SWINBURNE UNIVERSITY OF TECHNOLOGY

FACULTY OF SCIENCE, ENGINEERING AND TECHNOLOGY

The Microbial Ecology of Urban Organic Waste Treatment (Compost)

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1. Background

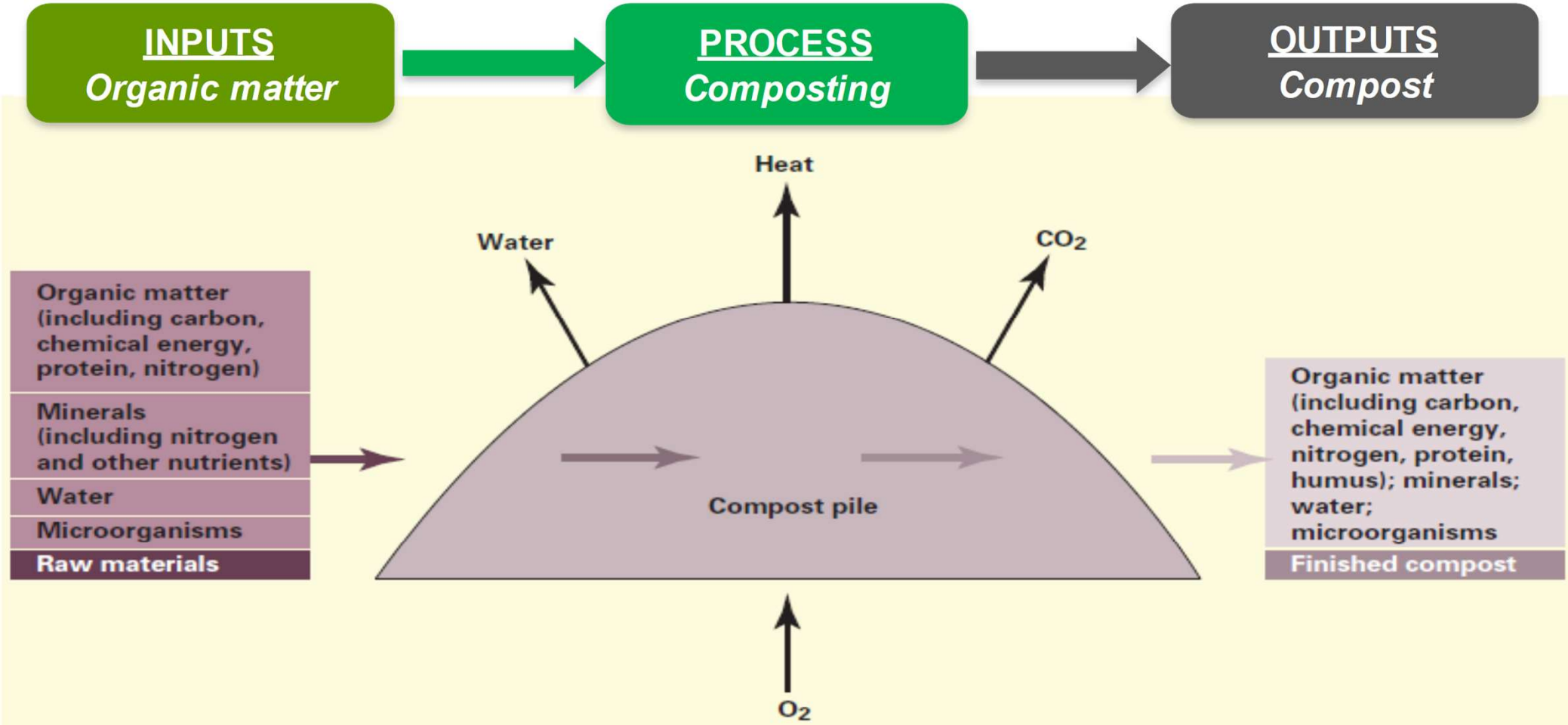
By wasting food, each Australian household loses AU$616 per year, AU$5.2 billion per year for Australia (5.3 Mt of food waste 2015).

~2%

~12%

~80%

Composting process



Composting process, (Cooperband, 2000).

Optimal parameters for composting

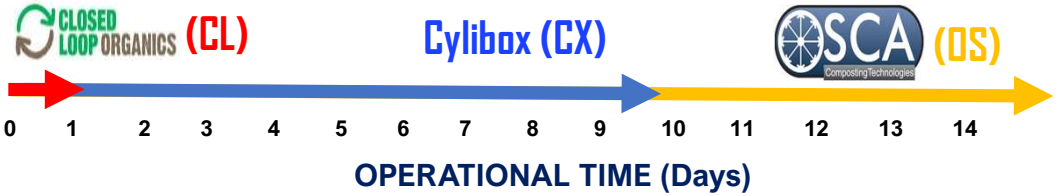
Parameters	Optimum conditions
Particles sizes	Regular (2 to 5 cm)
C:N ratio	27:1 to 30:1
Final compost (inoculum)	15%
Moisture content (MC)	50 to 60%; Min. 30%, Max. <65%
Oxygen (O_2)	>10%, Min. 5%
Temperature (°C)	•Mesophilic (10°C to 40°C) •Thermophilic (40°C to 60°C) <70°C •Pasteurization (Keep at ~55°C for three days)
pH	•Bacteria (6 to 7.5) •Fungi (5.5 to 7.5)
Electrical Conductivity (mS/cm)	1 to 3 mS/cm; <10 mS/cm (AS 4454-2012)
Time (Months)	•Windrow: Four to six •In-vessel: ~Two

Sources: Rynk, (Ed.) 1992; Australian Standard -AS 4454-2012; Cooperband 2000; Griineklee 1998, Sustainability Victoria 2009; Trautmann & Krasny 1997.

2. Aims

- How does the quality of final compost depend on the type of inputs?

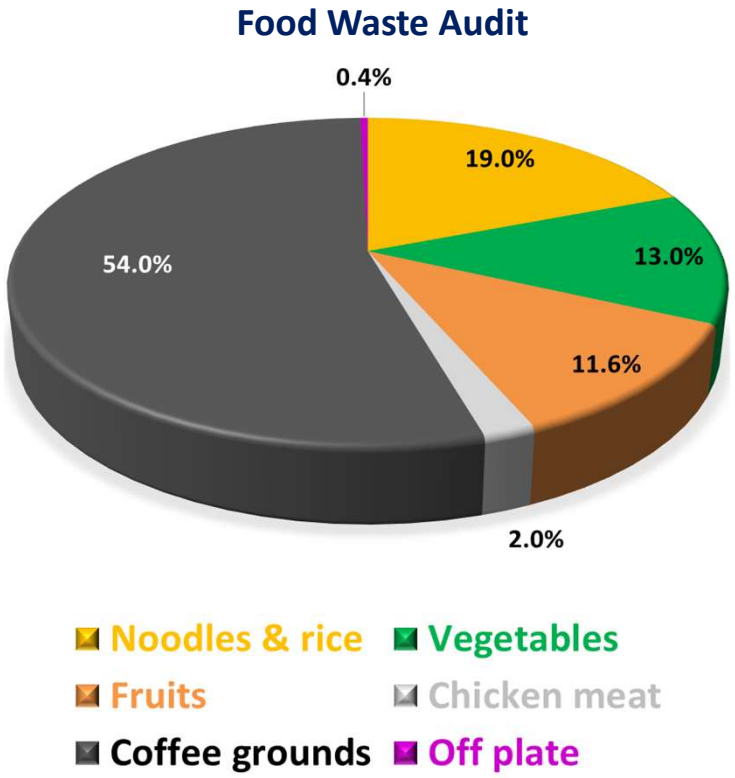
- What are the operating conditions and time necessary for in-vessel composting to produce stable and acceptable quality compost?



