

# Sustainable Waste Management by Composting in NIT Warangal

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## Abstract :-

**Purpose** India being a developing country is facing massive waste management challenges due to rapid urbanization and increasing population. According to a solid waste manual in the last decade compared to latest, biodegradable waste increases. In biodegradable waste, most part is food waste and yard waste. Improper management of organic waste leads to bad odor, fly nuisance, rodents, mosquitos are harmful to humans and aesthetically not good for environment. It is a big challenge for all human beings.

**Method** Composting is one of the effective methods to destruct organic waste and useful bioproduct as a compost. Composting is the best useful method in India to consider the climatic conditions and typical composition of solid waste. The objective of the study is to identify the effects of carton and wood chips in the vessel composting of the process using an experimental vessel composter of 80L. Four different mixes are set up based on different composition and different amendments, which consists of food waste, yard waste, bagasse, carton, wood chips. Temperature, PH, moisture content, volatile solids percentage, and electrical conductivity variations are monitored for a period of 45 days.

**Result** The system is in thermophilic condition for a short period due to the very small size of the reactor. The maximum temperature of 52 °C is observed in Bin 2 due to the porosity of amendments used in the composting process. The moisture content was maintained between 50-65% in all the bins throughout the composting period to ensure proper composting process. Initially, pH started increasing and became alkaline and then slowly decreased to neutral conditions. There was an initial increase in the electrical conductivity and the highest EC of 5.12S/m is observed in Bin 1, and then EC values decreased. The volatile solids steadily decreased from 70%-80% to 47%-56% during the composting process. The germination index ranged from 0.62 to 0.79 with highest observed in Bin 3.

**Conclusion** The effect of carton and wood chips in the composting process influence the temperature, pH, electrical conductivity, volatile solids, and Germination index. Bin 3 shows good quality compost with a Germination index of 0.78. The best quality compost was obtained with food waste 50%, yard waste 30% and carton 20%.

**Key Words:** Vessel Composting, Food waste, Microorganisms, Carton, Wood chips, Compost

## 1. INTRODUCTION

Solid waste management is a worldwide phenomenon. The composition of municipal solid waste differs from country to country and changes significantly with time. Different steps involved in the disposal of solid waste like waste generation control, collection, transfer, and transport, disposal. The process also includes the separation of waste materials, processing, treatment and recovery of some of this waste. It is one of the vital services conducted by local governments. Improper management of solid waste (SW) causes hazards to inhabitants [sharholly. et al., 2008]. It is a big challenge all over the world for human beings [UNEP.2005 and Zaihua. et al, 2018]. The physical composition of solid waste changes from decade to decade.

### 1.1 physical composition municipal solid waste

Table 1 physical composition municipal solid waste in India (NEERI Survey)

YEAR	COMPOSITION (%)							
	Biodegradables	Paper	Plastic/ Rubber	Metal	Glass	Rags	Other	Inerts
1996	42.21	3.63	0.60	0.49	0.60	-	-	45.13
2005	47.43	8.13	9.22	0.50	1.01	4.49	4.016	25.16

### 1.2 Integrated solid waste management

Integrated solid waste management is dealing with waste prevention, recycling reuse, composting and disposal program. An effective integrated solid waste management system considers how to reduce the amount of waste sent to disposal. An effective way of management of solid waste helps to provide good environmental conditions to humans and protect their health.

