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COMPARATIVE STUDY OF IN-VESSEL COMPOSTING OF MUNICIPAL SOLID WASTE USING INDUSTRIAL ORGANIC WASTES AS INOCULUMS

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ABSTRACT

Several studies were conducted on co-composting of organic fraction of municipal solid waste with industrial organic wastes and using animal manures as inoculum in in-vessel reactor. An attempt was made to compost MSW with saw dust and Spent wash & treated distillery effluent as inoculums in vertical in-vessel reactor with stirrer. Composting process was monitored by analyzing temperature, moisture content, pH, EC, TOC, TKN, P, K and C/N ratio on alternate days. Stability of compost was assessed based on C/N ratio, matured composts were obtained in all the trials using treated distillery effluent as inoculum and the compost obtained in all the trials of spent wash as inoculum could be applied as soil conditioner after maturation.

Keywords: Inoculum, spent wash, treated distillery effluent, bulking agent.

1. INTRODUCTION

India, the world's second highest populated and one of the fastest urbanizing countries, has a population of 1210.2 million as per 2011 census. The increase in population has led to a drastic increase in Municipal Solid Waste (MSW) generation. As per Central Pollution Control Board, the per capita generation of MSW in Indian cities is about 500 gpcd and a study conducted in 128 cities revealed that only 8% of the cities have compiled 50% of their waste processing. About 94% out of total MSW collected, is disposed by open dumping and the rest is composted (Kurian Joseph, 2008). Improper disposal of a huge volume of MSW can cause serious environmental problem. According to National Environmental Engineering Research Institute 1996, the compostable fraction of MSW in Indian cities varies in the range of 31 – 55%. A study by Sriramulu Anantha Krishnasamy reveals that about 3000 million tonnes per annum of organic waste is generated in India. An environmentally sound, cost effective and high efficient technology is needed to manage increasing generation of MSW. Apart from various treatment strategies such as anaerobic digestion, incineration, and gasification, composting can be considered as an economical technology which not only removes organic wastes, recycle nutrients and convert organic matter into stable soil conditioner (Zohida Nasreen et.al. 2012) Several studies have been conducted to monitor the influencing factors such as pH, temperature, moisture content, Total Nitrogen, Total Carbon, C/N ratio by in-vessel composting but only a few have worked on vertical in-vessel reactor.

The aim of this study is to design a vertical in-vessel reactor with stirrer arrangement to have homogenous mixture and to find out the feasibility of utilising spent wash and treated distillery effluent as inoculums. Few researchers have studied co-composting of various industrial organic wastes (Manjula Gopinathan et.al., 2012, Suthar and Singh, 2008, Suthar 2008, Hemalatha B, 2012). It is an attempt to monitor the composting process and quality of compost using industrial effluents as inoculums.

2. MATERIALS AND METHODS:

The vertical type in-vessel reactor has been fabricated by locally available Fiber Reinforced Glass Plastic (FRGP) material. The material selected for fabrication of in-vessel reactor is of good structural strength and 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 an 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.

In this study, composting of municipal solid waste was carried out with saw dust as bulking agent and spent wash /treated distillery effluent as inoculums. The experiment was carried out for varying proportions of organic fraction of municipal solid waste, saw dust and inoculum.

