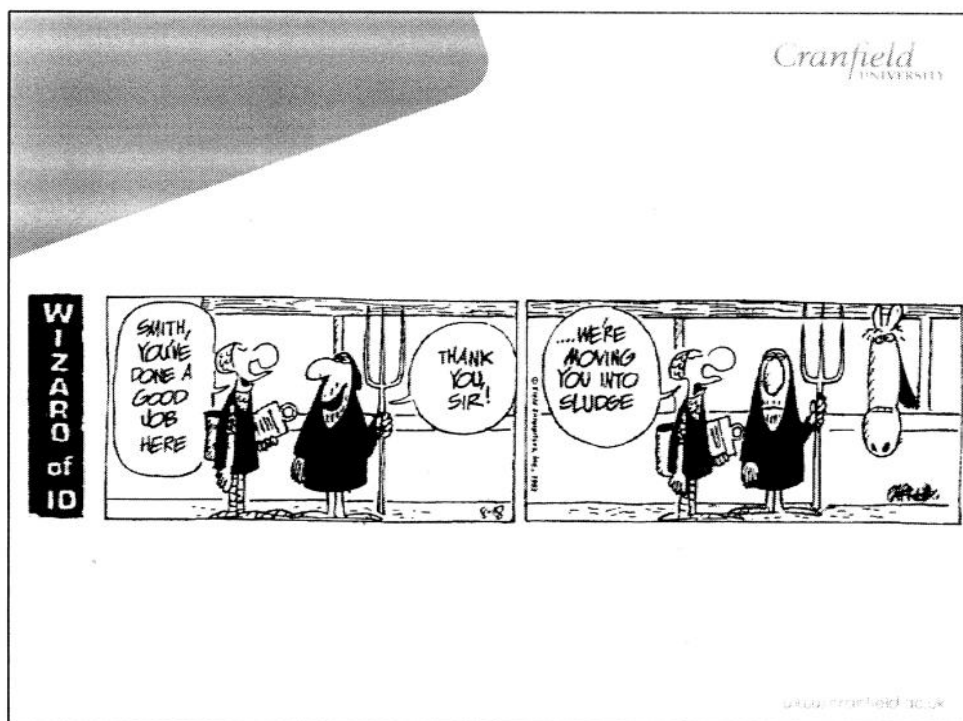
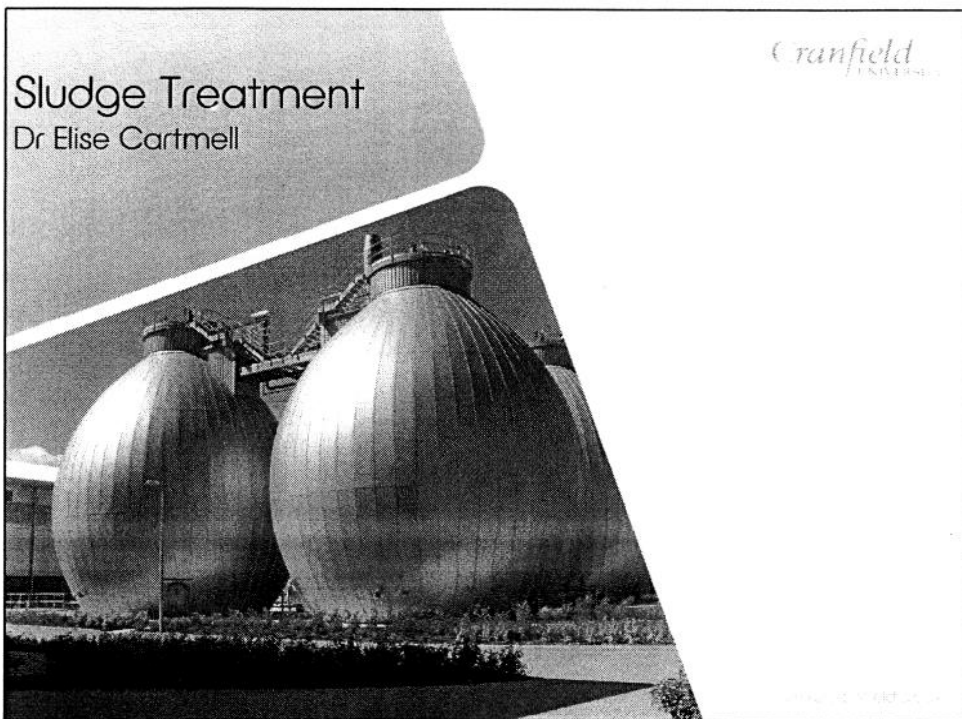
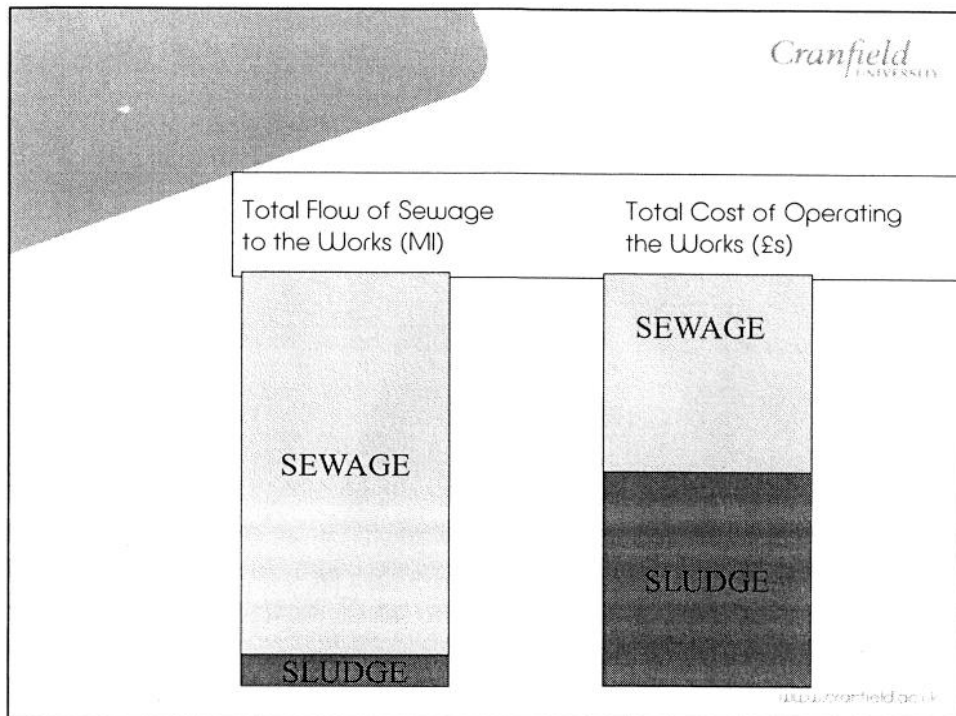






