Biosolids-survival of pathogens during storage

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Biosolids

- Represent a renewable organic source for:
  - Fertilizing crops and pastures
  - Remediating degraded or poor soils
- Q: Can biosolids be produced in a shorter time than allowed by current regulations in Victoria, while still providing public health safety?
  - Currently biosolids in Victoria are generally stored on site for 3 years before land application
  - However, we have shown that storage leads to loss of key plant nutrients, N & P (SWF project Round 4).
  - Also significant greenhouse gas (CH_4, NH_3) emissions

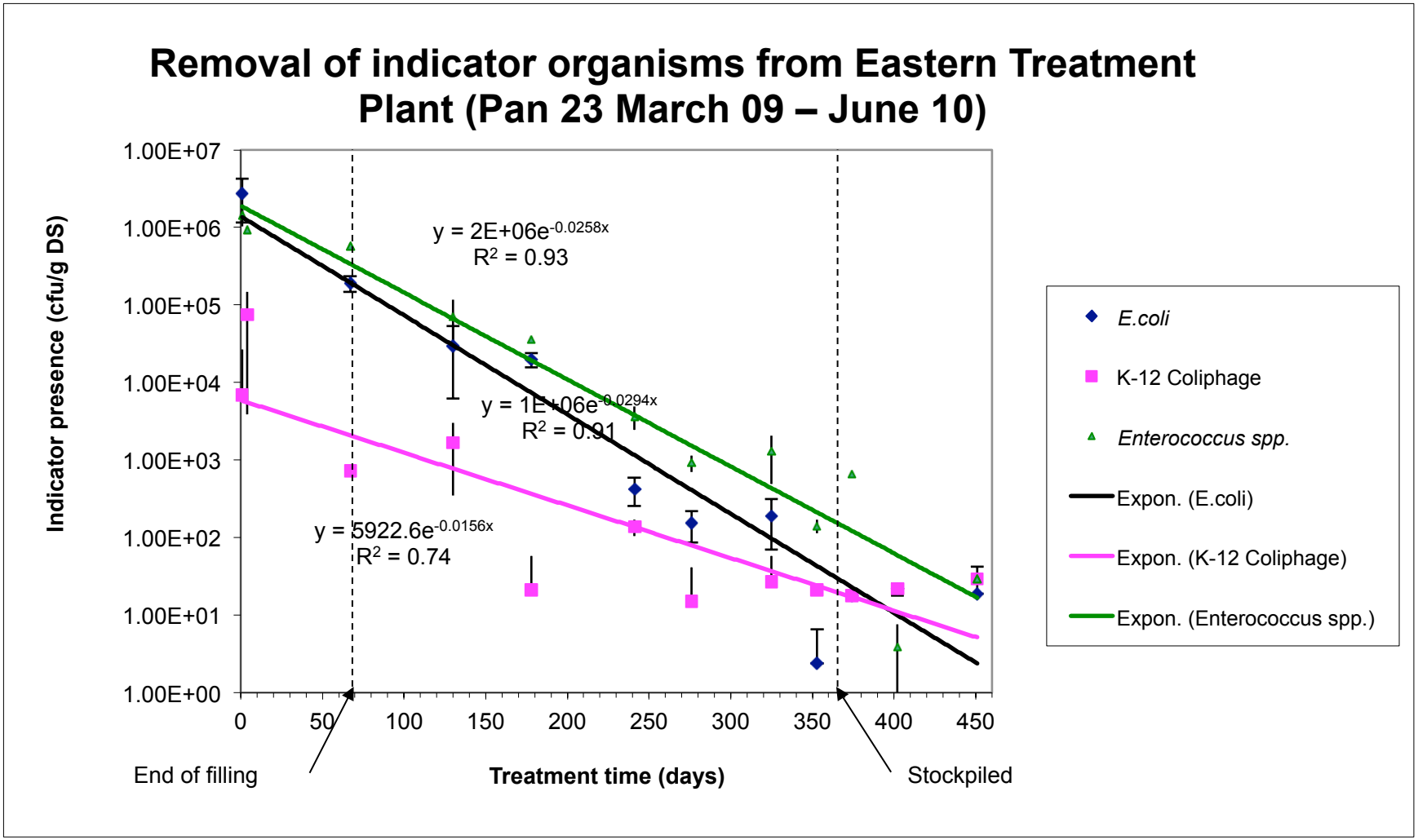
Pathogen presence and survival in biosolids is one of the key reasons for the requirement for 3 year storage-is this really necessary?

