Clean compost: pollution control: during composting of livestock and poultry manure

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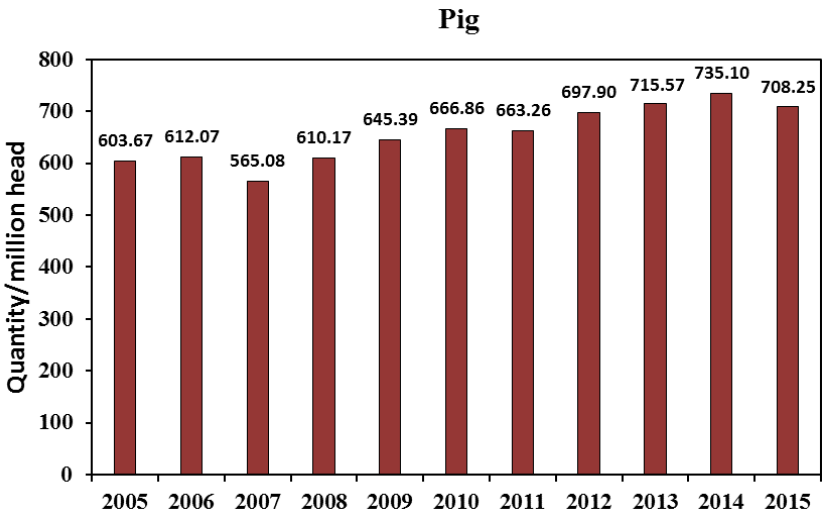
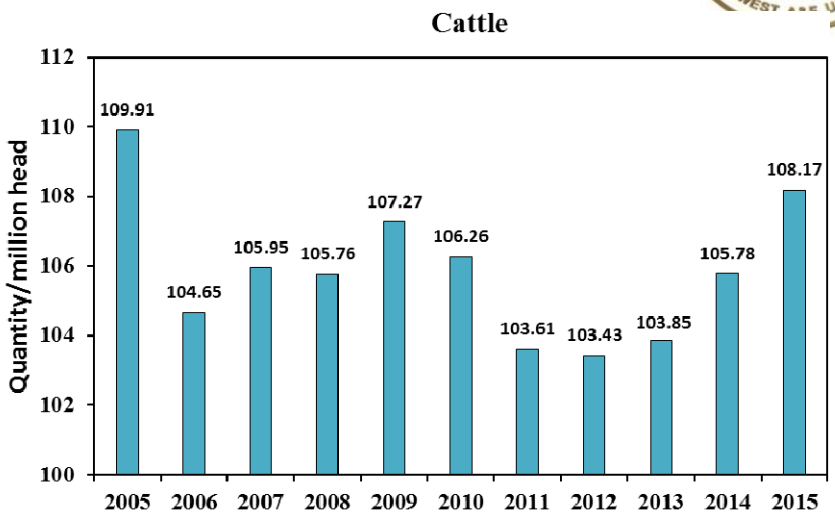
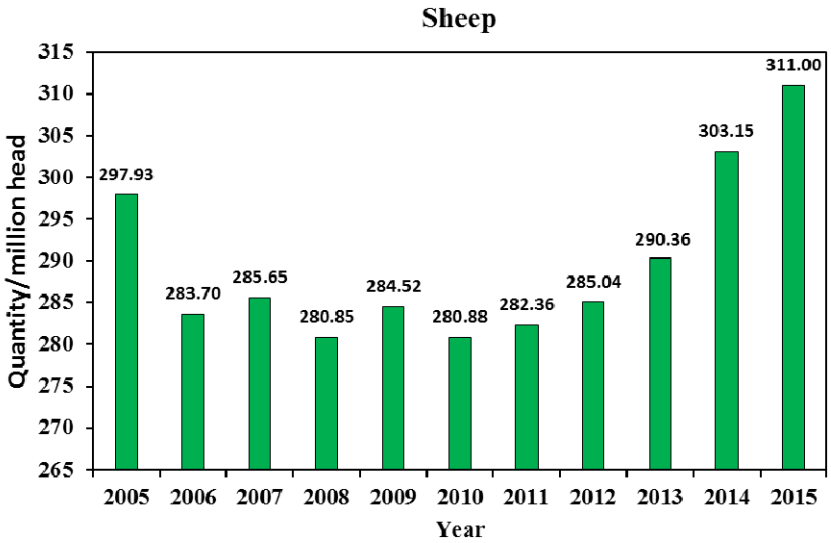
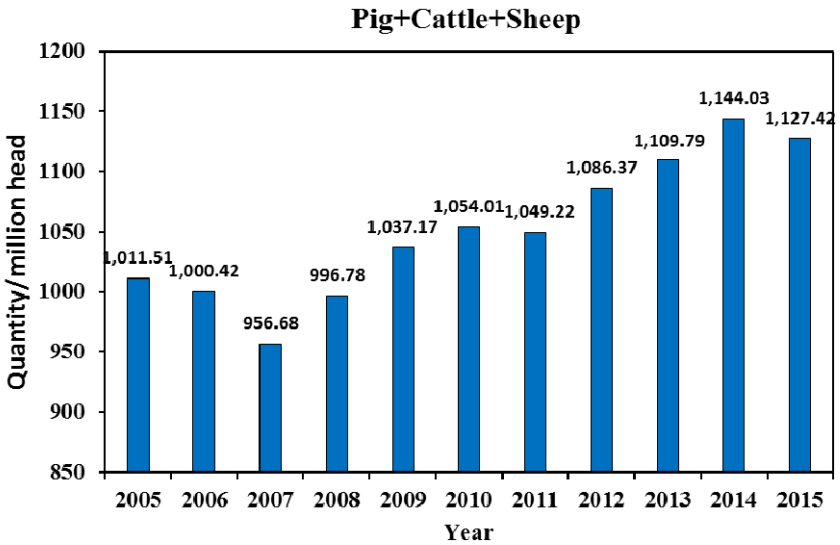








Source: China Statistical Yearbook (based on slaughter)

Livestock Farming Status in China

With rapid development of the livestock industry, the production of manure increased year by year.

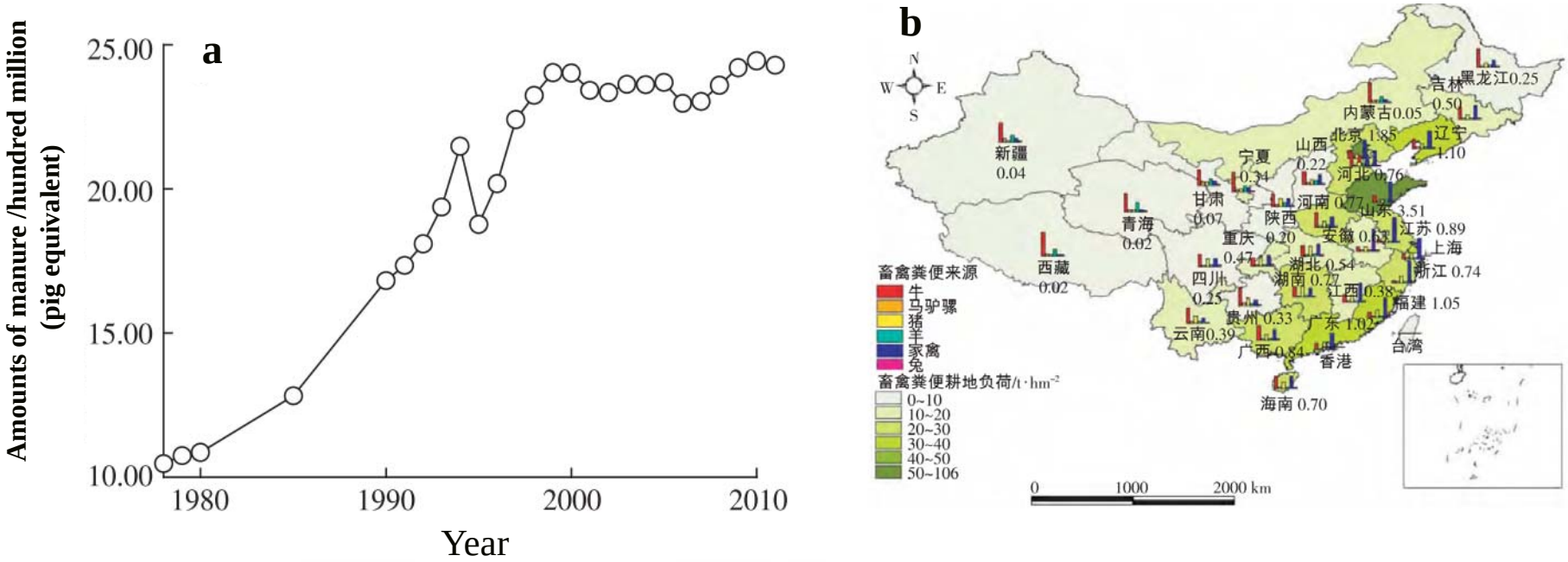


Fig. Amounts (a) of livestock manure in China during 1978 to 2011, and cropland load of manures in 2011 (b)

Source: Zhu et al., 2014.

