

Viscous Heating Effect on Deactivation of Helminth Eggs in VIP Sludge

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Introduction:

- Viscous heating by extrusion of faecal material alone can deactivate Soil Transmitted Helminth (STH) eggs present in sludge.
- Baseline parameters for deactivation:
 1. Minimum temperature required for deactivation
 2. Local maximum temperatures
 3. Thermal efficiency
- Laboratory-scale units built and tested with results presented here.

Background:

Soil Transmitted Helminthes (STH)

- parasites transmitted via eggs or larvae which are deposited in soil through indiscriminate defecation.
- Methods to “interrupt the vicious cycle of disease transmission” are desired.
- Destroying eggs at the point of deposition has the potential to reduce infection rates.

Background:

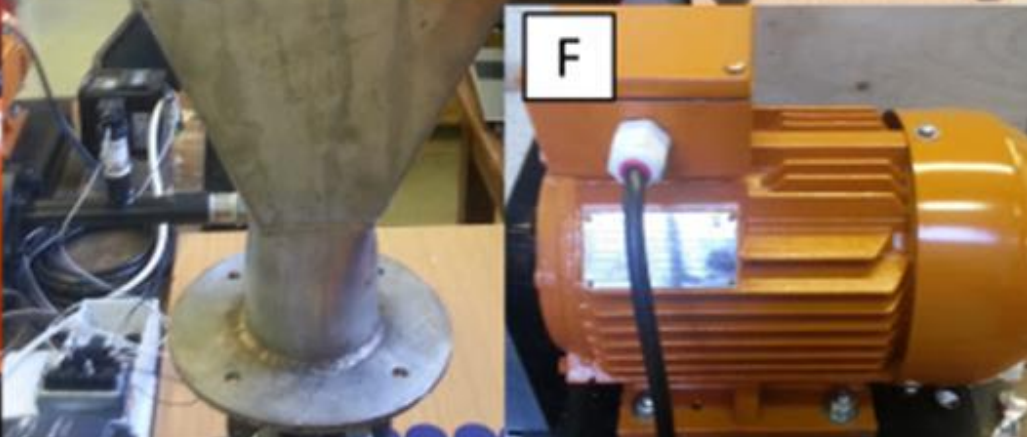
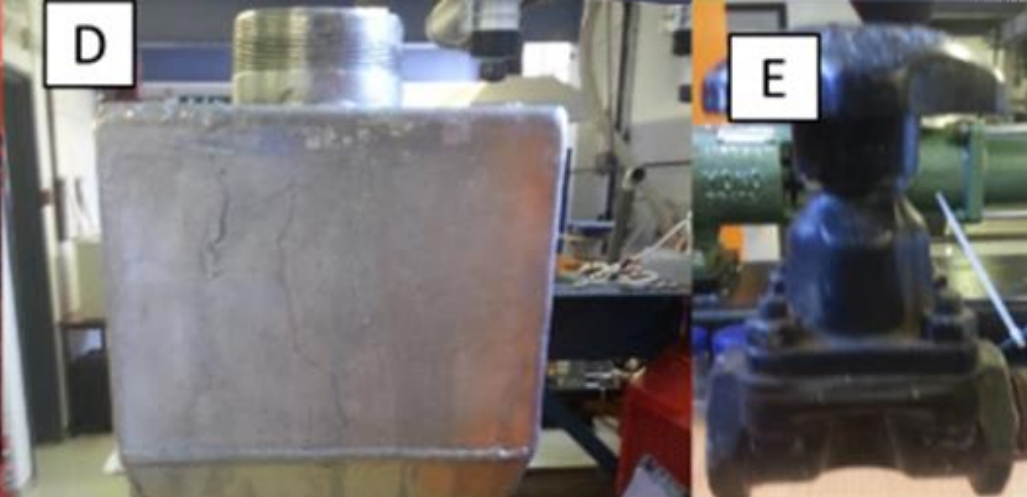
Viscous Heating

- Can be used to increase the temperature of faecal sludge uniformly.
- Friction among the molecules generate heat when in a high shear field.
- Amount of heat generated is a function of: (1) Fluid Viscosity, (2) System Pressure, and (3) Shear Rate
- Effluent temperatures can range from pasteurization to greater than the boiling point of water.

