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Studies On Parameters of Compost of Kitchen Waste Prepared Using Promising Microbial Consortium

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ABSTRACT

In the present work microbial consortium approach was used to treat the kitchen waste. The kitchen waste contains large amount of organic matter susceptible to microbial degradations. Effective microbial consortium was prepared using bacterial isolates having enzymatic potentials of cellulase, pectinase, amylase, protease, gelatinase and lipase. Microbial consortium, designated as consortium no 7 containing, Micrococcus luteus, Brevundimonas mediterranea, Bacillus tequilensis, Exiguobacterium mexicanum and Serratia marcescens based on maximum enzyme production and thorough compatible with each other. The study on pH, temperature, moisture content, volume, mass & density changes in the kitchen waste was carried out for 30 days using this consortium. It was found out that there was rapid degradation of waste where moisture content, volume and mass were reduced drastically as 10-15%, 35-40%, 10-15%, respectively after 30 days, while there was slight increase in density (0.01-0.03%) pH (0.1-0.2) & temperature (40-450C) due to microbial activities. The consortium members were found thermotolerant. The physicochemical parameters of compost (fertilizer) produced in this process indicated that the colour was bit darkened, texture was grainy, no foul smell, the pH near 6.0, % organic matter, K2O, P2O5 & sulfur were 17.8, 0, 45, 0.55 & 0.11, respectively & C: N ratio was increased and all the parameters of fertilizer obtained in the present study are comparable with chemical fertilizer commercially available in the market. The shelf life of the consortium No. -7 was 4-6 months at 40C where CFU/mL was maintained to >108 upto 6 months. In the present studies the compost maturity period was decreased from 25-30 days (without consortium treatment) to 15- 20 days with consortium treatment.

Keywords; *Consortium, Compost, Kitchen waste, Degradation, Physical and Chemical parameters*

1. INTRODUCTION

Based on biodegradability waste is classified as biodegradable, moderately degradable, and non-biodegradable wastes. Cow dungs, poultry droppings, kitchen waste, etc are some examples of biodegradable wastes. The rate of degradation was increased due to aerobic and anaerobic organisms acting on biodegradable wastes. Moderately degradable wastes include the tough textured components containing wastes and they are slowly degrading wastes. Examples of such wastes are wood and cardboards (Bhat et al.,2018). In recent decade, the rapid increase in human population and accelerated economy has caused an exponential increase in the waste generation rate. Approximately 188500 tonnes (68.8 million tonnes per year) of municipal solid waste is generated per day in urban India (Gupta and Arora, 2016). However, only 24% of this homogenous waste is processed, treated and disposed of by suitable methods. The waste disposal in India is mainly done by open dumping, landfilling, composting and incineration; open disposal being the cheapest and most common method currently practiced (Ghosh et al., 2015). Thus

2. REVIEW OF LITERATURE

Composting is a safe way of managing organic wastes, but it is associated with odour production and the release of greenhouse gases (CO_2, SO_2, and NO_2). Composting can eradicate bio degradable organic wastes. (Abdel-Shafy et al., 2018). The degradation of organic waste by use of a microbial consortium is considered highly efficient, and the capability of waste degradation by a consortium depends on its functional and structural stability (Mirdamadian et al., 2011). The stability of a potential waste- degrading consortium can be observed by testing antagonistic (competition for substrate among different microbes present in the consortium) and synergistic (co-operation between different microbes present in the consortium for better degradation of wastes) activities within the strains and testing the concomitant production of different enzymes by the bacterial strains within the consortium to study the consortium's functioning under natural conditions of substrate availability (Sarkar et al., 2011). Food waste has a low C/N ratio between 20 to 30 and pH, compared to fruit-vegetable waste. Fruit vegetable waste, which includes fruits and vegetable peelings, is rich in lignocellulose waste

Significance and the aim of the Study:

The main aim of this study is to develop some microbial consortium that can effectively and rapidly bring about the degradation of the kitchen wastes and help in the process of rapid conversion of kitchen wastes into the fertilizer that can be applied to soil to increase soil fertility

Specific objectives of the study:

- To Prepare microbial consortium and selection of best consortium
- To Analyse the physical and chemical parameters of fertilizer/ prepared compost
- To study the SPC for bacteria.
- To compare the compost with commercial composts

