



Aeration in Composting Environments

Daryl McCartney, Ph.D., P.Eng.
Professor, University of Alberta

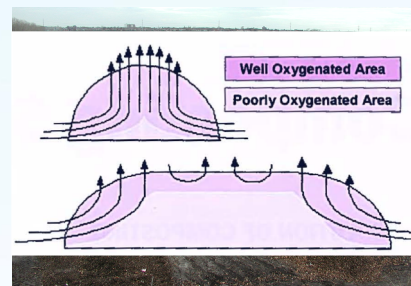
SWANA Northern Lights Conference
Edmonton, 11 May 2018

1

Aeration in Composting Background

(Chiumenti et al. 2005)

- Aeration used to:
 - supply oxygen.
 - remove moisture (drying).
 - cooling (ventilation).
- Passive systems:
 - thermal convection.
 - aeration rate function of:
 - ✓ temperature differences &
 - ✓ air flow resistance in pile.
- Forced systems:
 - Pressure loss related to air flow resistance in pile.
 - Increased pressure loss equals:
 - ✓ Increased blower size.
 - ✓ Increased costs.



UNIVERSITY OF
ALBERTA

2

Aeration in Composting Today's Focus

Participants should understand:

- 1) Poor O_2 supply a root cause of odour.
- 2) Relative aeration requirements:
 - ✓ Metabolic oxygen (breathing).
 - ✓ Cooling (ventilation).



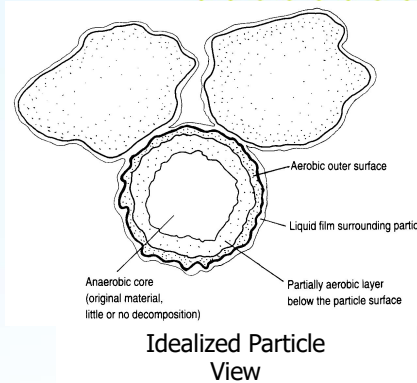
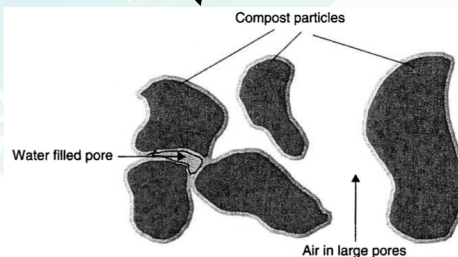
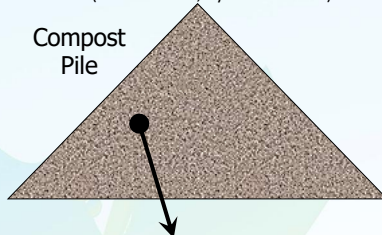
UNIVERSITY OF
ALBERTA

3

Root Causes of Odour Engineering Science 101 Poor Oxygen Supply

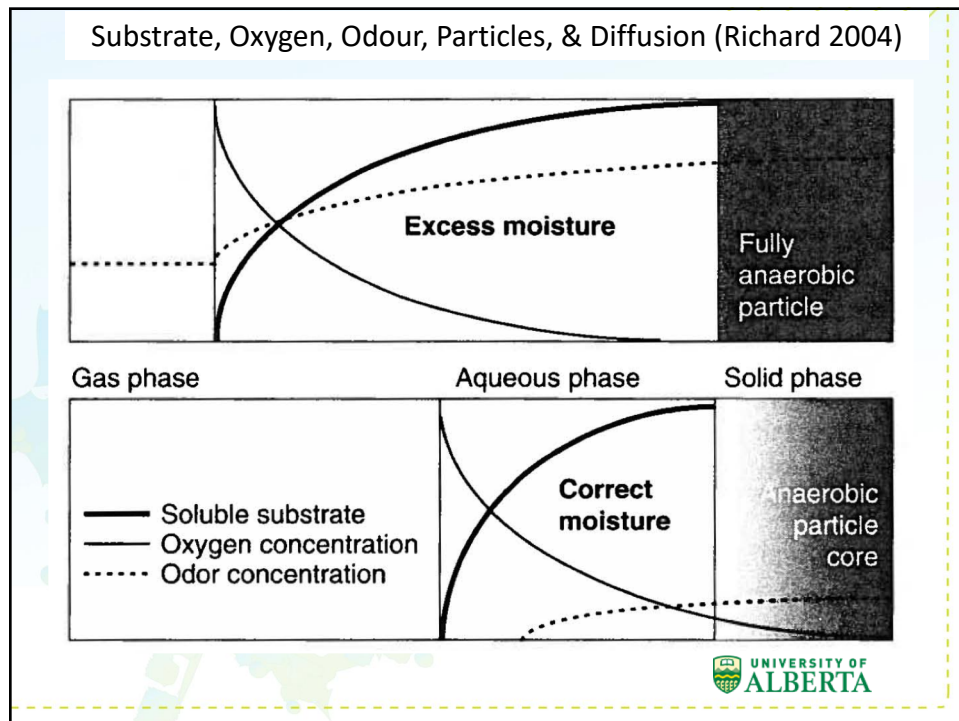
(Richard 2004; Rynk et al. 1992)