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How much?

- 1.78 million tonnes of dry solids was produced in the UK 2007/08

From
<http://www.water.org.uk/home/news/press-releases/sustainable-water/sustainability2008.pdf>

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What will be covered in the lecture

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- Drivers for sludge treatment
- Wastewater sludge production
- Treatment
 - Removal of water - Thickening/Dewatering
 - Stabilisation – Digestion/Composting

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Lecture aims

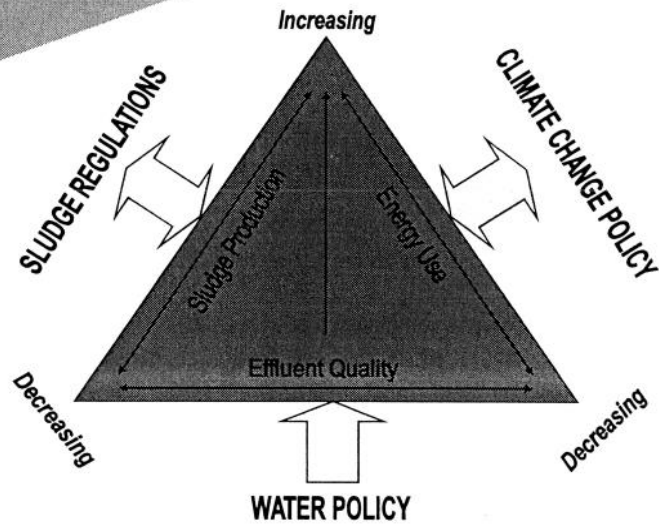
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- To be aware of the common methods of sludge treatment
- To appreciate the regulatory drivers for sludge treatment

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Current drivers in sludge treatment and re-use

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Why treat sludge

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- Reduce risks to public health
- Reduce smell nuisance
- Reduce volume
- Reduce cost
- Increase sludge stability
- Prepare for utilisation
- Treatment increasingly 'product driven'

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Sludge treatment requirements

Conventional treatment

- 2 Log₁₀ reduction *E.coli*
- Cropping and land use restrictions apply

Advanced treatment

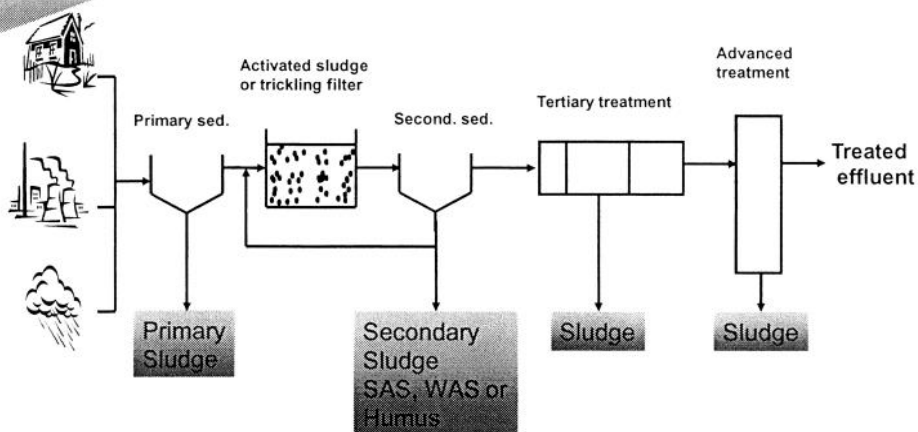
- 6 Log₁₀ reduction *E. coli* to $<5 \times 10^2$ CFU/g
- No *Salmonella* spp in 50 g
- No cropping restrictions