3. MATERIAL AND METHODS

1) **Preparation of microbial consortium:** Microbial consortium was prepared using permutation combinations (Sarkar *et al.* 2017)
2) **Selection of best consortium:** A bacterial consortium which showed excellent ability of enzyme production was selected and used for kitchen waste degradation trials and compost preparation and analysis
3) **Analysis of fertilizer/ prepared compost:** (Ref: APHA, 2005)

   i) **Physical observation of the samples:** (Ref: APHA, 2005)

After 25 days of incubation, the waste samples were observed for color, texture, pH and odour.

   ii) **Chemical analysis**

The final fertilizer was analyzed chemically for parameters such as pH, organic matter, C:N ratio, K2O, P2O5 and Sulphur (Ref: APHA, 2005)

4) **SPC for bacteria** :

The SPC of compost after 20& 25 and 30 days was determined to

study any influence of high temperature of composting on the consortium organisms.

5) **Comparison of the compost with commercial composts** (Sarkar *et al.* 2017)

The product formed after 25 days from the best consortium was compared with the commercially available market fertilizers

The finally prepared fertilizer was analyzed both for physical and chemical characteristics**.**

4. RESULTS AND DISCUSSION

1) The physiochemical parameters of the domestic kitchen waste samples were initially as below (table-1)

Table1: Physicochemical characteristics of kitchen waste sample:

Sr.No.	Type of analysis	Parameters studied	Average of triplicates (Results)
	Physical		
		Color	Reddish brown
		Texture	Slimy
		Odour	Foul
2	Chemical	pH	5.75
		Organic matter %	3.8
		Carbon %	1.5

		N%	0.9
		K2O ppm	13
		P2O5ppm	0.35
		Sulphur ppm	25

Among the food waste, the pH tends to differ. However, they could be categorized as low pH. The lowest pH recorded was 3.65 from the institute's dining hall in Japan (Kawai,*et al.*, 2014). The C:N ratio may vary from 11 to 30 which suffices to be good for promoting the bacterial growth as reported by Rawat,*et al*., (2008). The Sulphur content of the soil was found to be 25 ppm as similarly reported by Pillai, *et a.,l* (2014)

2) **Molecular characterization of the bacterial isolates selected in consortia:** Seven number of consortia were prepared using five number of promising bacterial isolates. It was found that consortium no 7 was best in its efficiency of degradation ok kitchen waste in short time. Hence consortium number 7 was used to prepare compost out of kitchen waste. On the basis maximum compatibility and concomitant enzyme production studies bacterial isolates of the consortium (no 7)used for degradation studies were identified using 16Sr RNA technique and identified as,

Sr.No	Isolate designation	% similarity	Isolates identified from consortium no 7 as	Accession number from NCBI
1	KW37	99.88	*Micrococcus luteus*	OP 482489
2	KW128	99.74	*Brevundimonas mediterranea*	OP482496
3	KW91	99.89	*Bacillus tequilensis*	OP482499
4	KW97	99.88	*Exiguobacterium mexicanum*	OP482500
5	KW104	99.85	*Serratia marcescens*	OP482501

Table 2: Isolate wise identification and their accession number

3) **Changes in kitchen waste by degradative activity of selected consortium:**

Results of efficiency of consortia 7 to degrade 1 and 5 kg of domestic waste in terms of changes in pH, volume, moisture, mass reduction, density and temperature are presented in sequential manner as detailed below.

i) Changes in pH of Kitchen waste during composting process

Changes in pH due to degradation of kitchen waste by consortium 7 are presented in Table 3 and as per fig 1

Table. 5.3 : Incubation period wise changes in pH

Incubation period (days)	Change in pH in the process in composting			
	1 kg volume waste		**5 kg volume waste**	
	control	**Test 1 kg**	**control**	**Test 5 kg**
0	**6.7**	**6.6**	**6.7**	**6.5**

5	**6.5**	**6.5**	**6.5**	**6.4**
10	**6.3**	**6.0**	**6.3**	**6.1**
15	**5.7**	**6.0**	**5.7**	**6.0**
20	**5.5**	**6.0**	**5.5**	**5.9**
25	**5.0**	**5.8**	**5.0**	**5.5**
30	**4.8**	**5.5**	**4.9**	**5.3**
t value	**0.4223**			
p value	**0.68 NS**			