Methods and Materials:

Sludge Source Acquisition and Processing

- Obtained from VIP latrines in the eThekweni Municipality (Durban) South Africa.
- Screened down to 1.2 mm prior to use.
- Two samples:
 - A. 25 L VIP Sludge with 0 STH/10 g sludge
 - B. 1.5 L VIP Sludge with $\approx 10,000$ STH / 10 g sludge
- Dehydrated potatoes were added to increase viscosity.



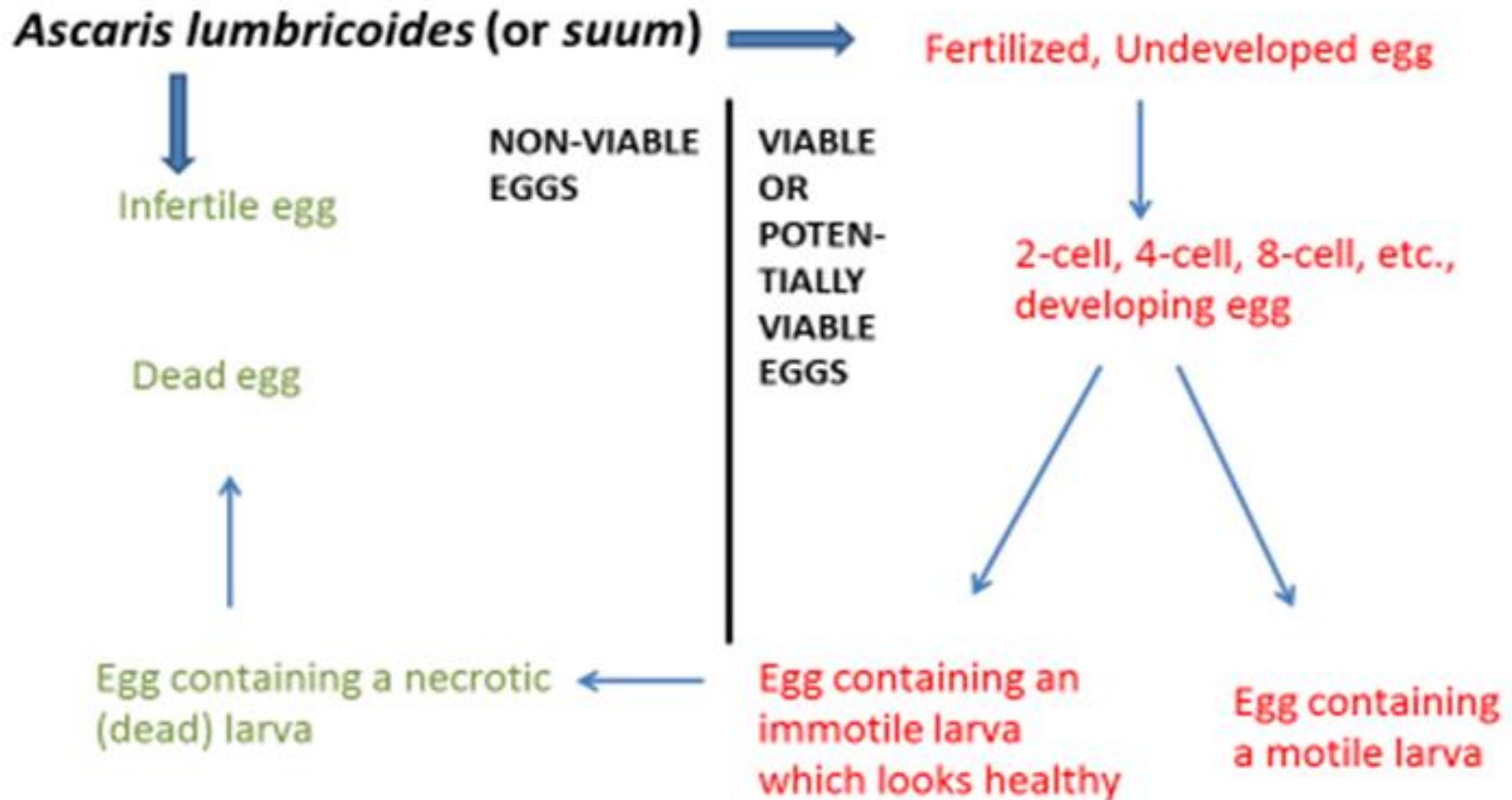
Methods and Materials:

Equipment Operation

- Deactivation evaluated at 3.5 degree intervals from 50-85°C
 - RPM Tested: 1100, 1300, 1400
 - Flow Rate Tested: 1, 2, 4 g/s
- 20 g samples set aside for STH analysis.
- Samples sealed and placed in 13 °C water bath.
- 1 Liter sample set aside for rheology analysis

Methods and Materials:

Sample Analysis



Methods and Materials:

Data Analysis

Deactivation regressed in JMP Statistical software and Excel.

$$\frac{C(T)}{C_0} = \exp \left(t * -A_{app} \exp \left(\frac{E_{app}}{RT} \right) \right)$$

Where:

C: Concentration (eggs/10g)

C₀: Initial Concentration (eggs/10g)

t: time (s)

A_{app}: Apparent Arrhenius Constant (s⁻¹)

E_{app}: Apparent Activation Energy (J/mol)

R: Gas Constant (8.314 J/molK)

T: Temperature (K)

Methods and Materials:

Data Analysis

Efficiency calculated from operating parameters and sludge properties.

$$\eta = \frac{Q_{sludge}}{Q_{in}} = \frac{(T_{out} - T_{in})C\dot{m}}{Q_{in}}$$

Where:

η : Efficiency

T_{out} : Temperature of effluent (C)

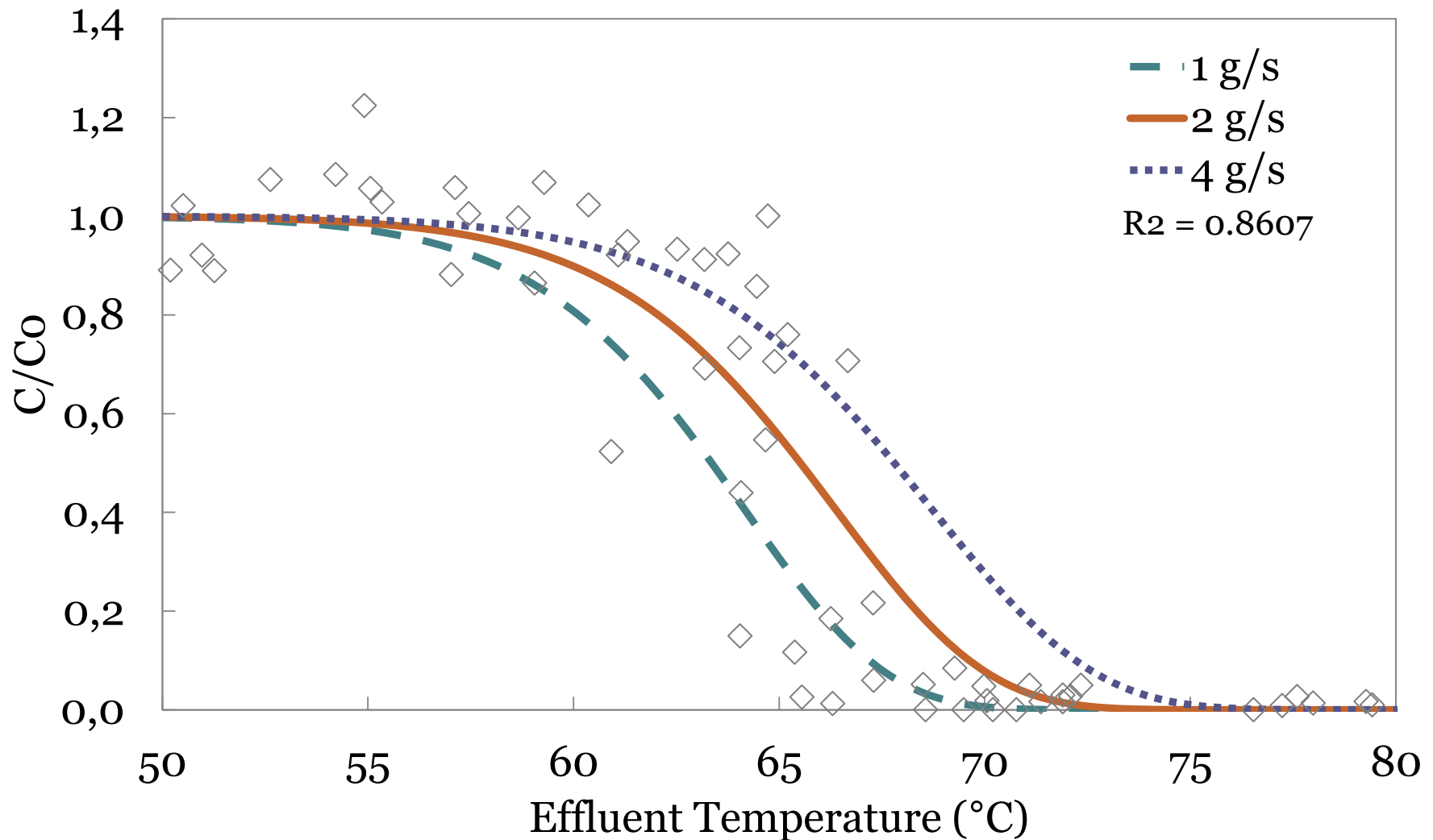
T_{in} : Temperature at inlet (C)