- Is the final product from in-vessel composting free of pathogens?

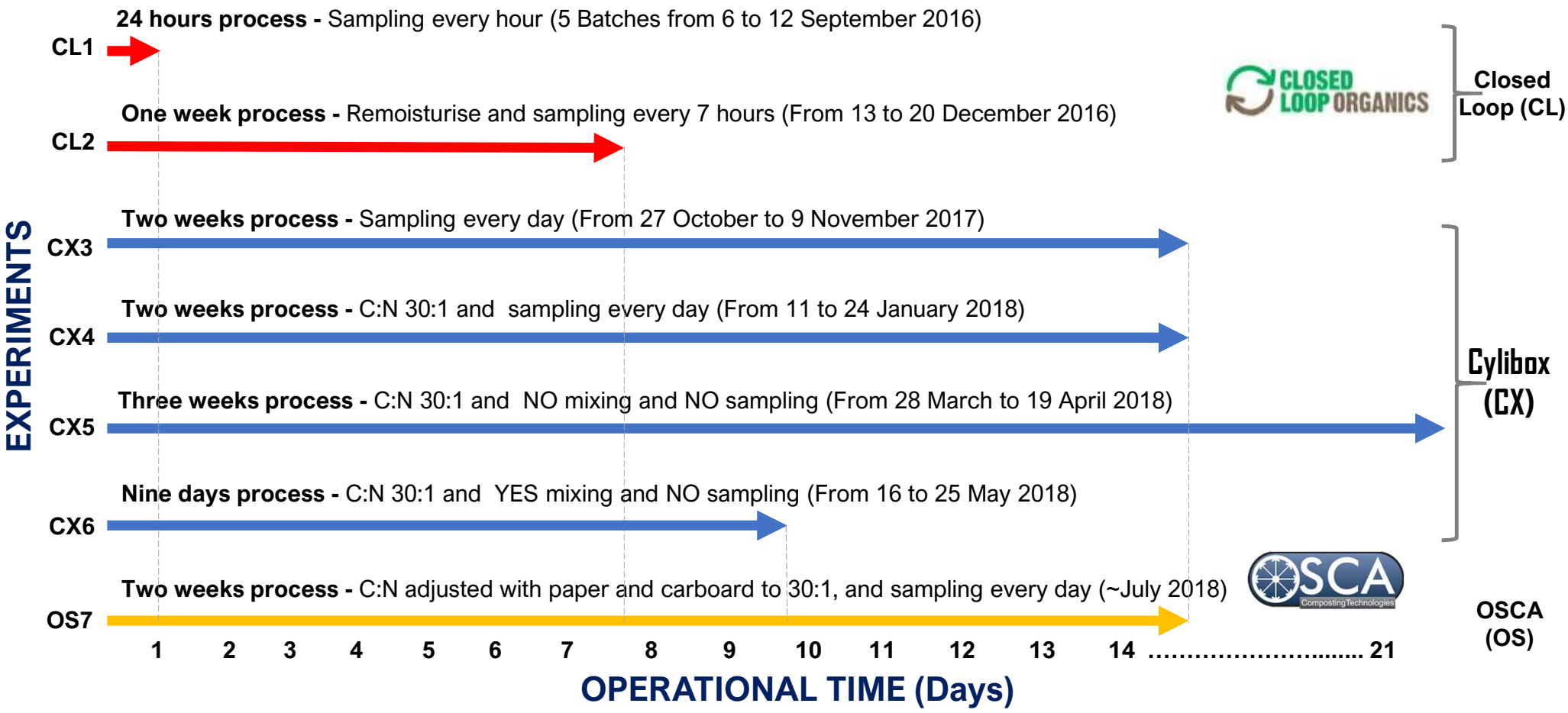
3. Experimental design - Food waste collection and characterization

TOTAL FOOD WASTE			
Type of Food Waste	Closed Loop-CL1.2 and CL2 experiments (kg)	Cylibox (CX) experiments (kg)	%
Noodles & rice	3.9	1.95	19.5%
Vegetables	2.7	1.35	13.5%
Fruits	2.34	1.17	11.7%
Chicken meat	0.06	0.03	0.3%
Coffee grounds	10.9	5.45	54.5%
Off plate	0.1	0.05	0.5%
TOTAL	**20**	**10**	100%
Final compost as inoculum (35%)	7	Not included	
Sawdust (Adjust C:N = 30:1)	Not included	1.00	For CX4, CX5 and CX6