Nutrient And Pollutant Contents in Livestock Manure

A. The nutrient contents in livestock manure

Category	N(%)	P_2O_5(%)	K_2O(%)	Cu(mg/kg)	Zn(mg/kg)
Pig Manure	0.2~5.19	0.39~9.05	0.94~6.65	12.1~1742	40.5~2287
Cattle Manure	0.32~4.13	0.22~8.74	0.20~3.75	8.9~437.2	31.3~634.7
Chicken Manure	0.60~4.85	0.39~6.75	0.59~4.63	16.8~736.5	38.8~1017
Sheep Manure	0.25~3.08	0.35~2.72	0.89~3.00	13.1~47.9	30.2~161.1

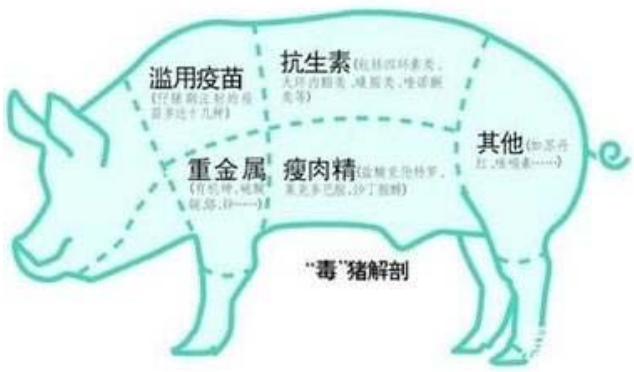
Source (Li et al., 2009)

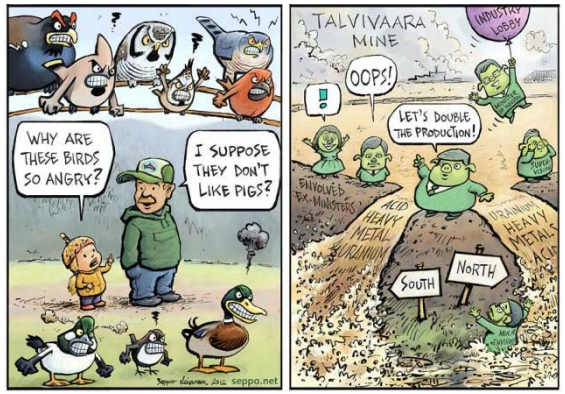
B. Heavy metals contents in livestock manure

Unit: (mg/kg)

Category	Cd	Pb	Cr	As	Hg	Ni
Pig Manure	0.06~2.75	0.71~16.02	0.20~116.20	0.54~88.97	0~0.13	4.03~20.45
Chicken Manure	0.04~1.48	0.92~26.94	0.60~42.75	0.57~66.99	0~0.12	7.44~15.08
Cattle Manure	0.10~1.67	2.11~23.61	0.05~29.04	0.42~5.95	0~0.11	3.73~19.15

Source (Jia et al., 2016)

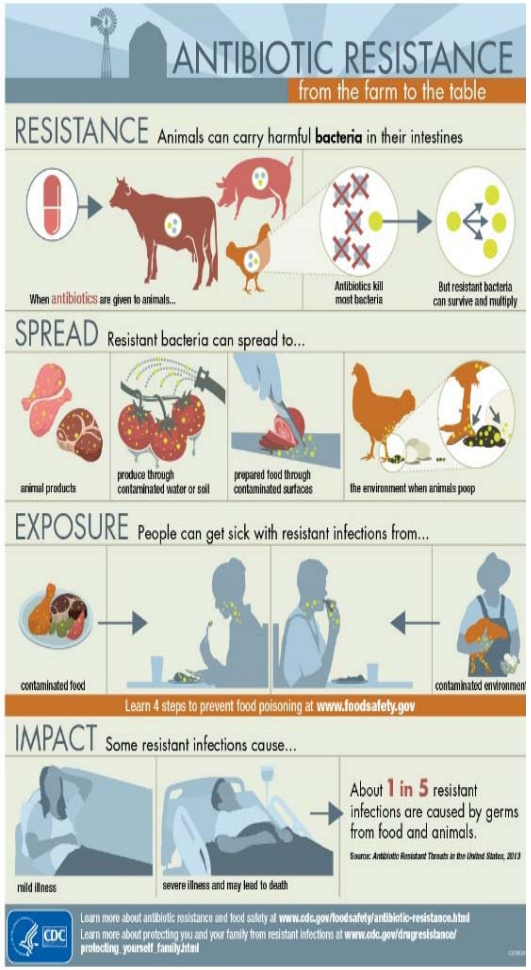


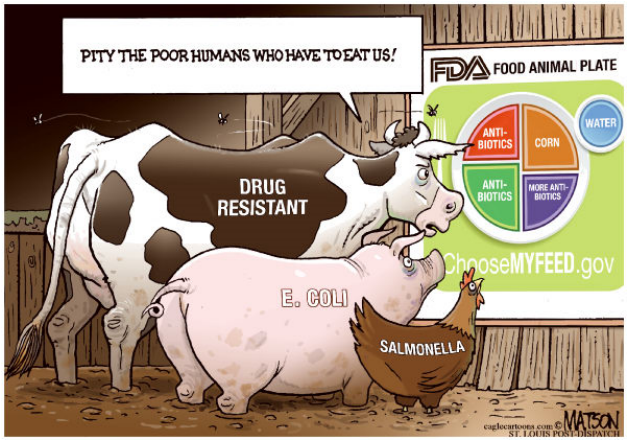


C. Antibiotic contents in pig and chicken manure

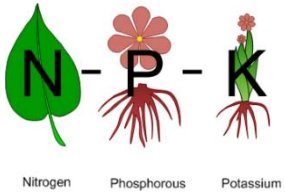
Parameter (mg/kg)	Tetracycline TTC	Oxytetracycline OTC	Aureomycin CTC
Pig Manure	0.4~78.57	0~524.4	0~124.8
Chicken manure	0~14.56	0~23.43	0~121.78

Source (Wang et al., 2013)





Environmental Pollutions of Livestock Manure/ Solid waste



Pathogens

Heavy metals

Antibiotic and resistance gene

Discharge

Air pollution

(**Obnoxious gases**)

Water contamination

(Eutrophication)

Soil pollution

(Heavy metals、resistance gens)

Food safety

(Heavy metals)

Causing bacterial disease

Environmental pollution of municipal solid waste

Municipal solid waste

Water

Enter into

Eutrophication

Aquatic organisms
(plastic, toxic elements)

Soil

Enter into

Destroy soil structure
(plastic, rubber)

Soil pollution
(organic pollutant,
heavy metals)

Air

Burning

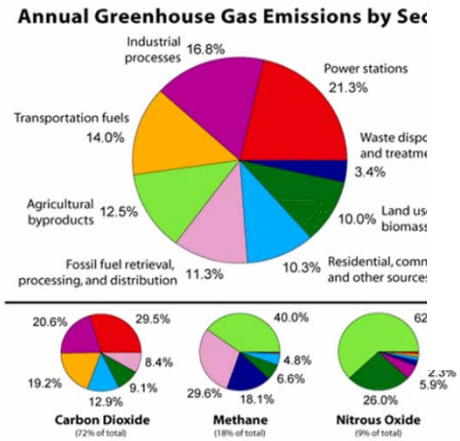
Air pollution
(dust, dioxin, odor)

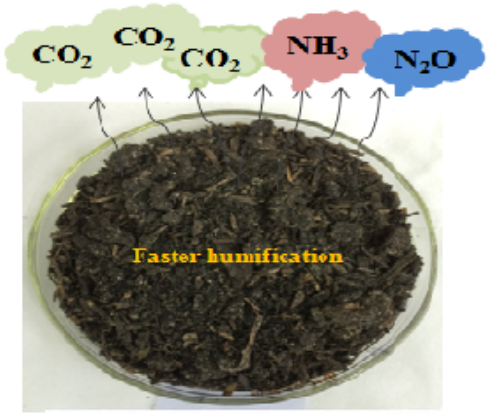
Acid rain
(nitric oxide)

The Disadvantage of Traditional Composting

- The emission of greenhouse gas

  CH_4、N_2O





- The Nitrogen loss

  NH_3, N_2O

- High mobility of heavy metals

  Cu、Zn、Cd、Pb、As

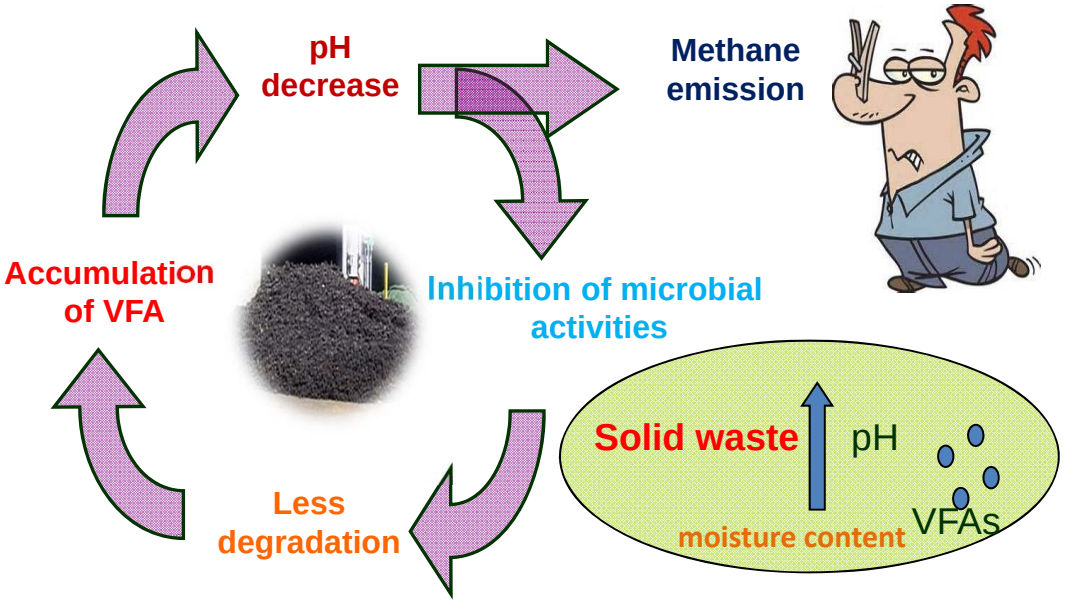
- Low degree of humification

  Humus 、Humic acid、fulvic acid

Composting is one of the possible opportunities for Solid Waste management

Households	→	Domestic composter
Small community, etc.	→	Commercial composter Centralized composting facility
Small city, etc.	→	Centralized composting facility

Major Problems in Solid Waste Composting



How to break the vicious cycle ?

- **Thermo acidophilic stage**
  - Reduced pH
  - Acidic odour
  - Microbial inhibition
  - Reduced composting efficiency
  - Huge quantity of GHGs emission
- **Controlling the acidity**
  - Improves the composting
  - Prevents acidic odour
  - Requires alkaline substances
- **However, increased pH results**
  - Ammonia/ nitrous oxide emission
  - Reduce the N content of compost
  - Increase the salinity
- **Resulting in**
  - Compost product with low nutrient content, especially N
  - Higher EC content that affects the soil application in high quantities

Improving the Composting Process and Quality of Compost

◆ Optimizing the physical-chemical parameter

Adjust C/N, moisture content, aeration rate

◆ Adding various kinds of additives

Microbial additive, mineral additive, chemical additive

◆ Improve composting pattern

Windrow composting, trough composting, fermentation cylinder

Aims of this study

Formulation of novel feedstock mixture

To evaluate heterogeneity of additives amendment for total organic carbon loss mitigation through CO_2 and CH_4 emission and nitrogen conservation by N_2O and NH_4 reduction

To study the relationship between the mechanisms involved in the total gaseous emission, carbon, nitrogen losses and humification of the composting mixtures.