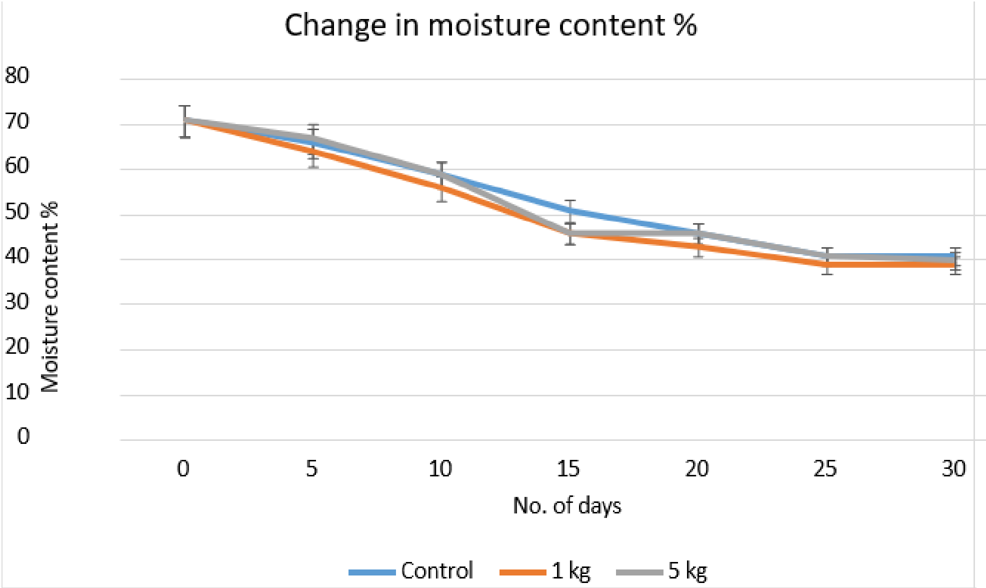

Fig1: Incubation period wise changes in pH of Kitchen waste during composting process

Slight decrease in pH towards acidic side with increase in duration was observed in both 1 kg and 5 kg volume kitchen waste. The decrease in pH may be attributed to acids released after fermentation by test bacteria. On the other hand, Caceres, *et al.*, (2006) reported increase in pH of compost to 7.2–8.0 and explained this by the release of ammonia following the degradation of organic compounds, such as protein and amino acids

Anwar, *et al.*, (2017) reported amylase, protease and cellulase activity by eight isolates which indicated their ability for kitchen waste degradation. They used 500gKitchen waste in five different trials separately at different pH (5.7, 6.5 and 7.0) and temperature (37ºC, 40ºC and 45ºC). Acid, heat and freeze thaw methods were used to enhance degradation. 59.29 g (11.85%), 39.91g (7.98%) and 37.63g (7.5%) weight reduction was observed within 7 days in three different trials with consortium.

ii) Changes in volume of Kitchen waste during composting process:

Changes in volume due to degradation of kitchen waste by consortium 7 are presented in Table 4and as depicted in Fig 2:

Table. 4: Incubation period wise changes in volume

Incubation No of days	Change in volume (remaining %)		
	Control	**Test 1 kg**	**Test 5 kg**

0	**100**	**100**	**100**
5	**86**	**70**	**80**
10	**84**	**68**	**73**
15	**84**	**65**	**68**
20	**82**	**50**	**55**
25	**80**	**40**	**45**
30	**78**	**40**	**44**
t value	**0.405**		
p value	**0.6935 NS**		

