LABORATORY-SCALE INVESTIGATION OF AN AEROBIC BIOREACTOR OPERATED UNDER COMBINED VAPOR EXTRACTION AND AIR INJECTION

A precursor to field implementation

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ABSTRACT

The prospect of accelerated stabilization of municipal solid waste (MSW) under aerobic conditions has been confirmed to a certain degree in both laboratory and field settings. However, such stabilization is highly dependent on the optimal control and distribution of moisture and air throughout a typically heterogeneous mixture. Moreover, the extent of this control has direct bearing on safety considerations associated with hazards such as landfill fires and slope failures. This poster presents elements of a large ($\approx 7.5\ m^3$) laboratory-scale bioreactor used to evaluate the aerobic decomposition of municipal solid waste under combined air injection and vapor extraction. One of the objectives of this project is to investigate the extent to which optimal moisture, temperature and oxygen conditions can be maintained through the use of pulsed injections of a water-saturated air stream. The laboratory investigation is also intended to provide information for field application.

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Project Phases and Current Status

- Phase I Research and Conceptual Design
- Phase II Laboratory Reactor Design, Testing and Modeling
- Phase III Prototype Well Design and Preliminary Testing
- Phase IV Permitting and Field Study Design
- Phase V Field Study Implementation

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Laboratory Reactor Construction

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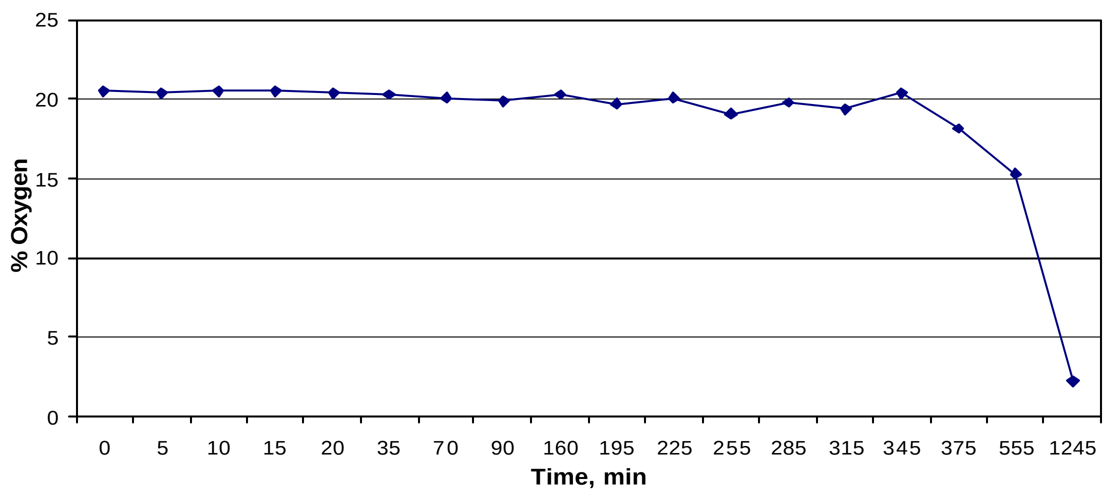
Laboratory Reactor Construction

Oxygen Uptake Testing



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Process Equations

Airflow required to maintain process temperature:

$$q^* = \left(\frac{1}{m - m_e}\right)\frac{h_c \frac{dm}{d?}}{HAO - HAI} = \frac{-kh_c}{HAO - HAI}$$

Where:

$q^* =$ Theoretical Airflow Rate, $\frac{kg_{air}}{kg_m \cdot day}$

$m =$ dry compost, kg

$m_e =$ equilibrium dry compost, kg

$h_c =$ heat of combustion ($\approx$ 20,000 kJ/kg)

HAO - HAI = change in enthalpy, kJ/kg

$k =$ first order decay constant, day^{-1}

Time until moisture addition:

$$?_1^* = \frac{-\ln\left(\frac{z1}{z2}\right)}{k}$$

Where:

$z1 = w_c m_c + F_w - ß_o(w_{c,L} + F_w)$

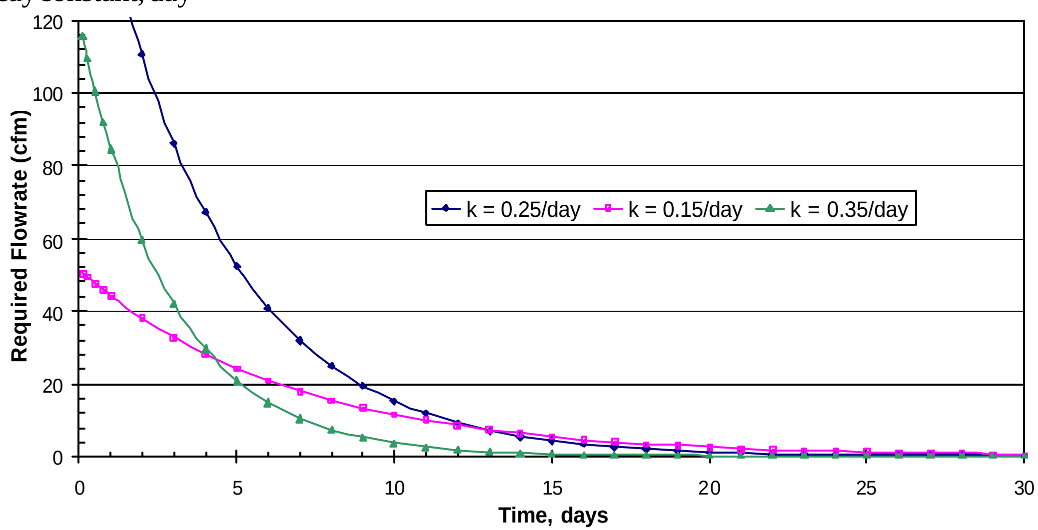
$z2 = (1 - ß_o)(w_{c,L} + F_w)$

$w_c =$ intial moisture content, % dry basis

$w_{c,L} =$ lower bound for moisture content

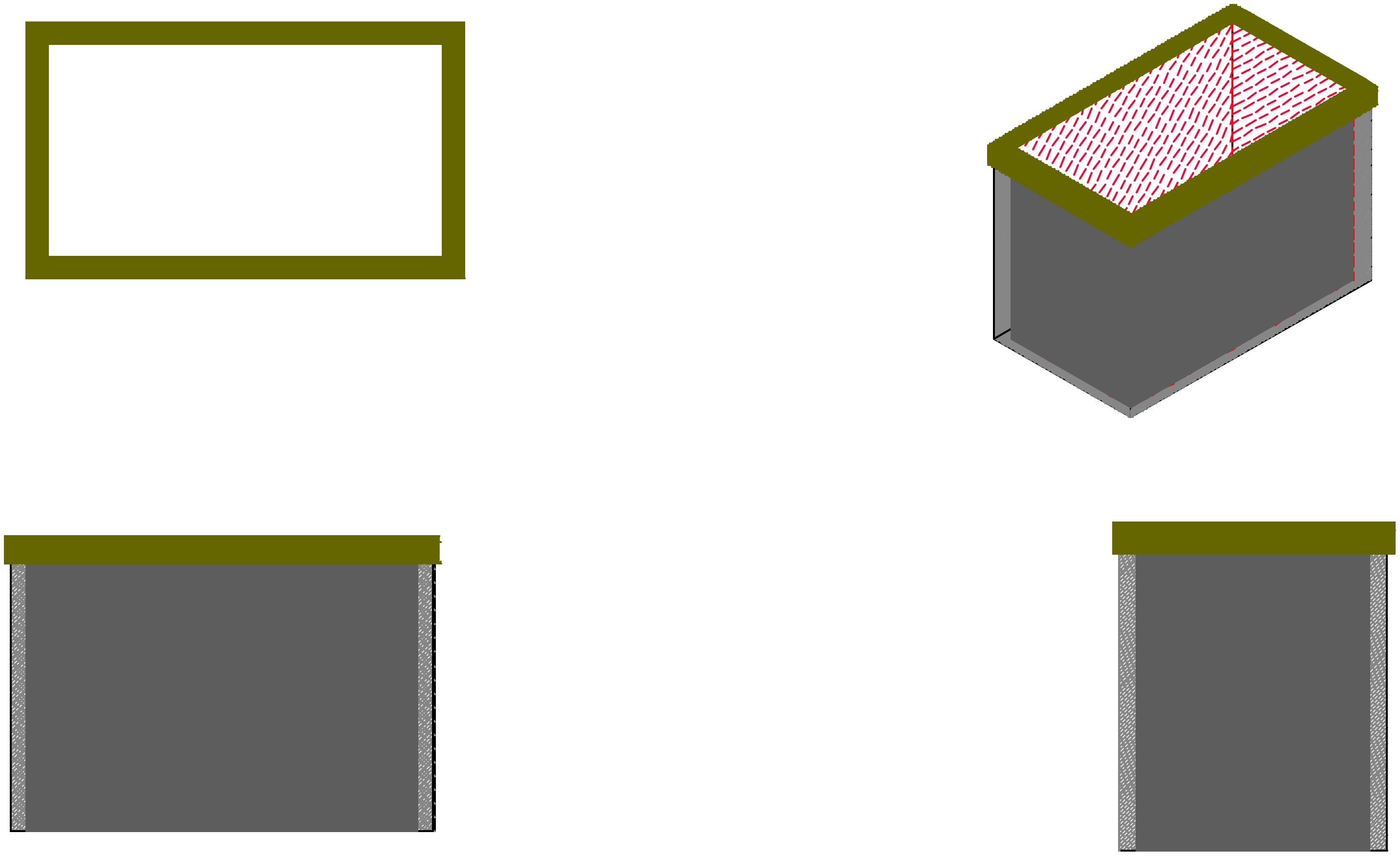
$\Phi_w =$ moisture removed per unit compost decomposed