C: Specific Heat (Approximated at water)

m: mass flow rate (g/s)

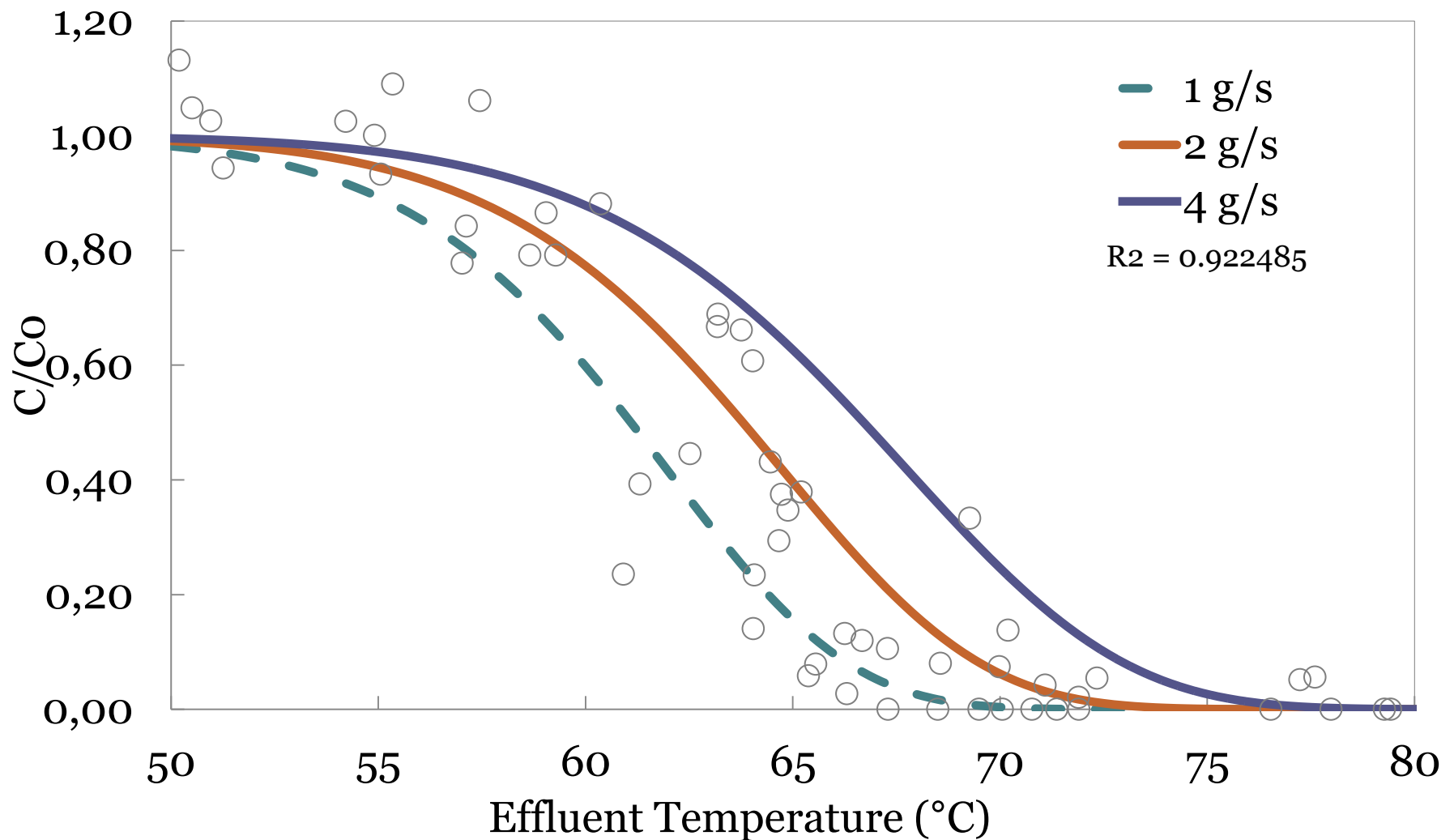
Results:

Pre Incubation Deactivation



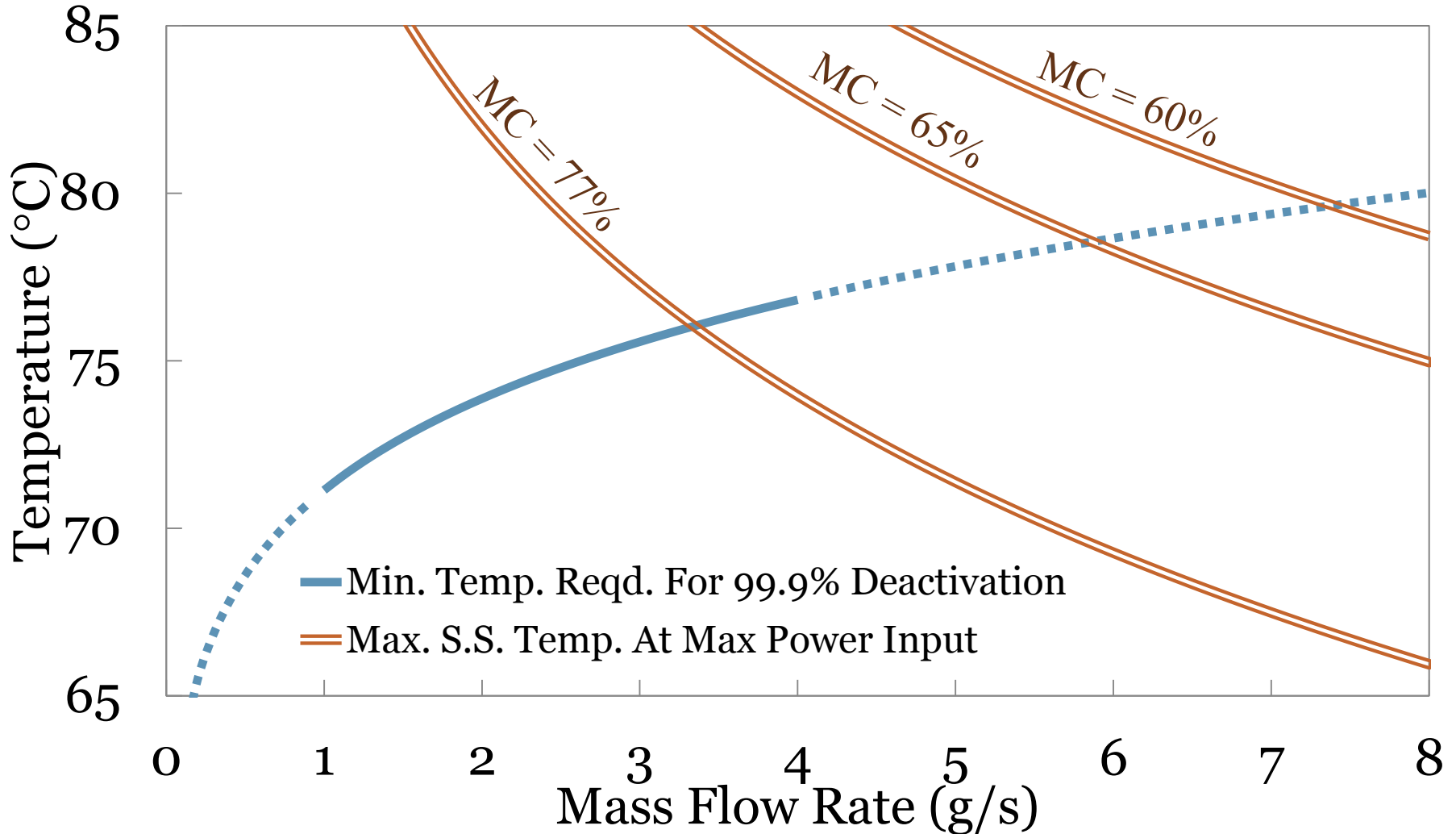
Results:

Post Incubation Deactivation

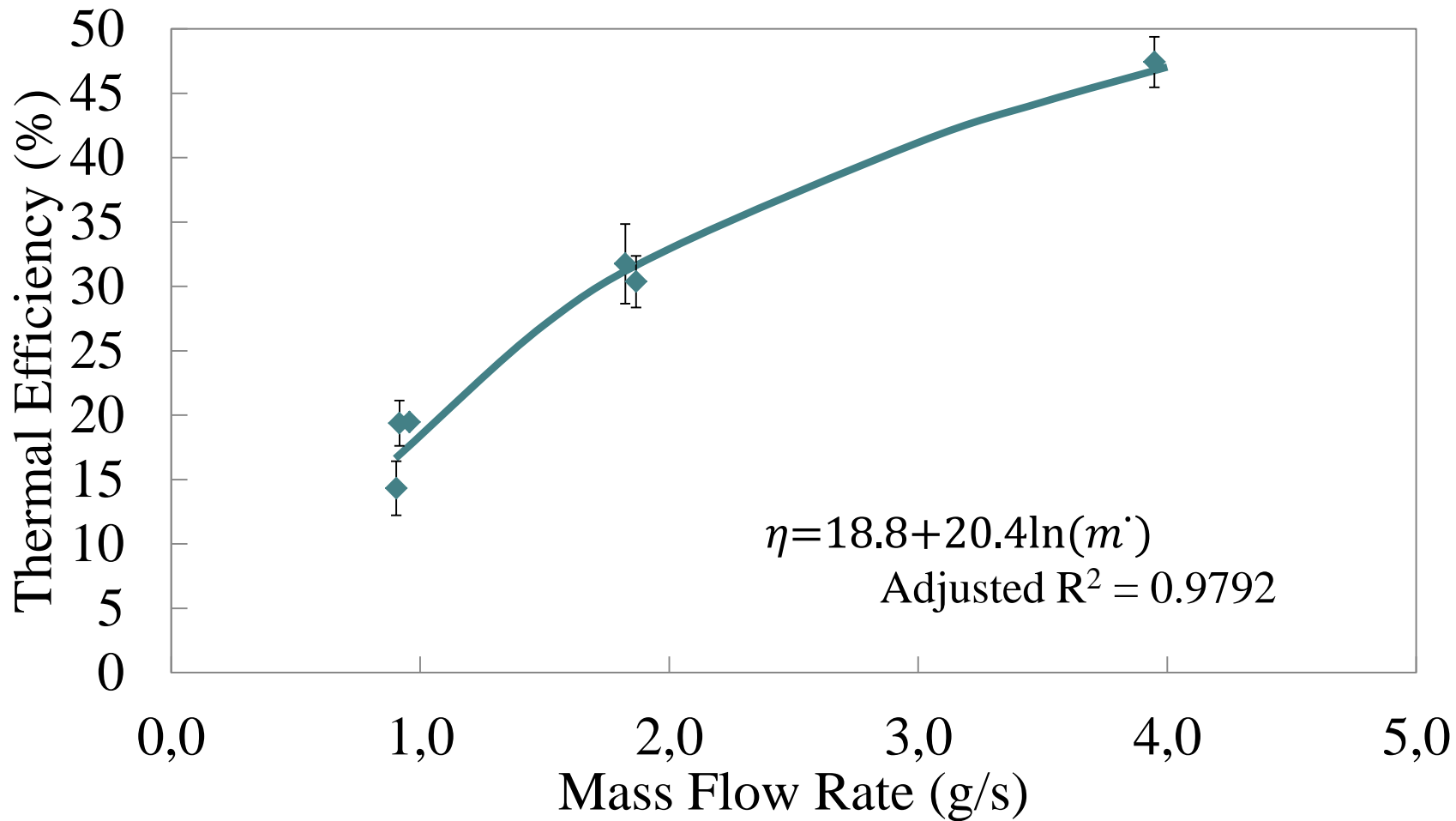


Results:

Max Steady State and Min Required Temperature as a Function of Mass Flow Rate



Results: Pre Incubation Deactivation



Conclusions:

- Viscous heating by extrusion of faecal material alone can deactivate Soil Transmitted Helminth (STH) eggs present in sludge.
- Temperatures above 70°C showed greater than 90% deactivation.
- Operating near a temperature of 85°C showed 100% deactivation.
- High Moisture content is undesirable.

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