- We have assessed the decay of regulation pathogens and indicators in field and simulation treatment of sludge (SWF projects: Round 4, Round 6).
- Focussed on assessing time required to achieve a 2 log reduction of indicator organisms during drying and stockpiling.

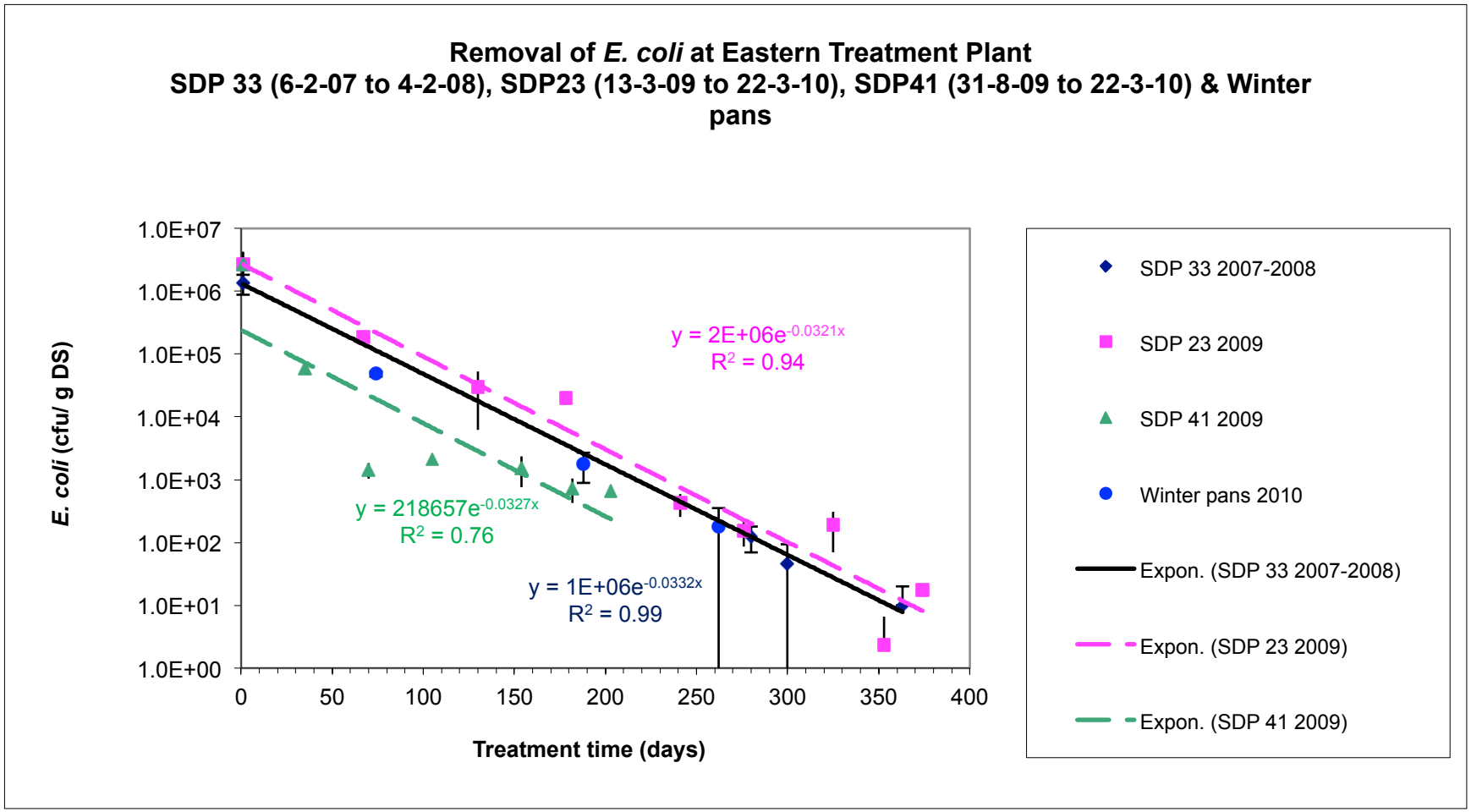
Decay of indicators in field treatment

- Waste Water Treatment Plants
  - Eastern treatment plant (Melbourne Water Corporation)
  - Mt Martha (South East Water Limited)
- Indicators: *E. coli*, *Enterococcus* spp, K-12 coliphage
- Treatment processes
  - Anaerobic digestion
  - Pan-drying
  - Stockpiling