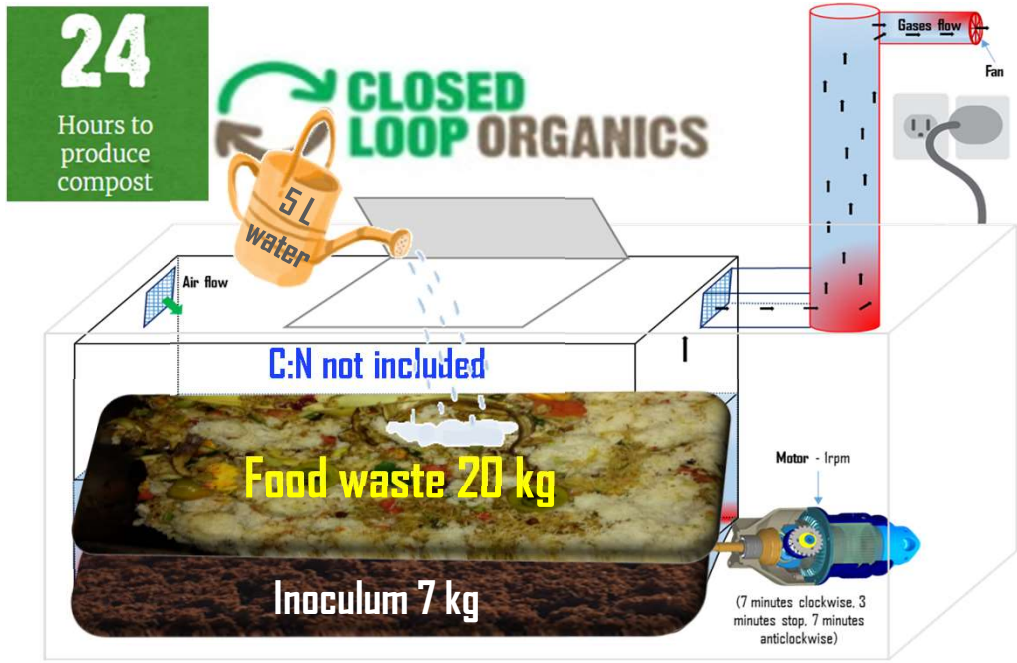


4. Experimental design – In-vessel composting technologies

4. Experimental design - Composting food waste experiments

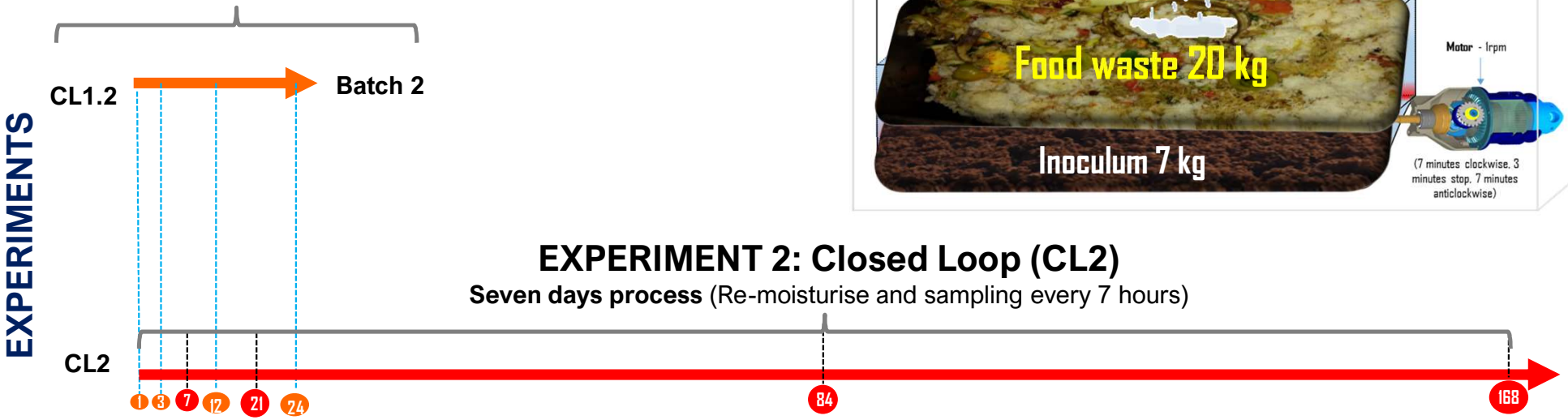


5. Results and Discussion - Composting in Closed Loop composter



EXPERIMENT 1: Closed Loop (CL1)

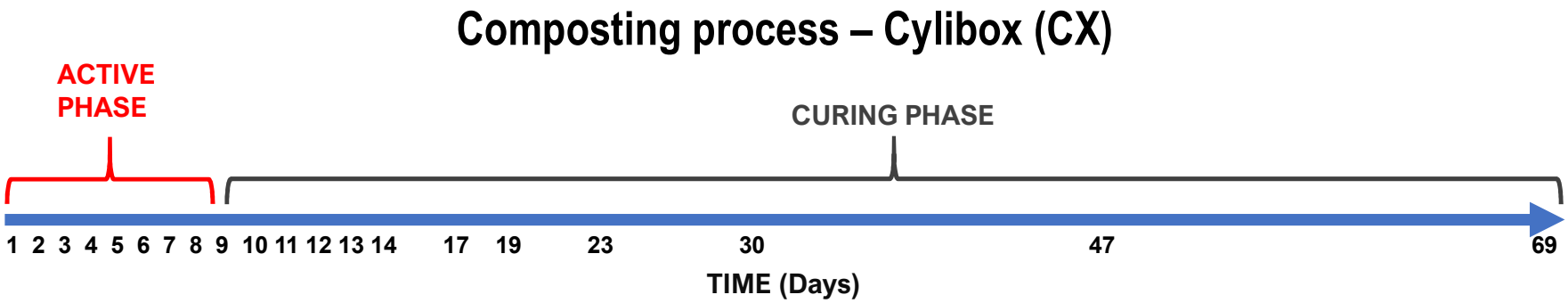
24 hours process
(Sampling every hour)



EXPERIMENT 2: Closed Loop (CL2)

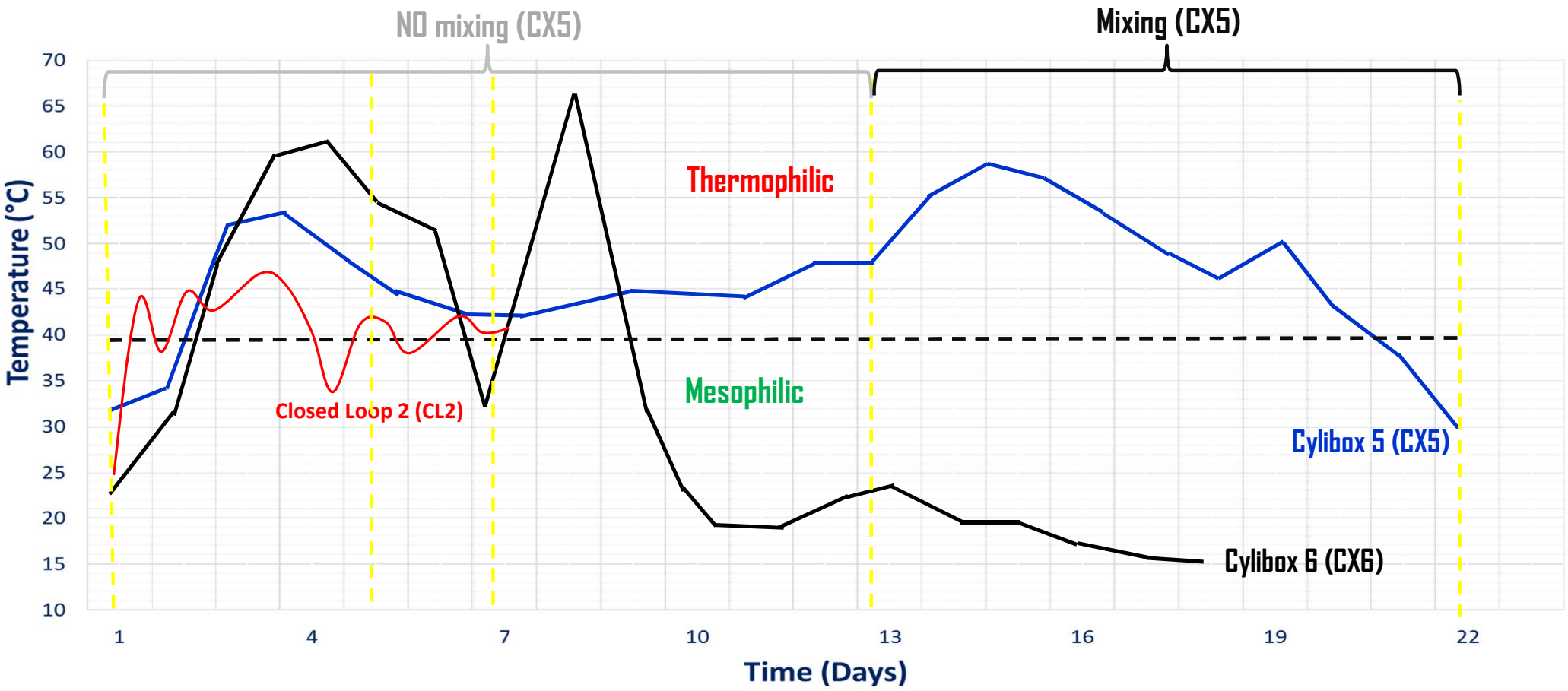
Seven days process (Re-moisturise and sampling every 7 hours)

