Optimization of process variables for enhanced organic matter degradation and nitrogen conservation during food waste composting at an academic campus

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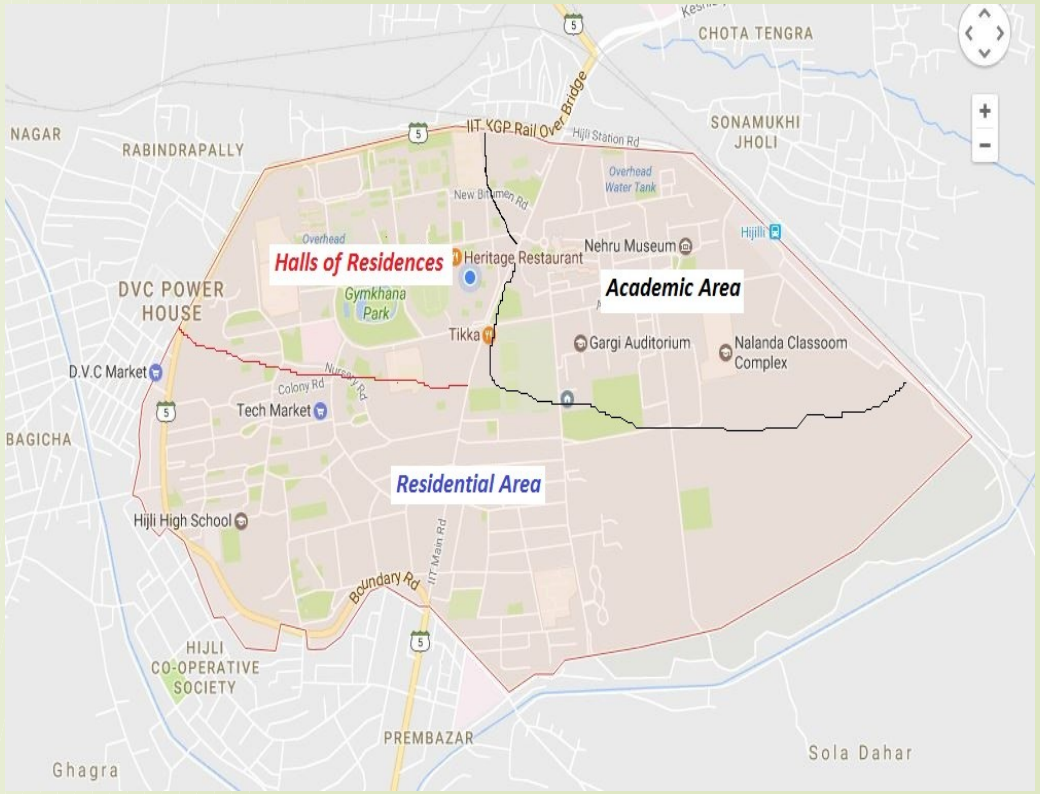
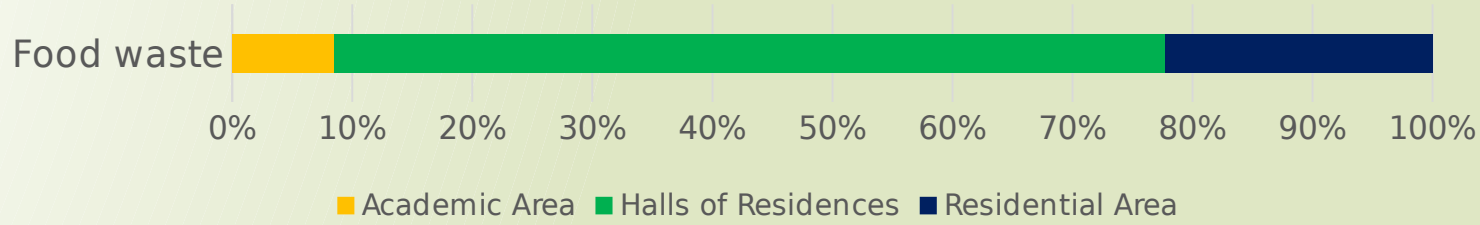
Background