The end product quality improvement

Methodology

1 Formulation of starting mixture

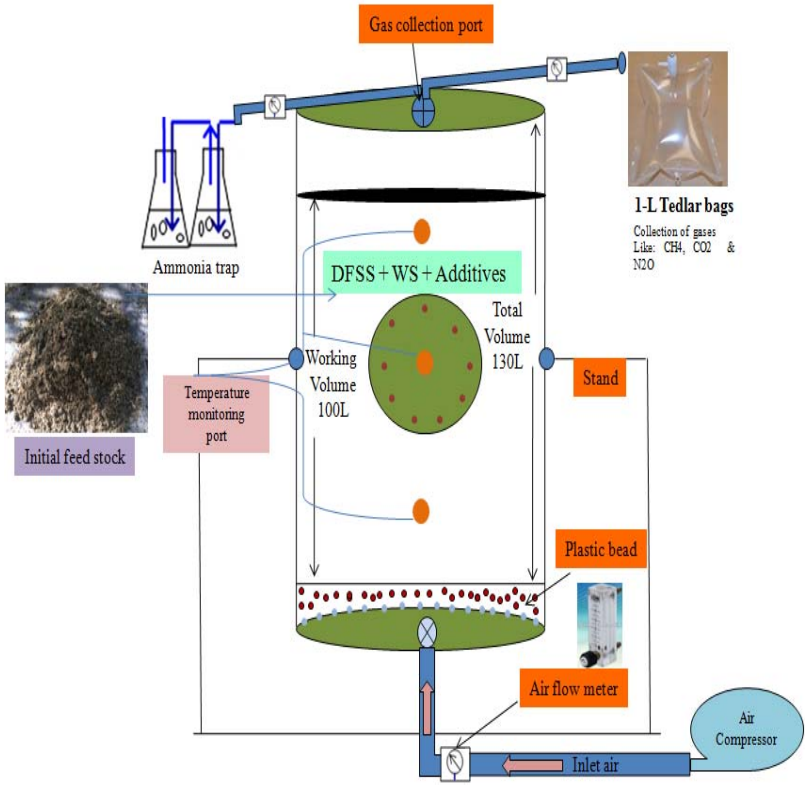
2 Mixing of additives: Zeolite, Lime, biochar and Ca- bentonite

3 Monitored the gaseous emission, temperature, pH, moisture, EC, C/N ratio, NH_4^+-N, during 0, 3, 7, 10, 14, 21, 28 42 and 56 days of the composting period.

4 Compost maturity was evaluated and compared with HKORC/TMECC compost quality standard.

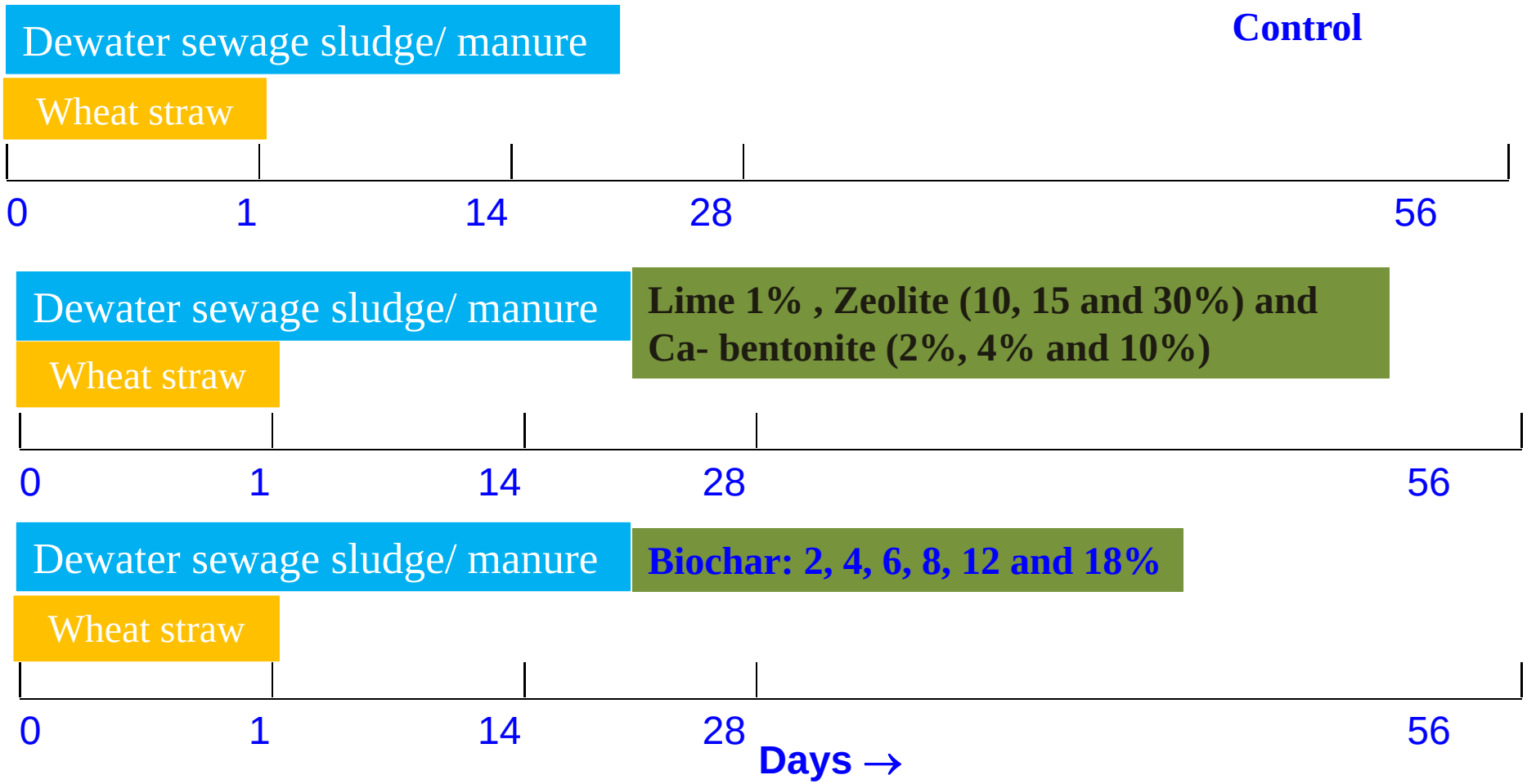
Collection of Sewage sludge and mixing with bulking agents

Flow diagram of composter



0.35 L h^{-1} kg^{-1}

Treatments & Substrate addition



Dewatered fresh sewage sludge (DFSS) or sewage sludge (SS) and wheat straw mixed 1:1 ratio on dry weight basis, while additives added on SS dry weight basis; Day 0: 50-60% moisture content Bulk density of the compost mass in the reactor was determined to estimate the compost weight in the reactor ; Continuous thermophilic (55 ºC)

Initial properties of mixing ratio

Parameters	DFSS	WS	Mix
Moisture content (%)	81.24±1.85	10.43±0.20	56.23±1.45
pH (solid:water = 1:5)	7.27±0.04	4.93±0.14	8.12± 0.05
EC (mS cm^{-1}) (Solid: water = 1:5)	5.10±0.16	0.71±0.03	3.05± 0.03
Total organic matter (%)	79.28±2.18	97.86±2.74	93.63± 2.78
Total organic carbon (%)	41.38±2.40	62.30±2.41	44.89± 1.02
Total Kjeldahl nitrogen (%)	2.81±0.15	0.80±0.03	1.78± 0.05
C:N ratio	14.72± 0.05	77.90±0.25	25.21± 0.12

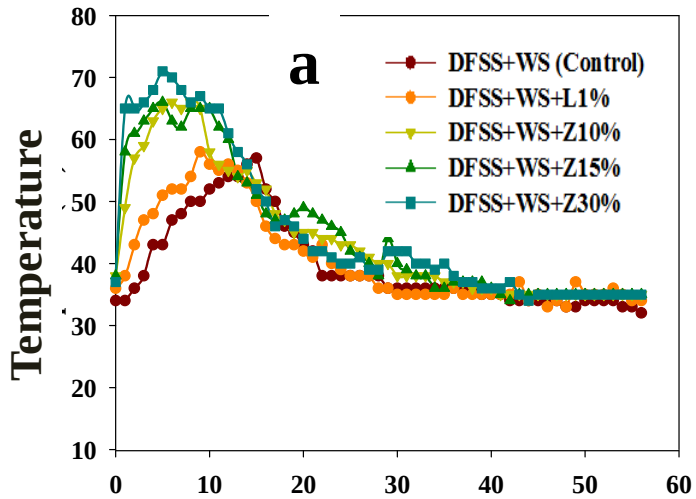
DFSS (dewatered fresh sewage sludge or biosolids) and WS (wheat straw)

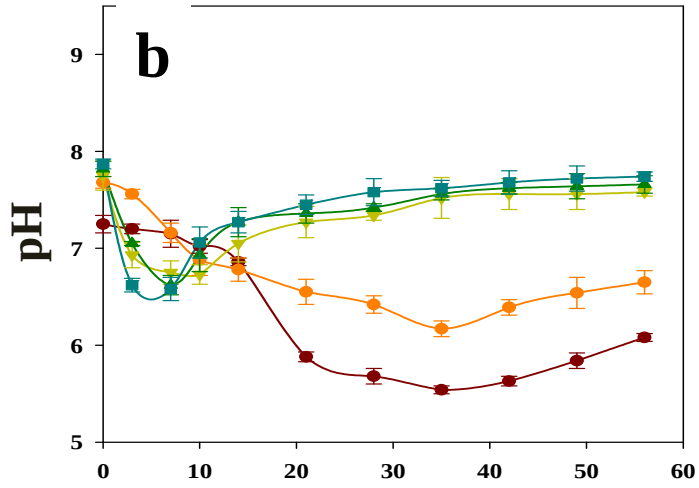
Initial properties of additives

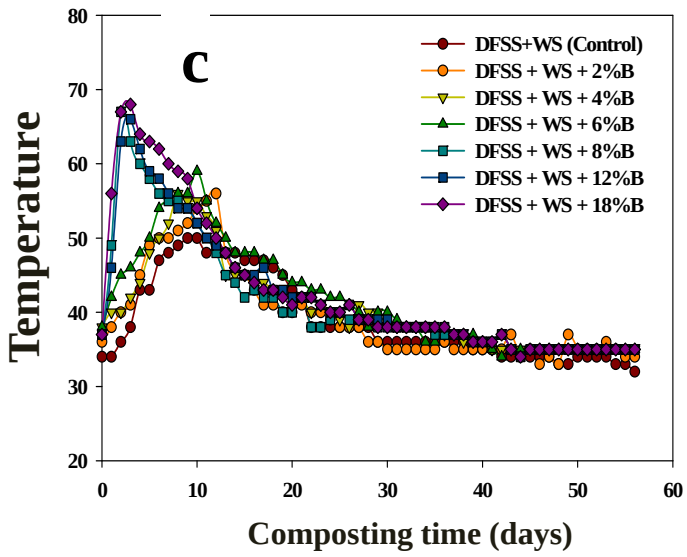
Parameters	Biochar	Zeolite	Ca- bentonite
Moisture content (%)	2.42±0.50	1.23±0.06	1.20±0.10
pH (solid:water = 1:5)	8.78±0.10	8.58±0.02	8.35±0.04
EC (mS cm^{-1}) (Solid: water = 1:5)	0.98 ±0.03	0.14±0.04	0.11±0.08
Total organic matter (%)	96.23±2.84	ND	ND
Total organic carbon (%)	67.75±1.78	ND	ND
Total Kjeldahl nitrogen (%)	0.58±0.02	ND	ND
C:N ratio	116.81 ± 1.43	ND	ND

