What is going on inside pits and septic tanks? The Science of sludge decompostion

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Previously

- Matter cannot be created or destroyed
  - Food + O_2 → BUGS + CO_2
  - Food (no O_2) → bugs + CH_4

Characteristics of pit latrine contents

- Faeces
- Urine
- Anal cleansing material (paper, plastic, rags)
- Washwater
- Detergents
- Disinfectants

The main biodegradable content comes from faeces:

- Moisture content: 70% – 80%
- Bacteria (30%)
- Fat (10% - 20%)
- Protein (2% - 3%)
- Inorganic matter (10% - 20%)

- Implies not more than 80% biodegradable

What happens to material in the pit?

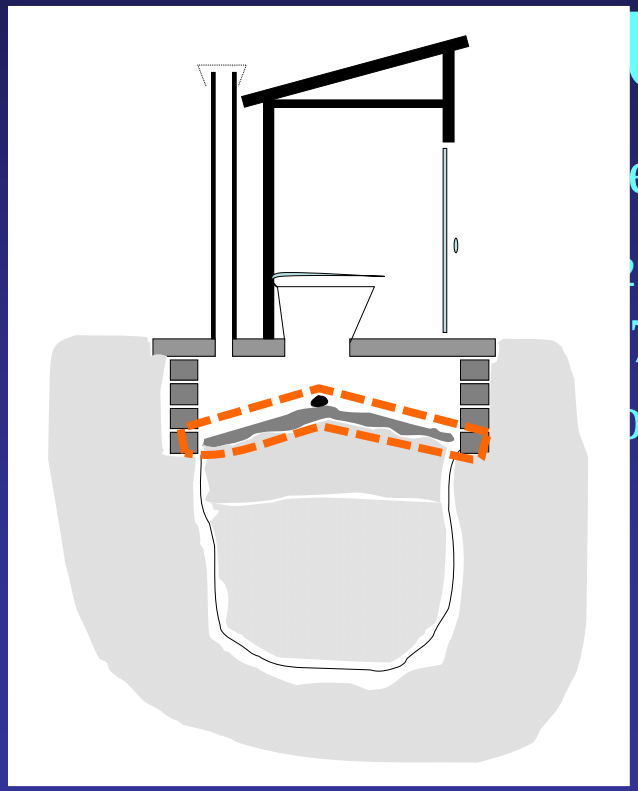
- Non-degradable particulate material remains unchanged
- Biodegradable organics may be degraded
- Particulate nitrogen and phosphorus may be released into the liquid phase by digestion
- Dissolved components may leave the pit as a result of leaching or ground water flow

Pit latrine contents

	Analyte	Units	Average	min	max	n	C of V
Total	**COD**	mg/g wet weight	105	46	199	21	45
		mg/g dry	445	71	987	17	58
	Moisture	% of wet sample	76	29	81	13	6
	Total Solids	% of wet sample	33	19	71	17	54
	Organic Solids	% of solids	36	6	62	17	48
	Inorganic Solids	% of solids	64	38	94	17	26
	Biodegradability						
Soluble	COD	% of total COD	31	7	91	7	97
	Nitrate	mg N/g wet sample	0.028			1	

What happens to the organics?

a) In the presence of air (oxygen)



