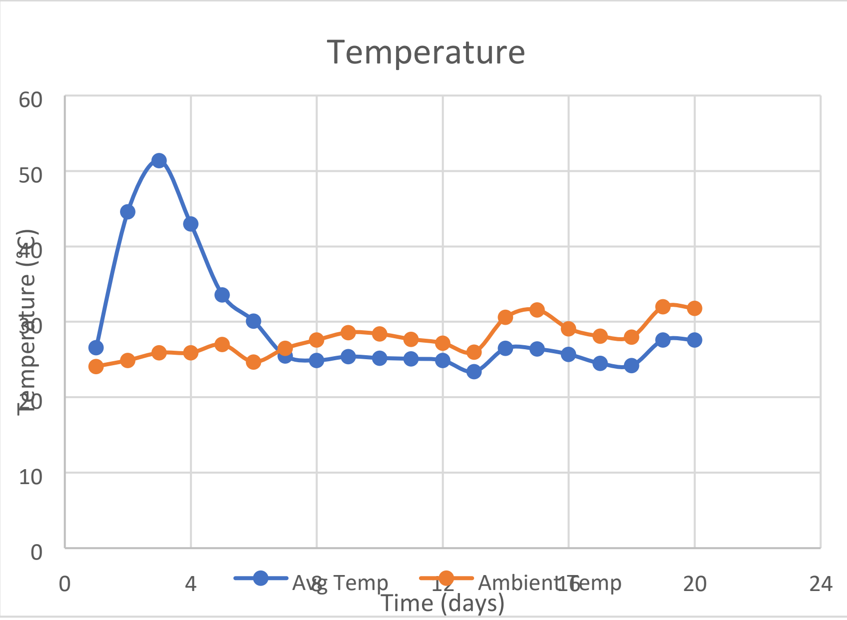

Figure 6 Temperature Profile for Composting

Day	Avg. Temp	Ambient Temp
1	26.6	24.1
2	44.6	24.9
3	51.4	25.9
4	43	25.9
5	33.6	27
6	30.1	24.7
7	25.5	26.5
8	24.9	27.6
9	25.4	28.6
10	25.2	28.4
11	25.1	27.7
12	24.9	27.2
13	23.4	26
14	26.5	30.6
15	26.4	31.6
16	25.7	29.1
17	24.5	28.1
18	24.2	28
19	27.6	32
20	27.6	31.8

4.2 Moisture Content

Moisture loss during the composting process can be viewed as an index of decomposition rate, since heat generation which accompanies decomposition drives vaporization or moisture loss. Moisture content reduced from 73.5 to 49.5%. Very less difference (2-3%) in moisture contents was observed in the top and bottom portions of the composter, implying uniformity of mixture rotation.