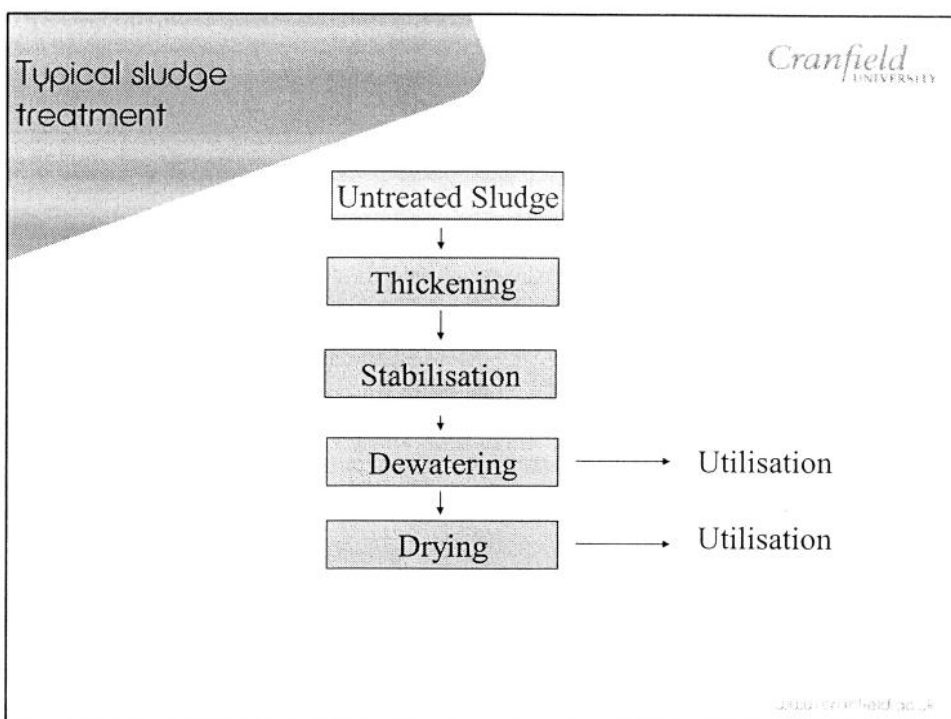
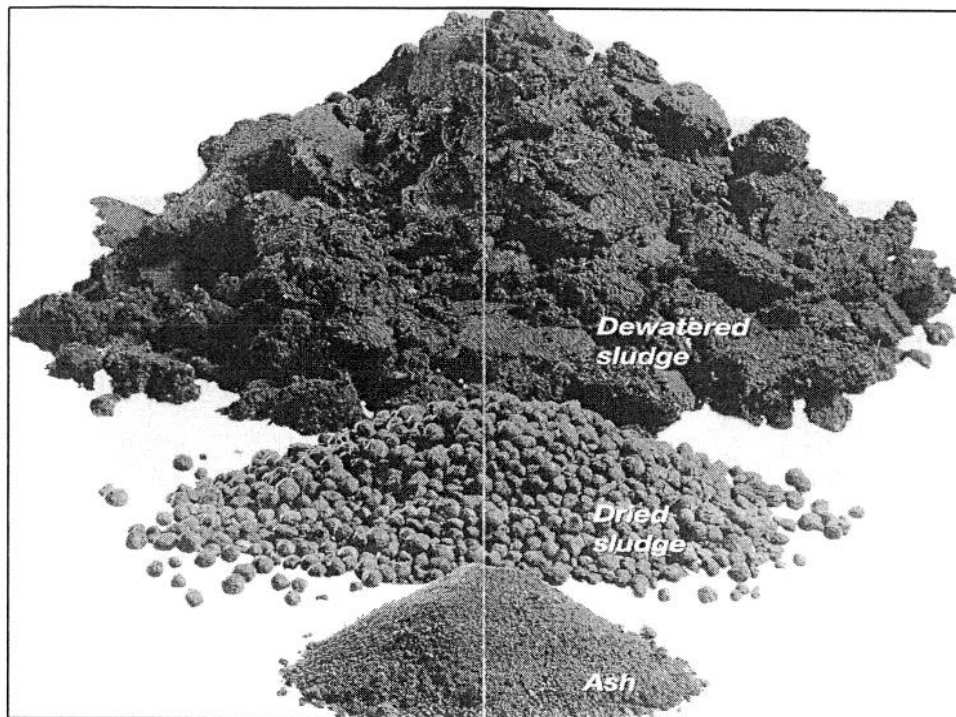
Continuous record of processes

Validation to common standards

HACCP – Hazard Analysis and Critical Control Point Monitoring

Where does sludge come from?





Removal of Water

Terminology

Stage	Water Content (%)
Feed	0%
Thickening	5%
Dewatering	25%
Drying	>25%

Background

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Higher volumes of sludge are being generated by....

EU legislation driven effluent improvements

Increased use of advanced biological treatment

...the result is increasing levels of sludge production
with an increasing degree of difficulty to thicken and
dewater