Results


Removal of indicator organisms from Eastern Treatment Plant (Pan 23 March 09 – June 10)
Indicator presence (cfu/g DS)
1.00E+07
1.00E+06
1.00E+05
1.00E+04
1.00E+03
1.00E+02
1.00E+01
1.00E+00
y = 2E+06e-0.0258x
R2 = 0.93
y = 1E+06e-0.0294x
R2 = 0.91
y = 5922.6e-0.0156x
R2 = 0.74
0
50
100
150
200
250
300
350
400
450
End of filling
Treatment time (days)
Stockpiled
E.coli
K-12 Coliphage
Enterococcus spp.
Expon. (E.coli)
Expon. (K-12 Coliphage)
Expon. (Enterococcus spp.)

E. coli decay across 3 different weather conditions



Conclusions: ETP Field data

- The pan-drying process at ETP is relatively robust for decay of pathogen indicators, as shown from results in three drying seasons, including one exceptionally dry season and one exceptionally wet season.
  - Decay of all three indicators (*E. coli*, *Enterococcus spp.* and coliphage) occurred during pan-drying across all conditions. The results also suggest that *Enterococcus* spp. could be an alternative indicator to *E. coli* for decay of bacterial pathogens in pan-drying treatment.

- The rate of decay of *Salmonella* spp. in pan-drying treatment could not be quantified because only small numbers of *Salmonella* spp. were detected in anaerobic digester sludge and only two isolated pan samples showed presence of *Salmonella* spp. A pan-drying simulation was therefore required to address this issue.

- None of the microbial indicators were detected in stockpiles, except for low levels of *Enterococcus* spp. on two occasions and these are most likely due to re-contamination of stockpiles by animals or birds.

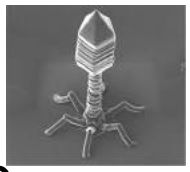
Pan-drying and Stockpiling Simulation

- At ETP, the shortest times in drying-pan treatment occur during the summer season, when pans are filled in spring and harvested in summer or early autumn.
- The average treatment time is 21 weeks, and the minimum is 7 weeks.
- Therefore the short drying during summer provides a worst-case for the required decay of pathogens.

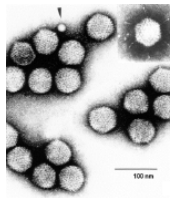
Pathogens and indicators

- **Bacteria:** *E. coli*, *Enterococcus* spp., *Salmonella typhimurium*

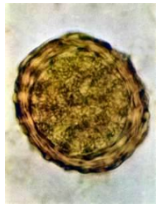
- **Bacteriophages:** Coliphages K-12, T2; P22 (indicators for decay of enteric viruses)



- **Enteric Viruses:** Adenoviruses; PAdV-3, HAdV type 40



- **Parasites:** *Cryptosporidium parvum*, *Ascaris suum* (indicator for *Ascaris lumbricoides*)