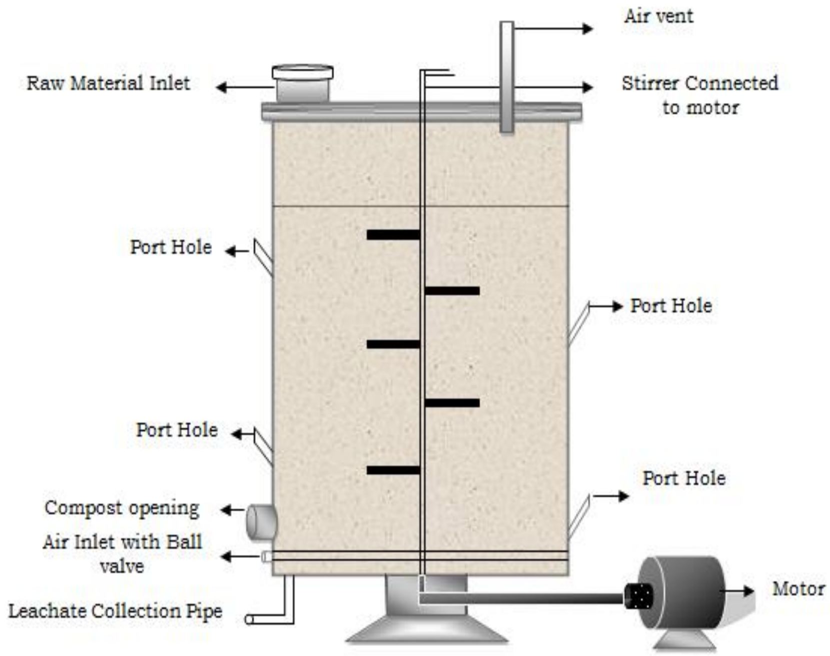

Figure1. Schematic Diagram of Vertical In-Vessel Reactor

The MSW was collected from the Annamalai Nagar town panchayat, segregated for its organic fraction and shredded manually. The spent wash and treated distillery effluent were collected from M/s. Thiru Arooran Sugars Ltd, Distillery Division, Thirumandangudi Thanjavur District, India. In this study two experiments were conducted, one with spent wash and another with treated distillery effluent as inoculum. Five trials were conducted in each experiment with various ratios of MSW, saw dust and spent wash/treated distillery effluent as shown in Table 1. Raw materials were manually mixed and loaded in the reactor. Air was supplied at the rate of 0.25Lt/min/Kg wet weight 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), Phosphorus, Potassium and C/N ratio. The temperature was recorded through the ports using digital thermometer.

Table – 1: Mixture Specification

Trial	Mix Ratio	Saw Dust (kg)	MSW (kg)	Spent Wash/ Distillery Treated Effluent (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: Spent Wash/ Treated Distillery Effluent

3. RESULTS AND DISCUSSIONS

Table 2 shows the initial characteristics of composting mixtures for experiments 1 and 2. The moisture content is maintained to optimum level in all the trials of both the experiments to enhance effective composting.

Table – 2: Characteristics of Initial waste mixture

Parameters	Range Values	
	Experiment 1 Spent Wash as inoculum	Experiment 2 Treated Distillery Effluent as inoculum
Moisture Content (%)	56.80 – 60.85	57.23 – 60.59
pH	6.65 – 6.92	6.51 – 7.27
EC (mmhos/cm)	5.21 – 5.81	4.1 – 4.52
Ash Content (%)	32.27 – 38.46	19.41 – 25.28
VS (%)	61.54 – 67.73	74.72 – 80.59
TOC (%)	34.19 – 37.63	41.51 – 46.64
TKN (%)	0.89 – 0.93	1.02 – 1.17
P (%)	0.11 – 0.17	0.39 – 0.43
K (%)	0.25 – 0.3	0.71 – 0.81
C/N ratio	38.42 – 41.35	38.18 – 41.21

TEMPERATURE:

Temperature is a key factor in the composting process. It determines the growth rate, metabolic activity and type of community structure of the composting organism. Temperature is also the main factor influencing the survival of pathogens present in the compost. Temperature patterns of various mix ratios I, II, III, IV & V using spent wash and treated distillery effluent as inoculums are shown in Fig. 2(a) and 2(b).