Plus increasing need to thicken raw sludge

sludge@cranfield.ac.uk

Background

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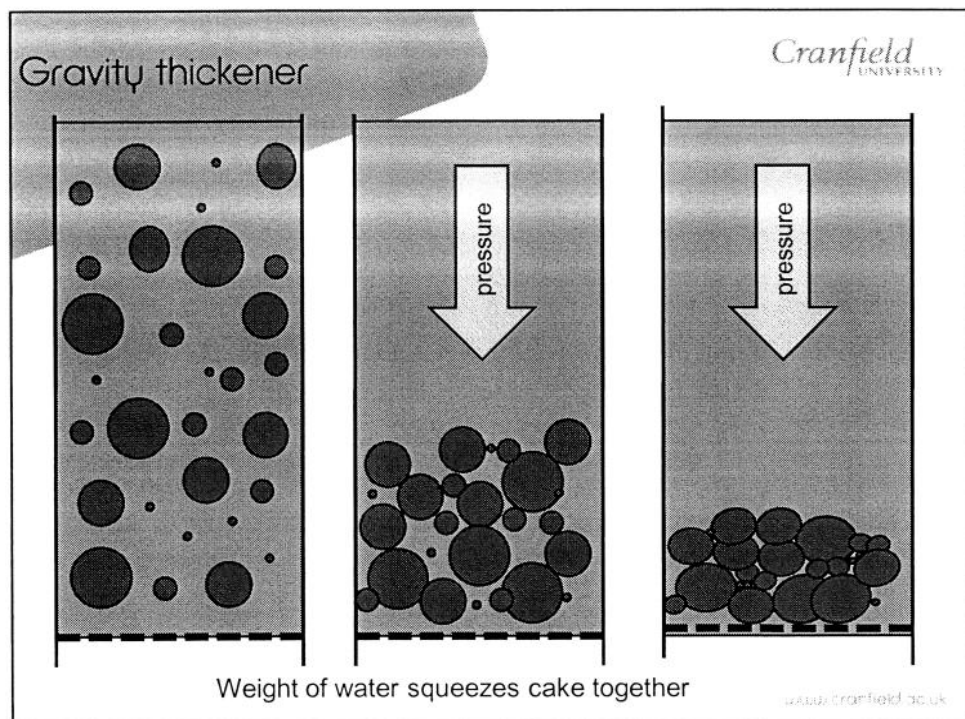
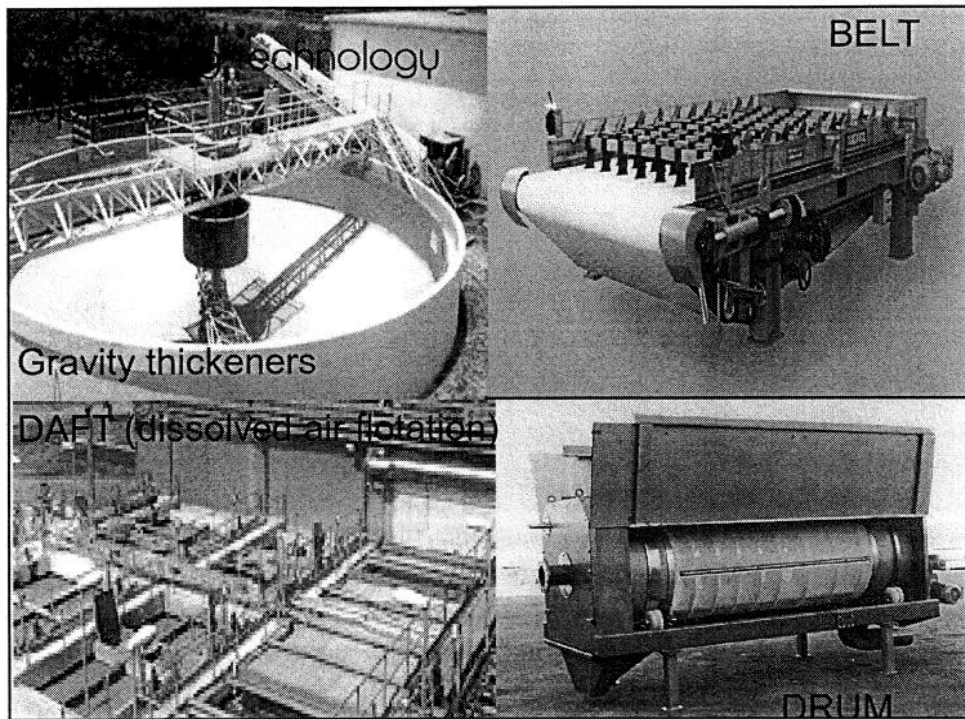
- Thickening target 6 – 8 % dry solids
- Mechanical thickening as opposed to gravity tanks
now industry norm
- Requires polyelectrolyte