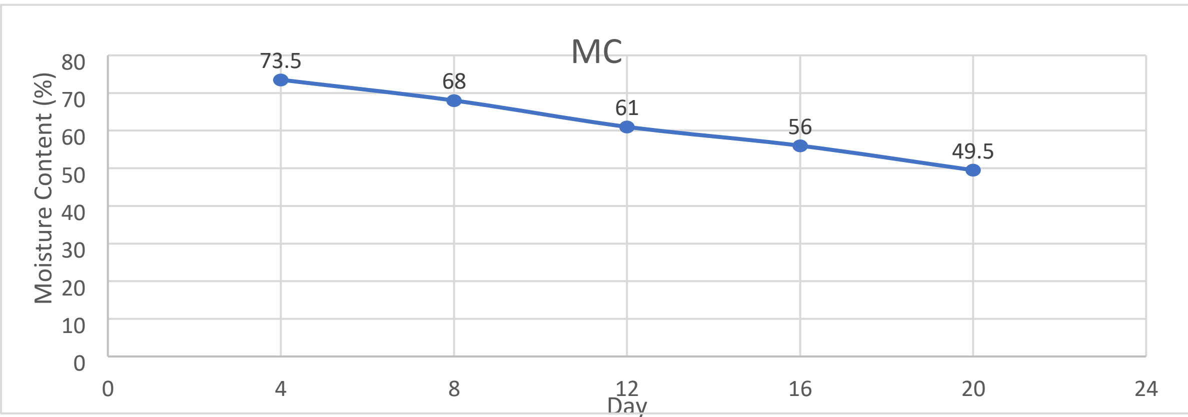

Figure 7 Moisture Content

Day	Moisture Content (%)
4	73.5
8	68
12	61
16	56
20	49.5

4.3 pH & EC

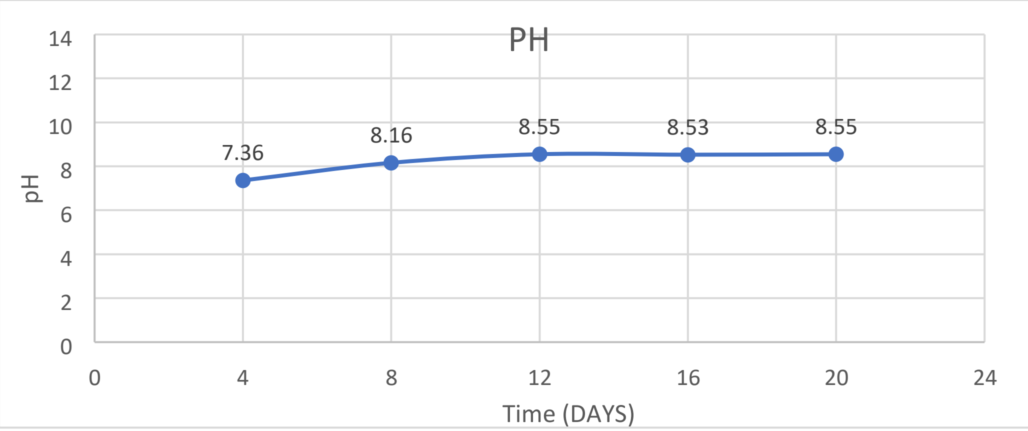

Figure 8 pH Profile

Day	pH
4	7.36
8	8.16
12	8.55
16	8.53
20	8.55

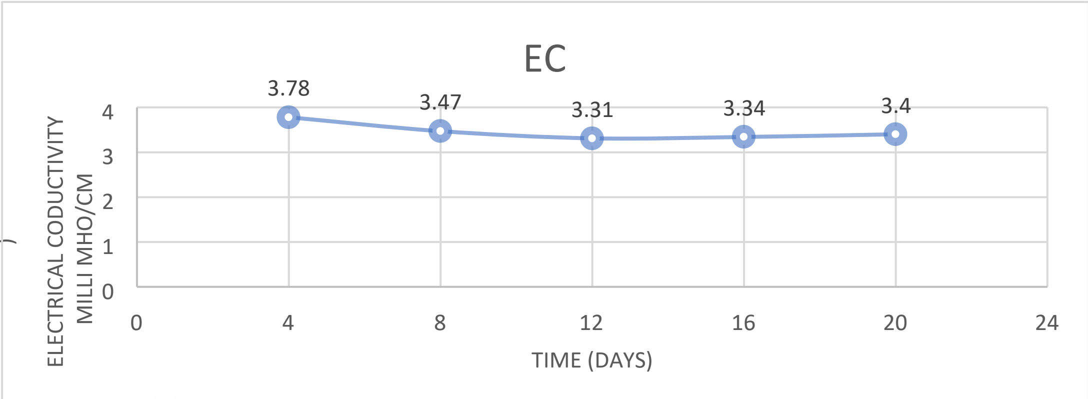

Figure 8 Electrical Conductivity Profile

Electrical Conductivity (milli mho/ cm)	Day
3.78	4
3.47	8
3.31	12