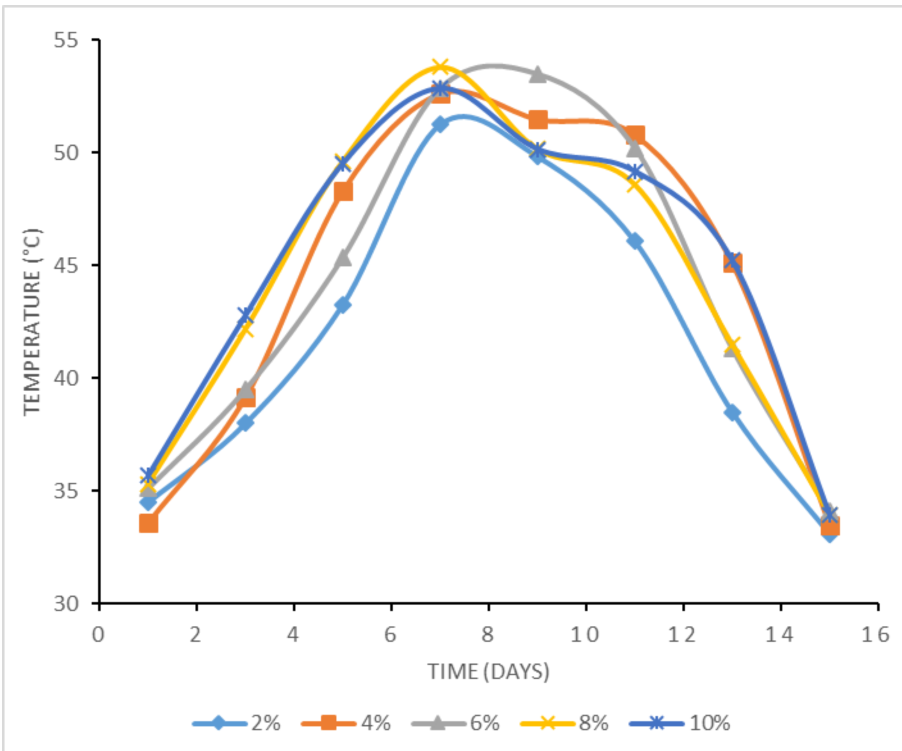

Fig. 2(a) Variation of Temperature using spent wash as inoculums

The curves show that the temperature follows a typical temperature profile for composting (mesophilic – thermophilic – mesophilic) in all the trials for both the experiments. In Experiment 1, the thermophilic stage was attained on the 4^{th} day in trials I, II & III and on 2^{nd} day in trials IV & V that inturn prolonged for 9 days in trail I, 10 days in trial III, 11 days in trial II, 12 days in trial V and 13 days in trial IV.