Gravity Belt Thickener

Rotary Drum Thickener

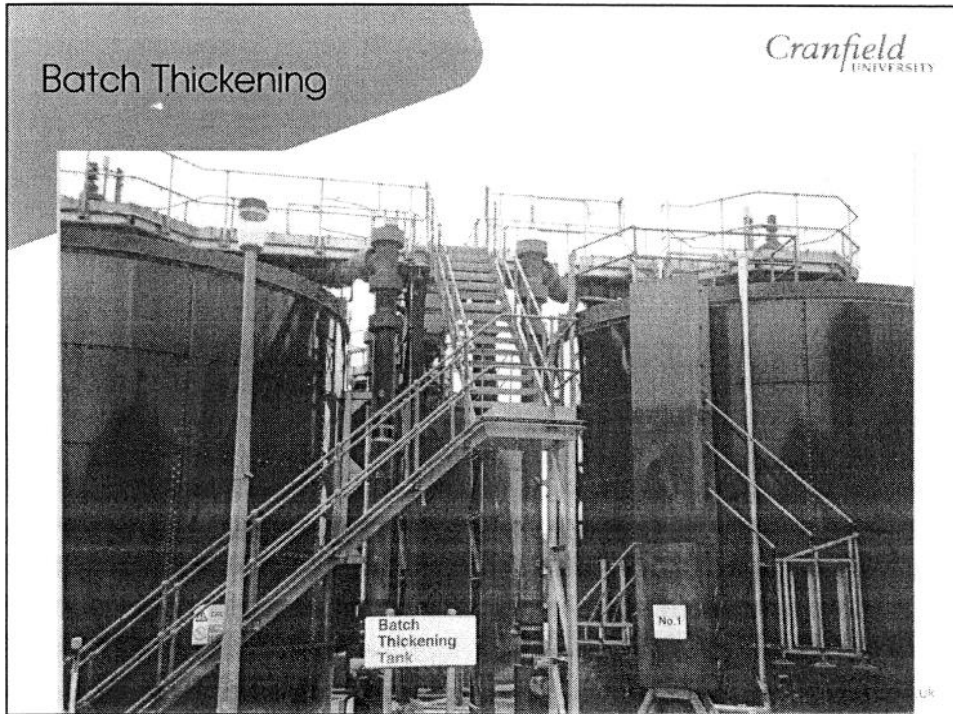
Centrifugal Thickener

sludge@cranfield.ac.uk



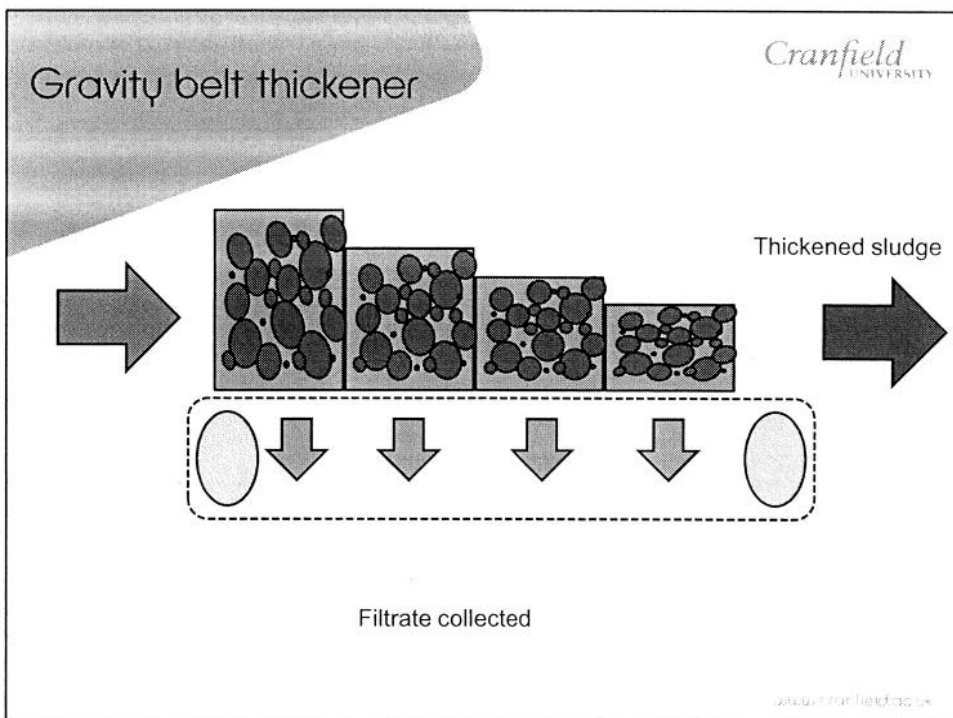
Batch Thickening

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Gravity belt thickener

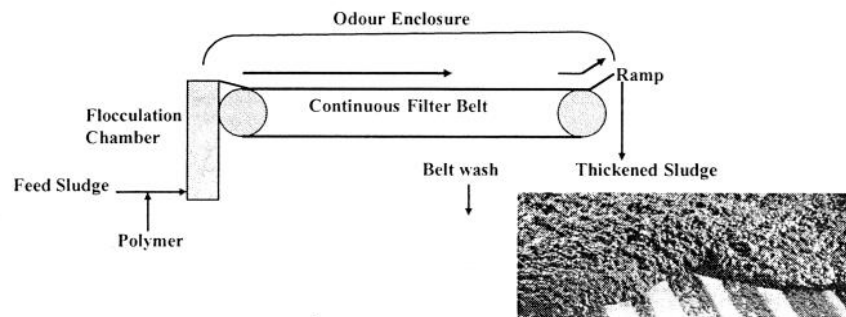
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Gravity Belt Thickener

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Base technology: Gravity filtration