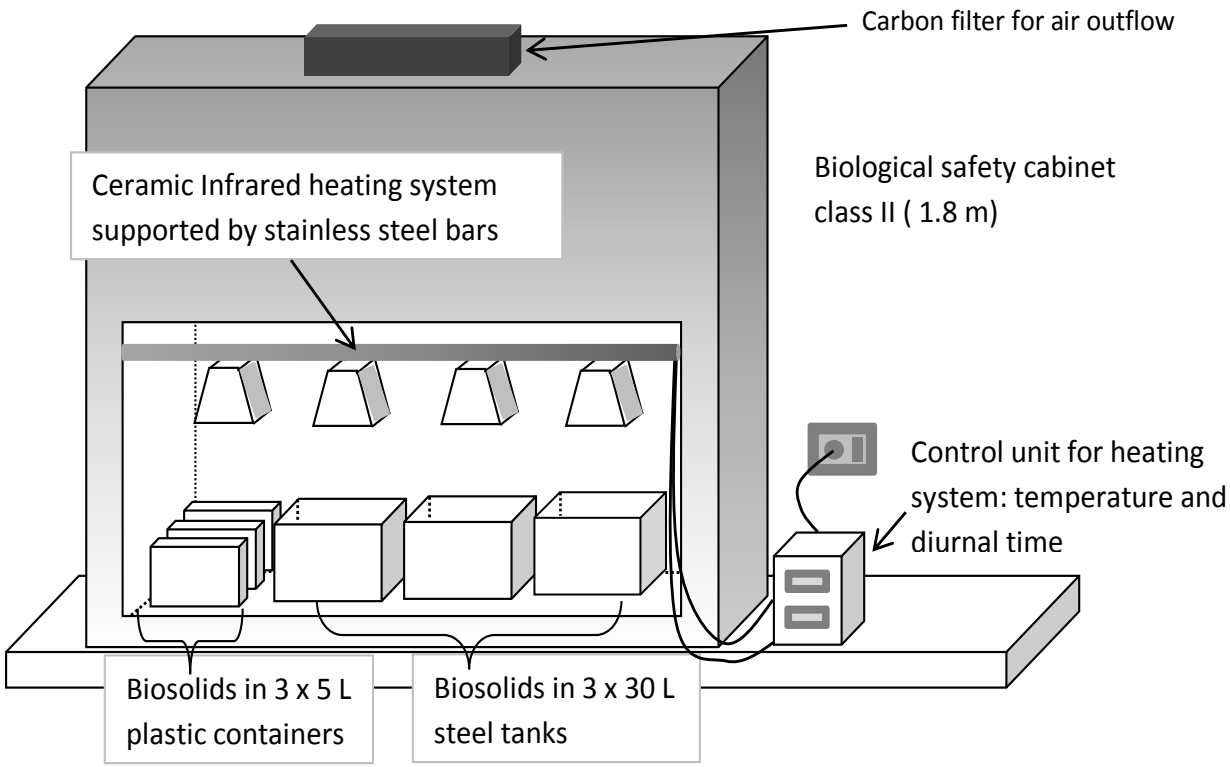


- The biosafety of the simulation allowed testing of a full range of pathogens, compared to field

Simulation setup 1 using laboratory facility

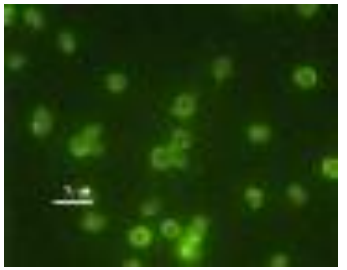
- Sludge from an ETP anaerobic digester
- Sludge was settled for 4 days then decanted to produce solid material containing 3 to 4% DS content.
- This material was pumped into three 25 L tanks and three 4.5 L plastic containers, which were placed in a biological safety cabinet class II (BSC II) within a purpose built PC2 facility at RMIT