5. Results and Discussion - Composting in Cylibox composter

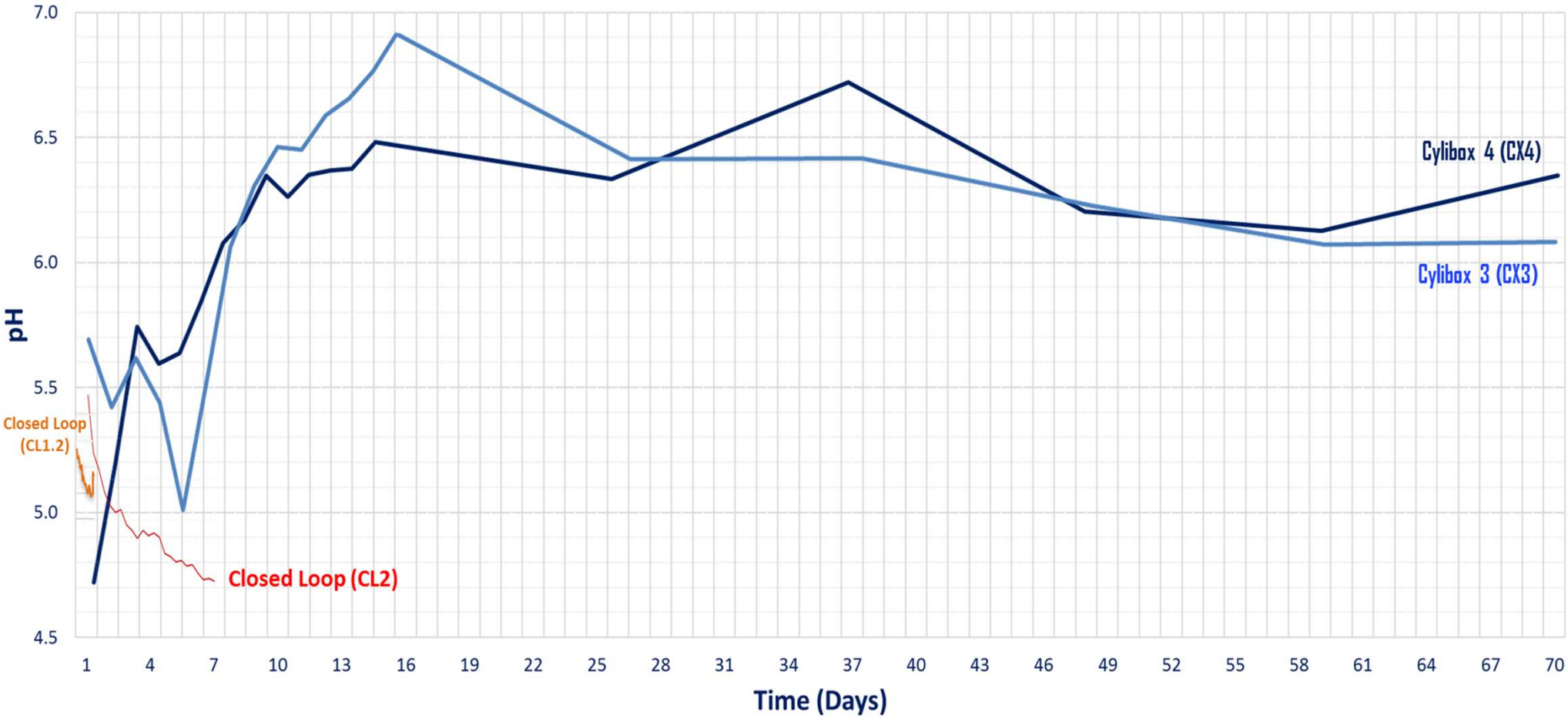


5. Results and Discussion

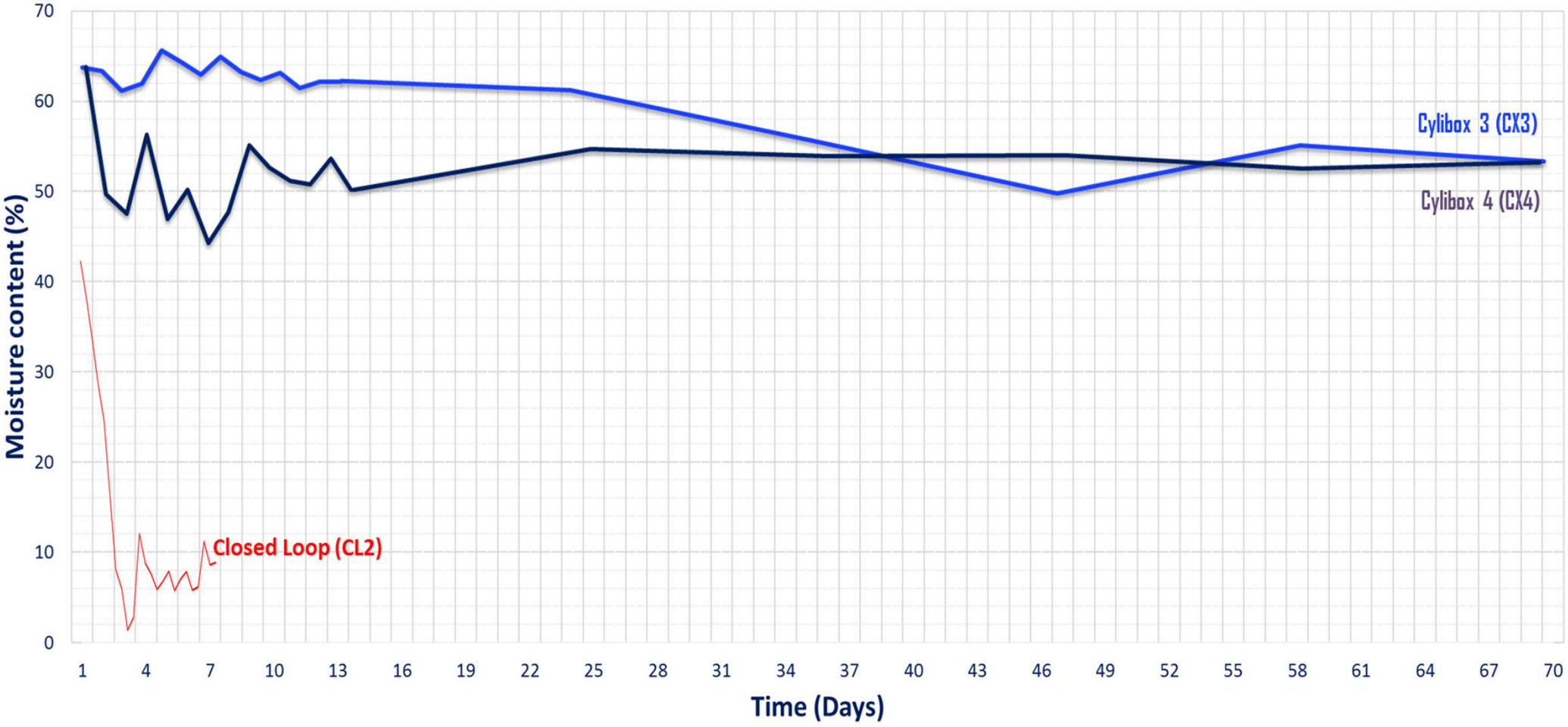
Impact of Mixing - Temperature CX5, CX6 and CL2