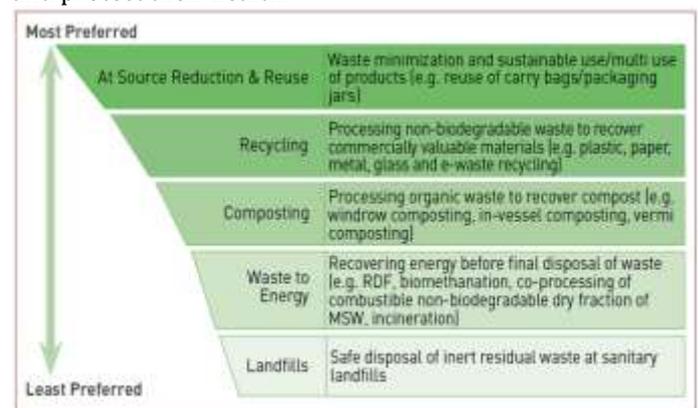


Fig.1 Integrated Solid Waste Management Hierarchy

A developing country like India facing massive waste management challenges due to rapid urbanization [Raj Kumar.et.all., 2016]. Management organic waste on a larger scale is difficult but one alternative solution for treating organic waste is recycling [Walker.et.all. 2009], [Shahzad.et.all., 2017]. Composting is one of the best recycling processes and pollution-free involving disinfect pathogens and recycling of nutrients to give a stable end product and used as a soil amendment [Karnchanawong.et.al.,2011],[Gonzalez.et.all., 2015]. The composting process highly depends on Aeration, Moisture content, Particle size, carbon to nitrogen ratio, Temperature [Soonitha.et.all., 2017]. Carton is variable layers of paper that absorb moisture content, high rich in carbon content and it helps maintain C/N ration in the composting [Soonitha.et.all.,2017]. Cellulose-based cardboards are used for packaging and after it is useless, reported that cardboard and paper make up 40-45% of MSW by mass, it helps reducing the amount of carton send to landfills [Soonitha.et.all.,2017]. Bagasse has acidic nature it maintains P<sup>H</sup> levels, high rich in carton content, provides nutrients to grow the microorganisms in the composting [Lu Zhang.et.all., 2016]. Wood chips are helping degrade the organic matter and increase the macro-micro nutrient level concentration. It reduces nitrogen concentration loss during composting [Lu Zhang.et.all., 2016].

### 1.3 Composting Process in In-Vessel Composting:

In-vessel composting system enclosed the feedstock in a reactor that provides adequate aeration, moisture content. There are several types of in-vessel available: drums, silos, digesters, and tunnels. These are single or multidimensional units. In some cases, reactor stationery and other cases reactor are rotated thus providing adequate oxygen supply. Most of the in-vessel reactors are continuous system although some are batch mode. Fig.2 represents the in-vessel composting process.

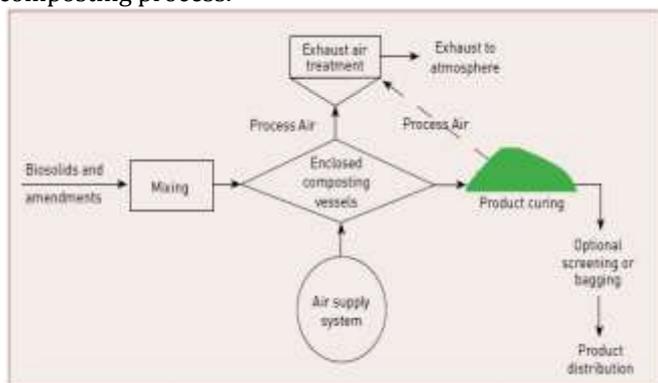
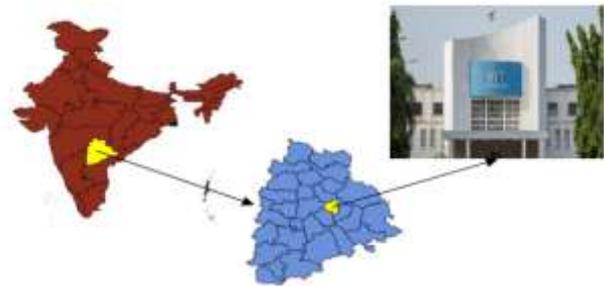


Fig.2 The Composting process In-Vessel Composting

## 2. STUDY AREA

NIT Warangal (Fig. 3) college is producing lots of waste like a paper waste, yard waste, food waste.

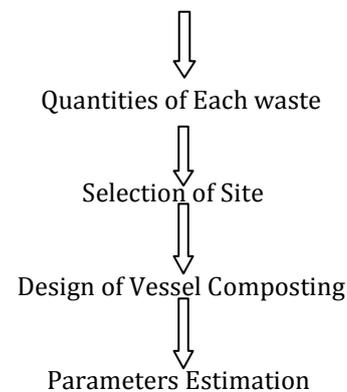


Location: 17.9834327, 79.5292113 (Latitude, Longitude)

Fig.3. location of setup

## 3. MATERIALS AND METHODOLOGY

### Selection of Substrate and Materials



### 3.1 Selection of Substrate and Materials

**Food waste:** India is the most populated country producing lots of Food waste daily. This is a big problem for developing countries like India. Generally, NIT Warangal has 7 messes producing a lot of food waste.

**Yard waste:** NIT Warangal producing a lot of green waste like garden trimming and fallen trees. This was cut about 2inch for the composting process.