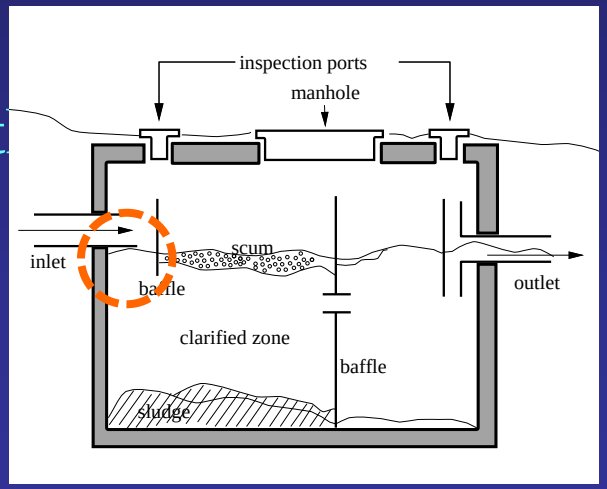
UGS + CO_2

e organics to produce more

2

70% of t

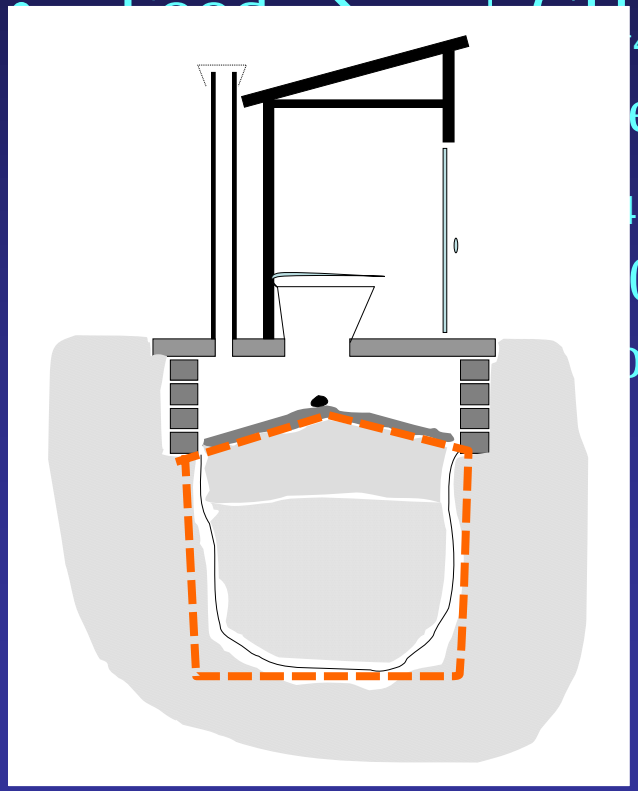
omass

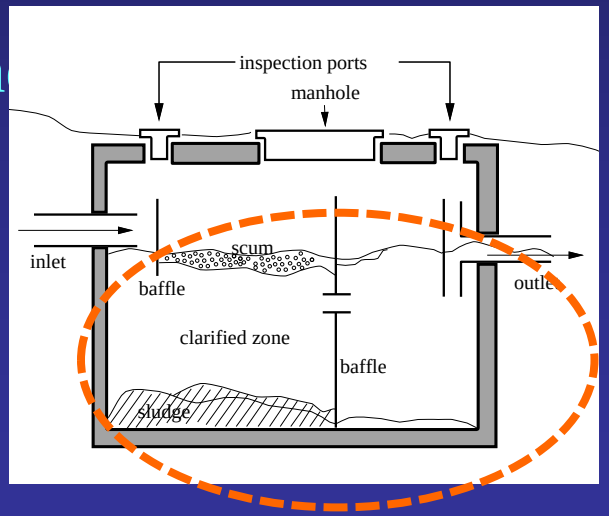


What happens to the organics?

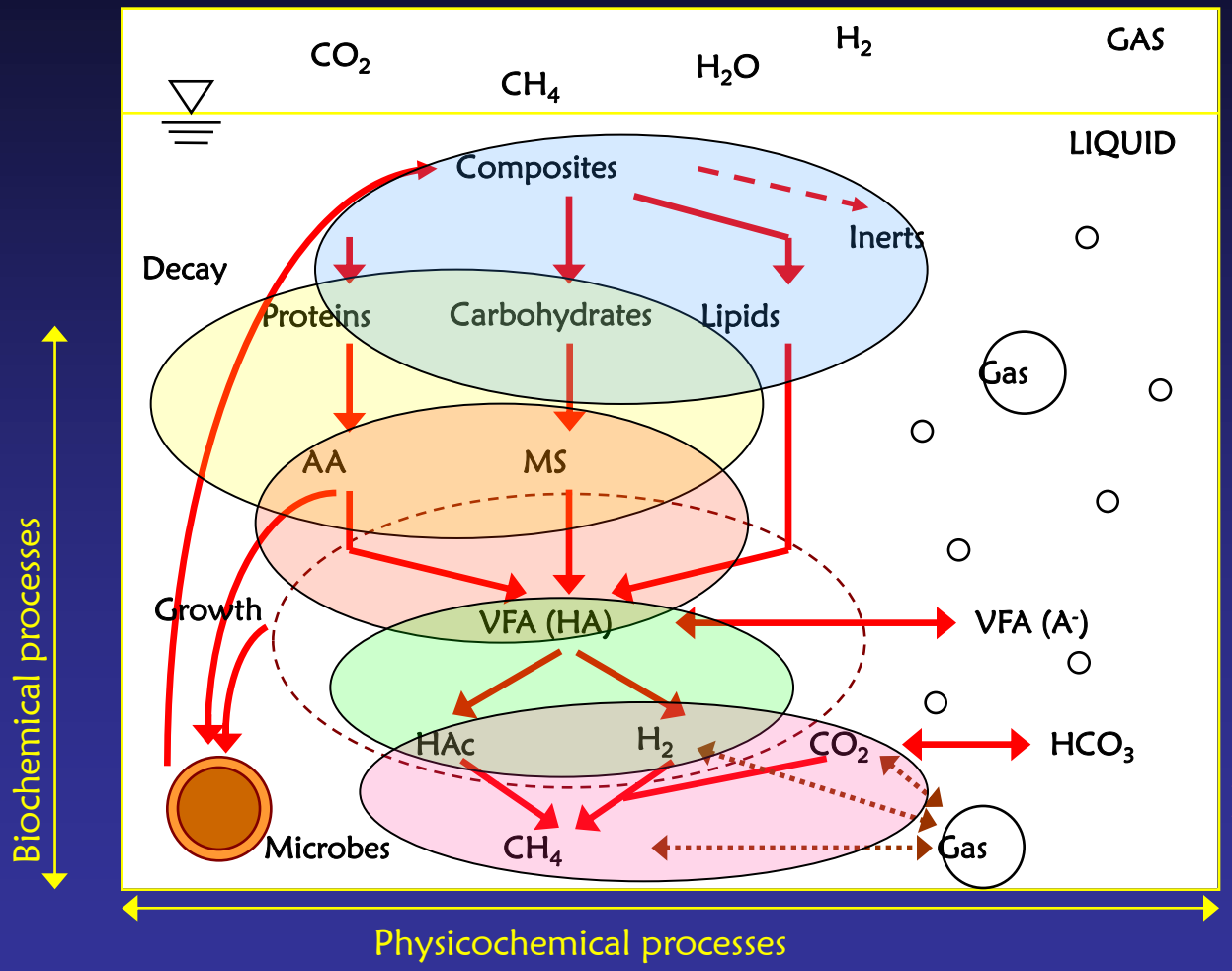
b) In the absence of air (oxygen)