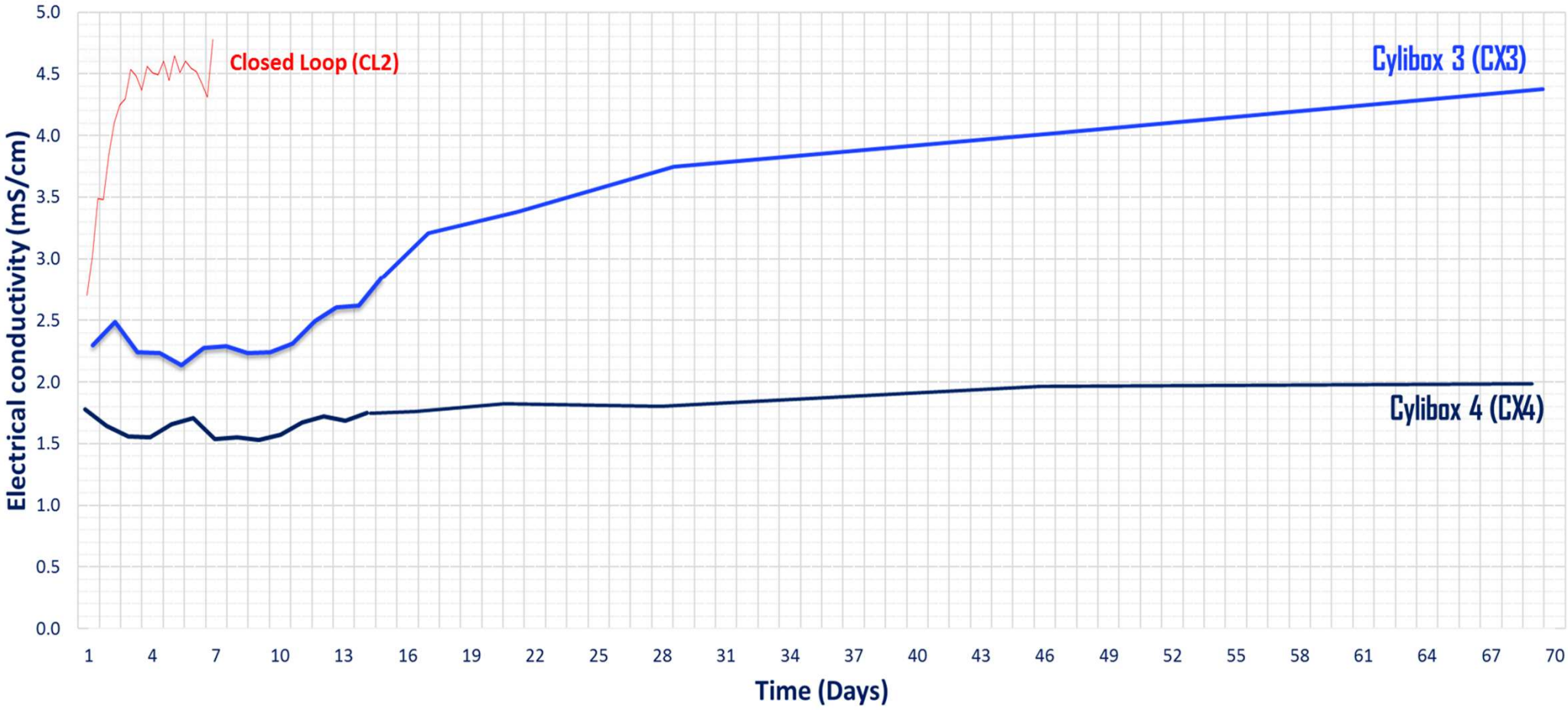
5. Results and Discussion - pH



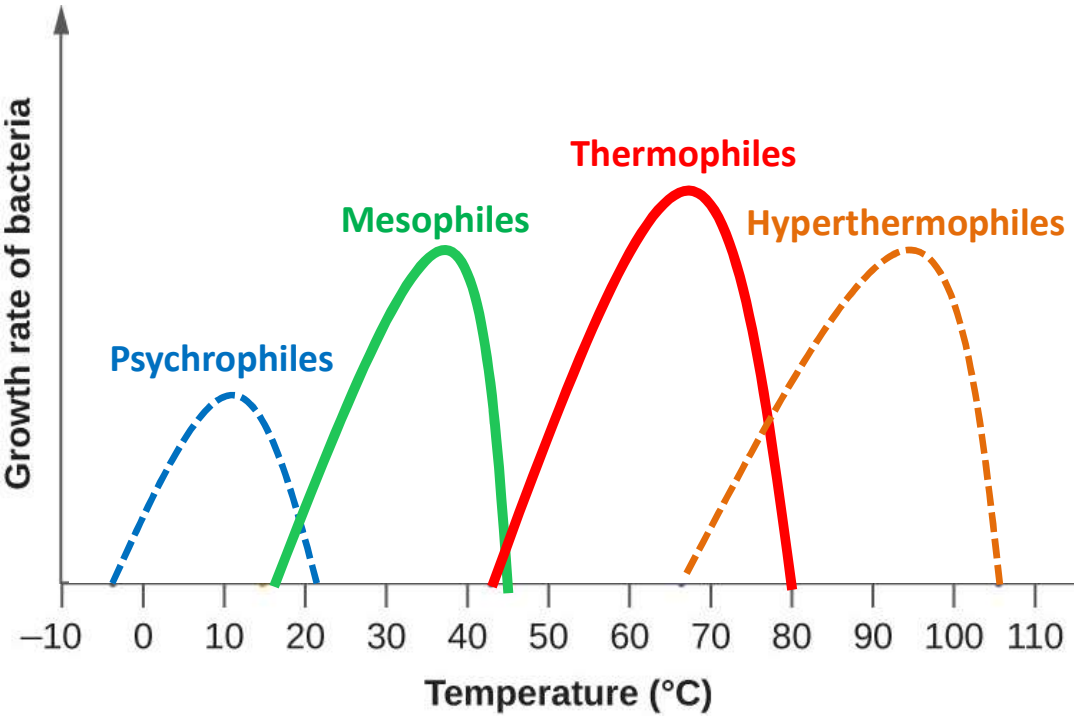
5. Results and Discussion - Moisture Content (%)