Compost
Pile



UNIVERSITY OF
ALBERTA

4



Root Causes of Odour

Engineering Design & Operation Best Practices For Odour Mitigation

(McCartney 2017; ECS 2017)

- ✓ Soluble substrate risks:
 - ✗ High odour potential:
 - ✗ Substrates, e.g. gypsum ($\text{SO}_4\text{-S}$).
 - ✗ Feedstocks, e.g. S + wet.
 - ✗ Fresh, easily degradable, e.g. →
- ✓ Oxygen supply risks:
 - ✓ Air flow resistance & uniformity:
 - ✗ Compaction, e.g. loss of air-filled porosity.
 - ✗ Secondary particle formation, e.g. aeration short circuiting.
 - ✗ Air distribution homogeneity, e.g. low O_2 in pile core. →
 - ✓ Pore space $[\text{O}_2] > 15\%$.

Prince George's County, Maryland Composting Facility

Covered Aerated Static Pile (Gore, Chiumenti et al. 2005)

The diagram shows a cross-section of a covered aerated static pile. Air is blown into the pile through 'Sheet Anchors' at the base. Arrows indicate the flow of 'Air' into the pile, 'Heat' being released, 'Odors' and 'Humidity' escaping through the 'Atmospheric Agents Resistant' cover, and 'CO₂' being produced. A 'Temperature Measuring Probe' and 'Oxygen Measuring Probe' are shown inserted into the pile. 'Bacteria' are indicated within the pile material. The cover is labeled 'Gore-Tex®'.

Aeration in Composting Today's Focus

Participants should understand:

- 1) Poor O_2 supply a root cause of odour.
- 2) Aeration requirements:
 - ✓ Metabolic oxygen (breathing).
 - ✓ Cooling (ventilation).



UNIVERSITY OF
ALBERTA

7

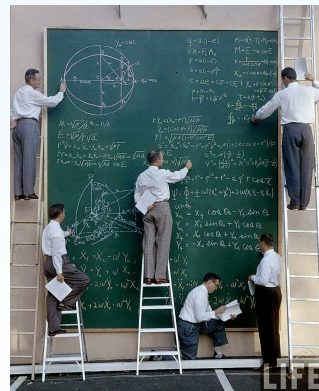
Aeration Requirements

Steps to Calculate Quantity of Air Required

(Haug 1993)

- Metabolic metabolism (breathing):
 - 1) Estimate feedstock chemical composition ($C_{xx}H_{yy}O_{zz}$).
 - 2) Prepare stoichiometric equations:

$$C_{xx}H_{yy}O_{zz} + ??O_2 \longrightarrow xx CO_2 + ??H_2O$$
 - 3) Calculate oxygen demand.
 - 4) Calculate air required based on biodegradability.
 - 5) Convert to dry weight basis.
- Cooling (ventilation):
 - 1) Calculate heat generation (kcal per total solids).
 - 2) Calculate heat required to heat inlet gases to $55^\circ C$.
 - 3) Calculate dry air required to keep T at $55^\circ C$.