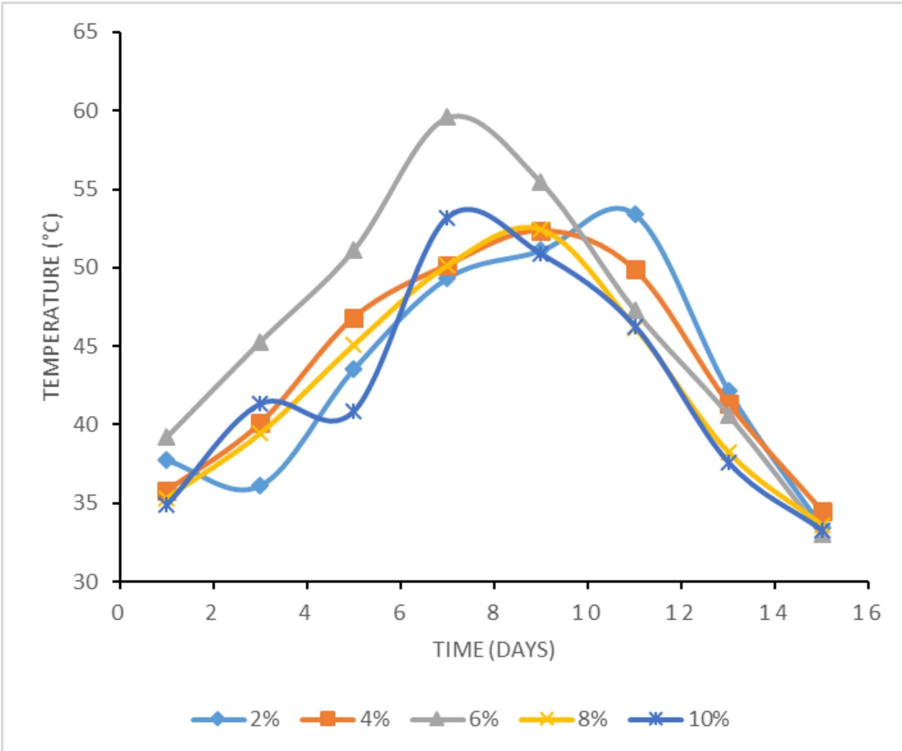

Fig. 2(b) Variation of Temperature using treated distillery effluent as inoculum

In the 2nd experiment, the thermophilic temperature was attained on 4th day in trails I & IV, 3rd day in trial II, 2nd day in trials III & V and prolonged for 10 days in trial I, 12 days in trials II & III, 9 days in trial IV and 11 days in trial V. As per Yun Zhang and Yang He, 2006, a temperature of more than 55° C has to be maintained for at least three consecutive days to destroy pathogens. The maximum temperature of 53.81° C was attained in trial IV of 1st experiment and 59.57° C in trial III of 2nd experiment, indicating the higher degree of biodegradation of organic matter than other trials. In all the trials, in both the experiments, the thermophilic stage was prolonged for a minimum of 9 days to a maximum of 13 days ensured higher level of composting and destruction of pathogens (Luz Ruggieri et.al., 2008). The curves show the increase in temperature during initial stage of composting, attaining maximum and then declining to ambient temperature at the end of the process reveals the completion of biodegradation of organic matter.

pH:

The variation of pH in all the trials of experiments 1 and 2 are shown in Figs. 3(a) & 3(b). In both the experiments and in all trials the pH curves followed a similar pattern of initial decrease, increase to alkaline and a decline to near neutral at the end of the composting process. Initial decrease in pH during composting is due to the production of organic acids by microbes that act on easily degradable material and the subsequent release of ammonium as a result of ammonification and mineralisation of organic nitrogen (Sangodoyin A.Y.et.al. 2013). Increase in pH indicates the maturity of compost.