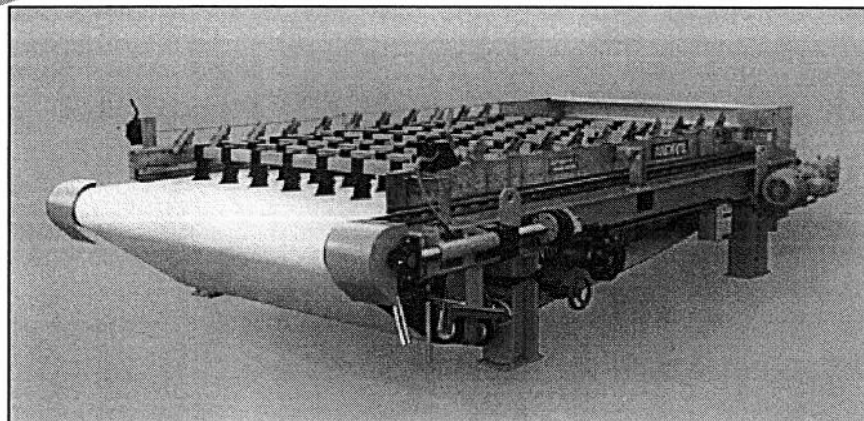


throughputs of 15-50m³ /hr

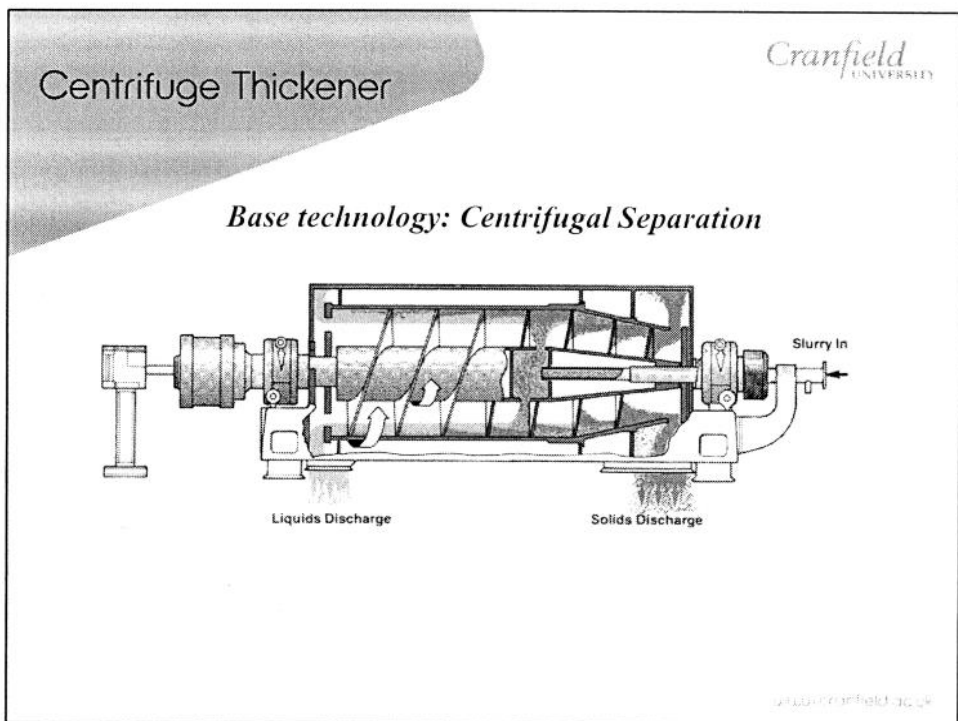
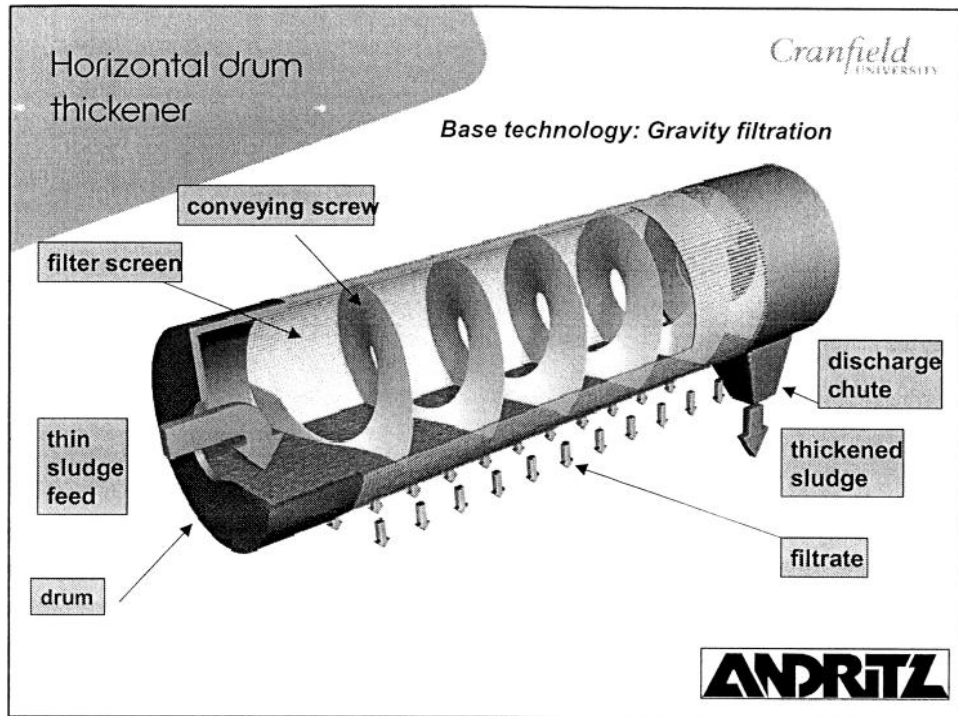
www.cranfield.ac.uk