- Food → + CH4
- e organics to produce more
- 0% of th
- omass



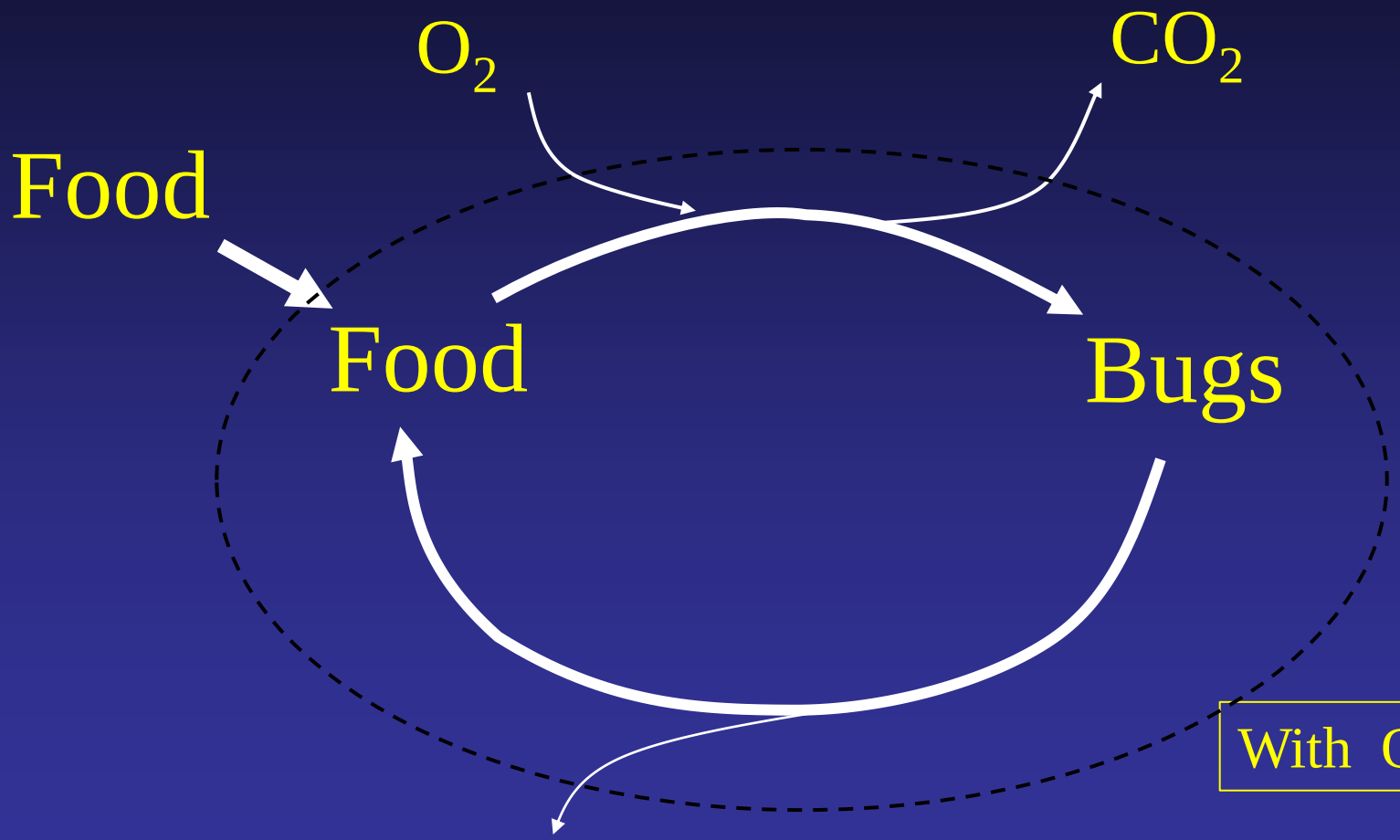


AD details

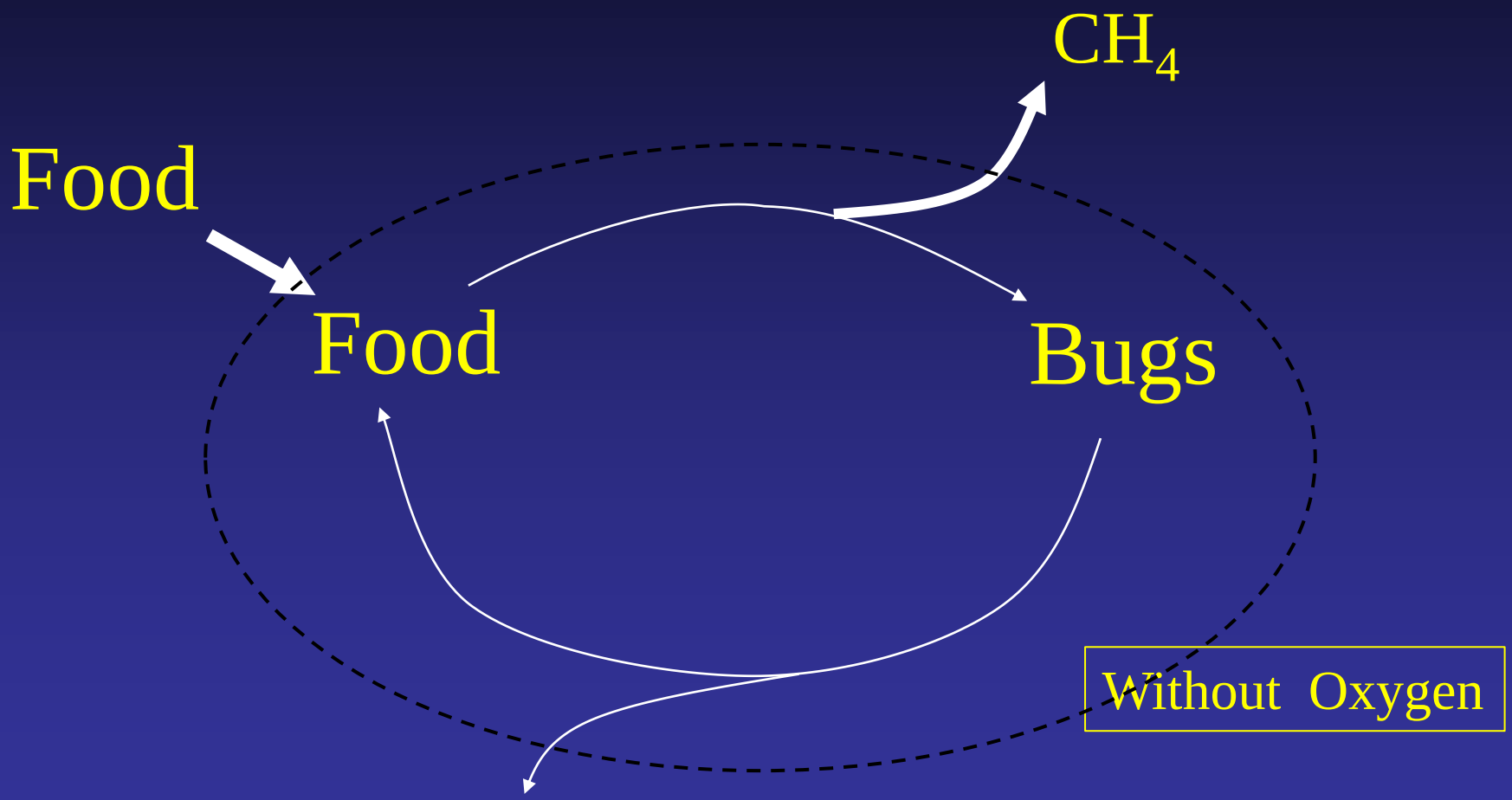


Anaerobic degradation of composite matter, in a