International J. of Multidispl.Research & Advcs. in Engg.(IJMRAE),
ISSN 0975-7074, Vol. 8, No. I (April 2016), pp. 57-69

FEASIBILITY STUDIES ON IN-VESSEL COMPOSTING OF ORGANIC FRACTION OF MUNICIPAL SOLID WASTE WITH YEAST SLUDGE AS INOCULUM

POONGODI S[1*] AND DAMODHARAN V[2]
Research Scholar, Department of Civil Engineering, Annamalai University[1]
Assistant Professor, Department of Civil Engineering, Annamalai University[1]
Annamalai Nagar, Chidambaram, 608002, India.
*Corresponding author

Abstract

The municipal solid waste generated in Indian cities contains heterogeneous composition with high percentage of compostable matter, high moisture content and low calorific value, which is best suitable for bio composting. An attempt was made in this study for designing a vertical in vessel reactor with stirrer arrangement for aerobic composting of organic fraction of municipal solid waste with saw dust as bulking agent and yeast sludge as inoculum at various ratios in five trials. This study examined the interdependence between biological, physical and chemical factors during composting by monitoring the temperature, moisture content, volatile solids, Total Organic Carbon, Total Kjeldahl Nitrogen and C/N ratio for samples collected on alternate days. The process was completed in 15 days and the compost obtained in Trial III and IV can be applied as soil conditioner and the products obtained from rest of trails can be utilized after maturation.

Keywords: Organic fraction of municipal solid waste, Yeast sludge, Inoculum, Bulking agent, C/N ratio.

1. INTRODUCTION

Rapid urbanisation and escalating growth in urban population have led to dramatic increase in per capita production of Municipal Solid Waste (MSW), which has a crucial socio-economic and environmental impact. Inefficient and improper methods of disposal of solid waste result in scenic blights, create serious hazards to public health including pollution of air and water resources, accident hazards and increase in rodent and insect vectors of disease have an adverse effect on public health. Municipal Solid Waste generated in Indian cities is of heterogeneous in nature, containing 40 – 50% of compostable material with high moisture content and low calorific value influence the feasibility of treatment options (Goutham S. P., et.al., 2010). Composting is a self-heating, aerobic, solid phase of bio-degradation and mineralisation of organic matter and is considered as an environmentally sound method for biodegradation of MSW (Guet.al. 2011). Composting of Municipal Solid Waste reduces the volume of wastes, kills pathogens, decreases germination of weeds in agricultural fields and destroys malodorous compounds (Narkhede S. D., 2010).

Due to large composition variation in MSW, managing the optimizing parameters affecting the process of composting turned out to be more important problem to be resolved, even though the aerobic composting process is being used many years worldwide. Hence, developing an experimental device for aerobic composting of Municipal Solid Waste is of great necessity. Now-a-days, most composting researches were taken by field experiments such as windrow system, pile composting and only a few prefer laboratory scale experiments (Das et.al., 2011; Gu et.al., 2011; Hua Li et.al., 2011). Compared with field experiment, laboratory or pilot experiment is easier to control, with lesser space requirements and least disturbances under controlled conditions. To achieve a successful composting, the influencing factors such as moisture content, temperature, aeration, pH, C/N ratio and composting mixtures should be appropriately controlled (Mengchun Gao et.al. 2010)

The aim of this study is to develop a vertical in-vessel reactor for aerobic composting of MSW, since most of the researchers have adopted horizontal reactors as it requires larger area and involves higher operational and maintenance cost. Also to study the feasibility of composting of MSW with various industrial organic inoculums.