Simulation setup 2

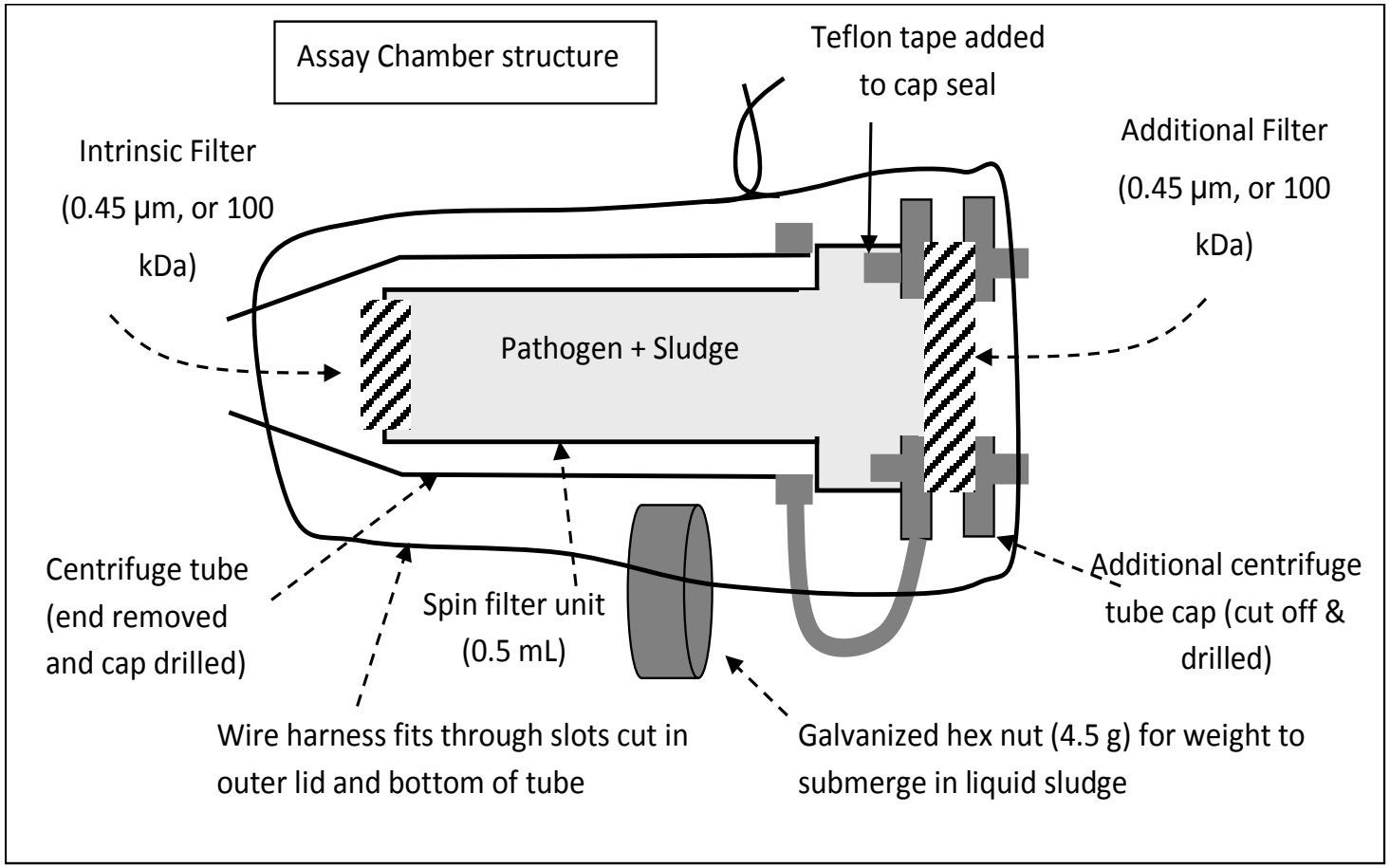


Assay Chambers

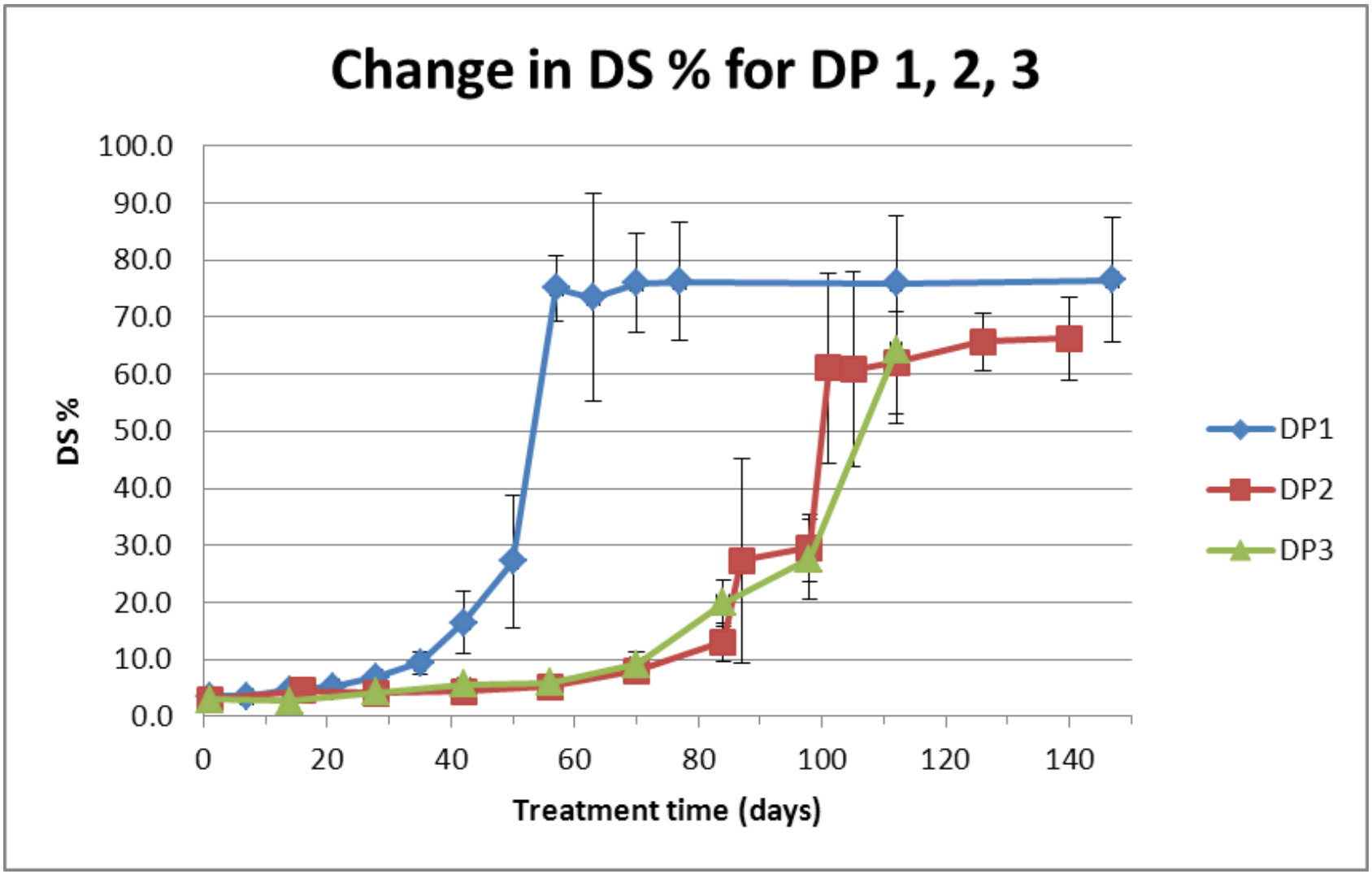
- Assay chambers (0.5 mL) were used because of limited supplies of porcine adenovirus, *Cryptosporidium parvum* and *Ascaris suum* for the simulation experiments.