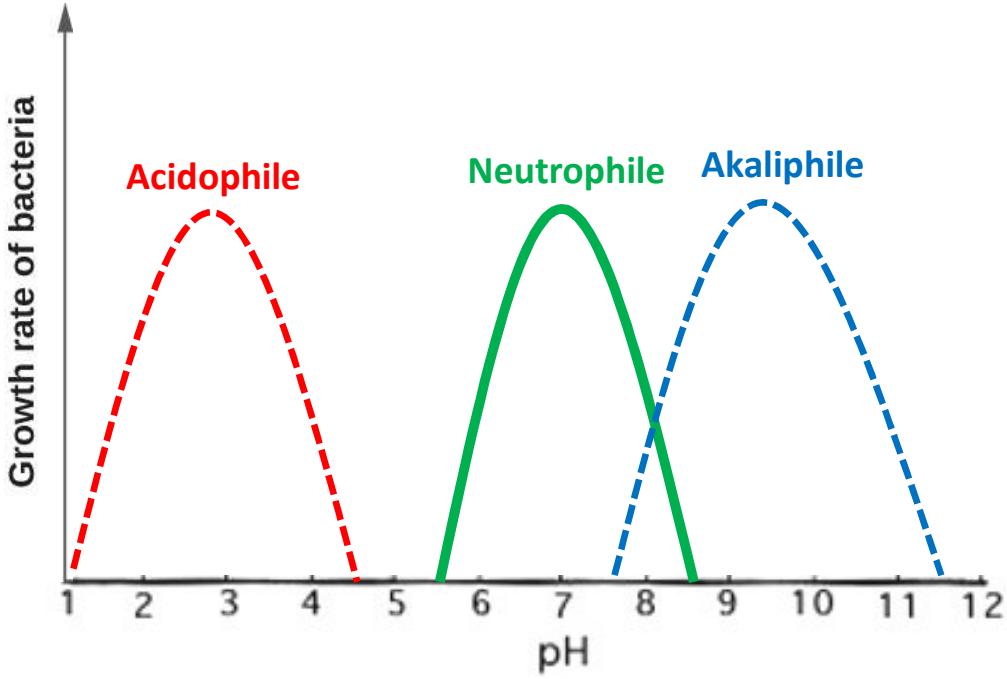


5. Results and Discussion - Electrical Conductivity (mS/cm)



Bacteria temperature and pH descriptions

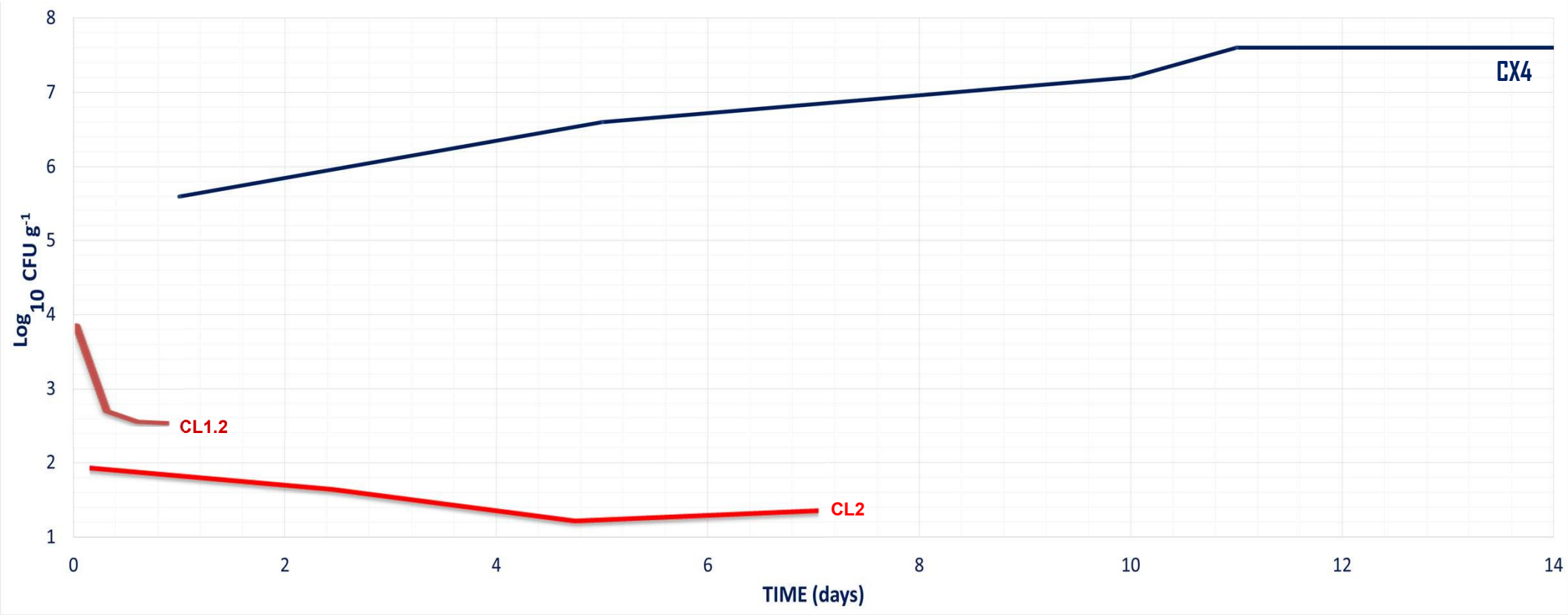




Source: Black, J. G. 1999

5. Results and Discussion - Numbers of culturable microorganisms

Medium	Target bacteria	Target Bacteria in compost	Isolated – CL1.2, CL2 CX4	Interpretation
Plate Count Agar	All culturable	All culturable	CL: <1x10^4 CFU/g of compost.	• Low amount of colonies due to the dehydration process (Normal compost 1x10^6 CFU/g of compost)