2. MATERIALS AND METHODS:

The vertical type in-vessel reactor has been fabricated by locally available Fiber Reinforced Glass Plastic (FRGP) material. Design was set after considering the climatic conditions, available waste characteristics, bulking agents required to balance the moisture content, Carbon to Nitrogen ratio and the inoculums readily available as a starting culture. The material selected for fabrication of in-vessel reactor is of good structural strength, resistive to heat and corrosion. The vessel is designed for the capacity of 180 Litres with 50cm diameter and 92cm height, which is mounted vertically on a platform. The vessel is cylindrical in shape with an opening at the top for feeding of raw materials. A stirrer arrangement is provided at the centre of the reactor which is connected to a motor with gear arrangement, in order to have homogenous mixing of waste. 4 Nos. of sampling ports are provided at various heights. The leachate collection arrangement is provided at the bottom and the opening for removal of finished compost is provided at the lower end of the cylinder. Air is supplied through an air pipe provided at the bottom of the reactor, which is connected to the compressor. An air vent is provided at the top for letting out the gaseous emission. The schematic diagram of vertical in-vessel aerobic reactor is shown in Figure 1.

The composting of municipal solid waste was carried out with bulking agents and yeast sludge as inoculum. The experiment was carried out for varying proportions of municipal solid waste, bulking agent and inoculum by supplying optimum rate of aeration of 0.25Lt/min/Kg wet weight.

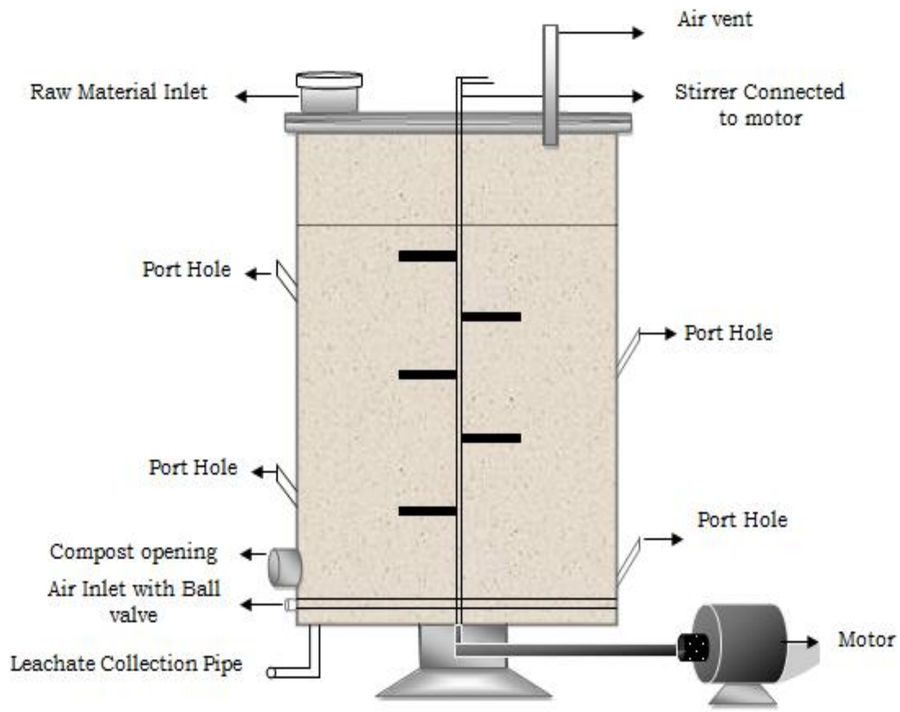

Figure1. Schematic Diagram of Vertical In-Vessel Reactor

The MSW was collected from the Annamalai Nagar town panchayat, segregated for its Organic Fraction of Municipal Solid Waste (OFMSW) and shredded manually. In this study, composting of OFMSW was carried out with saw dust as bulking agent and yeast sludge as inoculum at various ratios. The yeast sludge was obtained from M/s. Thiru Arooran Sugars Ltd, Distillery Division , Thirumandangudi Thanjavur District, India. The bulking agent is the material that provides optimum free air space, which is an important factor in determining the quantity and movement of air through the composting matrix (Nabam Rich et.al., 2014; Igbal M.K. et.al., 2010). In this study various ratios of waste mixtures, saw dust and yeast sludge, as required for individual trials, amounting to approximately 30Kg as shown in Table 1 were manually mixed and loaded in the reactor. The composting was carried out for 15 days. The rate of composting was monitored by collecting samples on alternate days and analysed for pH, moisture content, Electrical Conductivity (EC), Total Organic Carbon (TOC), Total Kjeldahl Nitrogen (TKN) and C/N ratio. The temperature was recorded through the ports using digital thermometer.