- Nearly 2 tons of food waste is generated from the campus per day.
- 70% food waste is contributed from the kitchen of halls of residences alone
- No waste treatment is currently followed.
- Composting is affected by mainly
  - Environmental factors
  - Substrate characteristics

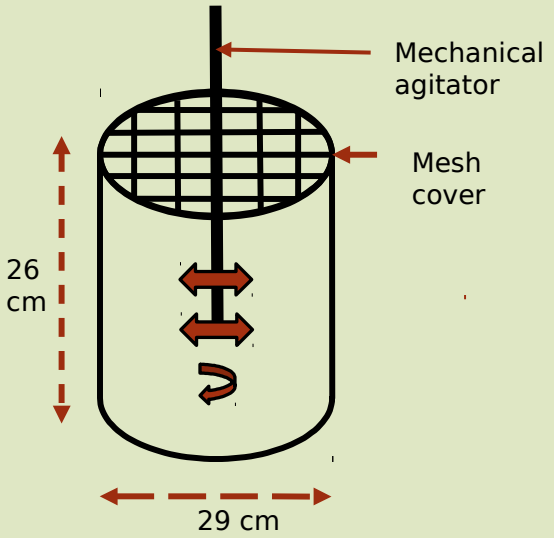




Materials and methods

Reactor system

- Cylindrical reactor made up of HDPE.
- Measures 29 cm internal diameter ×26 cm height (volume 18 litres)
- A rotatory stirrer at a constant speed of 400 rpm is used for mixing and turning.
- Mixing is performed once a day for the 1st 30 days and every week for the remaining 60 days
- Open end of the reactor is covered by a mesh cover when not stirred.
- A mercury thermometer is inserted into the reactor to record temperature readings every day.
- All reactors are run in triplicates.



Experimental design

- 2^{4-1} fractional factorial selected for the designed study

Independent variables	Code	Units	Low level (-1)	High level (+1)
Feed stock ratio	FR		1:1	3:1
Moisture content	MC	%	50	70
Mixing time	MT	minutes/day	20	60
Starter culture	SC	ml/kg	No	Yes

Response variables included

- OM decomposition (%)
- Final C/N ratio at the end of composting
- N loss (%)