$b_o =$ compost equilibrium value $= m_e/m_o$



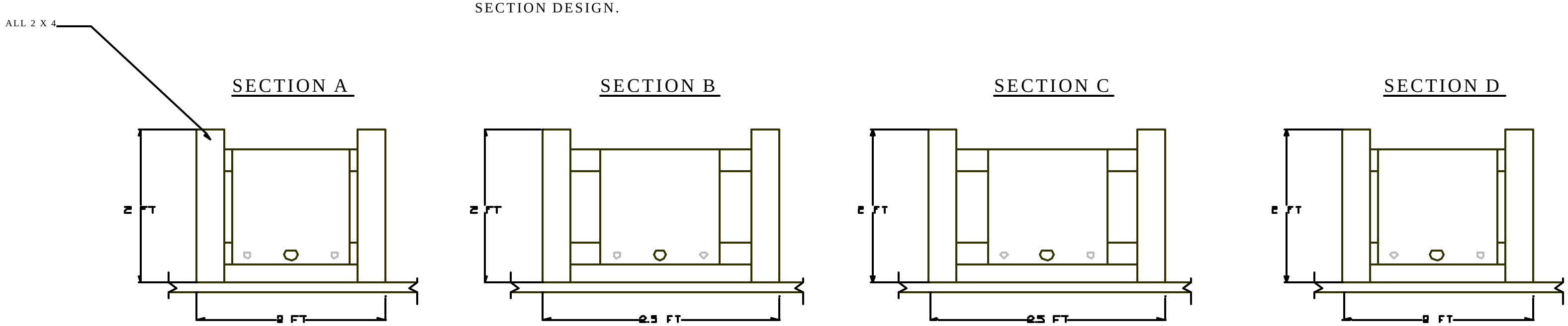
Laboratory Reactor Layout

3.3 m X 1.5 m X 1.5 m (7.5 m³)



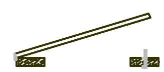
Laboratory Reactor Cover Details

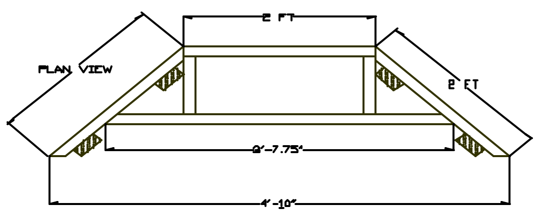
DIVIDE FIXED COVER INTO FOUR SECTIONS TO ALLOW FOR EASIER CONSTRUCTABILITY AND PLACEMENT.
EACH SECTION HAS THE SAME CROSS SECTION DESIGN.