**Carton:** Huge College like NITW producing lots of paper waste and cardboard daily because students buying many packaging things through delivery and office paper waste. This is cut about 3cm\*3cm.

**Wood chips:** wood chips mainly found from woodworks. In Warangal, the region lots of woodworks are going on; take this waste as useful for composting process producing as useful products and less harmful to the environment.

**Bagasse:** Sugar companies producing lots of waste after extracting sugar bagasse useless. Bagasse cut about size 2inch.

### 3.2 Quantities of each waste

Composition of waste based on the study of C/N ratio and physical, chemical characteristics divided into two cases. Here primary substrate as food waste, the second substrate as yard waste and bagasse, additives as carton and wood chips. Each bin took the 13.5kg waste of four bins.

Table 2 The Composition of Wastes

Case1	Case2
Primary 60% ( Food waste)	Primary 50% ( Food waste)
Secondary 30% (Yard waste, bagasse)	Secondary 30% (Yard waste, bagasse)
Additives 10% (Either of Carton or Wood chips)	Additives 20% (Either of Carton or Wood chips)
Bin 1, Bin 2	Bin 3, Bin 4

Under case 1: two bins of different additives but the same composition.

Table 3 Quantities of each waste (Bin 1, Bin2)

Mix substates	Bin1	Mix substates	Bin 2
Food waste	8.10kg	Food waste	8.10kg
Yard waste	3.05kg	Yard waste	3.05kg
Bagasse	1.00kg	Bagasse	1.00kg
Carton	1.35kg	Wood chips	1.35kg
Overall C/N ratio	24.1	Average C/N ratio	27.20
Overall moisture content	44.75%	Average moisture content	44.82%

Under case 2: Two bins of different additives but the same composition.

Table 4 Quantities of each waste (Bin 3, Bin4)

Mix substates	Bin3	Mix substates	Bin 4
Food waste	6.75kg	Food waste	6.75kg
Yard waste	3.05kg	Yard waste	3.05kg
Bagasse	1.00kg	Bagasse	1.00kg
Carton	2.70kg	Wood chips	2.70kg
Overall C/N ratio	25.20	Average C/N ratio	31.28
Overall moisture content	41.66%	Average moisture content	41.82%

### 3.3 Design of the Composter

Four 80 L medium density polyethylene bins are taken for composting experiment (Fig. 4). The Bins are 61cm long, 33cm at the top and 44cm at the bottom. The sides of the reactor have perforated for optimum conductive aeration has dimensions of each hole is (Adhikari et al., 2013) 100mmX50mm of 16 holes are made for each bin (Fig. 5). The top of the bin has perforated for passing the PVC pipe

into the composting bin (Fig.6). The bins are perforated along the height 3 holes are made at 15cm from the bottom, 30cm from the bottom, and 45cm from bottom respectively. These holes made for recording temperature readings (Fig.7). Four perforations (Yang et al., 2016) are made for collecting leachate from the bottom of the bin of the size of 1cm (Fig. 8). 50mm diameter PVC pipe and 1m long were passed through the bin, it helps to provide aeration and expelled hot air from the bin (Fig.9). The perforations are made for PVC pipe for optimum aeration size of every 10mm, 3mmholes are made (Karnchanawong et al.,2013). Rectangular bars are supported for composting bins and leachate collection pan dimensions 20cm X 7cm.



Fig.4 medium density bin



Fig.5 Rectangular holes



Fig.6 bin top circular hole



Fig.7 Temperature hole



Fig.8 PVC pipe



Fig.9 leachate holes

### 3.4 Parameter Estimation

All parameters are examined and tests were performed as per the Test Method for the Examination of Composting and Compost [TMECC 2011]. Moisture content, volatile solids,  $P^H$ , Electrical conductivity, Germination index, moisture content monitored every 4 days

## 4. RESULTS

### 4.1 Temperature

The temperature was recognized as the most significant parameter among the various parameters that affect the process of composting as it has been affecting largely the microbial activity. For example, as demonstrated by the experiments of Koivula et al., 2004; Eyheraguibel et al., 2008, to maintain the high temperatures, the wood chips or carton sources were added to the compost to increase the air permeation and water retention, which enhances the degradation of organic material. The variation in the temperatures in different mixtures was shown in figure 10.