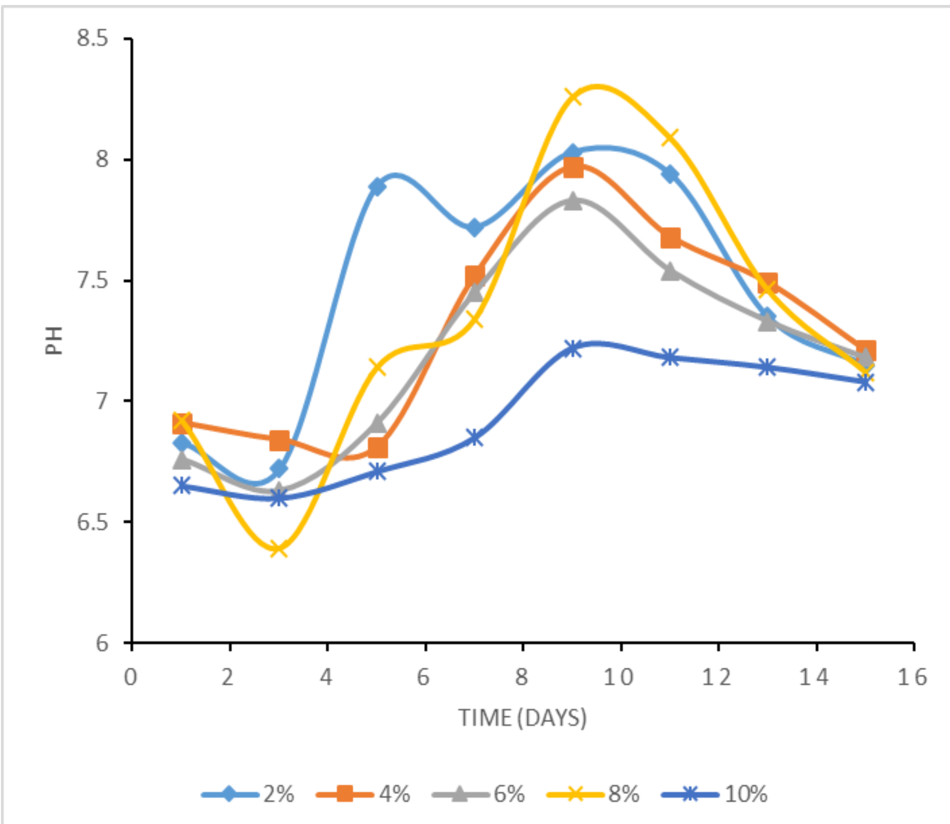

Fig. 3(a) Variation of pH using spent wash as inoculum

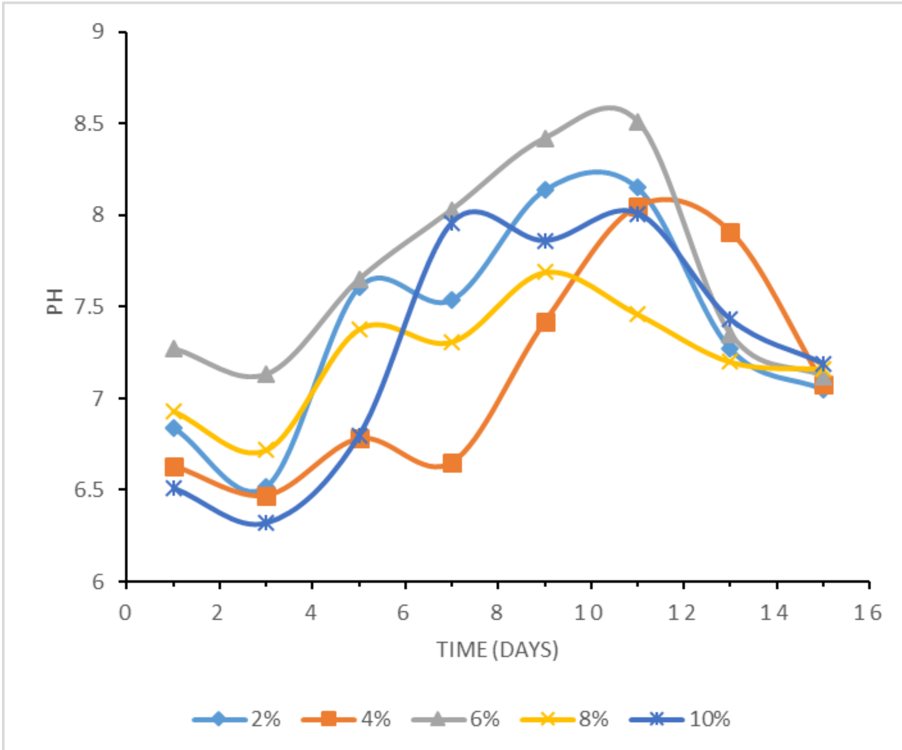

Fig. 3(b) Variation of pH using treated distillery effluent as inoculum

In the 1st experiment, the initial pH in trials I, II, III, IV & V were 6.83, 6.91, 6.76, 6.92 and 6.65 respectively, which increased on 9th day to a maximum of 8.03, 7.97, 7.83, 8.26 and 7.22 respectively. Subsequent decrease in pH was observed in all the trials and reached the near neutral at the end of the process. The decrease in pH at later stage of composting may be caused by the mineralisation of organic acids and the release of large quantity of Carbon-di-oxide during composting (Nonglak Saithep et.al. 2009).

In the 2nd experiment, the initial pH in trials I, II, III, IV & V were 6.84, 6.63, 7.27, 6.93 and 6.51 respectively, which increased to 8.15, 8.05 and 8.51 on 11th day in trials I, II & III respectively, 7.69 on 9th day in trail IV, 7.96 on 7th day in trial V and further declined to near neutral.