Table – 1: Mixture Specification

Trials	Ratios	Saw Dust (kg)	MSW (kg)	Yeast Sludge (kg)
I	10:88:2*	3.0	26.4	0.6
II	10:86:4*	3.0	25.8	1.2
III	10:84:6*	3.0	25.2	1.8
IV	10:82:8*	3.0	24.6	2.4
V	10:80:10*	3.0	24.0	3.0

*Saw Dust: MSW: Yeast sludge

3. RESULTS AND DISCUSSIONS

Initial characteristics of composting mixture are shown in Table 2. Initial C/N ratio of 39.16 is suitable for composting process. High levels of EC indicate the presence of soluble salts and initial pH indicates acidic nature of municipal refuse. The organic matter in the waste indicates that it is highly bio-degradable. The presences of micro nutrients in the organic waste indicate its possible conversion into high quality compost.

Table – 2: Characteristics of Initial waste mixture

Parameters	Range Values
Moisture Content (%)	54.51 – 61.26
pH	5.4 – 6.92
EC (mmhos/cm)	3.12 – 3.62

Ash Content (%)	24.63 – 26.79
VS (%)	73.21 – 75.37
TOC (%)	40.67 – 41.87
TKN (%)	1.01 – 1.04
P (%)	0.27 – 0.33
K (%)	0.35 – 0.49
C/N	39.16 – 41.46

4. VARIATION IN TEMPERATURE:

The temperature is considered as one of the most important parameter to determine the progress of the composting process. The increase in temperature in the reactor results in the rate at which chemical bonds in substrate compounds are broken. To destroy pathogens, the temperature in the composting mixture has to be maintained more than 55^0C for at least three consecutive days (Yun Zhang and Yang He, 2006).

The temperature patterns of different mix ratios I, II, III, IV and V are presented in Figure 2. The temperature was monitored during the composting process on alternate days through the port holes provided along the sides at various levels. In the first trail OFMSW, saw dust and yeast sludge (as inoculums) were mixed in the ratio of 10: 88: 2 (weight basis). Maximum temperatures in the range of about 48 to 51^oC were reached within 7 days of operation and then started declining to about 34^0C at the end of the composting period.