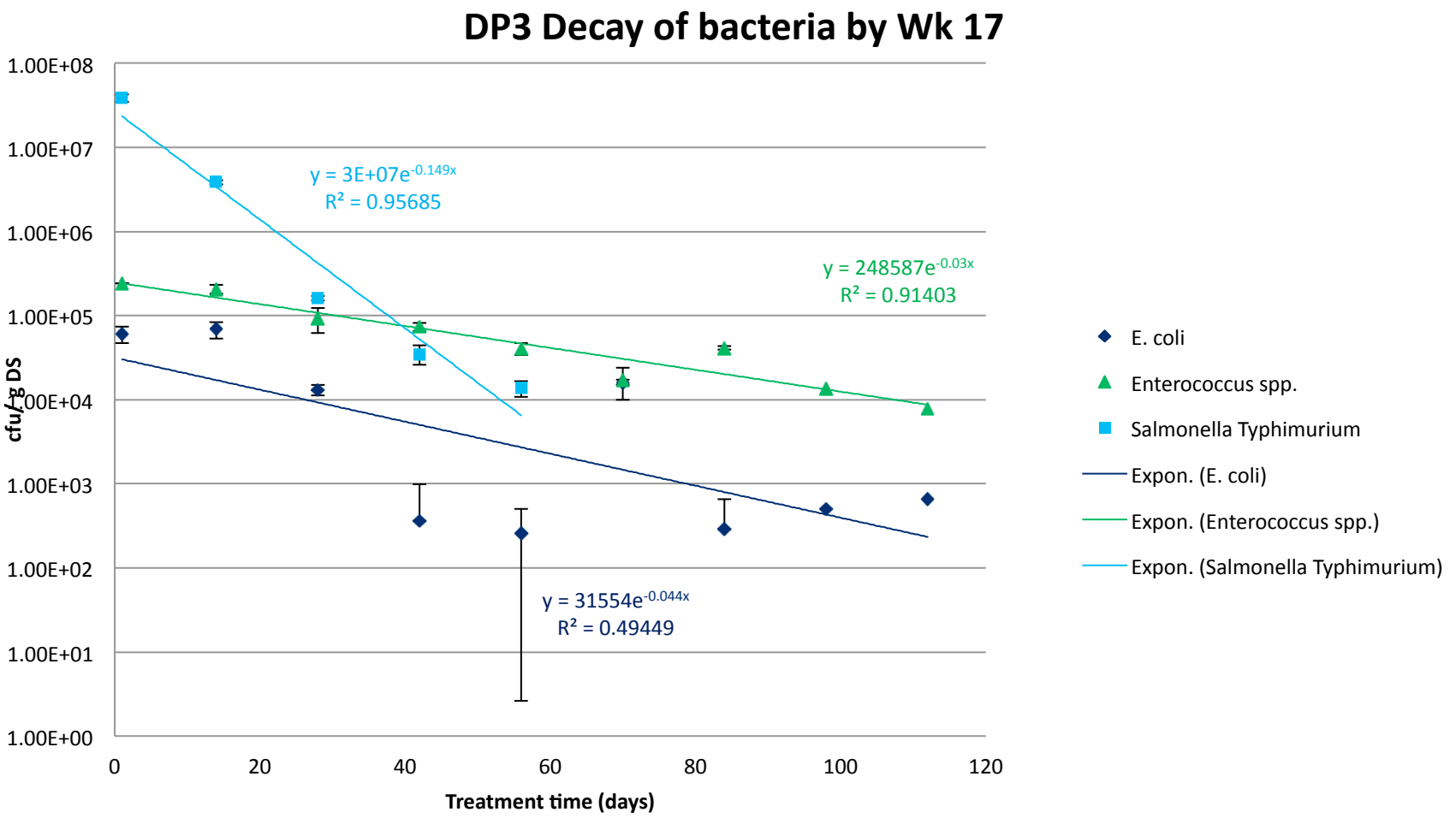
Assay Chamber design



Drying rates (Stockpiled at 20-25% DS)