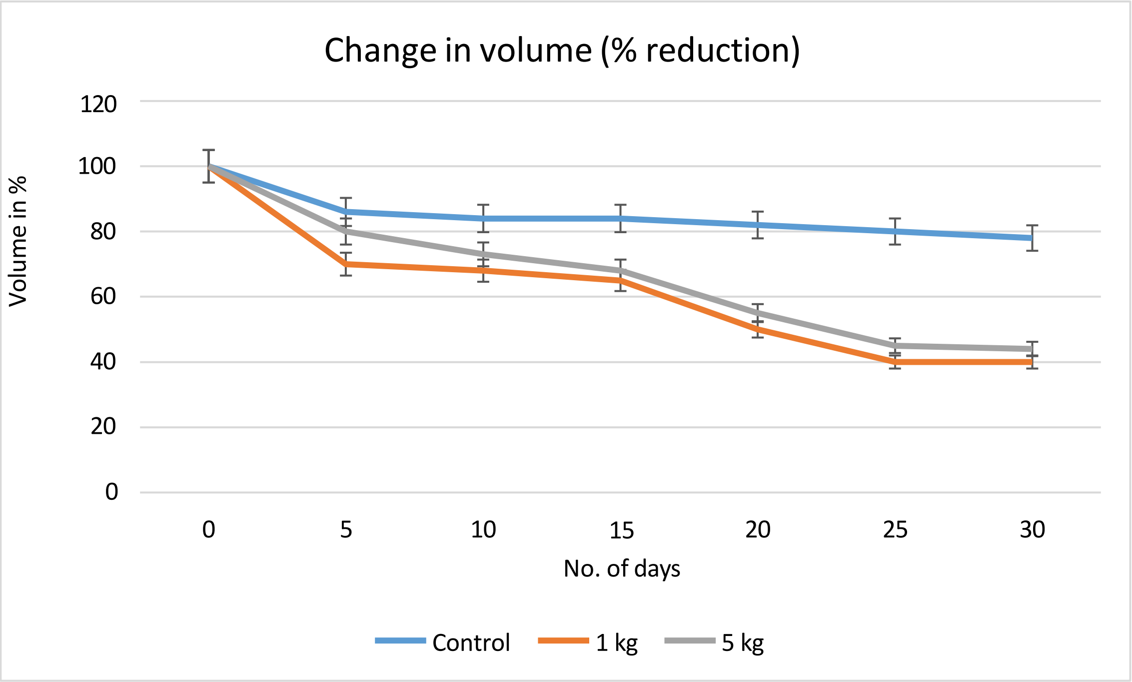

Fig 2: Incubation period wise changes in volume of Kitchen waste during composting process

A notable decrease in waste volume (weight) was observed in both in 1 and 5 kg and slight decrease in the control after the first week. After 25 days 40 and 45 % volume of the remaining waste were reported in 1 and 5 kg waste, respectively. (Fig. 5.15), whereas 80% volume was observed in the 20% decrease is attributed to its own microflora activity control. After 25 days of incubation no much decrease in volume was observed as compared at 25 days. Elango, *et al*., (2009) observed degradation of MSW (Muincipal Solid Waste) by thermophilic composting with 78% volume reduction of raw MSW in 40 days. The resulting compost provided good humus to build up soil characteristics and some basic plant nutrient.

Sarkar, *et al*., (2011) reported gradual decrease in the volume of the kitchen wastes during 30 days of incubation for degradation by seven successful microbial consortia seperately with ability to produce many enzymes, viz amylase, protease, lipase and cellulase in a specialized media

iii) Changes in moisture content of Kitchen waste during composting process:

Changes in moisture due to degradation of kitchen waste by consortium 7 are presented in Table 5 and as depicted in fig 3

Table. 5: Day wise changes in moisture

Incubation No of days	% Moisture content (remaining)		
	Control	**Test 1 kg**	**Test 5 kg**
0	**70**	**70**	**70**
5	**65**	**63**	**66**
10	**58**	**55**	**58**
15	**50**	**45**	**45**
20	**45**	**42**	**45**
25	**40**	**38**	**40**
30	**40**	**38**	**39**
t value	**0.253**		
p value	**0.805 NS**		