two-phase system, according to the ADM1 (adapted from Batstone et al., 2002)

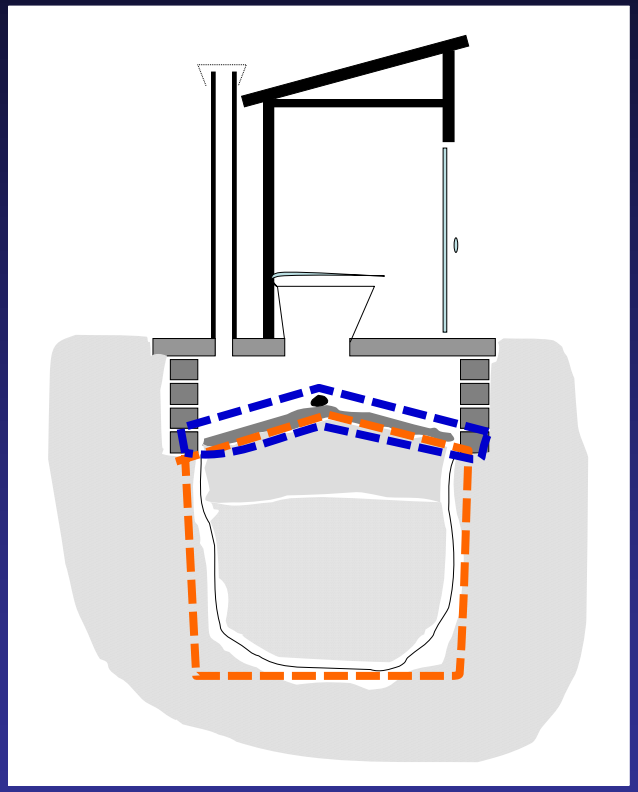
What happens to the bugs?

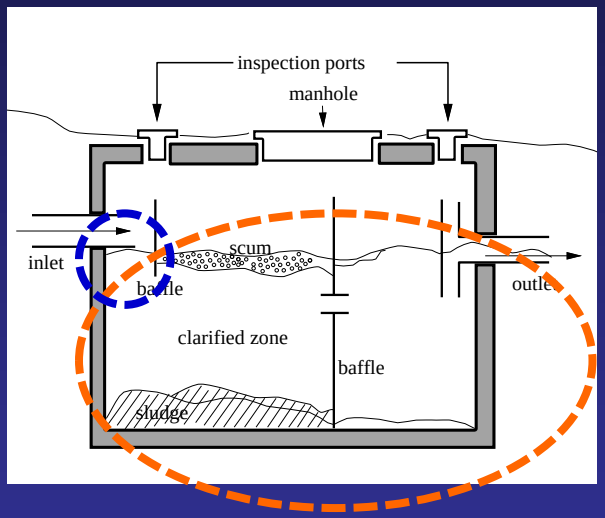


What happens to the bugs?