In the dynamics of the composting process, there exists, four phases according to the evolution of temperature; namely, mesophilic stage, thermophilic stage, cooling stage and maturation phases. The temperature of the composting reactor is measured starting from the day1 of setting-up of the process to the maturation phase. When the temperature of the compost achieved 31°C, i.e., the ambient temperature, the stabilization is said to be achieved. The temperature variation of bin 1, shown in figure 10, shows that the initial average temperature was found 35°C. An increased temperature on the second day, from 35°C to 44°C, indicates that the system is in the thermophilic stage. On the following day, a further higher temperature was recorded indicating the presence of microbial activity that is degraded the organic matter in the compost (Yang et al., 2016). This results in indicated that heat released in the composting process during the degradation organic. In the composting process temperature increased means thermophilic stage started and subsequently action of microbes present in the compost to degrade the organic matter. Figure 10 represents the temperature profile of various vertical positions of various mixtures and maximum the highest temperature recorded in bin 1, bin 2, bin 3, bin 4 are 52°C, 52°C, 53°C, 53°C respectively (at center and bottom of the composting vessel). Which can be explained from the low temperature of the composting vessel because of its relatively smaller volume.

Peak temperatures were observed center and bottom of the composting process, in Bin 1 at 52°C, Bin 2 at 52°C. Bin 3 at 53°C, bin 4 at 53°C. A sharp decrease in temperature observed in bin 3, bin 4 after 6th day. This can be explained by the exhausted degradable carbon substrates that lowered the microbial activity. The compost pile after the third week, reactor reached to half of the initial height of the composting vessel after which the fungi started growing in the vessel to

act as decomposers that degrade the lignocellulose materials in the substrates [Huang et al., 2013], [Awasthi et al., 2014], [Pandey et al., 2016]. Yang et al., 2003 suggested to turn up the compost mixture frequently so as to aerate and homogenize the system that also helps in balancing the temperature. It is observed that the mixture didn't decompose fully after the first turning of the first mix. The higher lignin content of Bin 3 explains the reason for the system to stay in the thermophilic stage for a shorter period of 7 days.

### 4.2 Moisture content

The moisture content of different bins during the composting process is shown in Fig.11. The calculated moisture content of carton and wood chips were 1.71% and 2.35%. During the decomposition of the organic matter, leachate is formed. In the composting process carton and wood chips are to absorb the moisture content and as well as absorb the leachate in the reactor that will help maintain the moisture content in the composting process. Fig. 11 represent moisture content of all bins during the composting process. The average moisture content of all mixture showed the unbalanced content of moisture content during the composting process. During the composting process, microbes count varies due to this reason accounted for unbalanced of moisture content in the composting process explained by Narkhede et al. (2010). At early stages of the composting moisture content is increased to 68.5%, 67%, 67.2%, and 66% respectively. After that moisture content is decreased due to thermophilic stage occurred because of temperature increase in the composting process in the presence of microbial degradation of the organic matter. After some time moisture content again increased due water vapors fall into the composting process.

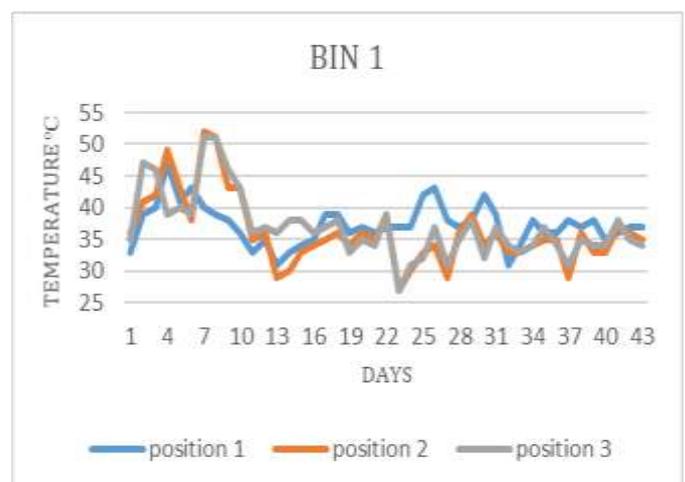




Fig.10 Temperature variations of Bin 1, Bin 2, Bin 3, Bin 4 for different vertical positions