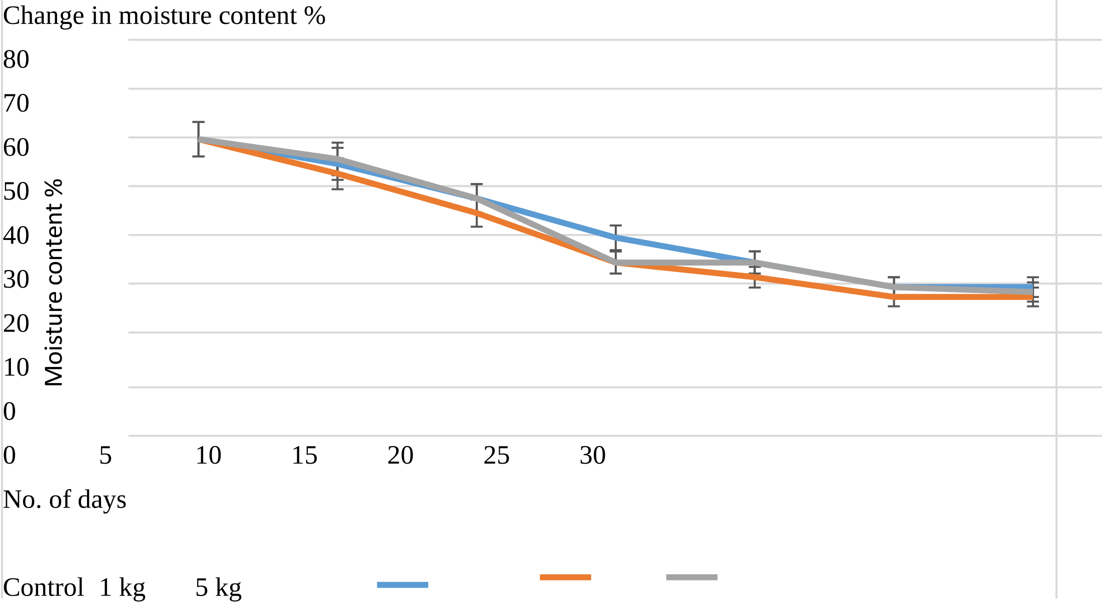

Fig 3: Incubation period wise changes in moisture

Water is a critical factor during composting. Compost moisture content above 80% leads to decrease of oxygen diffusion, resulting in the composting process to slow down and become anaerobic. A moisture content of 40–60%should be maintained during the composting process for proper microbial process. At lower moisture levels, microbial activity is limited. At higher level, the process is likely to become anaerobic and foul smelling. In present

experiment the moisture content reduction was uniform for test consortium in case of both

1 and 5 kg and control composts, indicating moisture reduction due to drying and evaporation. The 40%, 38 % and 40% moisture content was found after 25 days of degradation study in control,1kg and 5 kg, respectively. No much reduction in moisture contents was observed after 25 days of experiment as compared at 25- days of experiment. Increase in moisture reduction was more due to temperature rise, resulting from increased microbial degradation activities. Gautam, *et al*., (2010) performed composting of MSW of Jabalpur City (India) and observed moisture content of 36% in the final compost.

iv) Changes in % mass reduction of Kitchen waste during composting process: Changes in % mass reduction due to degradation of kitchen waste by consortium 7 are presented in Table 6 and as depicted in fig 4:

Table-6: Incubation period wise changes in % mass reduction

Incubation period (days)	% Mass reduction in kitchen waste		
	Control	**Test 1 kg**	**Test 5 kg**
0	**100**	**100**	**100**
5	**82**	**78**	**80**
10	**70**	**65**	**68**
15	**65**	**62**	**65**
20	**60**	**55**	**60**
25	**55**	**40**	**45**
30	**55**	**40**	**45**
t value	**0.2643**		
p value	**0.796NS**		