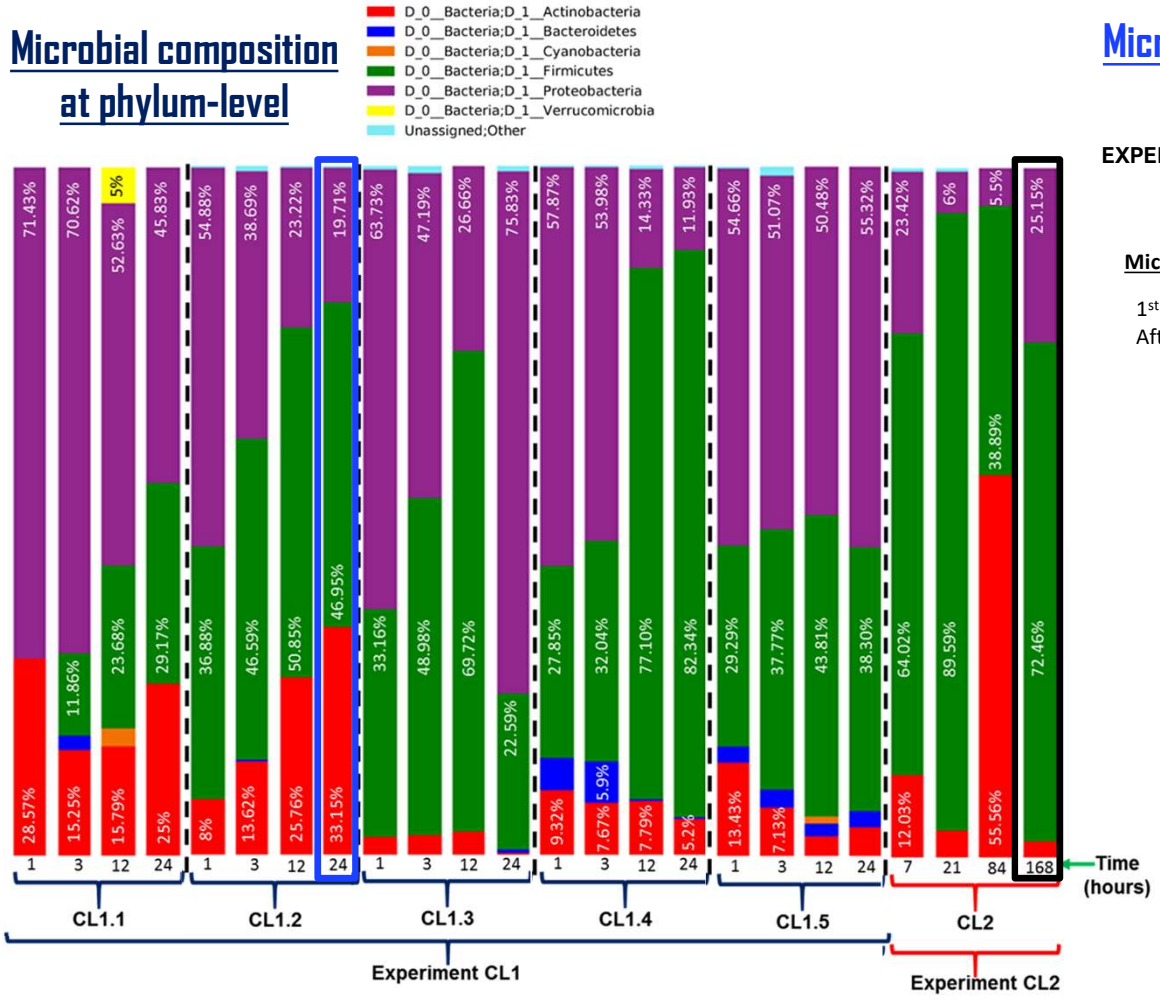
5. Results and Discussion - Pathogenic microorganisms

Organisms	Lethal temperature and necessary time
Salmonella spp.	15-20 minutes at 60°C; 1 h at 55°C
Escherichia coli	15-20 minutes at 60°C; 1 h at 55°C
Enterococci	Typical range of composting is 55-65°C

Source: N. M., Sunar, Stentiford, E.I., Stewart, D.I, and Fletcher, L.A. (2009).

5. Results and Discussion - 16S rRNA gene metabarcoding – CL experiments

Microbial composition at phylum-level



Microbial composition at genus-level

EXPERIMENT 1: Closed Loop (CL1.2)
24 hours process
(Sampling every hour)

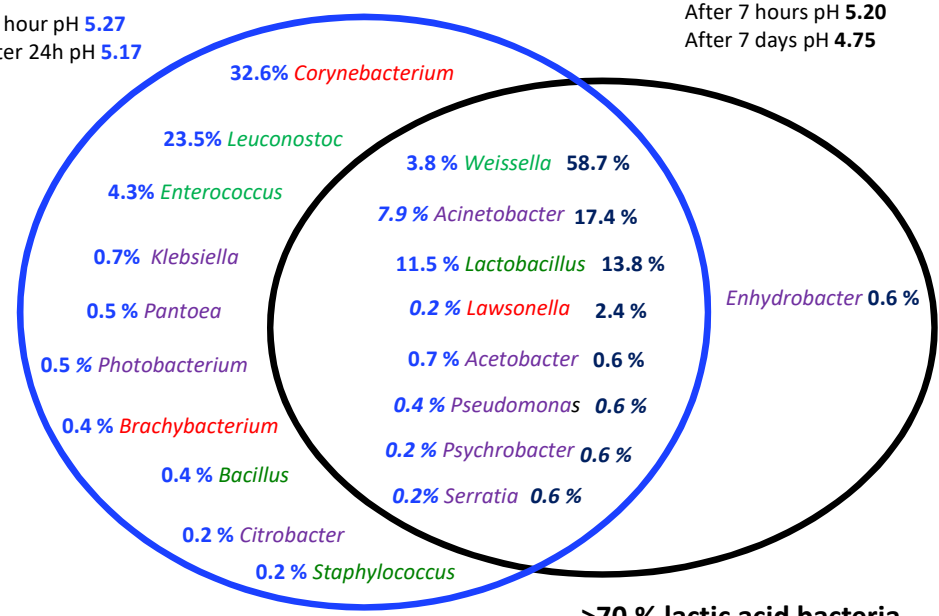
Microbes at hour 24

1st hour pH **5.27**
After 24h pH **5.17**

EXPERIMENT 2: Closed Loop (CL2)
Seven days process
(Re-moisturise and sampling every 7 hours)