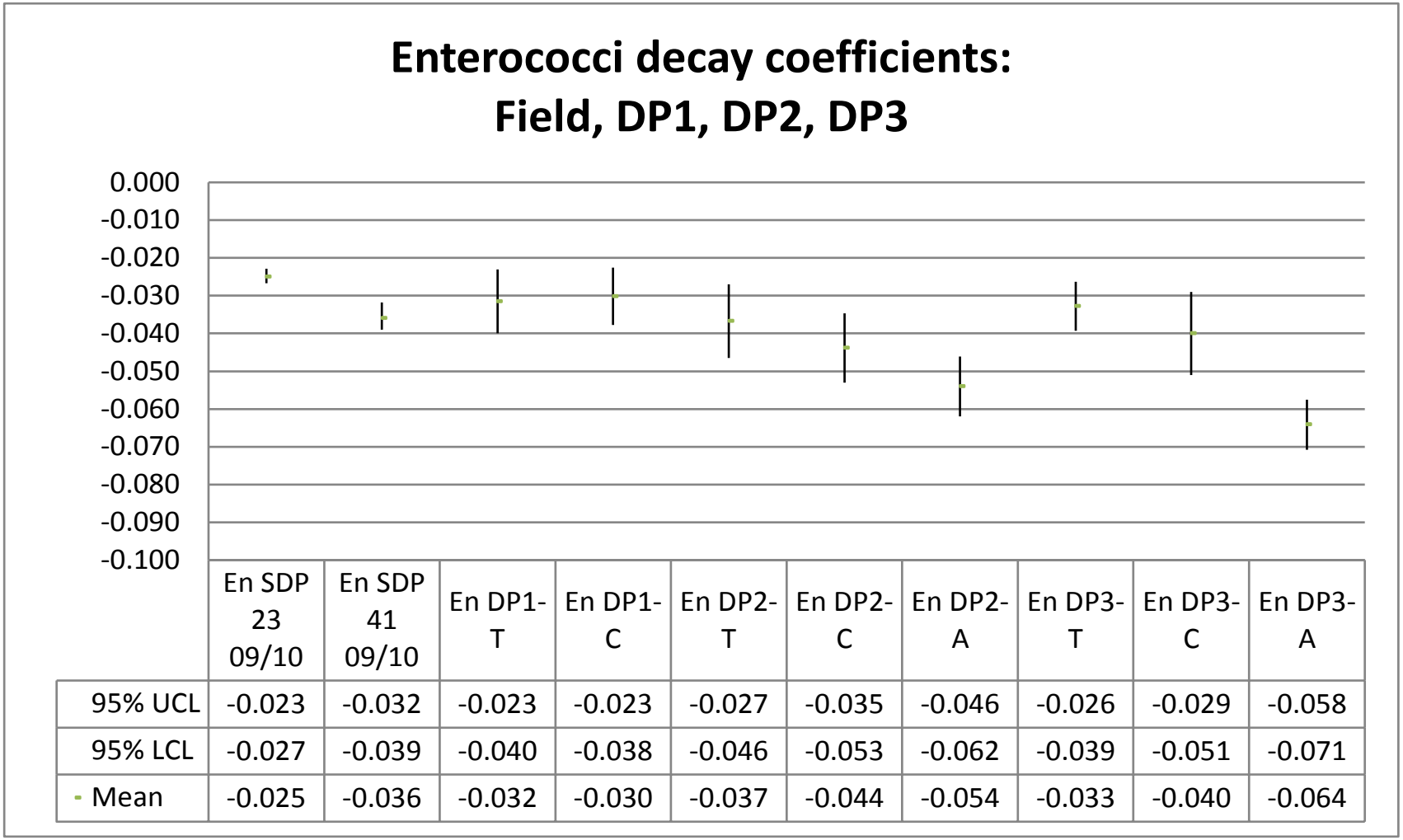
Decay graph for bacteria



Estimating the decay of indicators and pathogens

- The falling numbers of indicators and pathogens over treatment time in pan-drying and stockpiling can be estimated using the following equation
- $N_t = N_0 * e^{-DC*t}$
  - N_t is the number of organisms at time t (cfu or pfu /g DS);
  - N_0 is the number of organisms at time zero (cfu or pfu / g DS), e.g. at the start of pan filling;
  - DC is the organism-specific decay coefficient (Table 12.7, 12.8);
  - t is time t (days).

Plot of decay coefficients (mean & confidence limits)



	En SDP 23 09/10	En SDP 41 09/10	En DP1-T	En DP1-C	En DP2-T	En DP2-C	En DP2-A	En DP3-T	En DP3-C	En DP3-A
95% UCL	-0.023	-0.032	-0.023	-0.023	-0.027	-0.035	-0.046	-0.026	-0.029	-0.058
95% LCL	-0.027	-0.039	-0.040	-0.038	-0.046	-0.053	-0.062	-0.039	-0.051	-0.071
Mean	-0.025	-0.036	-0.032	-0.030	-0.037	-0.044	-0.054	-0.033	-0.040	-0.064

Estimated Log_{10} reduction values (LRV) across the full treatment train

Pathogen	Activated sludge	Anaerobic digestion	Drying-pan and or stockpiling (59 weeks)	Total LRV
Enteric viruses	1.04	1.14	2.2	4.4
Ascaris eggs	0.0	0.06‡	1.0	1.1
Cryptosporidium oocysts	0.98	0.77	2.0	3.8

Main Conclusions for Sludge Treatment

- For ETP and WWTPs with similar treatment trains both for average and worst-case data the forecast treatment time for verification to provide T1 grade biosolids in pan-drying and or stockpiling is 117 weeks, due to the requirement for 2 $\log_{10}$ decay of *Ascaris* eggs.
- This could be reduced to 59 weeks, if 1 $\log_{10}$ reduction of *Ascaris* eggs is accepted, given the apparently low level of *Ascaris* eggs in Victorian sludge.

Acknowledgments

- Smartwater
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- Staff and Students that supported the research