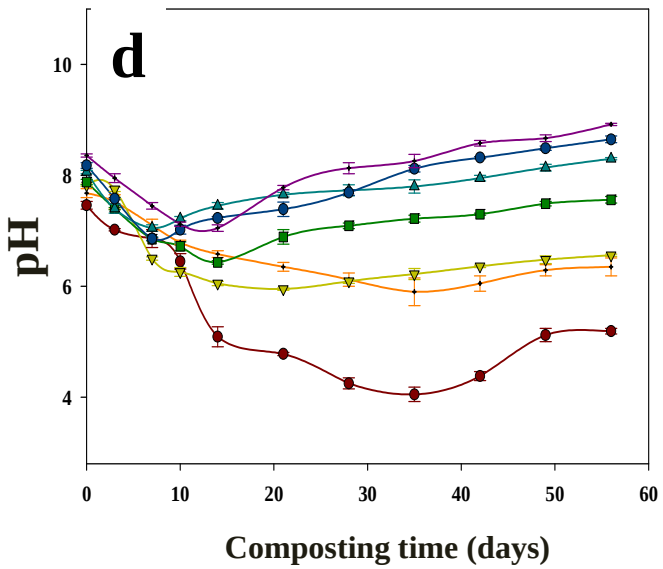
Flow diagram of composting process

Changes temperature and pH during composting









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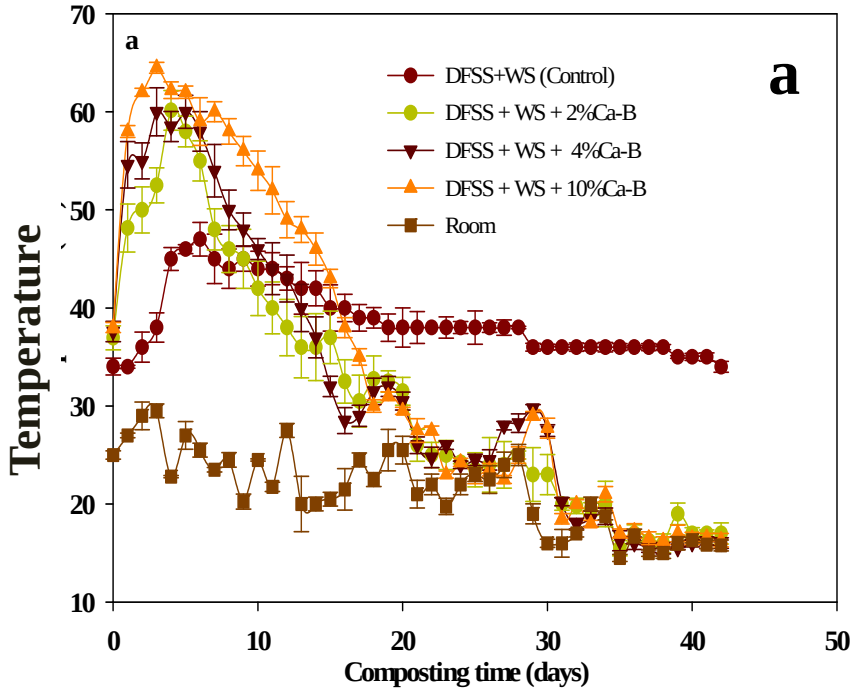
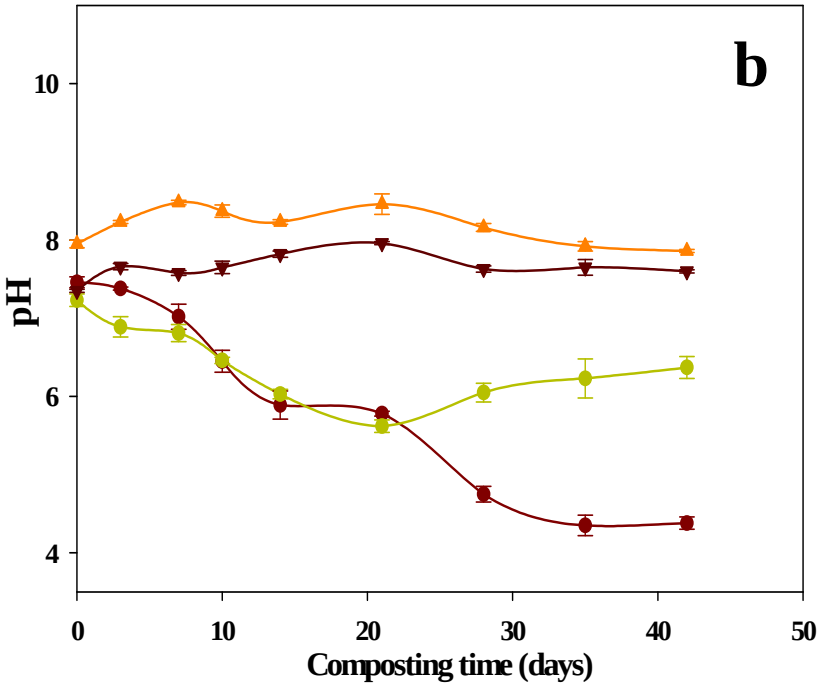
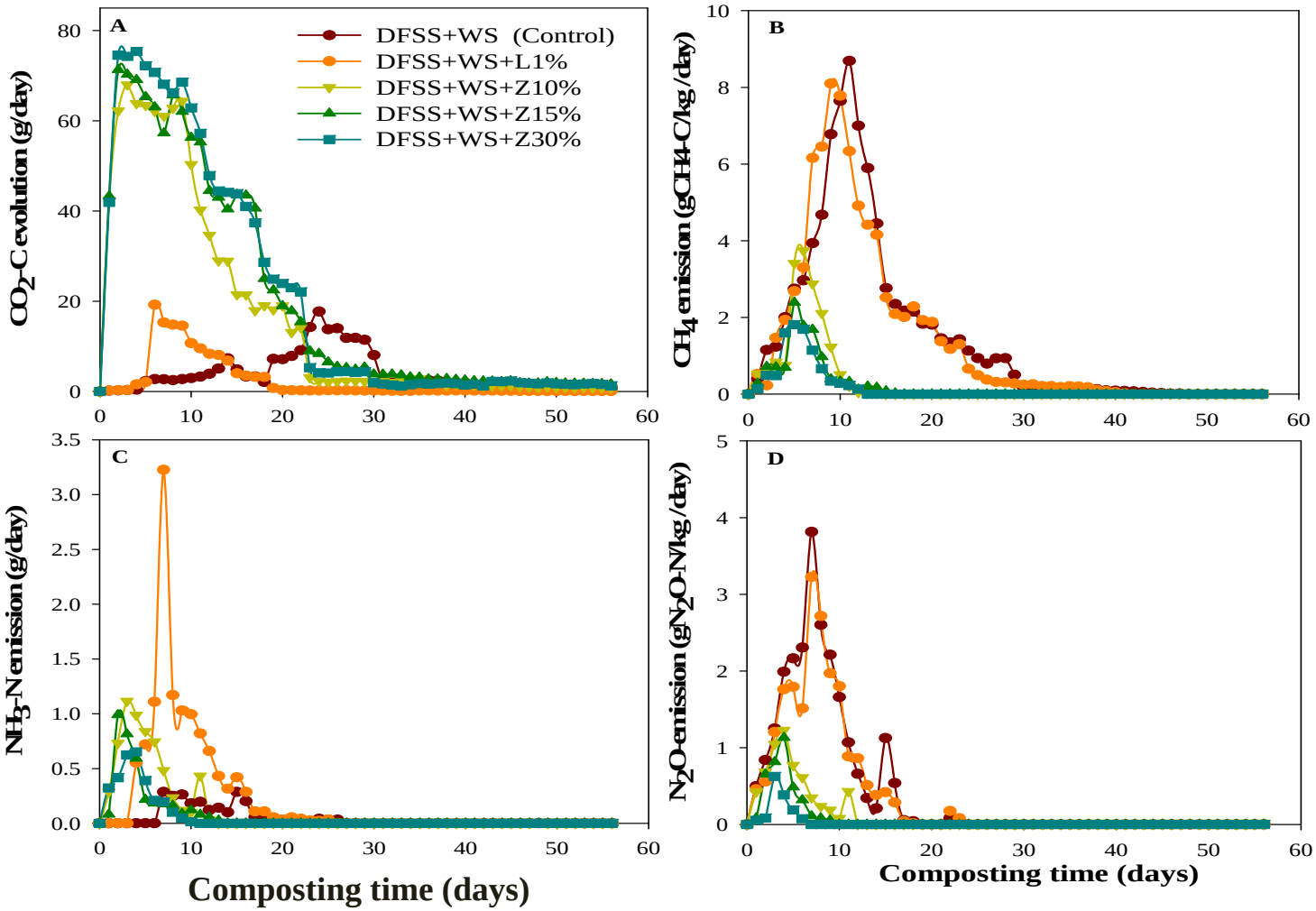