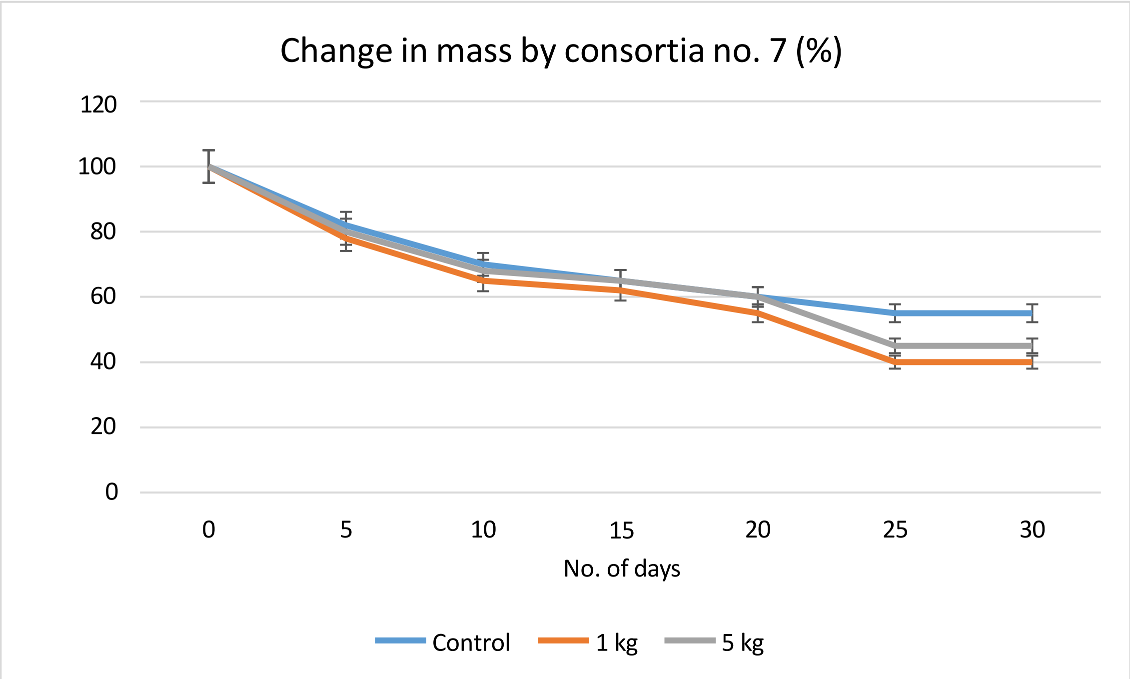

Fig 4: Incubation period wise changes in mass reduction

Mass reduction is a primary objective of waste treatment processes. Organic matter is utilized by degrading organisms and incorporated into cells and is also released as gas which causes a reduction in waste mass (Tom, *et al*., 2016). Significant reduction in mass was observed for 1 and 5 kg kitchen waste supplemented with consortium.

It is crystal clear from the values mentioned in Table 5.31 that there is notable reduction in mass % both at 1 and 5 kg level. Mass % values were reduced from 100 to 40 in case of 1 kg waste and 100 to 45 for 5 kg waste as compared to less reduction in case of control waste. No much reduction was observed after 25 days of experiment as compared to at 25 days. Reduction in mass % thus indicate the proper degradation of kitchen waste leading to expected texture.

v) Changes in density of Kitchen waste during composting process:

Changes in density due to degradation of kitchen waste by consortium 7 are presented in Table 7 and as depicted in Fig 5

Table-7 : Incubation period wise changes in density

Incubation period (days)	Density (g/cm-3) remaining		
	Control	**Test 1 kg**	**Test 5kg**
0	**1**	**1**	**1**
5	**0.90**	**0.95**	**0.98**
10	**0.90**	**0.97**	**0.99**
15	**0.93**	**0.97**	**0.99**
20	**0.95**	**0.98**	**0.99**
25	**0.97**	**0.98**	**1.0**
30	**0.97**	**0.98**	**1.0**
t value	**0.2643**		
p value	**0.7969NS**		

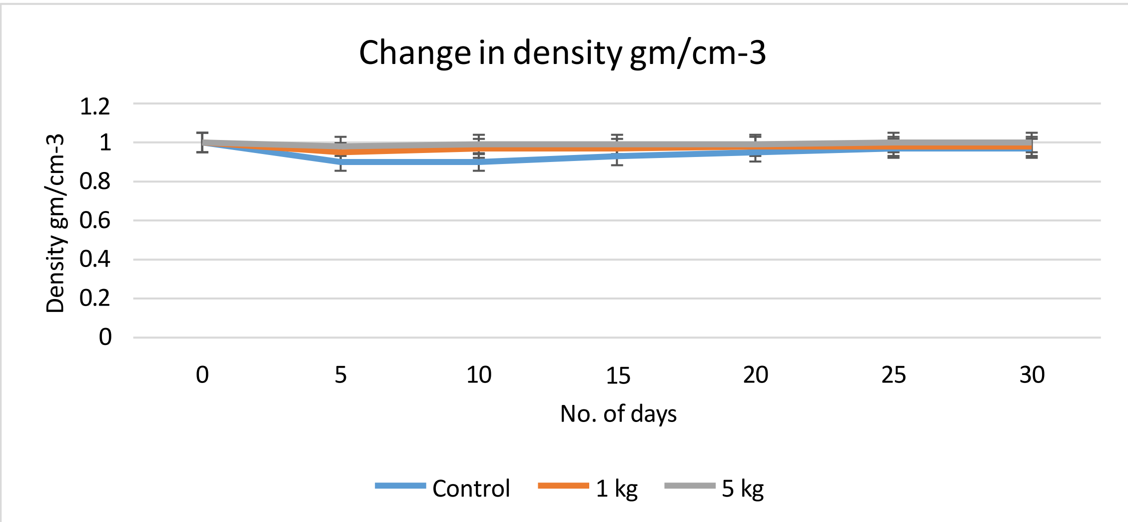

Fig 5: Incubation period wise changes in density

Increase in density with increase in duration was reported. More density was measured in 5 kg than 1 kg kitchen waste**.**

Density and volume are inversely related and a rapid decrease in volume indicates increasing density. Increase in density is important during composting, as it indicates particle size decrease due to waste degradation.