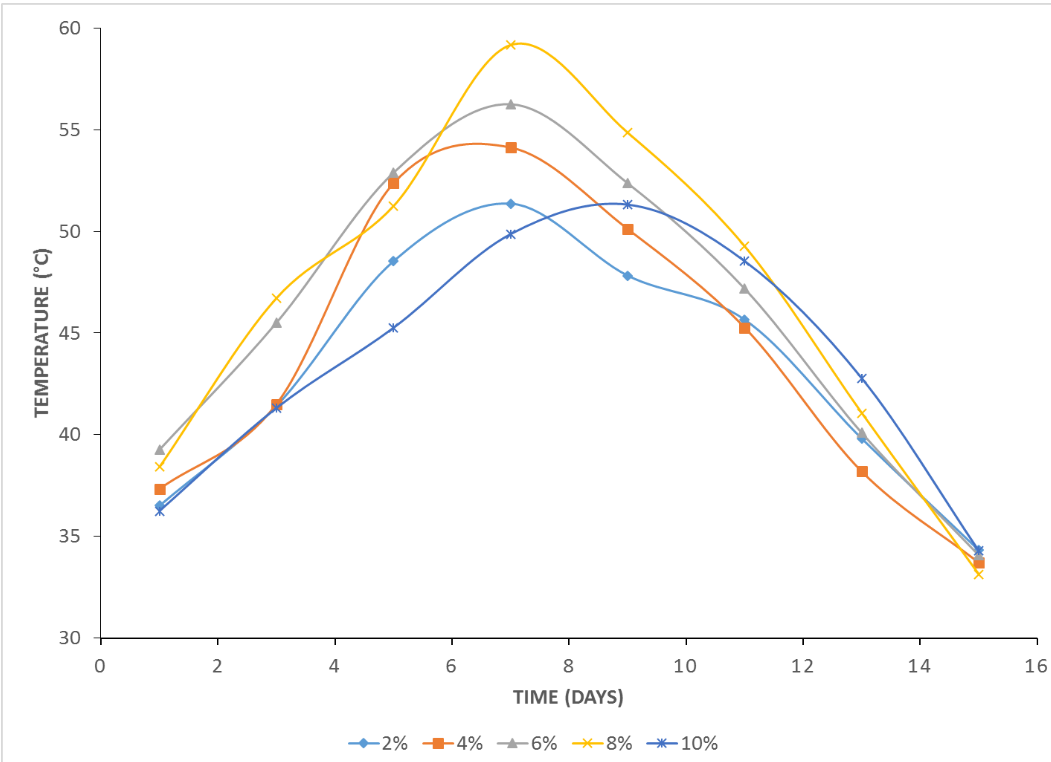

Fig. 2 Variation of Temperature during composting

In the second trial, 4% yeast sludge (weight basis) was added to the compost mixture and the maximum temperature in the range of about 52- 54^{0}C was attained within 7 days of operation. Then the temperature started decline to about 33^{0}C at the end of the process.

In the third trial, thermophilic stage was commenced from the 3rd day onwards and prolonged for 10 days and attained maximum temperature of about 56^{0}C on 7th day. In the fourth trial thermophilic temperature was reached on the 2ndday itself and prolonged for 10 days, the highest temperature of about 59^{0}C was attained on 7th day and then it rapidly reached the ambient temperature. Temperature more than 45^{0}C was observed on 5thday in trial V which then prolonged for 8 days.

The comparison of temperature variations in the trials I, II, III, IV and V reveals that the highest temperature of 59^{0}C in thermophilic stage was reached in trial IV on 7th day indicating a higher degree of biodegradation than other mix ratios. In this study, it was observed that in all the trials highest temperature ranges were attained on 7th day except trial V. In all the trials thermophilic temperature range was maintained for 8 to 10 days, ensuring a higher level of composting and destruction of pathogens.

4.1 Variation in pH:

The pH pattern of each mix ratio is shown in figure 3. The pH values of the initial waste mixtures were 6.83, 6.79, 6.12, 6.92 and 5.40, increased to a maximum of 7.57, 7.33, 7.54, 7.79 and 7.29 for trials I, II, III, IV and V respectively. The graph reveals that the pH was decreased during initial stage of composting in all the trials and increased to alkaline level, followed by a decrease to near neutral at the end of the process. Initial decrease in pH is due to the production of organic acids by the formation of carbohydrates and lipids (Muhammed Khalid Iqbal et.al. 2011). Further increase in pH is caused by the production of ammonium ion due to ammonification and mineralisation of organic nitrogen during the process of composting. An increase in pH indicates the maturity of the compost.