Gaseous emission



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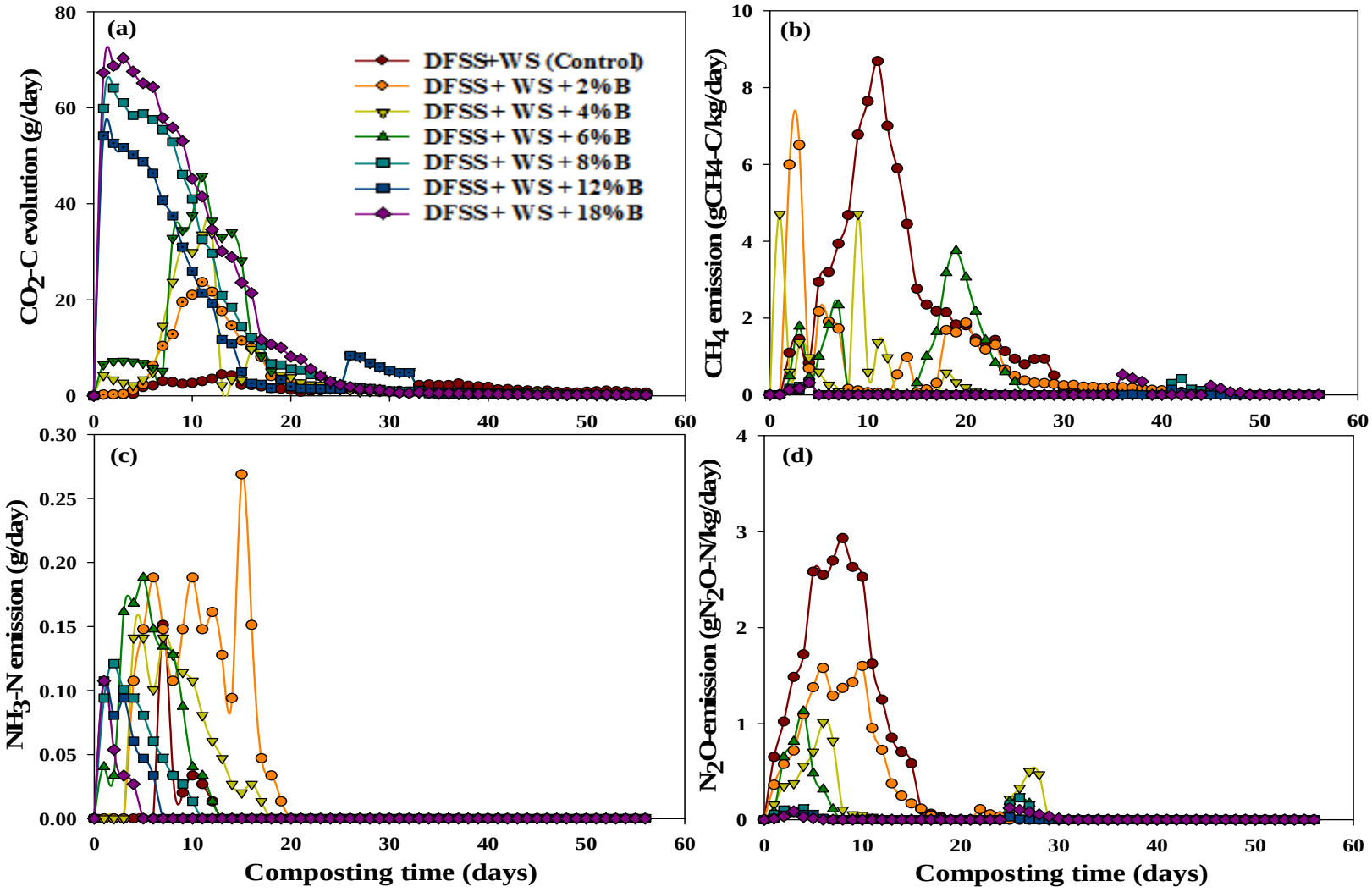
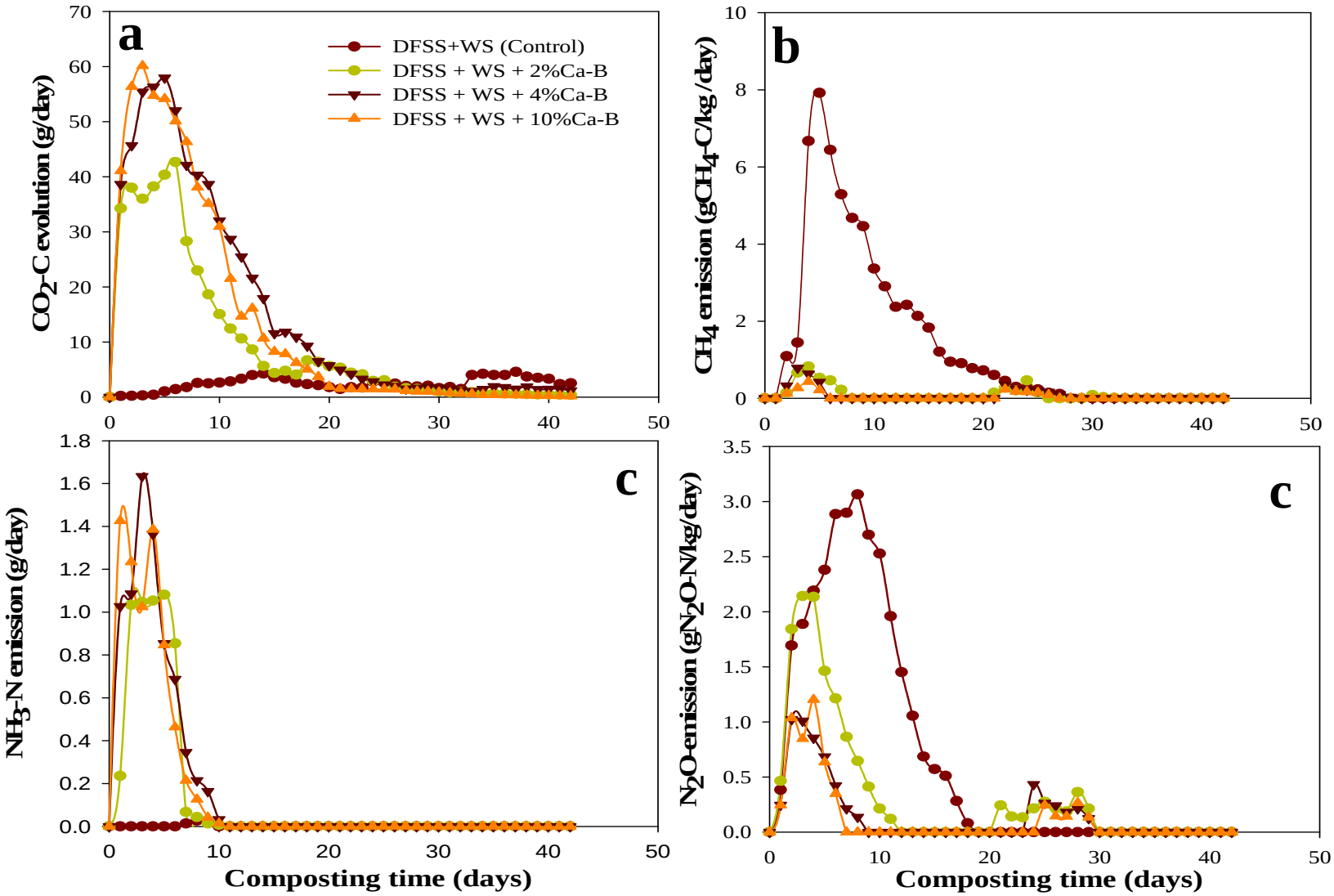
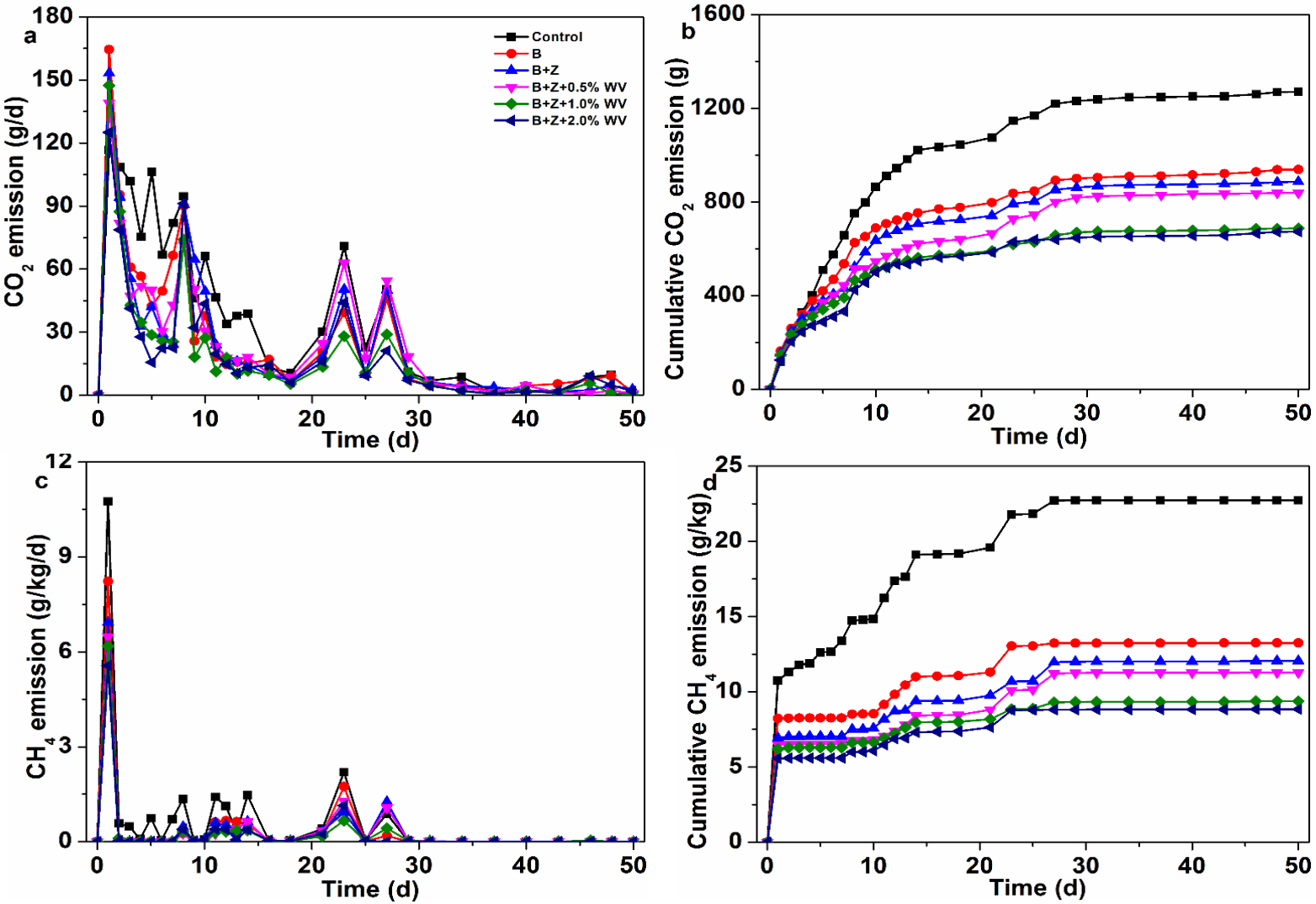