UNIVERSITY OF
ALBERTA

8

Aeration Requirements Case Study Example Feedstock

Feedstock	Q (wet t y ⁻¹)	Chemical Composition	TS (%)	VS (%)	BVS (%)
Food waste	66.7	C ₁₈ H ₂₆ O ₁₀	30	70	50
Yard waste	33.3	C ₂₇ H ₃₈ O ₁₆	40	70	30
	100.0				

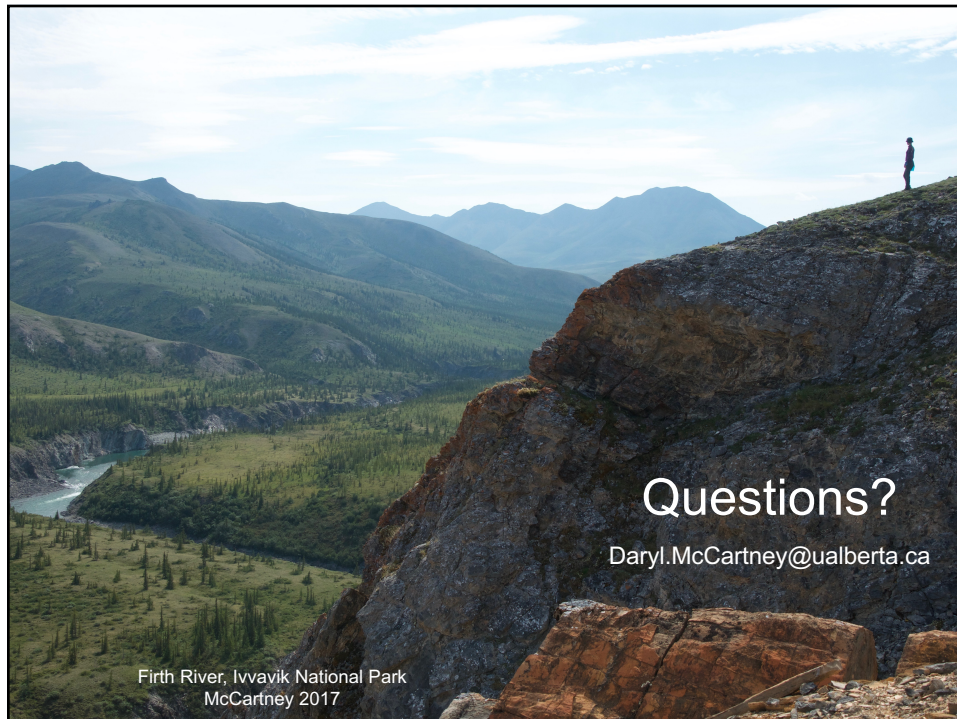
Aeration Requirements Metabolic versus Venting Summary

- Metabolic needs:
 - 1.94 kg air per kg TS (FW + YW)
 - 1.62 m³ air per kg TS
- Venting needs:
 - 39.3 kg air per kg TS
 - 32.8 m³ air per kg TS
 - Excess air ratio (EAR; kg:kg) = 20.2
- Based on venting needs over 25 days:
 - Average:
 - 55 m³ per h per dry tonne TS
 - 41.4 m³ per h per m³
 - Peaking: 2 to 7 times average, so 110 to 385 m³ h⁻¹ dry t⁻¹

Note:
Air mass ~ 2x mass TS

Composting Aeration Requirements Summary & Conclusions

- Engineering design & operations best practices:
 - Careful with high risk feedstocks.
 - Minimize compaction.
 - Ensure uniform air distribution.
 - Pore space oxygen conc. >15%.
- Aeration requirements:
 - Air largest mass balance requirement.
 - Venting needs ~20x metabolic needs.
 - Peak needs 2 to 7x average needs.



Key References

- Haug, R.T. 1993. The practical handbook of compost engineering. Lewis Publishers. Boca Raton, FL.