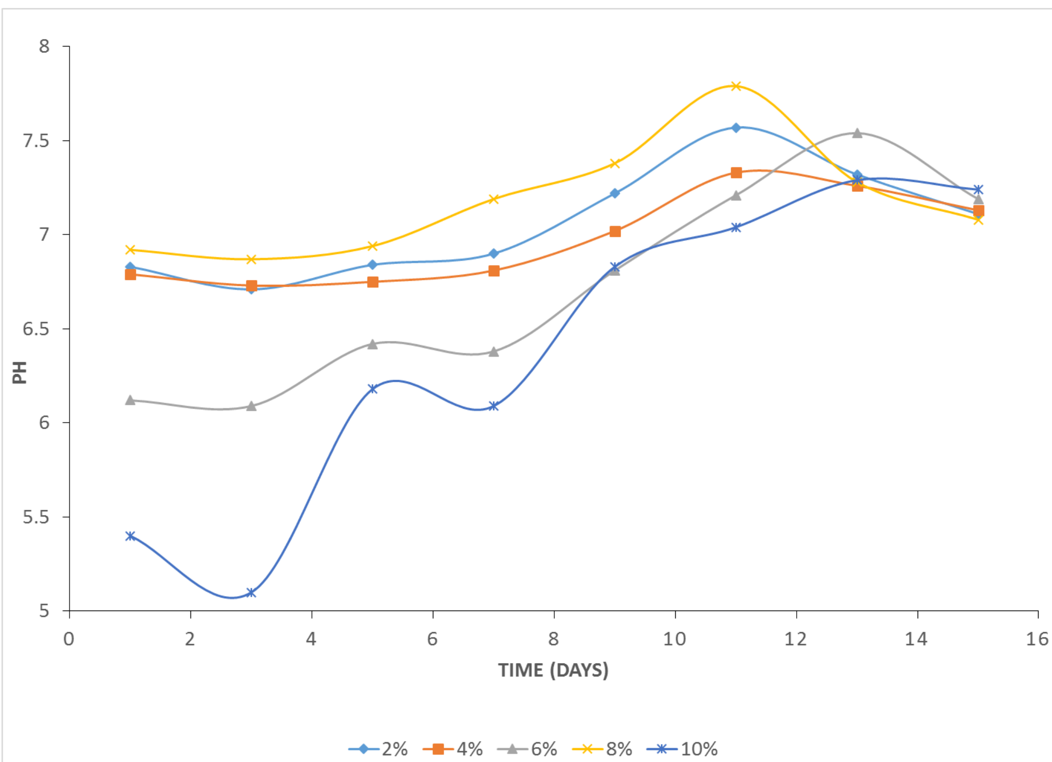

Fig. 3 Variation of pH during composting

4.2 Variations in EC:

Fig.4 shows a similar pattern of change in EC for the five composting mixtures. EC in composting mixtures of I, II, III, IV and V increased from the initial 3.12, 3.21, 3.62, 3.57 and 3.25mmhos/cm to the maximum of 3.61, 3.52, 3.94, 4.01,and 3.98 mmhos/cm on the 9th, 7th, 7th, 9th and 9th day respectively, followed by a gradual decrease till the end of composting process. The increase in EC during the initial stage of composting was due to the release of mineral salts such as phosphates and ammonium ions through decomposition of organic substances. The volatilization of ammonia and precipitation of mineral salts were responsible for the decreased values of EC at the end of the composting process. After 15 days of composting the EC contents of the composting mixture in trial I, II, III, IV and V were 2.95, 2.96, 2.91, 2.86 and 3.09 mmhos/cm respectively, were within the limit value of 3 dS/m for stable compost. (Manjula Gopinathan et.al., 2012).