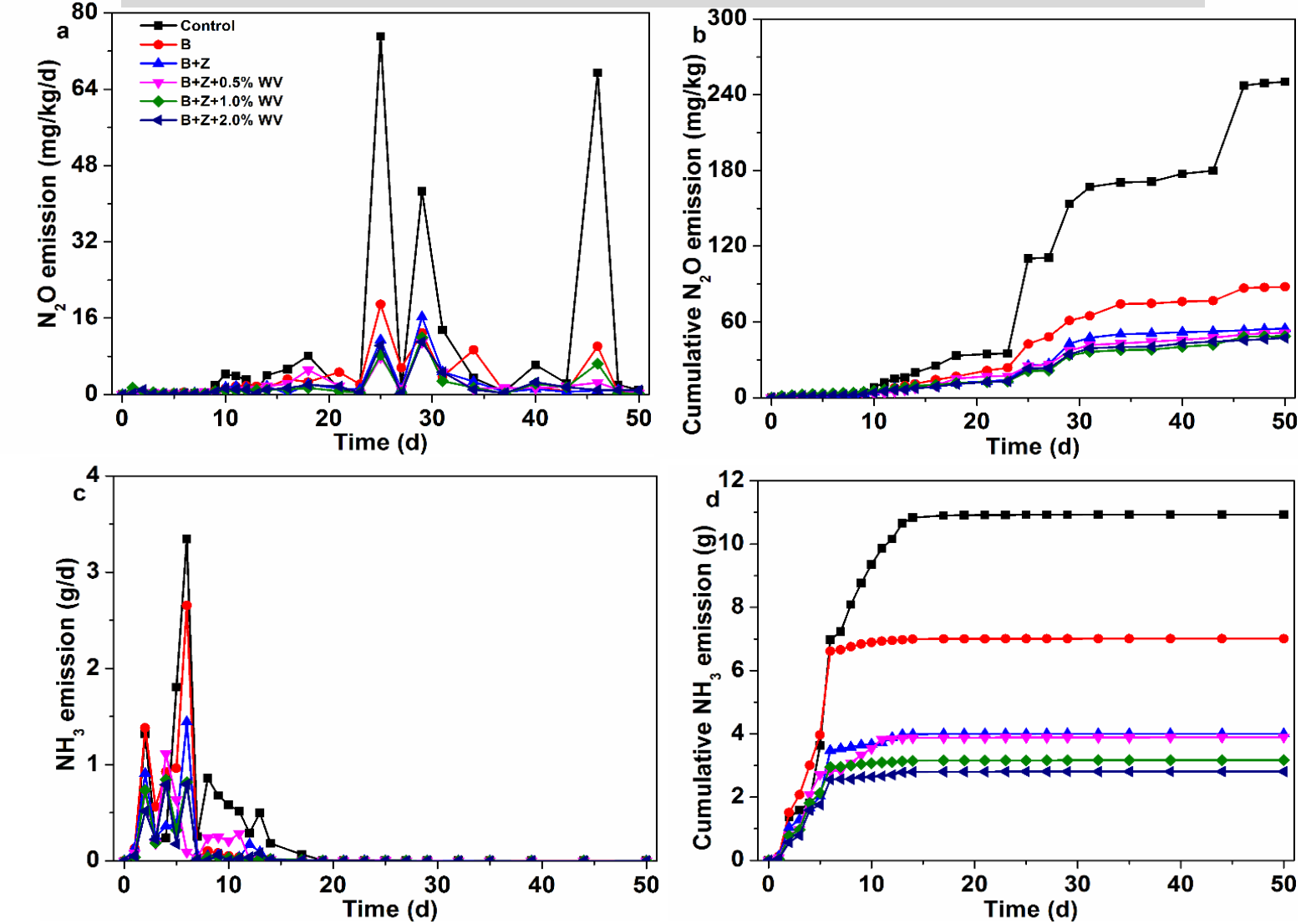
Gaseous emission



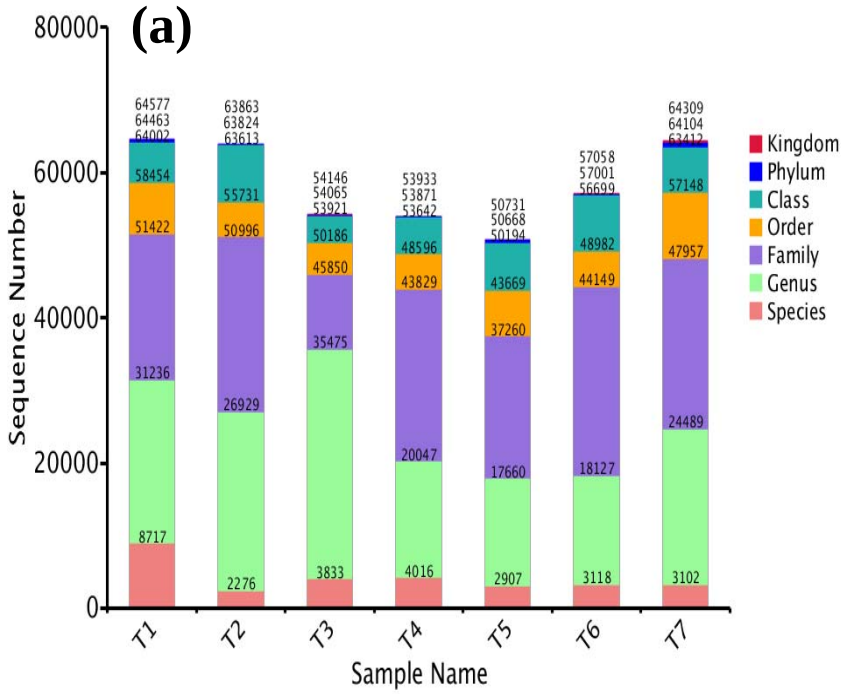
Pig manure composting/ Gaseous emission

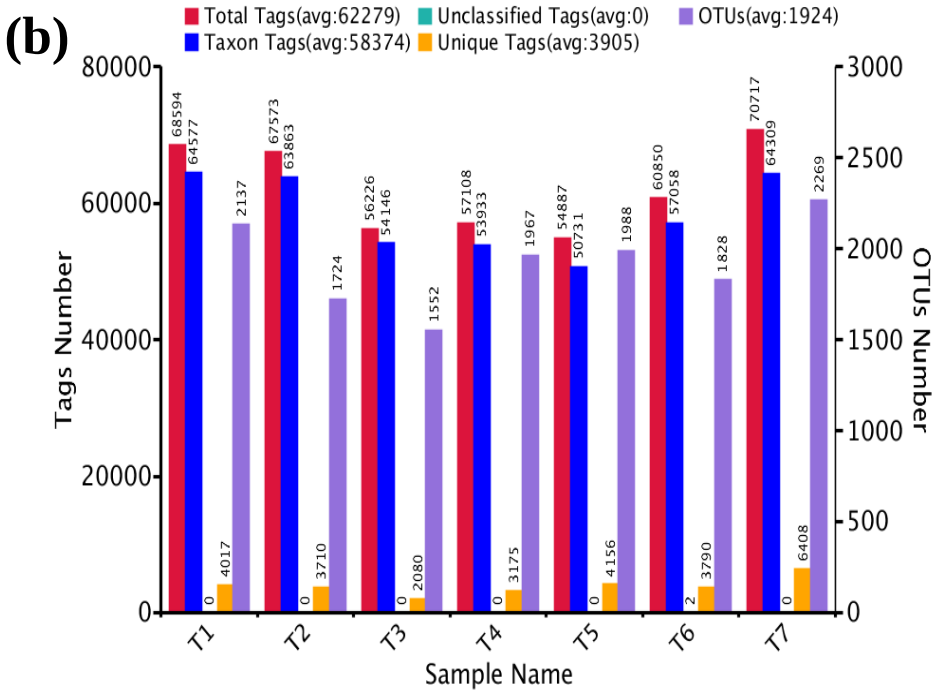


Pig manure composting/ Gaseous emission

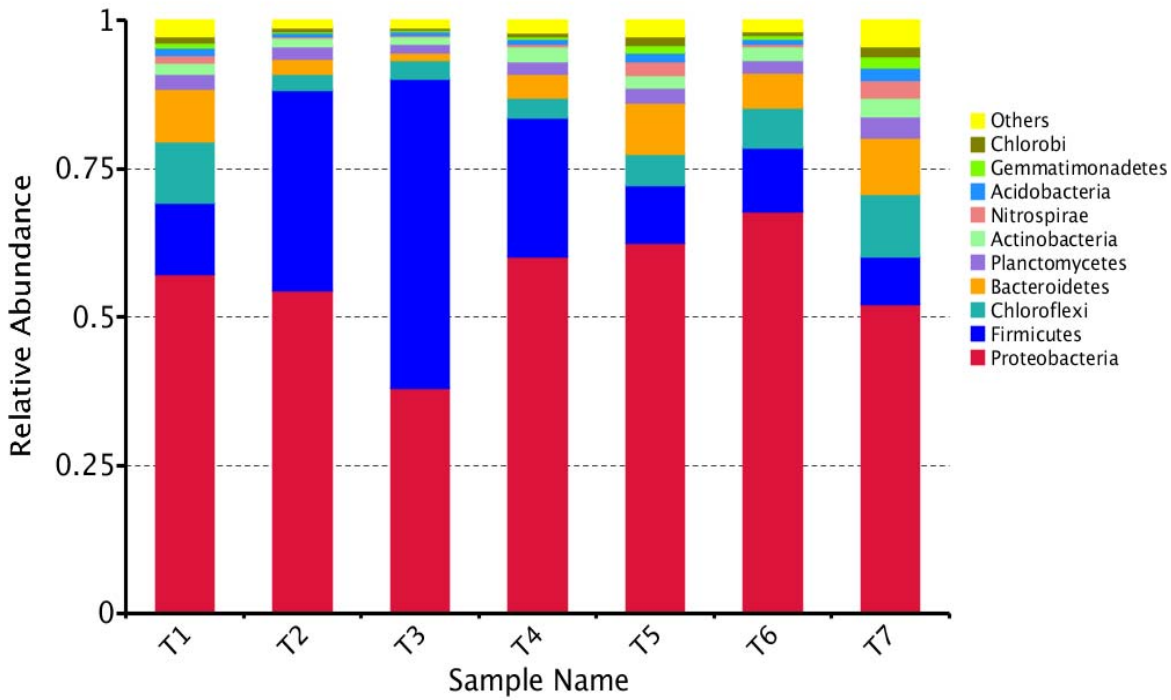


16SRNA technology for microbial dynamics



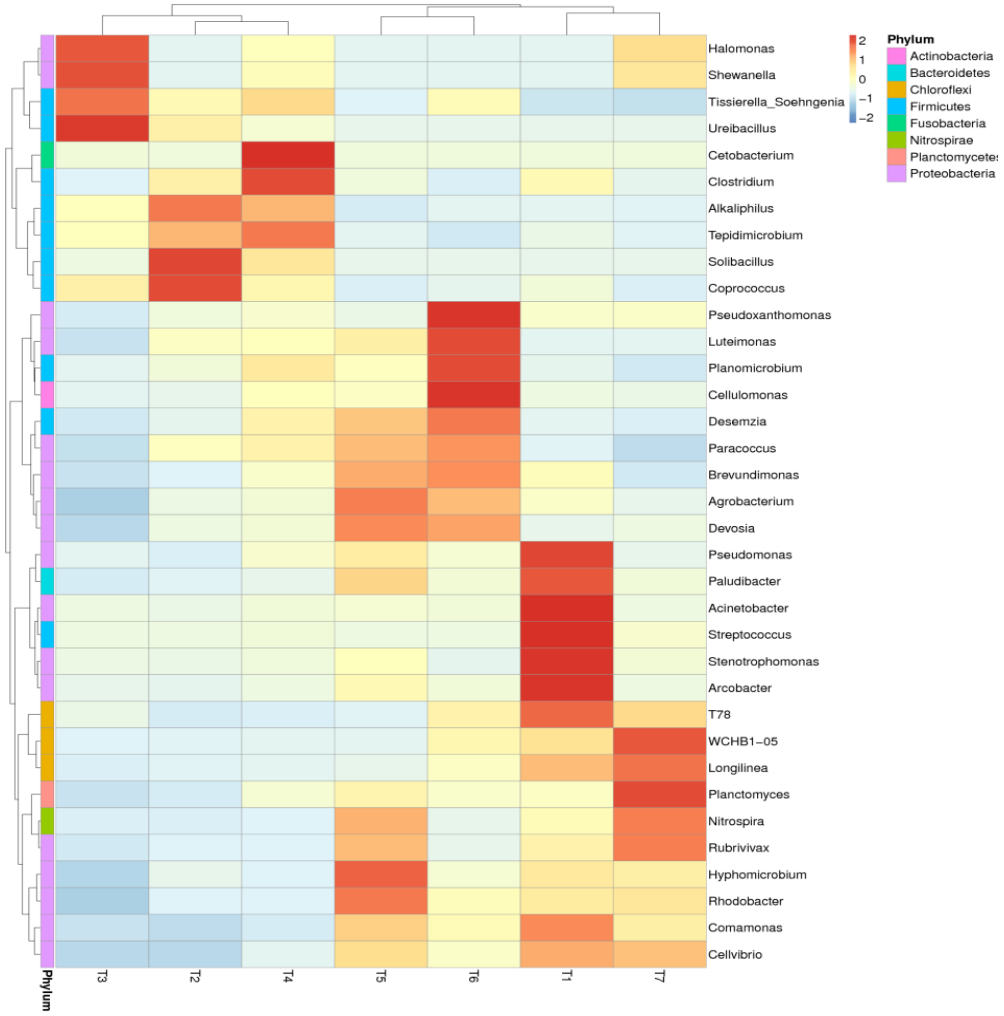


The relative abundance of the dominant bacterial taxonomic groups separated using total 16S rDNA gene sequences



16SRNA technology for microbial dynamics