PLAN VIEW OF SECTION'S A, B, C, AND D

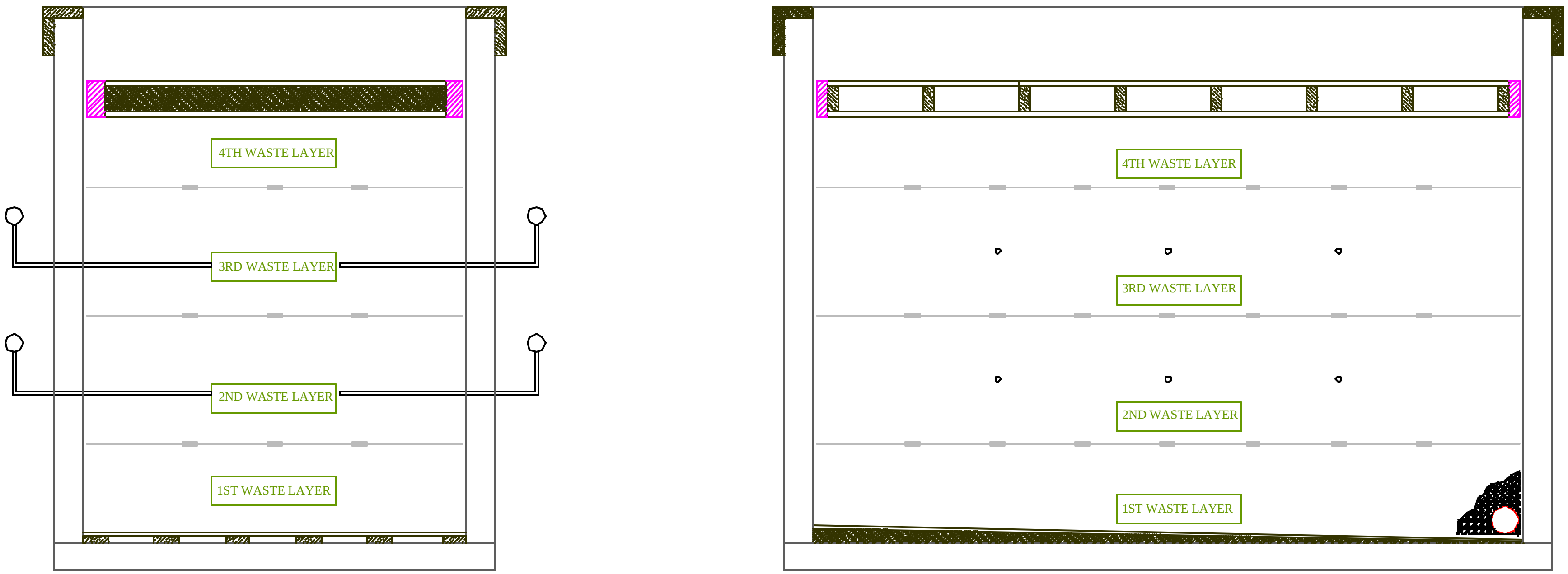
1/2" PLYWOOD



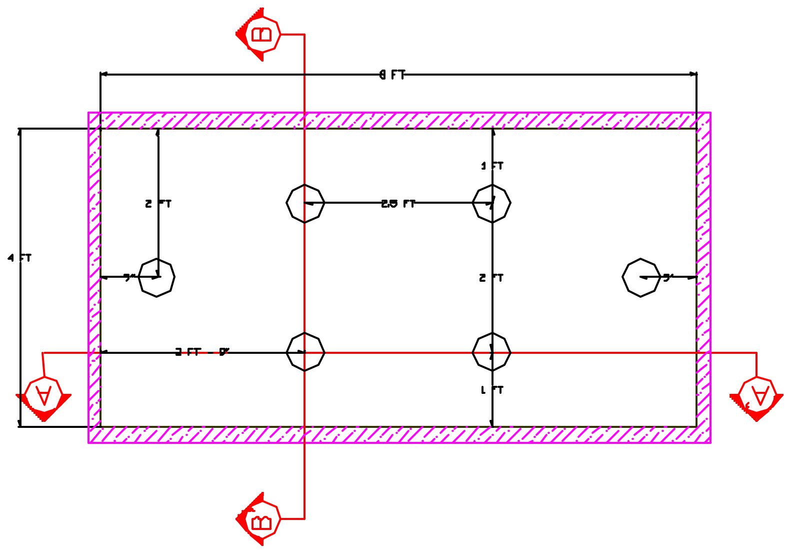


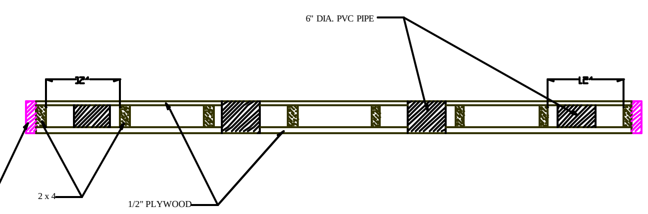
FRONT VIEW OF SECTION'S A, B, AND C

Laboratory Reactor Profile

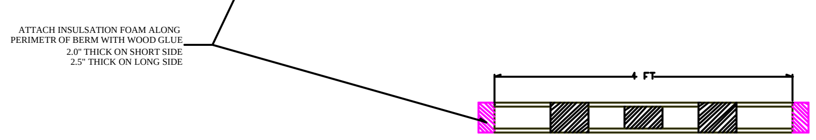


Laboratory Reactor Details





CROSS SECTION A-A'



CROSS SECTION B-B'

Field-Scale Well Design Features

- Control placement of injected liquids and air
- Enhance distribution of air movement through waste using vapor extraction and air injection
- Maximize well spacing by combining injection and vapor extraction
- Monitor moisture, vapor pressures and temperatures
- Utilize SCADA and Telemetry Systems
- Minimize operational interference and maximize efficiency of the Bioreactor

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