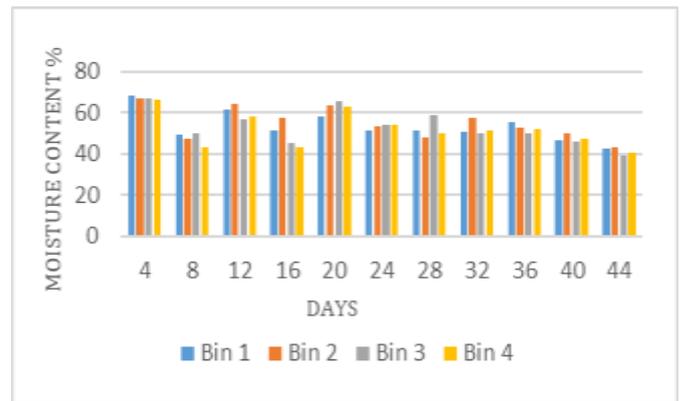


Fig.11 Moisture content profile

#### 4.3 P<sup>H</sup>

P<sup>H</sup> is another important factor that help to uphold microbial growth during the composting process. These values kept on changing during the composting process. The optimum p<sup>H</sup> value for microbial growth during composting is 6.5-7.5. Fig.12 represents p<sup>H</sup> of all bins during the decomposition of organic matter in the composter. Petric et al. 2012 explained that the p<sup>H</sup> graph towards to move neutral initially and then alkaline. This is happened because of degradation of organic matter acids are formed, this acid are converted to CO<sub>2</sub> in the presence of microorganisms activities. This increase is also explained for active degradation of weak or strong acids by flora present in the composting process and this leads formation of ammonia which has been formed due to degradation nitrogen substances present in the composting process. At the start of the analysis of p<sup>H</sup>, the average value of Bin 1 was 5.28. A steady increase in p<sup>H</sup> up to 16 days. The starting stage p<sup>H</sup> of Bin 2 was 5.03 represent the composite sample of solid waste is more acidic nature compared to Bin 1. On day 12, P<sup>H</sup> value observed to be 7.86 Peak p<sup>H</sup> observed on day 12 with value of 7.86 after that slowly decreases the value of p<sup>H</sup> is 7.14 at the later stages composting process. This generally represents that fall in p<sup>H</sup> due to temporary anaerobic conditions and also formation amino acid due to hydrolysis of polymers. In this study, the p<sup>H</sup> peak touched is in Bin 3 amongst the four compost mixes through a p<sup>H</sup> value of 8.10 on day 40 increasing from day 28.

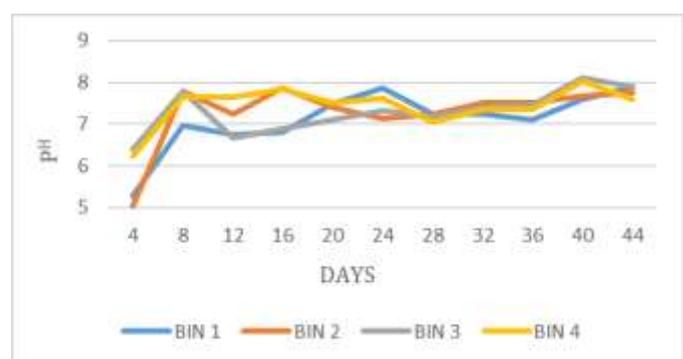


Fig.12 P<sup>H</sup> Variations

#### 4.4 Electrical Conductivity

The total salt content in the matrix indicated with Electrical conductivity (EC) reflects the quality of the compost as a soil texture amendment. Due mineralization of organic matter by the microbial actions formation of salt content includes Ca and Mg ions expelled from the reactor [Shah et al., 2015] and this replicates the quality of the product form from the reactor. In previous Gao et al. (2010) explains the electrical conductivity of the compost gives the salt content in the compost and gives information regarding any toxins there in the toxic in the compost. Fig.13 represents the variations of electrical conductivity in the composting process. The electrical conductivity of bin 1 slightly high compared to average value of 2.65 S/m. A gradual increasing the values of electrical conductivity up to 16 day after that fall the graph. According to Awasthi et al. (2014) the initially raise the electrical conductivity values because of composite substances to simple compounds. After 16 days, electrical conductivity values decline due to loss of salts in the composting in the form of leachate. According to literature, the generation of ammonia during the degradation of nitrogen content in the composting process and precipitate as well loss in the form of leachate [Wong et al., 1995, Echeverria et al., 2011 and Singh and Kalamdhad (2014)]. The initially of electrical conductivity of the bin 2 is 2.59 S/m and compared to bin 1 initially value less. The electrical conductivity of bin 2 reduced to 3.78 S/m. Bin 3, Bin 4 had an initial average EC of 3.12S/m, 3.08 S/m and decreased to final values of 2.98 S/m, 3.03 S/m respectively. Based on standard value of composting all values within range. So compost useful to farmers.