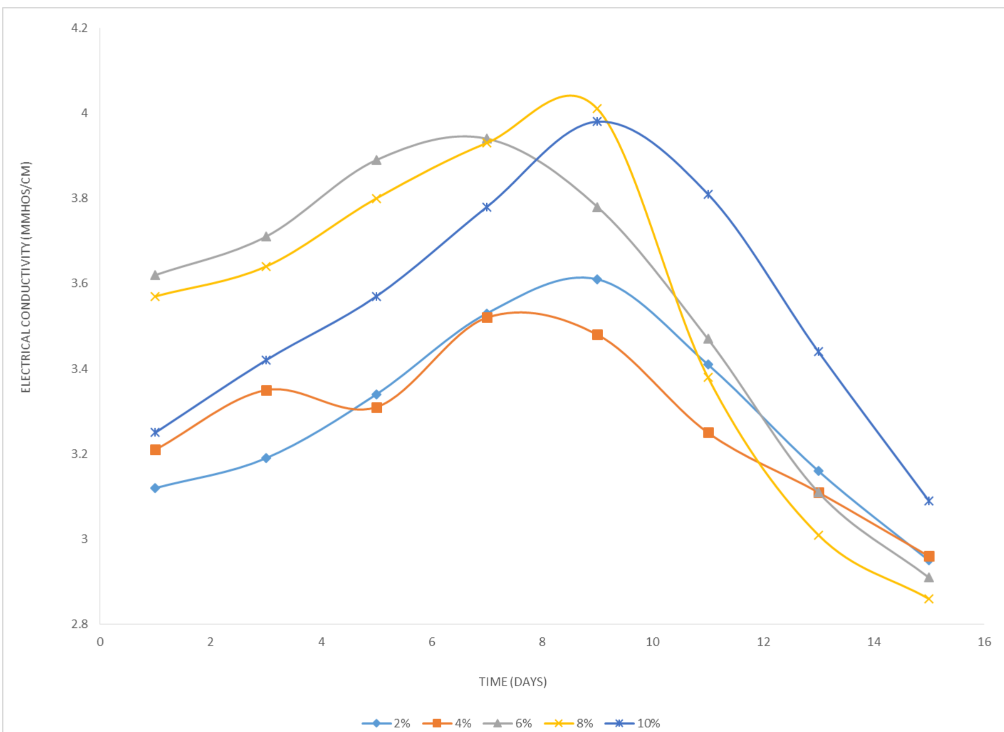

Fig.4 Variation of EC during composting

4.3 VARIATION IN TOC:

In the first trial, the composting mixture contains an initial value of about 40.6% of TOC, decreasing to 33.79% at the end of 15 days, as shown in figure 5.

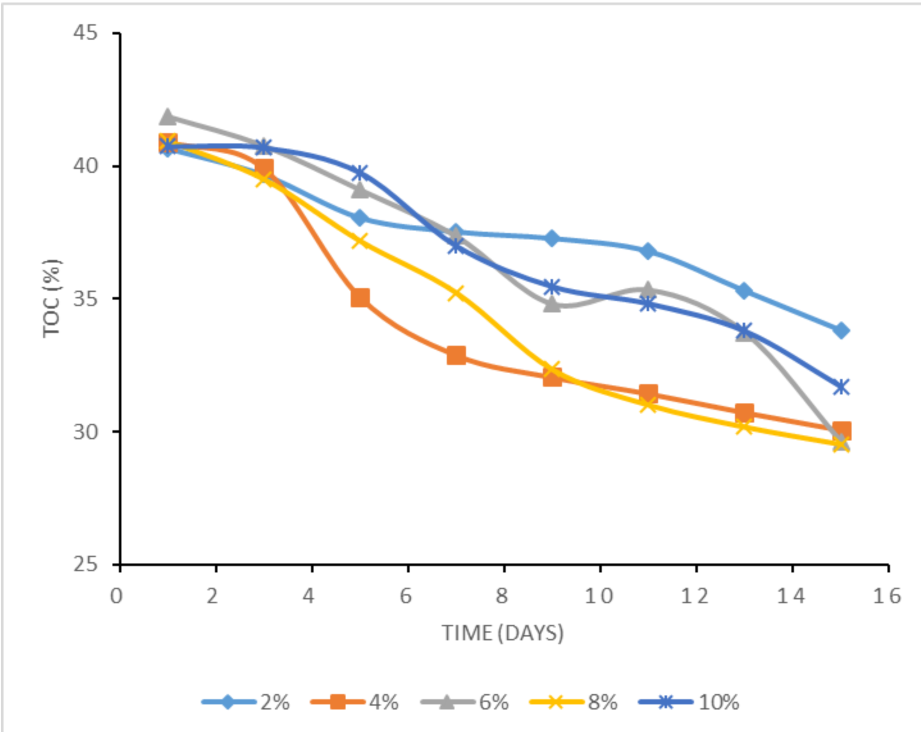

Fig. 5 Variation of TOC during composting

Trial IV showed a lowest value of 29.53% from the initial value of 40.94% after 15 days of active composting. Similar pattern of degradation of organic matter was followed in trials II, III and V and the final values after active degradation were 30.06%, 29.62% and 31.71% respectively.