EC:

Figs. 4(a) & 4(b) follow a similar pattern of variation in EC, in all the trials of both the experiments. In experiment 1, maximum values of EC in trials I, II, III, IV & V were 6.51, 6.71, 6.68, 6.47 and 6.54 mS/cm respectively and further declined to 6.07, 6.18, 6.05, 6.13 and 6.19 mS/cm respectively. These EC values are in agreement with the reports of Corti et.al. 1998 and Erhart et.al. 1997. A higher EC value of 14.4 mS/cm was reported by Hemalatha B., 2012.

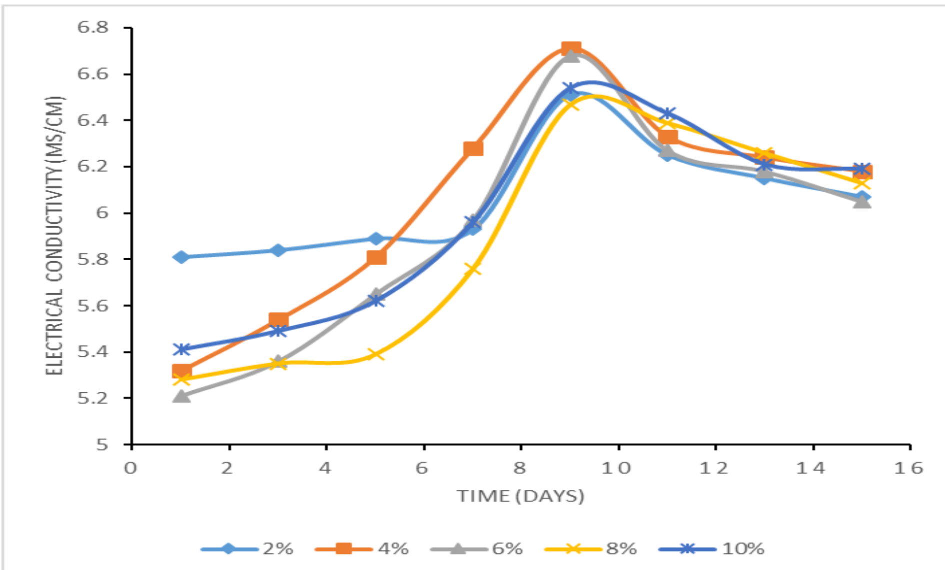

Fig. 4(a) Variation of EC using spent wash as inoculum

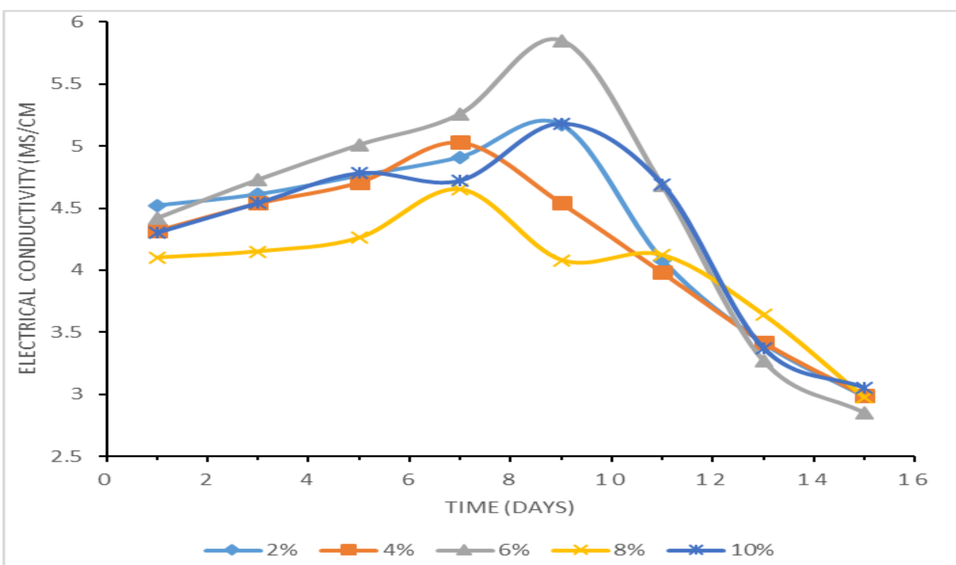

Fig. 4(b) Variation of EC using treated distillery effluent as inoculum

In experiment 2, EC increased to 5.17, 5.27, 5.85, 4.12 and 5.18 mS/cm from the initial values of 4.52, 4.32, 4.42, 4.10 and 4.30 mS/cm in trials I, II, III, IV & V respectively. The initial increase in EC is due to the release of mineral salts and ammonium ions through the bio-degradation of organic substances. The volatilization of ammonia and precipitation of mineral salts a caused decrease in EC during the later phase of composting. The final EC of 2.98, 2.99, 2.85, 2.97 and 3.05 in trials I, II, III, IV & V respectively satisfies the limit of 3 mS/cm for stable compost (Abdelhadi Makan et.al., 2013).

C/N ratio:

Figs. 5(a) & 5(b) show the variation of C/N ratio during composting of organic fraction of MSW using spent wash and treated distillery effluent as inoculum. C/N ratio is considered as one of the most widely used indices for maturity of organic wastes. During composting, carbonaceous and nitrogenous compounds are transformed by microbial activity into more stable complex organic forms which chemically and biologically resemble humic substances. Microbes digest carbon as energy source and ingest nitrogen for protein synthesis during composting. Optimum C/N ratio for effective composting is 25 to 40 (Rama and Vasanthi 2014).