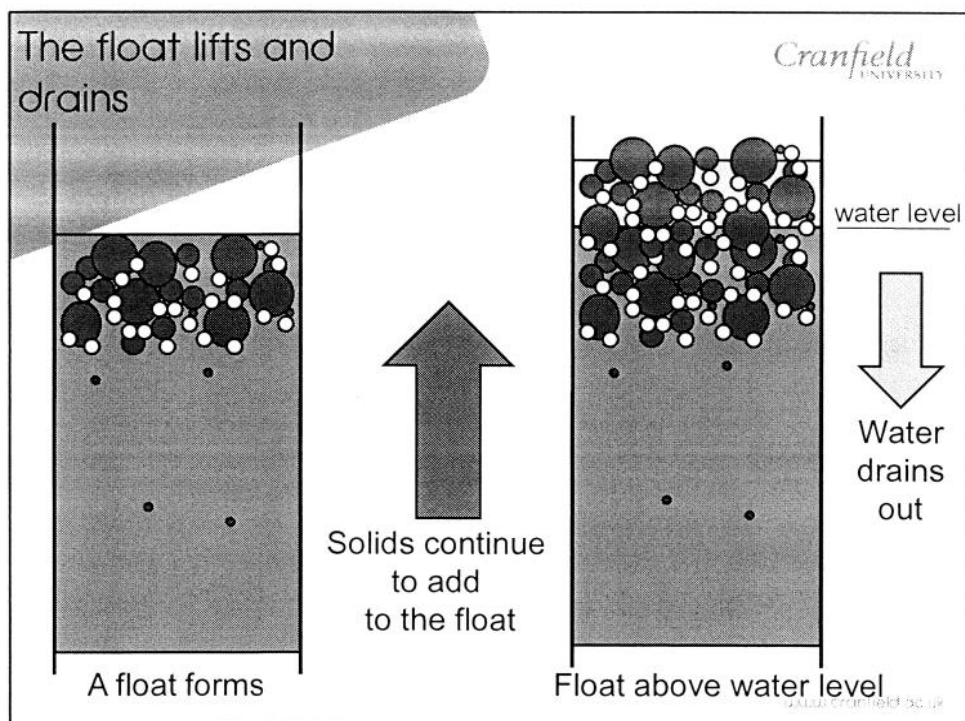
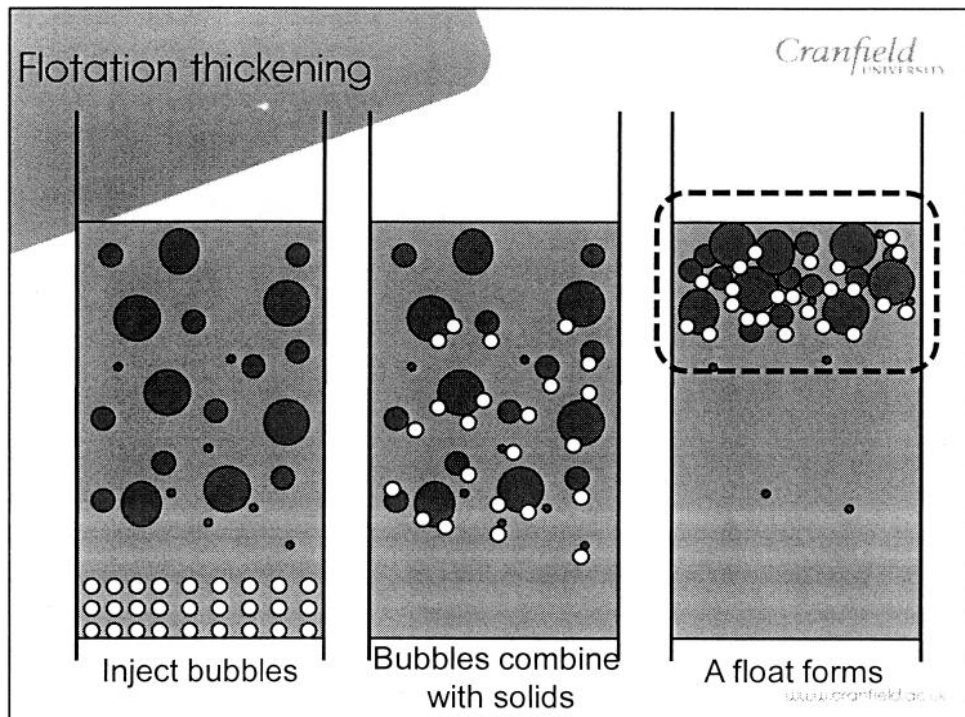
Typical Gravity Belt Thickener

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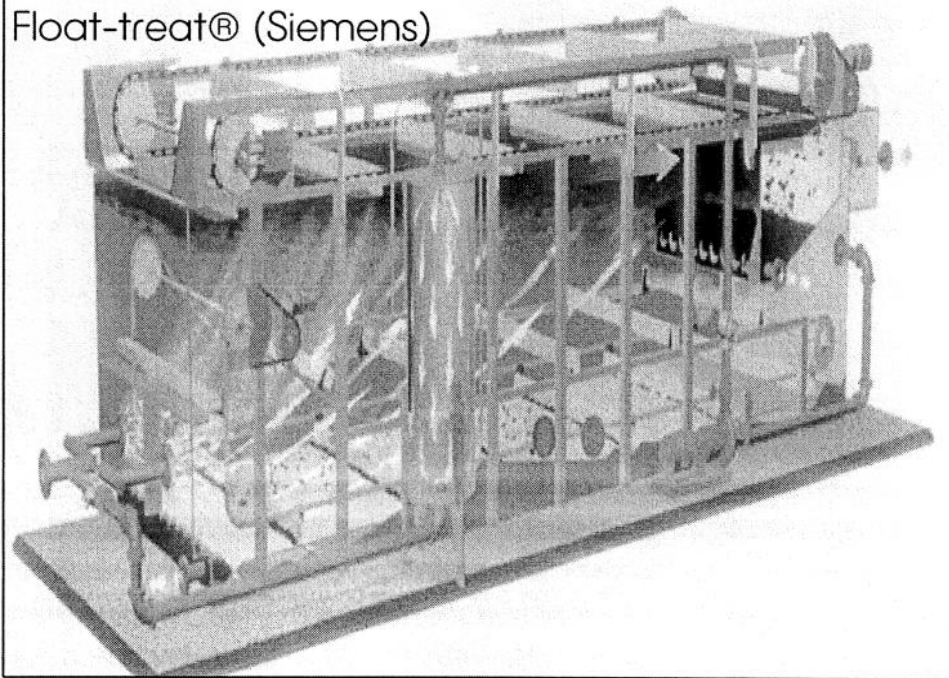


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Float-treat® (Siemens)