3.34	16
3.4	20

4.4 Phosphorus

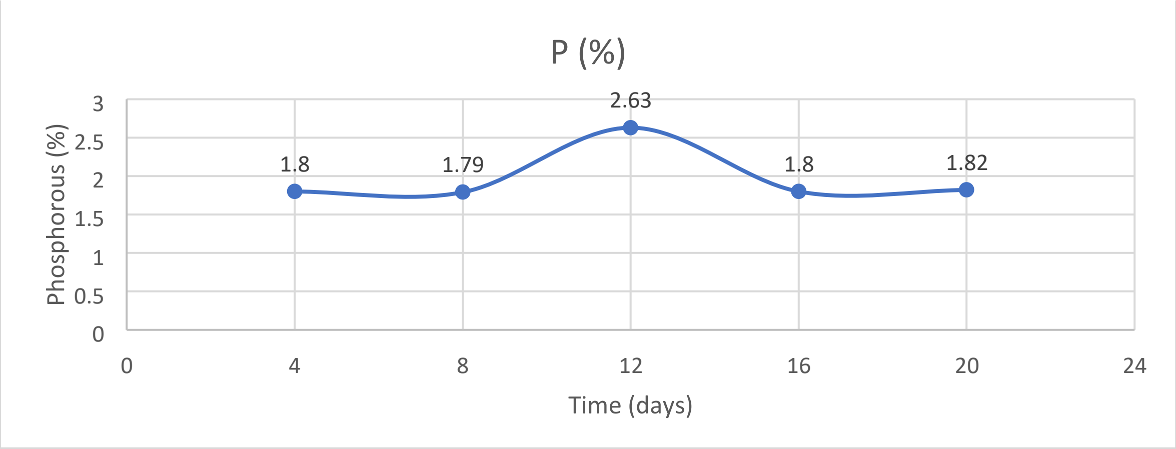

Figure 9 Phosphorus Concentration Profile

Day	Phosphorous (mg/kg)	P (%)
4	180	1.8
8	179	1.79
12	263	2.63
16	180	1.8
20	182	1.82

4.5 Potassium

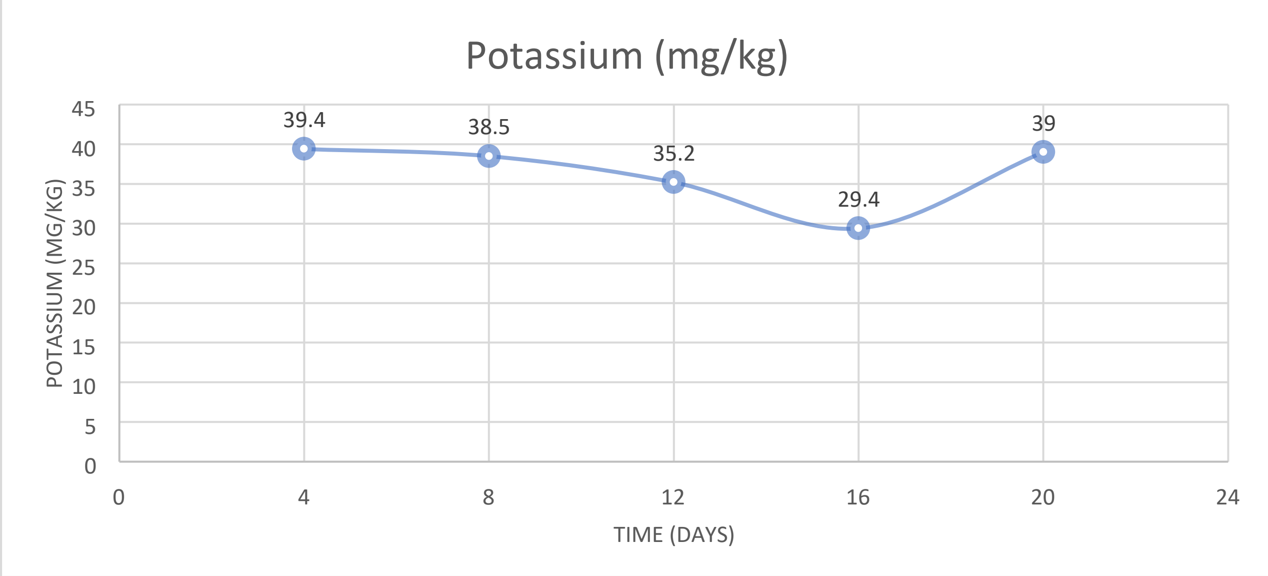

Figure 10 Potassium Concentration Profile

Day	K (%)	K (mg/kg)
4	2.32	23202.9
8	2.37	23726.45
12	2.5	25041.85
16	2.51	25198.45
20	2.04	20409.45