Aerobic vs. anaerobic





Aerobic zones are relatively small

But impact on overall biodegradation may be significant

Recap

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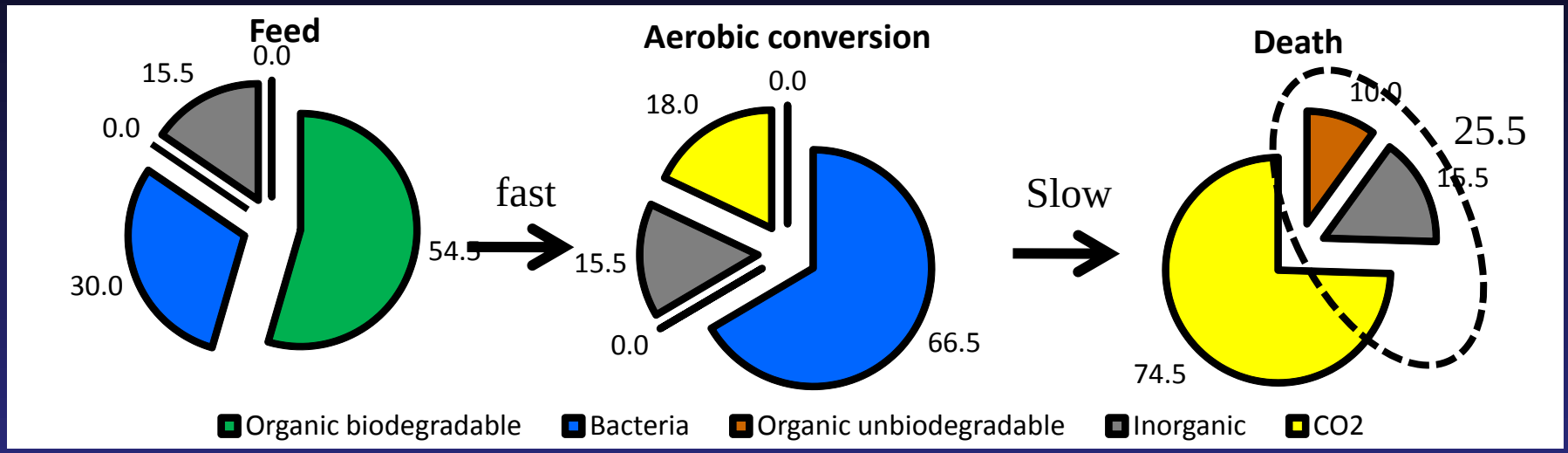
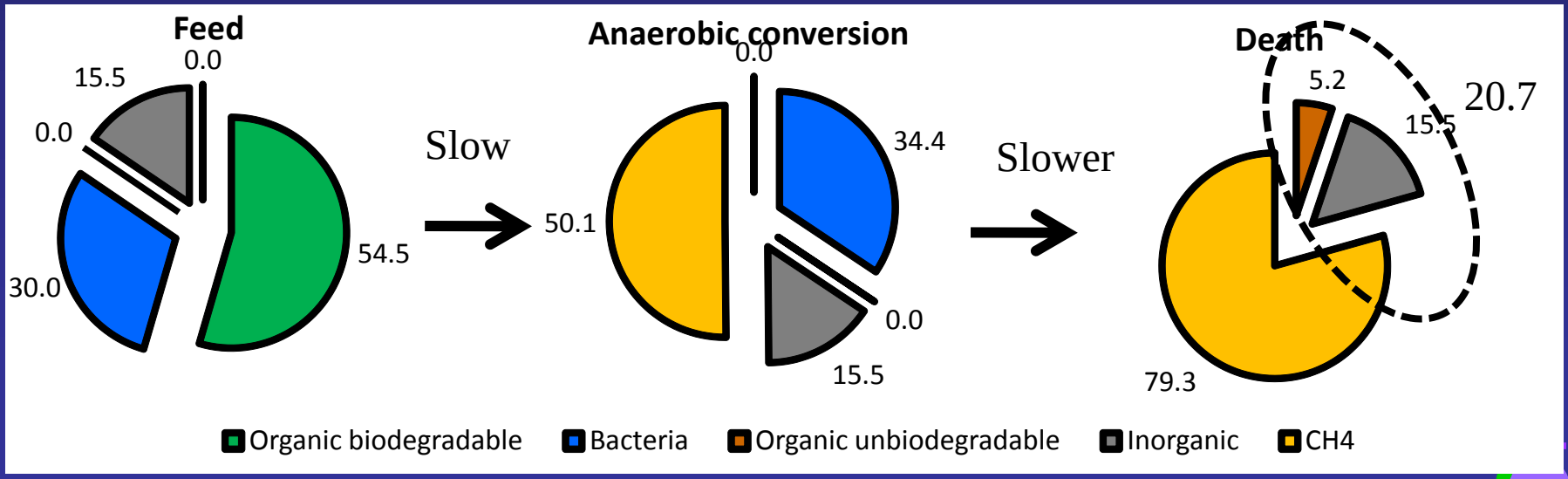
Evolution of pit contents