Std	Run	A:FR	B:MC	C:MT	D:SC	Measured final C/N ratio	Predicted final C/N ratio	Measured OM decomposition	Predicted OM decomposition	Measured N loss	Predicted N loss
		Independent variables				Response variables					
1	4	1	50	20	No	15.8	15.18	30.87	32.48	-39.2	-29.35
2	13	1	50	20	No	13.4	15.18	26.07	32.48	-27.2	-29.35
3	19	1	50	20	No	16.33	15.18	43.96	32.48	-32.2	-29.35
4	5	3	50	20	Yes	9.15	7.87	21.8	24.46	-24.3	-16.70
5	14	3	50	20	Yes	7.3	7.87	25.3	24.46	-4.5	-16.70
6	26	3	50	20	Yes	6.8	7.87	22.8	24.46	-22.8	-16.70
7	7	1	70	20	Yes	9.1	7.75	37.5	37.62	-32.2	-16.50
8	8	1	70	20	Yes	7.99	7.75	33.3	37.62	-15.5	-16.50
9	16	1	70	20	Yes	5.8	7.75	38.6	37.62	-3.3	-16.50
10	17	3	70	20	No	16.74	15.93	53.56	49.17	-19.3	-20.48
11	20	3	70	20	No	14.08	15.93	40.63	49.17	-33.8	-20.48
12	21	3	70	20	No	16.96	15.93	56.79	49.17	-18.9	-20.48
13	15	1	50	60	Yes	7.97	7.96	22.06	24.31	-39.7	-33.14
14	18	1	50	60	Yes	6.67	7.96	23.6	24.31	-42.3	-33.14
15	23	1	50	60	Yes	8.9	7.96	23.8	24.31	-18.9	-33.14
16	1	3	50	60	No	16.33	16.69	66.19	58.38	20.6	13.48
17	2	3	50	60	No	18.55	16.69	77.67	58.38	-7.7	13.48
18	27	3	50	60	No	15.18	16.69	34.76	58.38	17	13.48
19	6	1	70	60	No	10.1	12.07	21.47	21.36	-77.2	-67.02
20	9	1	70	60	No	13.71	12.07	24.5	21.36	-72.7	-67.02
21	24	1	70	60	No	12.4	12.07	21.58	21.36	-61.7	-67.02
22	11	3	70	60	Yes	9.37	8.88	26	24.26	-1.8	-28.97
23	28	3	70	60	Yes	8.2	8.88	23.2	24.26	-54.2	-28.97
24	25	3	70	60	Yes	8.71	8.88	20.1	24.26	-32.4	-28.97
25	3	2	60	40	No	16.58	14.97	54.12	64.40	15.7	-25.84
26	12	2	60	40	Yes	8.73	8.11	61.49	51.71	-33	-23.83
27	10	2	60	40	No	13.4	14.97	60.79	64.40	-25.2	-25.84
28	22	2	60	40	Yes	8.89	8.11	55.82	51.71	-8.7	-23.83

Significant interactions based on ANOVA

	Intercept	**FR**	MC	MT	**SC**	FR*MC	**FR*MT**	**FR*SC**	R^2
Final C/N ratio	11.48	**0.8**	-0.38	-0.14	**-3.48**	0.45	0.58	-0.54	0.96
p-values		**0.02**	0.22	0.65	**< 0.0001**	0.16	0.07	0.09	
OM decomposition	29.02	**-9.39**	4.31	-1.02	**-9.18**	-0.69	-2.69	**12.75**	0.80
p-values		**0**	0.07	0.65	**0**	0.76	0.24	**< 0.0001**	
N loss	-26.84	**11.67**	**-8.41**	-4.08	**2.52**	-3.15	**9.5**	**-10.68**	0.71
p-values		**0**	**0.02**	0.21	**0.44**	0.33	**0.01**	**0**	

Values in red impact negatively while in blue affect positively

The experimental data obtained after the completion of the composting were subjected to regression analysis and fit to the following second-order polynomial equation:

$$Y = \beta 0 + \sum_{i=4}^{4} \beta i Xi + \sum_{j=4}^{4} \beta j Xj + \sum_{i=1,j=1}^{4} \beta ij XiXj \quad (i < j) \qquad (1)$$

Eq No	Equations	Df	F value	R(sq)
(2)	$\frac{C}{N}$ ratio=20.16 – 3.04 FR – 0.1277 MC – 0.0652 MT – 2.345 SC + 0.0447 FR*MC+ 0.0291 FR*MT – 0.542 FR*SC + 0.419 Ct Pt	8	21.87	0.96
(3)	OM decomposition=32.5 + 5.4 FR + 0.200 MC – 0.514 MT + 10.39 SC – 0.145 FR*MC+ 0.209 FR*MT – 8.37 FR*SC + 24.05 Ct Pt	8	8.8	0.80
(4)	N loss=8.6 + 11.6 FR – 0.211 MC – 1.154 MT + 22.36 SC – 0.315 FR*MC + 0.475 FR*MT– 10.67 FR*SC + 14.04 Ct Pt	8	5.65	0.71
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Optimized result

- FR=1
- Moisture content=70 %
- Mixing time-60 minutes
- Addition of starter culture

Future work

- Model validation experiments are currently being run in triplicates
- Identification of the starter culture is yet to be identified


Thank
you!!