4.6 Volatile Content and Iron Content

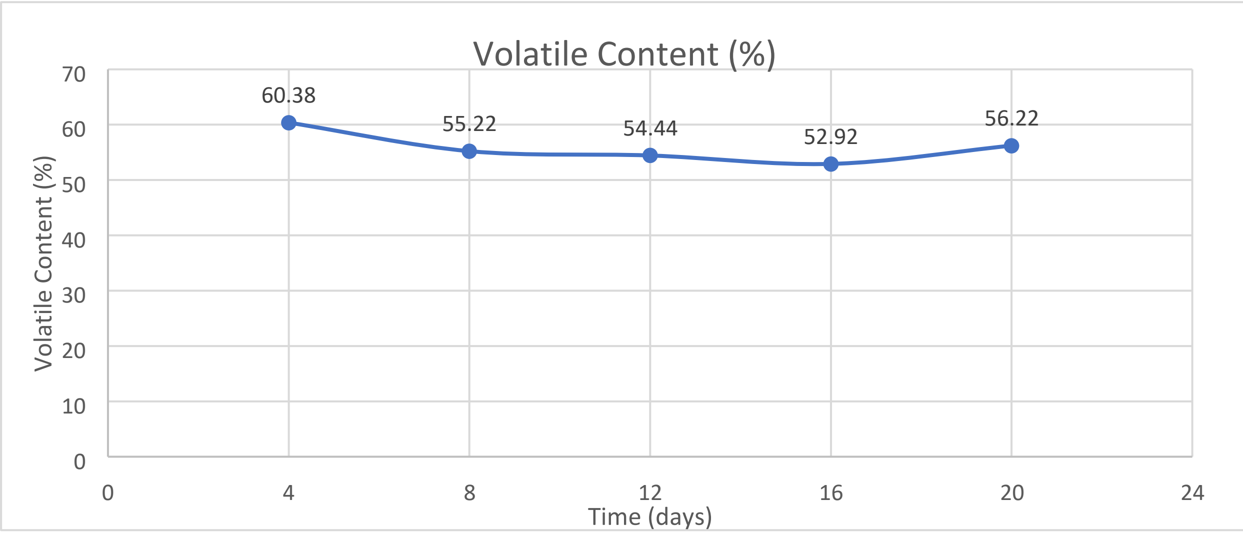

Figure 11 Volatile Content Profile

Day	Volatile Content (%)
4	60.38
8	55.22
12	54.44
16	52.92
20	56.22

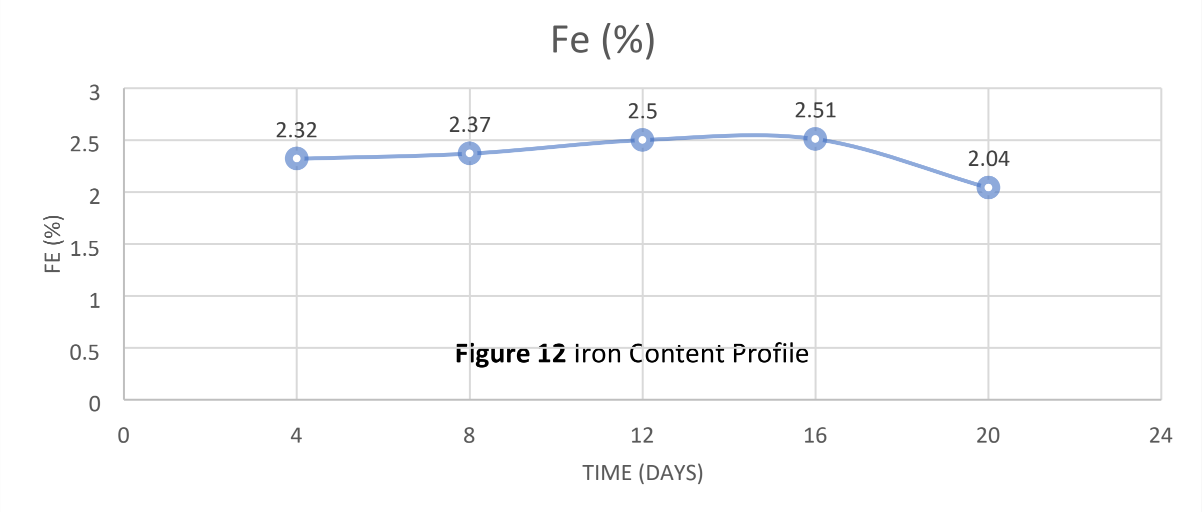

Figure 12 Iron Content Profile

Day	Fe (mg/kg)	Fe (%)
4	23202.9	2.32
8	23726.45	2.37
12	25041.85	2.5
16	25198.45	2.51
20	20409.45	2.04

5. Conclusion

MSW compost quality and degradation process were greatly influenced by the mixing of cattle manure. Composting of Vegetable waste with cattle manure and saw dust in 5:4:1 ratio. Lower pH, EC indicated its less phytoxicity effects on the growth of plant if applied to the soil. The longer thermophilic phase (3-4 days) as well as the higher rise in temperature at the beginning of all trials satisfied the regularity requirement for the destruction of pathogens.

6. References

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