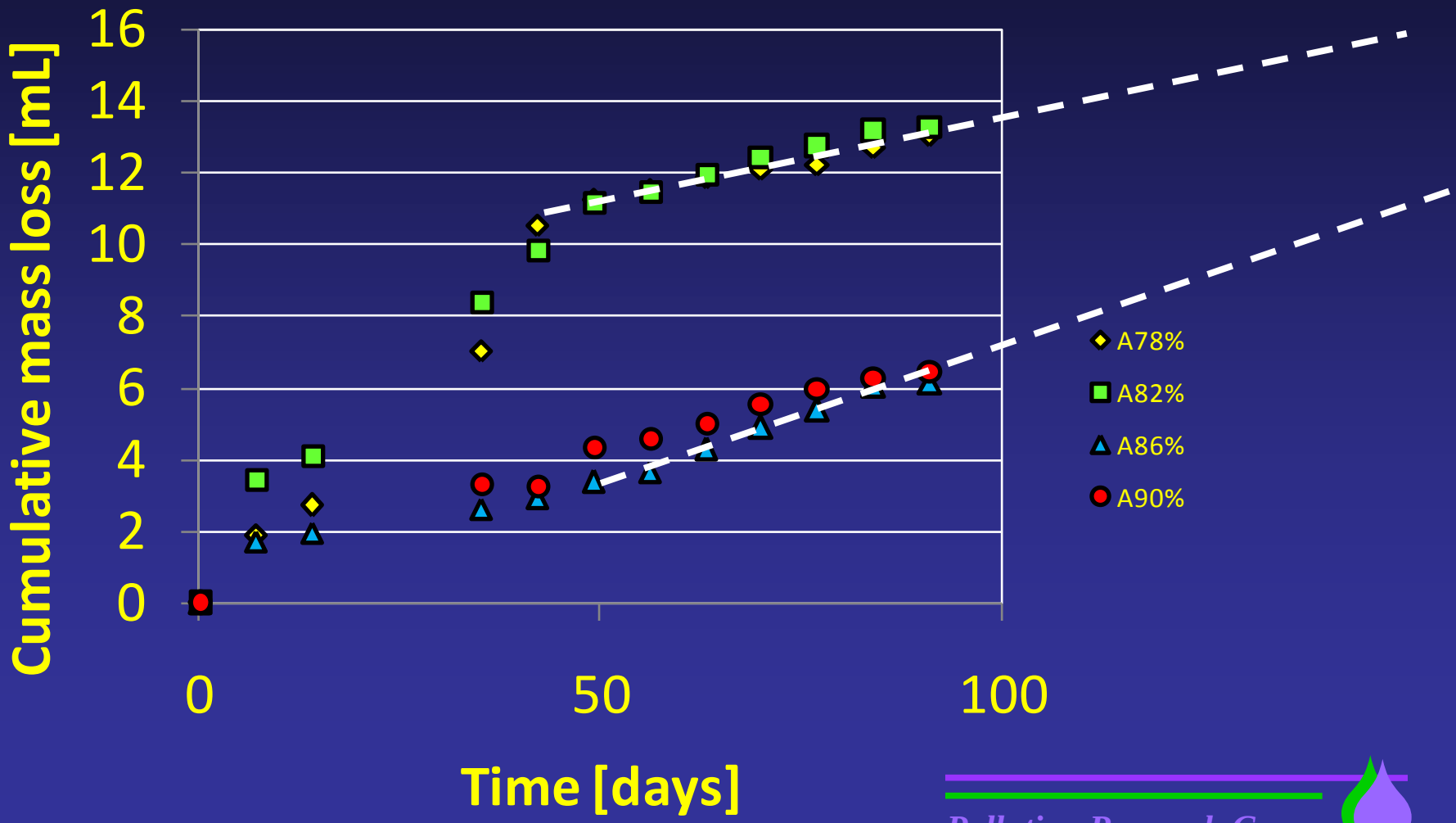
Evolution of pit contents

- If the contents are left long enough:
  - All biodegradable material disappears
  - In the presence of oxygen, material initially disappears faster, but the final amount of non-degradable material is more
  - In the absence of oxygen, material disappears relatively slowly, but the final amount of non-degradable material is less
  - Overall conversion factors are still being calibrated.

Experimental evidence?

- Many reports that "*wet pits fill more slowly*"
- Currently running an experiment to show that
  - more water = more anaerobic conditions
  - More anaerobic means initial degradation rate slower
  - But final residual mass is less

Preliminary Results (Not complete)