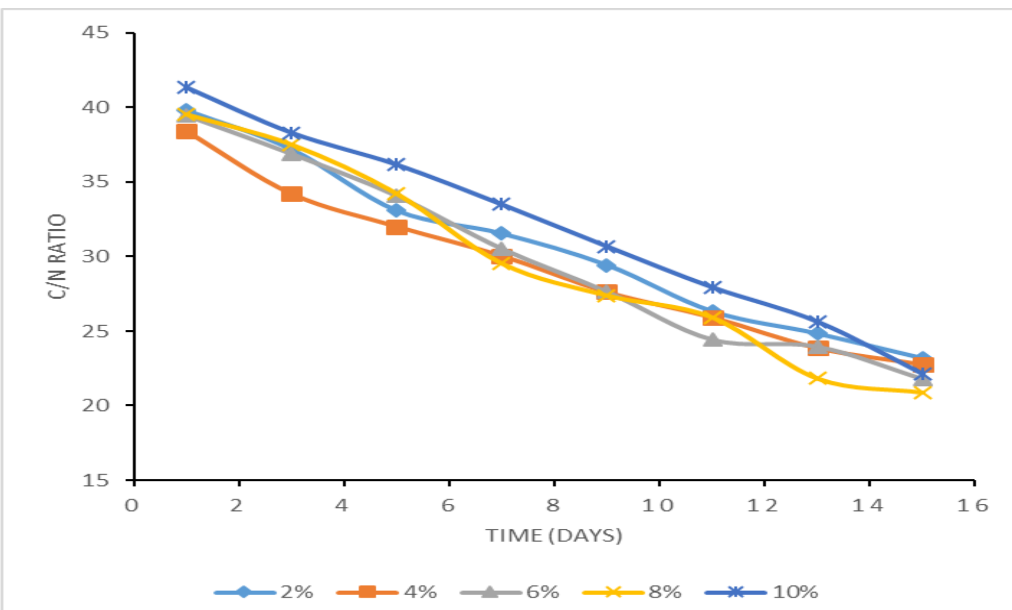

Fig. 5(a) Variation of C/N ratio using spent wash as inoculum

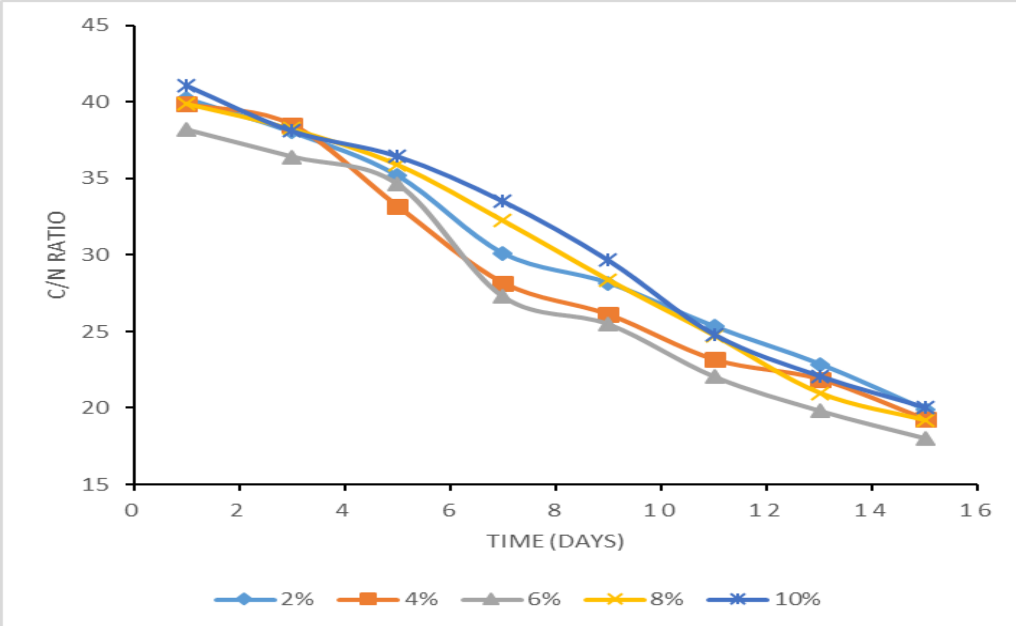

Fig. 5(b) Variation of C/N ratio using treated distillery effluent as inoculum

Initial C/N ratio was maintained in the range of 38.4 to 41.35 in 1st experiment and 38.18 to 41.21 in the 2nd experiment. Reduction in C/N ratio was observed in all the trials, show the effective biodegradation of organic matter and maturity of compost. At the end of the composting process, the C/N ratio of 1st experiment in trials I, II, III, IV & V were 23.17, 22.76, 21.77, 20.89 and 22.14 respectively agreed with the results obtained by Luz Ruggieri, during co-composting of raw sludge with proteins, fats and cellulose. C/N ratio of 25.8 was recorded by Adewumi I. K. For aerobic composting of MSW and poultry manure.

C/N ratio at the end of 2nd experiment in trials I, II, III, IV & V were 19.86, 19.25, 18.01, 19.16 & 20.04 respectively. These results are in agreement with Goutham S.P., et. al.,2010. Several studies have concluded that C/N ratio less than or equal to 20 is the indicator of stability of compost (Hirai M 1983, Manjula gopinathan et. al., 2012, Hamidi Abdul Aziz et. al., 2013,Nabam Rich et.al., 2014 and Chazirakis et. al.,2011).

NUTRIENTS:

The total nitrogen content of the matured compost was in the range of 1.18 to 1.23% and 1.52 to 1.75% in experiments 1 & 2 respectively. The phosphorus content of the matured compost was in the range of 0.26 to 0.29% and 0.5 to 0.56% for experiments 1 & 2 respectively. The potassium level at the end of the composting process was in the range of 0.35 to 0.41% and 0.91 to 1.01% for experiments 1 and 2 respectively.

CONCLUSION:

This work aimed to study the characteristics of aerobic composting of organic fraction of municipal solid waste using spent wash and treated distillery effluent as inoculums in vertical in- vessel reactor. Both inoculums enhanced the composting process and produced enriched compost in 15 days. When comparing the stability of compost with previous studies, the treated distillery effluent is concluded as the best inoculum as compost obtained can be readily applied as soil conditioner. The compost obtained by spent wash as inoculum can also be applied to soil after maturation.

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