- **Heat-map of species abundance is clustering; the genus classification position clustering (horizontal) and top 35 genera sample clustering (vertical clustering).**
- **Different color means the different relative abundance of the genus in the all seven treatments (red means great abundance).**

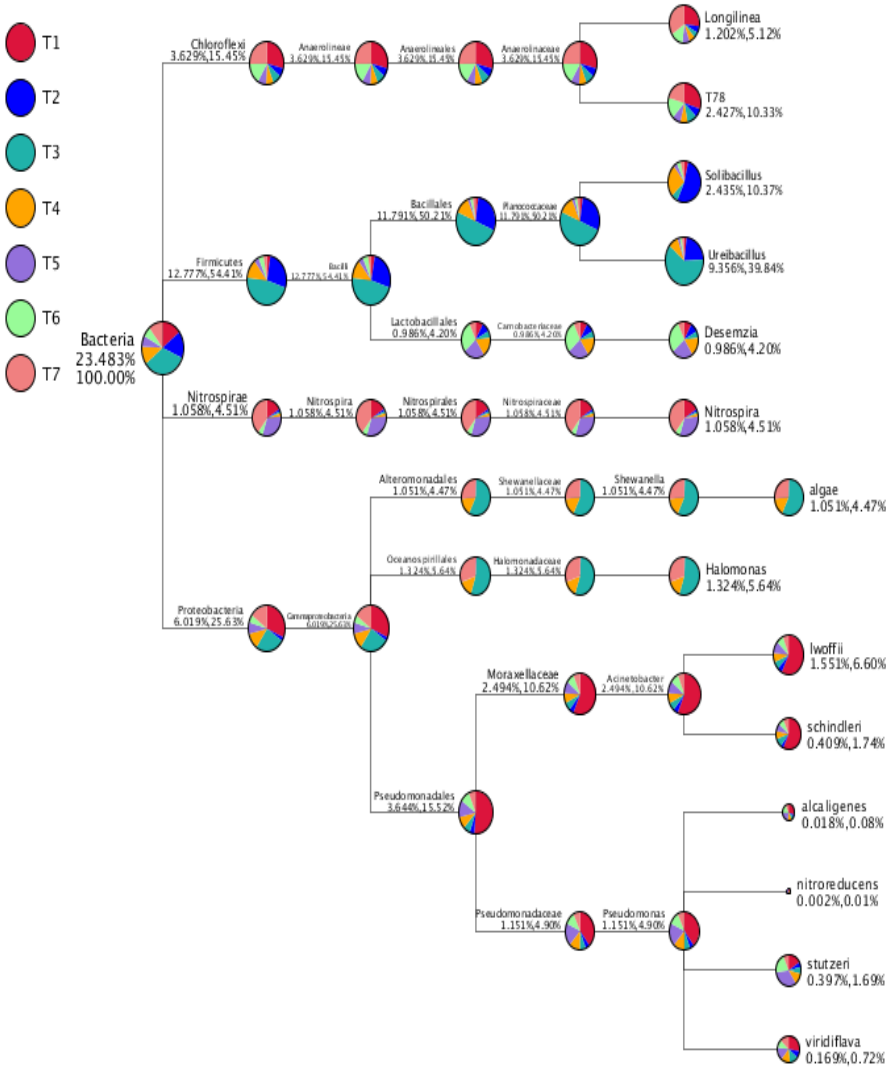


16SRNA technology for microbial dynamics

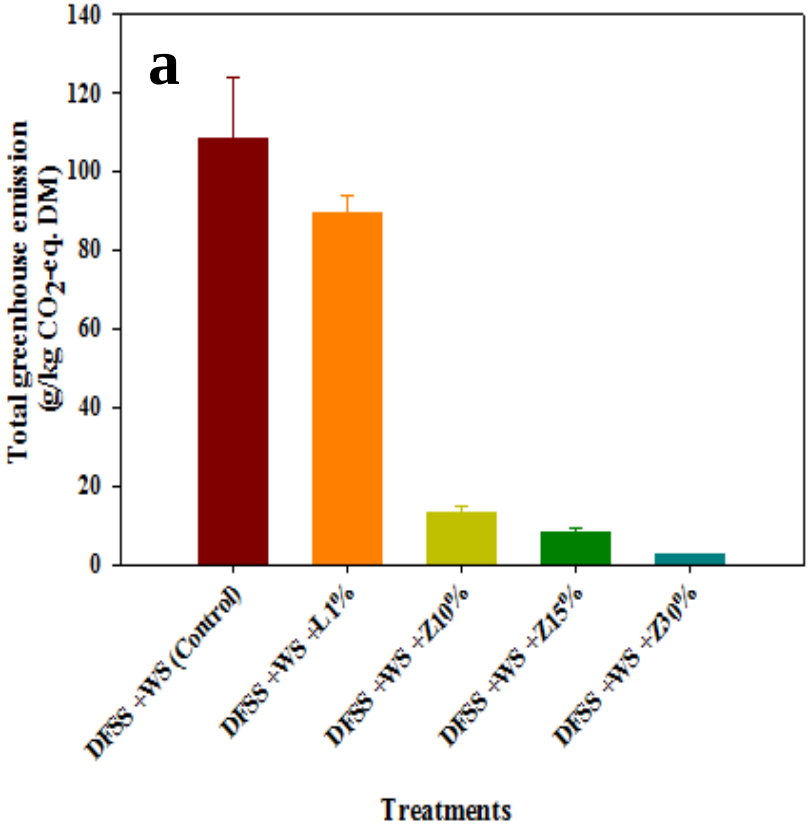
❑The relative abundance of each class based on 16S rDNA sequence analysis. The relative abundance is expressed in percentage and classification tree of complex samples.