Pollution Research Group

Model of pit degradation

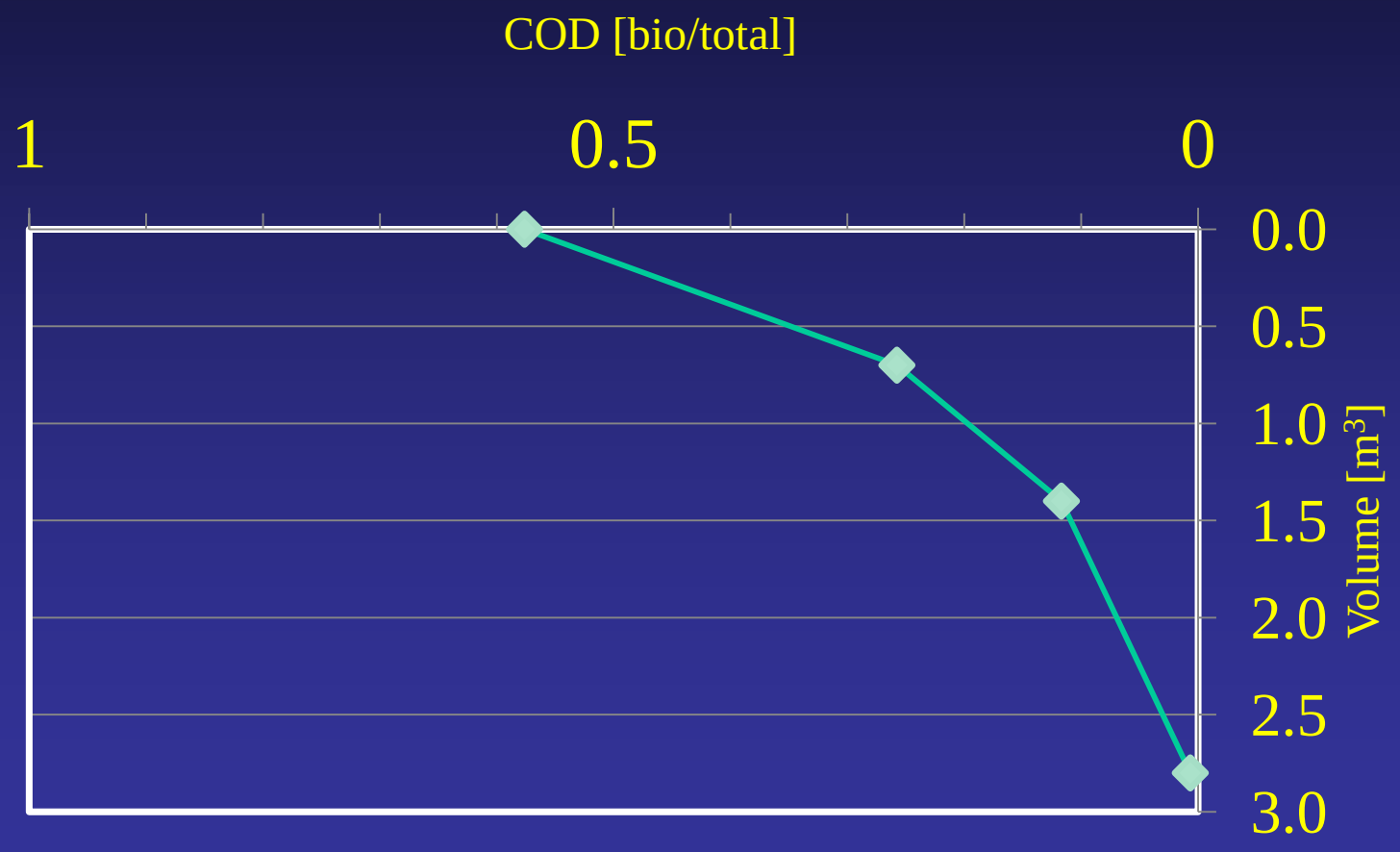
Volume of contents in pit

$$V(T_i,T) = R_u \cdot T \int_{T_i}^{T} f_u(t) \cdot \phi(t)\, dt = R_u \cdot \left[\left(1 + k \cdot \frac{v_{bo}}{v_{uo}}\right)(T - T_i) + \frac{\left((1-k)\frac{v_{bo}}{v_{uo}}\right)}{r}\left[e^{-rT_i} - e^{-rT}\right] \right]$$

Biodegradability of pit contents of a certain age

$$\beta(\theta) = \frac{v_b(\theta)}{v(\theta)} = \frac{v_{bo}e^{-r\theta}}{v_{uo} + kv_{bo} + (1-k)v_{bo}e^{-r\theta}} = \frac{\frac{v_{bo}}{v_{uo}}e^{-r\theta}}{1 + k\frac{v_{bo}}{v_{uo}} + (1-k)\frac{v_{bo}}{v_{uo}}e^{-r\theta}}$$