4.4 Variation in C/N ratio:

C/N ratio is considered as one of the most widely used indices for maturity and stability of organic wastes (Bernal M.P., et.al., 1998). The rate of reduction of carbon was greater as compared to nitrogen in all types of composting process, because microorganisms utilised carbon as the source of energy and nitrogen for cell building during the process of decomposition of organic matter. The percentage reduction in C/N ratio values were 33.84%, 44.49%, 49.69%, 55.79% and 44.15% for trials I, II, III, IV and V respectively. All the trials show the decrease in trend, as shown in figure 6

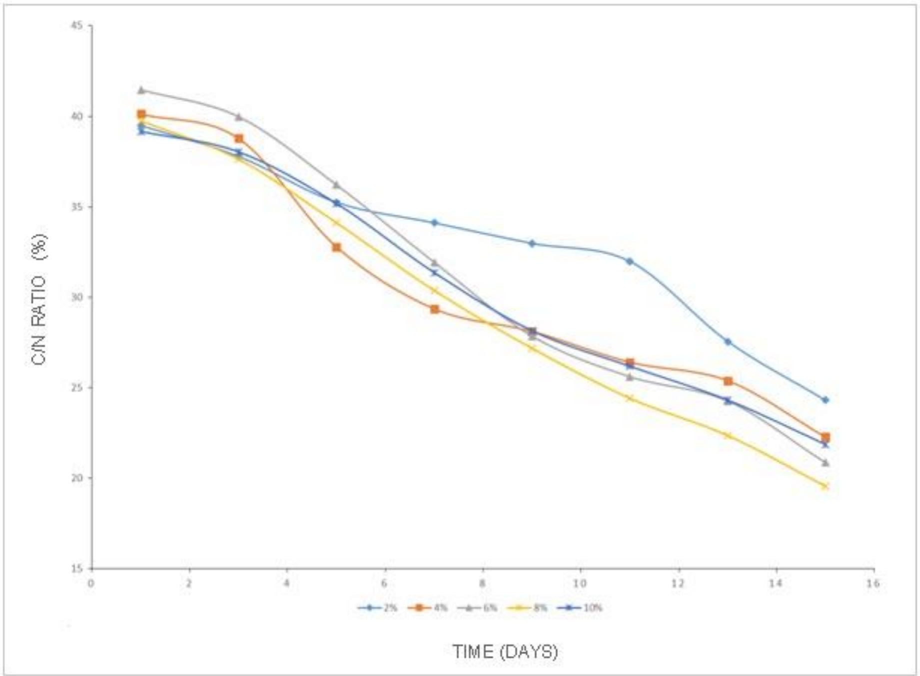

Fig. 6 Variation of C/N ratio during composting

The final characteristics of compost after completion of the process are represented in Table 3. The C/N values stabilised to less than 25 at the end of the composting process indicate stability of compost and is being within the standard limit as concluded in several previous studies that the C/N ratio of 20-25 indicates the maturity of the finished compost (Harada Y., et. al. 1981 and Levi-Minzi R., et. al.,1986). Hirai M. reported that C/N ratio less than or equal to 20 is considered as standard for mature compost which is agreed by subsequent several studies (Manjula Gopinathan et.al.2012, Hamidi Abdul Aziz et.al.2013 and Nabam Rich et.al.2014). From above literatures it is concluded that the compost obtained by trials III and IV can be effectively used as soil fertiliser. The products obtained from other trials can be used for soil conditioning after maturation.

Table 3 Final characteristics of Compost

Parameters	Trial I	Trial II	Trial III	Trial IV	Trial V
Volatile solids (%)	60.82	54.11	53.32	53.16	57.08
Total Organic Carbon (%)	33.79	30.06	29.62	29.53	31.71
Total Nitrogen (%)	1.39	1.35	1.42	1.51	1.45
C/N ratio (%)	24.31	22.27	20.06	19.56	21.87

CONCLUSION:

The physical and chemical characteristics of solid waste, method of composting and operating conditions maintained during composting impose significant effects on the ecological succession of microorganisms and the rate of biodegradation of organic matter. The vertical in-vessel composting using yeast sludge as inoculum can be applied for composting of municipal solid waste.