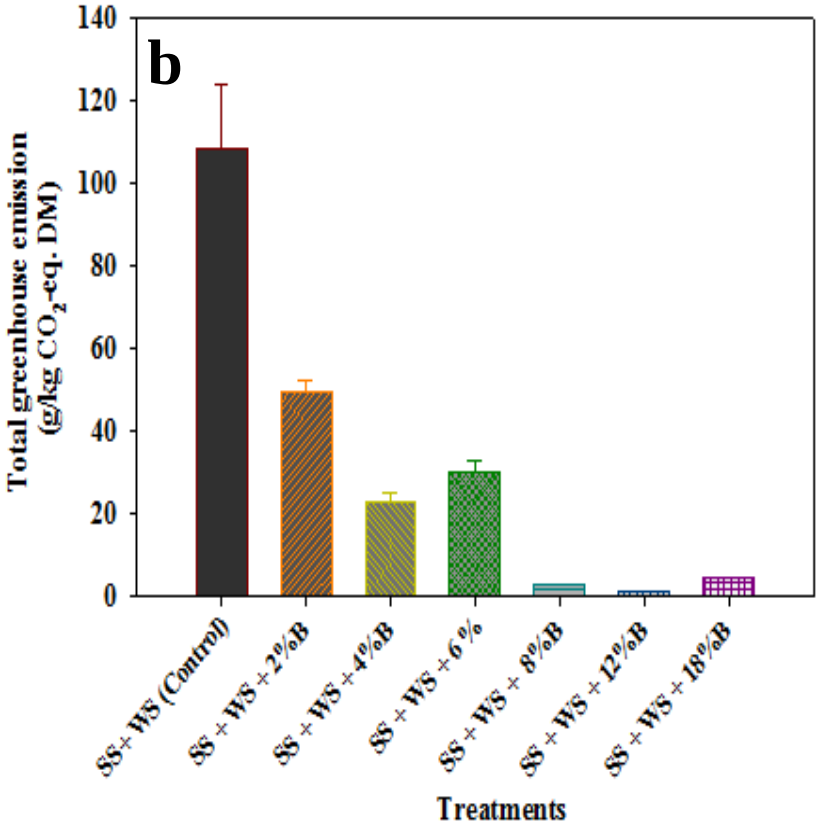
❑Different color of circle fan means different sample; the size of the fan means the relative abundance of proportional size on classification level of samples; the numbers below the classification name stands for the average percentage of relative abundance on this classification level in all samples.

❑There were two numbers, the former one means the percentage of all species, the latter one means the percentage of selected species.



Total greenhouse emission (g/kg CO_2-eq. DM)





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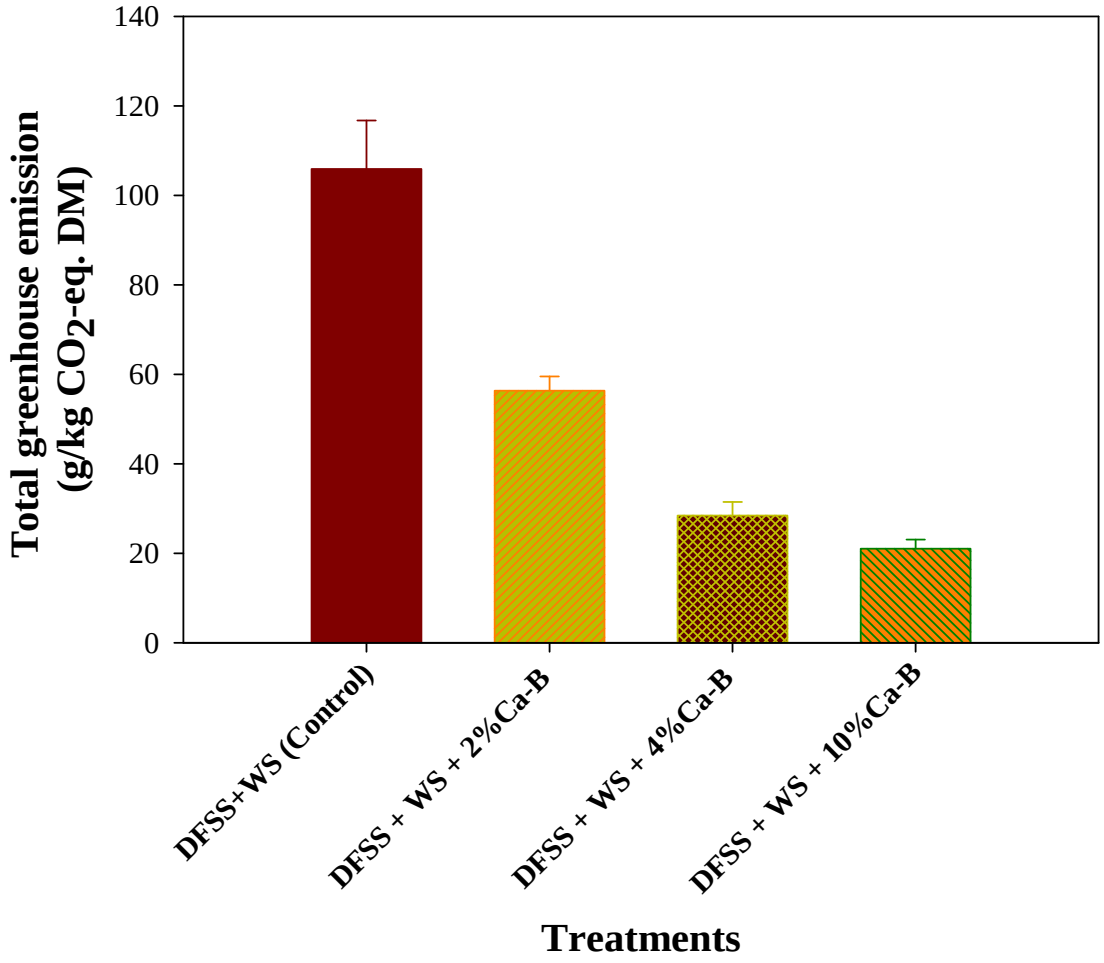
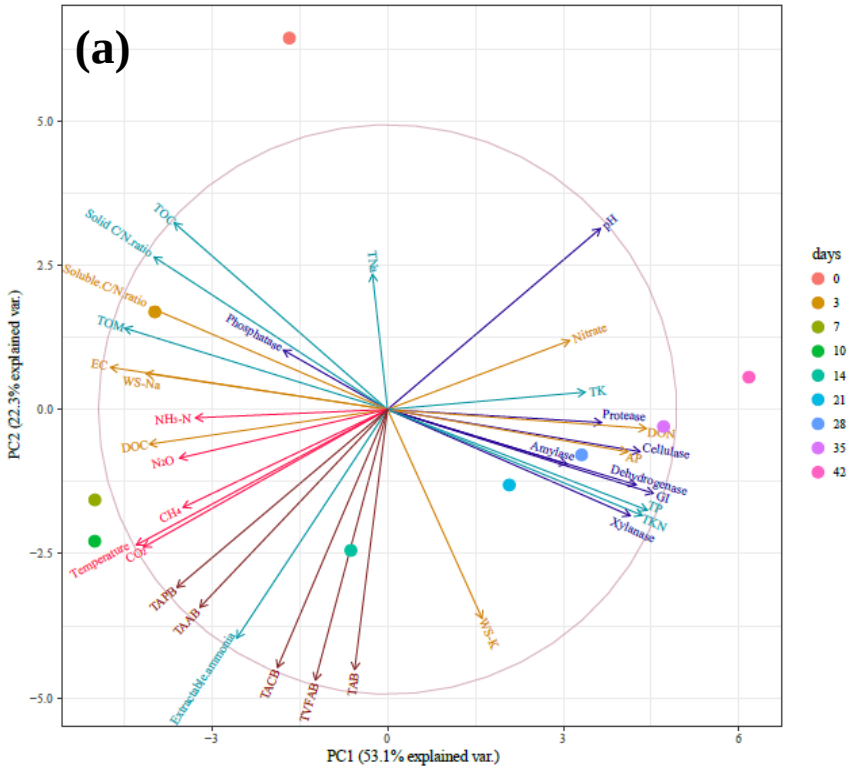
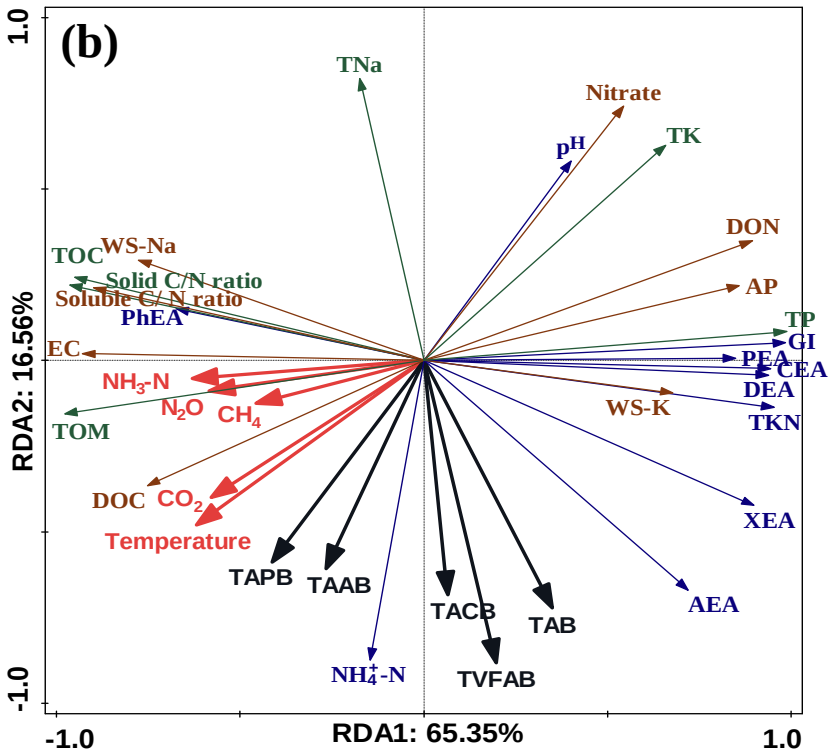


Principal Component and Redundancy Analysis





Conclusions

❖Higher dosage of biochar and zeolite added treatments significantly reduced the NH_3, CH_4 and N_2O emission by 58.0-65.2%, 93.0-95.3% and 95.1-97.3% as compare to control treatments.

❖Furthermore, it was estimated that the 30% zeolite and 12% biochar could reduce the length of the active phase and enhance the humification with significant reduction of total N loss and GHG emissions.

❖In addition, the RDA and PCA analysis were also shows significant correlation between gaseous emission and nutrients transformation during the composting.

❖Overall, the addition of 12% biochar for composting demonstrated to be a beneficial practice for the management of solids waste.

Thank You…

Questions?

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Web site: http://zhxy.nwsuaf.edu.cn/szdw/szxx/252817.htm