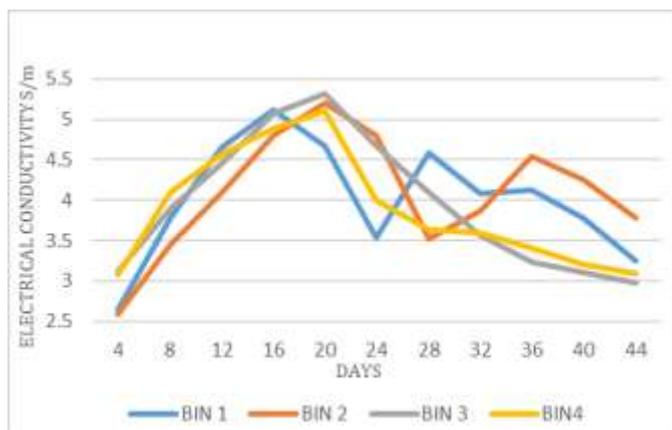


Fig.13 E.C variations graph

#### 4.5 volatile solids

Fig.14 represents variations in volatile solids during the composting process. During the decomposition of organic matter generally ash content increases in the composting process [Ramaswamy et al., 2010]. During the decomposition of the organic matter decline curve was observed in each mix. Initially volatile solids of bin1 are 69.62% after that declines and reached the final value of 47.36%. Initially

volatile solids content of bin 2 is 73.3% after that declines and reached the value of 48.34% because of slow decomposition in the composting process due to high lignin cellulose content. Bin 3 and bin 4 volatile solids content in the initially 80.11%, 79.8% after that declines reached the final volatile solids content of 55.58%, 54.2% respectively.

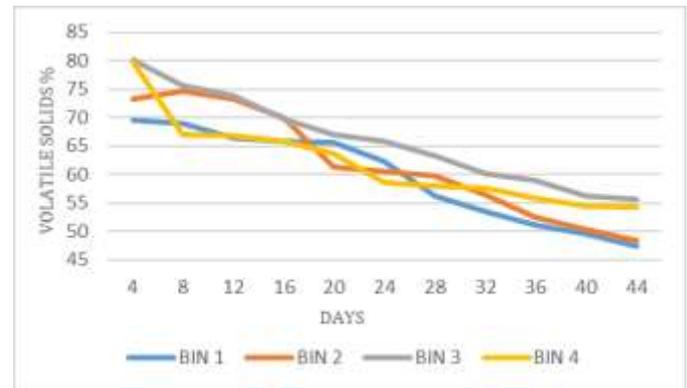


Fig.14 volatile solids variations

#### 4.6 Germination index

Fig.15 represents the germination values for different mixtures. The GI values attained for Bin 3, Bin 4 is almost equal to 0.8. This indication that plants easily growth for this compost. However, both GI values obtained for Bin 1, Bin 2 were 0.64, 0.60 respectively, and this could indicate that little amount of toxicity obstruct the plant growth when using this compost sample in the field. (Yang et al. 2013) and [Saidi et al. 2009] stated that a Germination value above 0.5 indicates that medium phytotoxic-free and a Germination index value exceeding 0.8 corresponds to good quality compost.

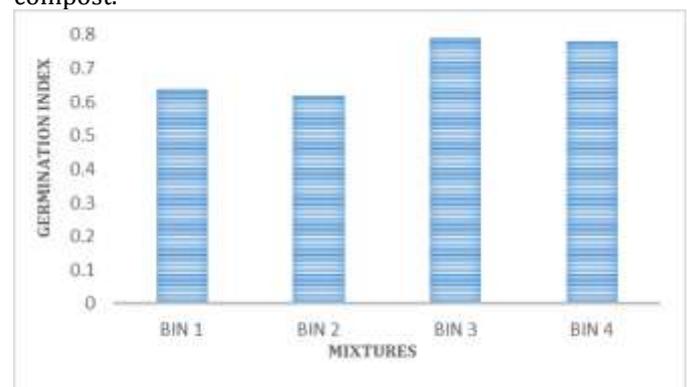


Fig.15 Germination index

### 5. CONCLUSION

In the present study, the effect of carton and wood chips in the vessel composting process helped to degrade the organic matter easily compared to normal composting. Compost produced from four mixes toxic-free and good water retention.

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