REFERENCES:

[1]. Bernal M. P., Paredes C., Sanchez-Monedero M. A., and Cegarra J., (1998), Maturity and Stability Parameters of Compost prepared with a wide range of organic wastes, Bioresource Technology, 63: 91-99.

[2]. Das M, Uppal H. S., Sing R., Beri S., Mohan K.S., Gupta V.C., Adholeya, 2011. Co–composting of physic nut (Jatropha Curcas) deoiled cake with rice straw and different animal dung. Biores. Technol., 102(11): 6541-6546

[3]. Goutam S. P., Bundela P.S., Pandey A. K., Awasthi M. K., and Sarsaiya S., 2010 Evaluation of Composting as a Strategy for Managing Organic Municipal Solid Wastes in Central India. Australian Journal of Basic and Applied sciences, 4(10), 5451-5455

[4]. Gu WJ, Zhang FB, Xu PZ, Tang SH, Xie KZ, Huang X, Huang QY 2011. Effect of sulphur and Thiobacillus thioparus on cow manure aerobic composting. Biores. .Technol., 102(11): 6529-6535.

[5]. Hamidi Abdul Aziz & Syed Mohammad Hosseini (2013), Evaluation of thermophilic pre-treatment and continuous condition in rice straw composting process enhancement, Bioresource technology, 133:240-247.

[6]. Harada Y., Inoko A., Tdaki M., and Izawa I., (1981), Maturing process of city refuse compost during pilling, Soil, Sci, Plant Nutr., 27, pp. 357-364.s

[7]. Hirai M., Chanyasak V., Kubota H., (1983), A standard measurement for compost maturity, Biocycle, 24:54-56.

[8]. Hua Li, Xianlai Zeng, Qina sun, Baoquan Huo, Changyong Jing, Hongfen Wang Liyun Wang 2011**.** Design of pilot device for municipal solid waste composting. Hainan Research

[9]. Institute of construction Project Planning and Design. Haikou 570203 China.

Igbal M. K., Shafiq T., & Ahmad K., (2010), Characterization of bulking agent and its effects on physical properties of compost, Bioresource technology, vol. 6, pp. 1913-1919.

[10]. Levi-Minzi R., Riffaldi R., and Saviozzi A., (1986), Organic matter and nutrients in fresh and mature farmyard manure, Agri. Waste, 16, pp. 225-236.

[11]. Manjula Gopinathan & Meenambal Thirumurthy (2012), Feasibility Studies on Static Pile Co Composting of Organic Fraction of Municipal Solid Waste with Dairy Waste Water, Environmental Research, Engineering and Management, No. 2(60), pp. 34-39.

[12]. Mengchun Gao, Fangyuan Liang, An Yub, Bing Li & Lijuan Yang (2010), Evaluation of stability and maturity during forced-aeration composting of chicken manure and sawdust at different C/N ratios, Chemosphere, vol. 78, pp. 614-619.

[13]. Nabam Rich, Sunil Kumar & Ajay Bharti (2014), Changes in Characteristic of Municipal Solid Waste by Bulking Agent In-vessel Composting: Critical Review, International Journal of Innovative Research in Science, Engineering and Technology, vol. 3, Special Issue 4, pp. 235-249.

[14]. Narkhede S. D., Attarde S. B. and Ingle S. T. 2010.Combined Aerobic Composting of Municipal Solid Waste and sewage sludge. Global Journal of Environmental Research 4 (2): 109-112.

[15]. Yun Zhang and Yong He 2006. Composting solid swine manure with pine sawdust as organic substrate. College of Biosystems Engineering and Food Science. Zhejiang University; Hangzhou. Zhejiang. China. Bioresource Technology 97: 2006`: 2024-2031.