Microbes at hour 168

After 7 hours pH **5.20**
After 7 days pH **4.75**



40 % lactic acid bacteria
8% other acid producer bacteria

>70 % lactic acid bacteria

6. Conclusions

Closed Loop

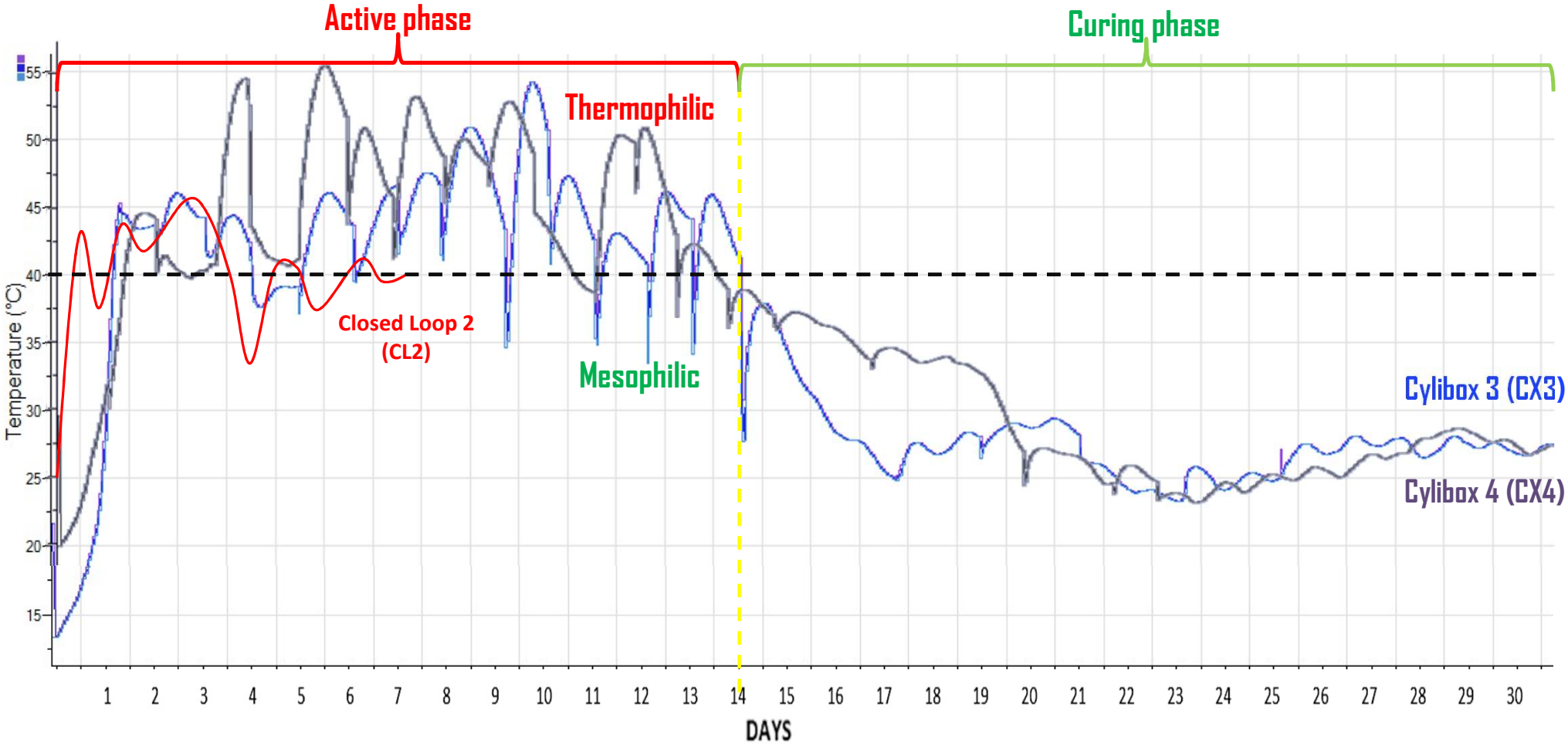
- Physicochemical and operational parameters not optimum
- Final product requires further treatment

Cylibox

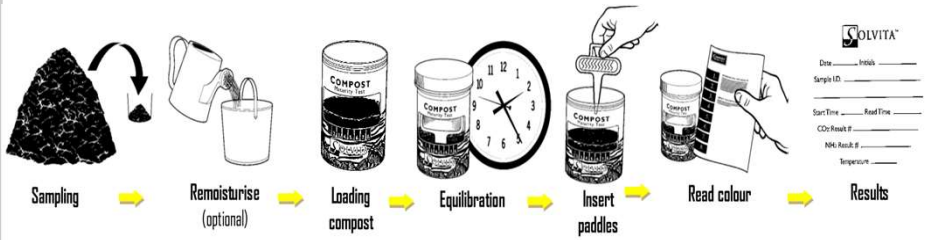
- Optimal physicochemical and operational parameters for microbial development
  - Key parameters:
    - Insulation maintains endogenous heat production
    - Temperature rises to >65^{o}C - pasteurisation
    - Moisture control
    - Appropriate mixing
- 9 days of active composting and 2 months maturation - compost ready for garden and agricultural use

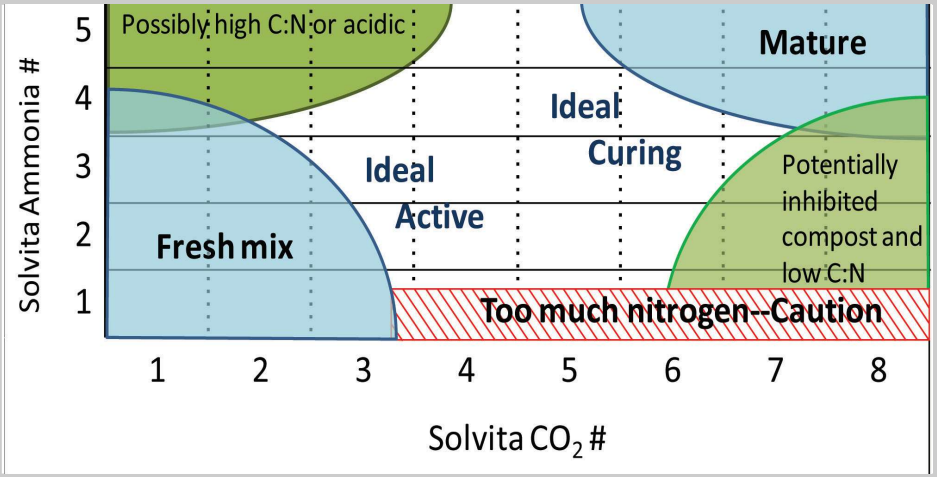
- **Thank you!**

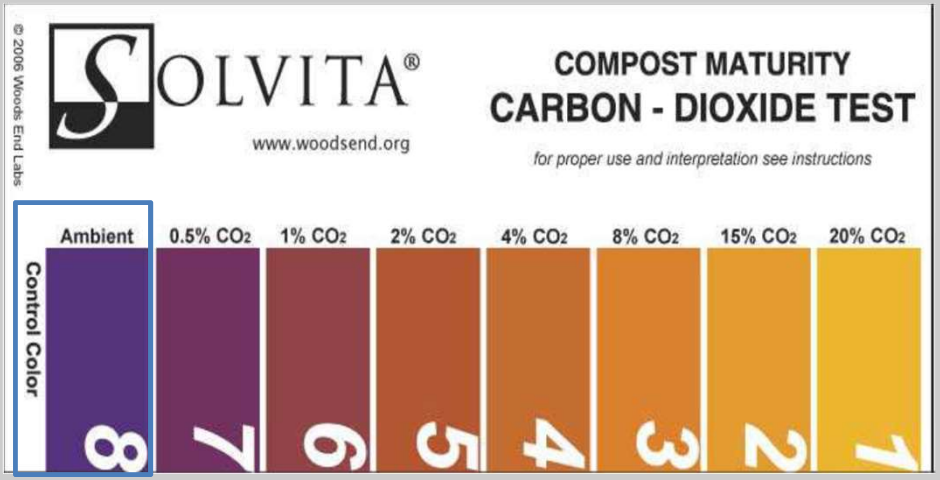
5. Results and Discussion - Temperature CL and CX



Compost maturity test
(Solvita test)







5. Results and Discussion - Solvita compost maturity test

CX5 and CX6 – compost maturity test