Tom, *et al.*, (2016) reported a 50% density enhancement of bio-treated MSW resulting in compaction of the compost.

vi) Changes in temperature of Kitchen waste during composting process:

Changes in temperature due to degradation of kitchen waste by consortium 7 are presented in Table 8 and as depicted in fig 6

Table. 8 : Incubation period wise changes in temperature

Incubation period (days)	Level of kitchen waste	Temperature (0 c)		
		Control	**Test 1 kg**	**Test 5 kg**
0	**Surface**	**33**	**33**	**35**
	Centre	**38**	**39**	**41**
	bottom	**36**	**37**	**39**
5	**Surface**	**36**	**37**	**40**
	Centre	**40**	**41**	**43**
	bottom	**38**	**40**	**42**
15	**Surface**	**37**	**38**	**40**
	Centre	**40**	**42**	**44**
	bottom	**39**	**43**	**43**
20	**Surface**	**38**	**39**	**41**
	Centre	**41**	**41**	**43**
	bottom	**37**	**40**	**42**
25	**Surface**	**39**	**40**	**41**
	Centre	**40**	**42**	**44**
	bottom	**38**	**41**	**45**
30	**Surface**	**39**	**40**	**41**
	Centre	**40**	**42**	**44**
	bottom	**37**	**39**	**43**
t value	**1.045**			
p value	**0.3052 NS**			

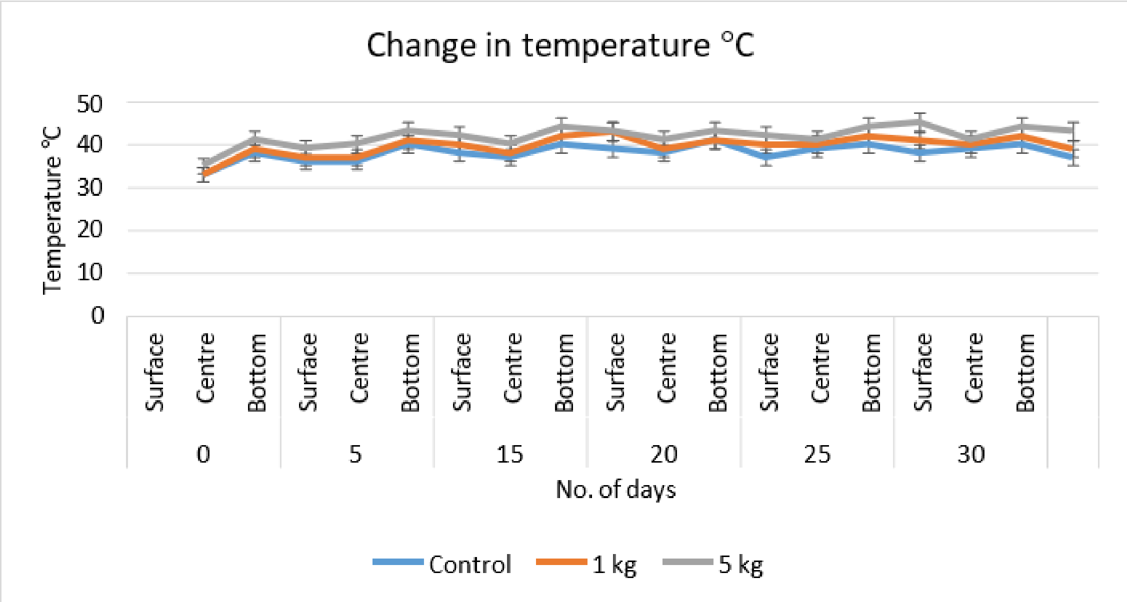

Fig 6 : Incubation period wise changes in temperature

Increase temperature by 1 to 3°C in both 1 and 5 kg was reported at every stage of testing with gap of 5 days & increased upto 40-45^{0}C around 5 to 30 days of experiment.

vii) Standard Plate count (SPC) of compost (total viable count): Rise of temperature is common phenomenon in composting and associated with vigorous microbial activity and rapid organic matter degradation exothermic processes of microbial metabolism. Temperature increase leads to reduction in pathogenic microbial population, though turning of the compost pile at regular interval was employed to prevent further increase of temperature to such extents that would kill the degrading organisms and stop the degradation process. The criteria used for completion of composting process was determined total viable count. The organisms were active at the temperature attained in composting (40-45^{0}C) (Table 9).On the basis of increase in total viable count in microbial count & no smell production the compost maturity was determined. Additionally, the predominance of bacterial isolates from consortium 7 was confirmed by performing standard plate count (table 9).