Biodegradable COD profile in pit - with rubbish



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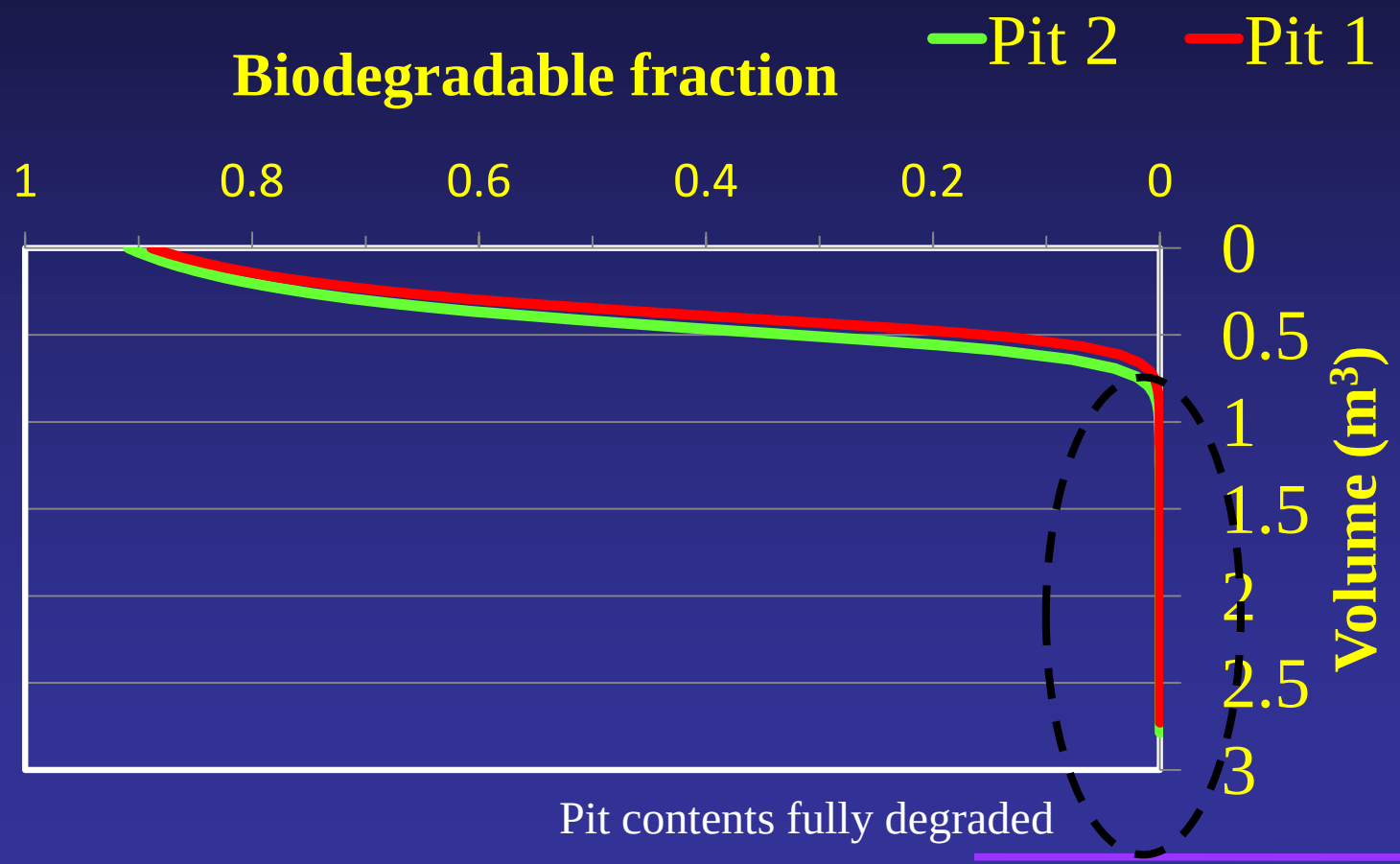
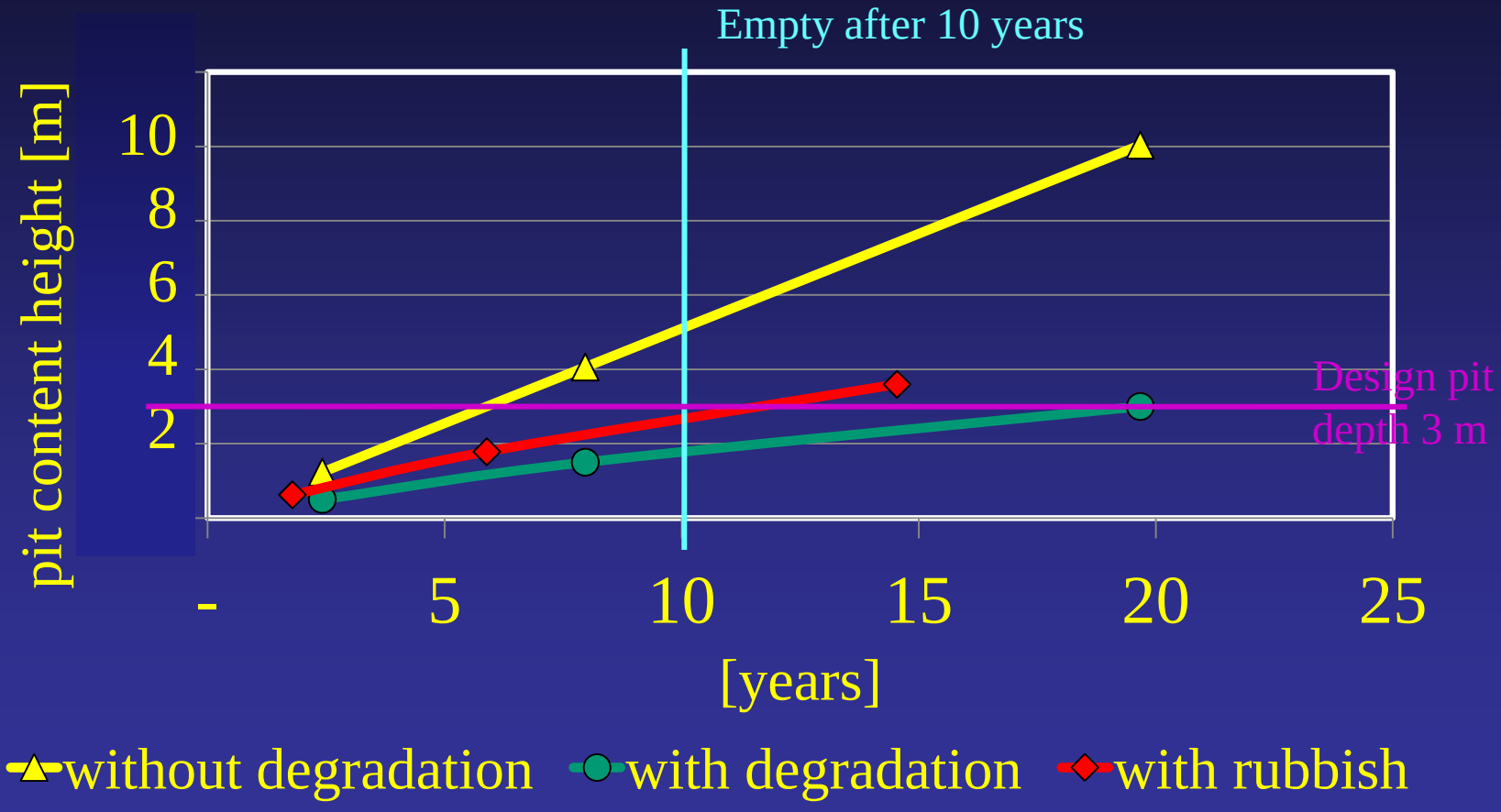


Model prediction: filling rate



Conclusions from modelling real pits

- Significant degradation occurs in pit
- Bottom layers of pit are completely degraded after a few years
- Only top 0.5 m or so still contain biodegradable material (depends on pit size and number of users)
- Presence of rubbish significantly shortens life of pit

Conclusions

- Organic material breaks down due to aerobic and anaerobic processes
- Micro-organisms that do the work are *already present in faeces*
- Presence of non-degradable rubbish significantly increases the pit filling rate
- Anaerobic digestion results in (slightly) lower pit filling rates

Acknowledgements

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