Table. 9: SPC for compost after 25 days of incubation

Sr. No.	Type of microorgani sms	Initial SPC (At zero-day CFU/g (Average of triplicates)	SPC (average of triplicates) of compost after 20 days CFU/g	SPC (average of triplicates) of compost after 25 days CFU/g	SPC (average of triplicates) of compost after 25 days CFU/g
1	Bacteria	$5x10^8$	$1.5x 10^{10}$	$2x10^{10}$	$2.1x10^{10}$

Table 9 indicates that SPC at 20 & 25 days of experiment was 30 to 40 times more as compared to initial at the time of inoculation of consortium into waste which further indicated that the microflora of consortium was thermotolerant & active at 40- 45 ^{0}C & being active must have produced enzymes throughout the process & effectively.

Singh and Sharma, (2003) observed the highest temperature (58^{O}C) at the bottom of the compost pile with maximum temperature increase from the 14th to the 21st day. Tom, *et al.*, (2016) stated that increase in temperature leads to degradation of waste by thermophilic organisms that supplement mesophilic degradation.

Anwar, *et al.*, (2017) studied biodegradation of kitchen waste by isolates due to amylase, protease and cellulase activity.

They used 500gKitchen waste in five different trials separately at different temperature (37ºC, 40ºC and 45ºC). Acid, heat and freeze thaw methods were used to enhance degradation. They obtained results with and without use of consortia. the 55g (11%), 100.9g (20.18%) and 3g (0.6%) weight reduction was reported without consortium by thermal, acid and freeze-thaw pre-treatments respectively. The

59.29g (11.85%), 39.91g (7.98%) and 37.63g (7.5%) weight reduction was observed within 7days in three different trials with consortium.

Zaved, *et al.*,(2008**)** noted changes of color, odour, weight loss, volume loss, temperature and pH of decomposing garbage by the most effective strain.

viii) Analysis of fertilizer (compost) prepared using consortium no 7 and comparison with commercial compost:

Results of analysis of fertilizer produced due to consortial microbial activity in terms of physical parameters viz appearance color, texture & odour and chemical parameters viz pH, organic matter, C:N ratio, K2O, P2O5 and Sulphur are tabulated in Table 5.3.4 & Photoplate 1:

Table 10: Analysis and comparison of fertilizer (compost) with commercial compost

Sr. No.	Type of analysis	Parameter	Sample type			Annapurna & Neemurja
			Domestic waste	Control	Test compost	Commercial compost
1	Physical	Color	Reddish brown	Dark brown	Blackish brown	Dark brown
		Texture	Slimy	Grainy	Grainy	Grainy
		Odour	Foul	mild foul smell	No foul smell	No foul smell
	Chemical	pH	6.0	5.5	5.8	6.0
		Organic matter %	40	20.8	17.8	18.7
		C:N	38	35	30	32
		K2O	0.31	0.41	0.45	0.40
		P2O5	0.35	0.41	0.55	0.40
		Sulphur	0.07	0.07	0.11	0.09

Photoplate -1 : Compost of kitchen waste

Our results of physical and chemical analysis are similar to the results obtained by Sarkar and Chourasia, (2017) who carried out physical analysis of compost produced by use of consortia after 25 days and reported a dark colour and grainy texture without any crustacean population and lacked foul smell. They also carried out chemical analysis of compost produced from 30kg wastes inoculated with consortium 2 and found C:N ratio of 22:1compared to 32:1 in control, increased C:N ratio indicates remaining of non-biodegradable organics and decreased N contents and increased percentage of K, P and S which are required for enhancement of soil fertility.

Conclusion :The physicochemical parameters of compost (fertilizer) produced in this process indicated that the colour was bit darkened, texture was grainy, no foul smell, the pH near 6.0, % organic matter, K2O, P2O5 & sulfur were 17.8, 0, 45, 0.55 & 0.11, respectively& C:N ratio was increased and all these parameters of fertilizer obtained in the present study are comparable with chemical fertilizer commercially available in the market. The shelf life of the consortium No. -7 was 4-6 months at 4^0C.

It is clear from the table that decrease in organic matter and C: N of domestic waste, control and wastes inoculated with consortia were 40, 20.8, 17.8 and 38, 35, 30 respectively.

The degradation period reported by previous workers ranged from 25 to 35but in the present study due to use of consortia, period was reduced to 25 days with desirable characteristics. The degradation of organic wastes by the bacterial consortia is highly significant. The use of microbial consortium generated through natural selection or improvement of the performance of these microorganisms in organic kitchen waste degradation through genetic manipulation, may be the best option for the efficient treatment of organic kitchen waste or domestic wastewater in the near future.

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Conflicts of interest:

The authors declare that they have no conflicts of interest

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