Dewatering -removal of
water to produce
cake at
18-35% dry solids

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Equipment types

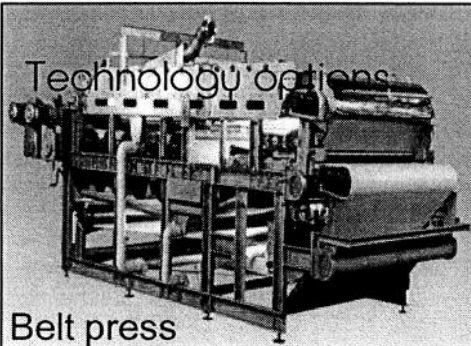
Belt Press

Centrifuge

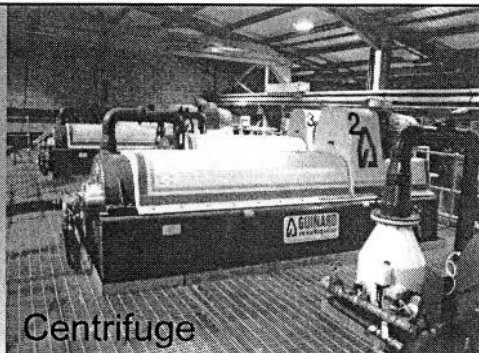
Filter Press

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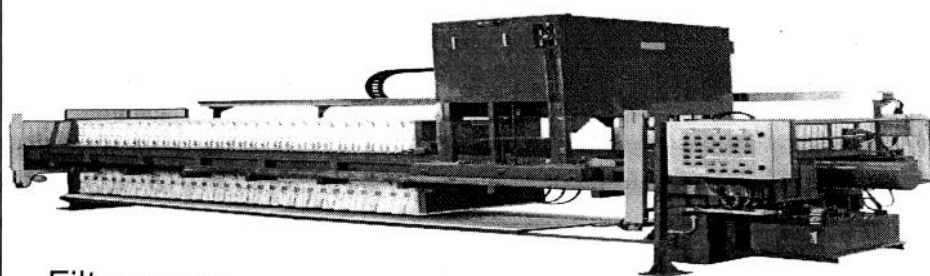
Technology options



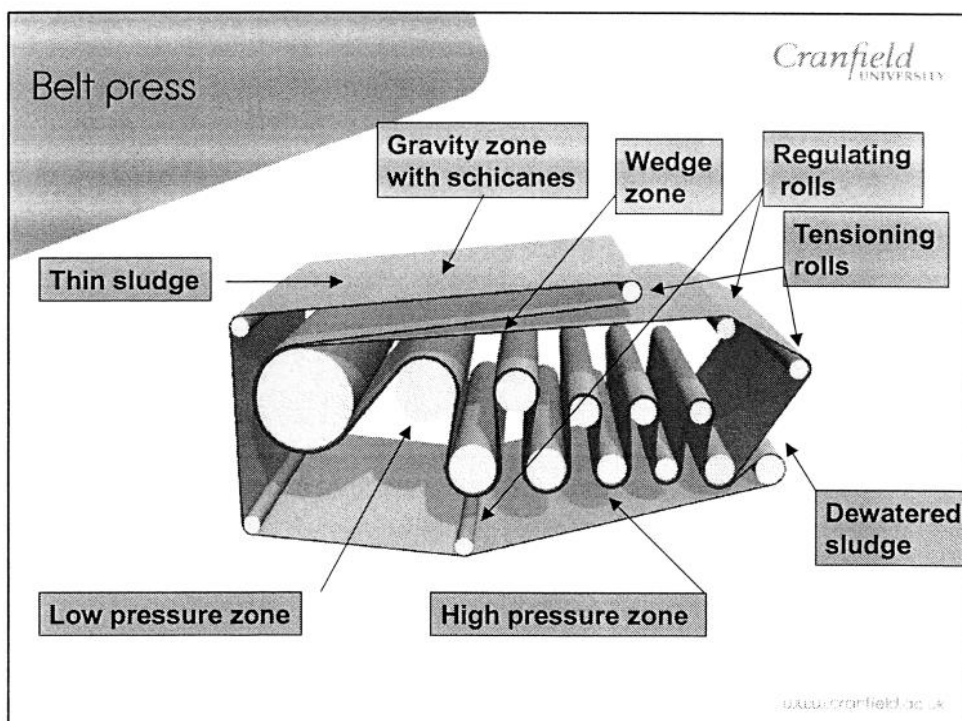
Belt press



Centrifuge

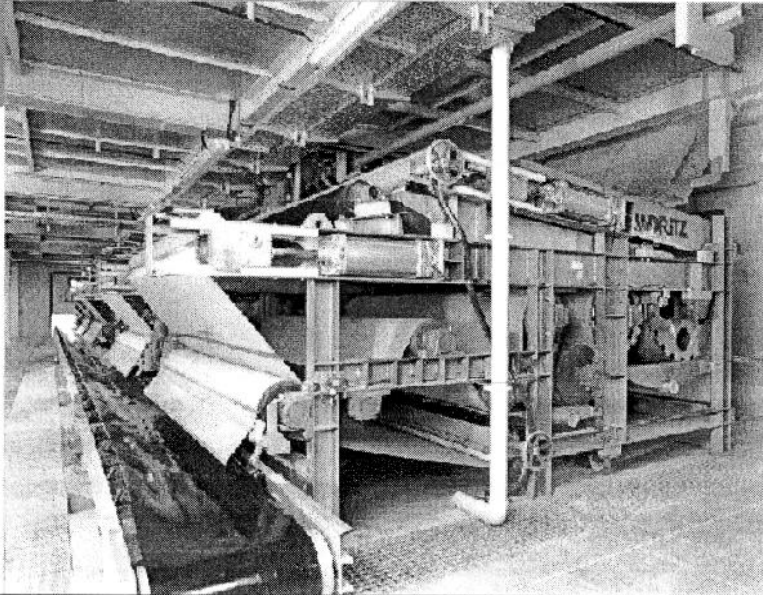


Filter press



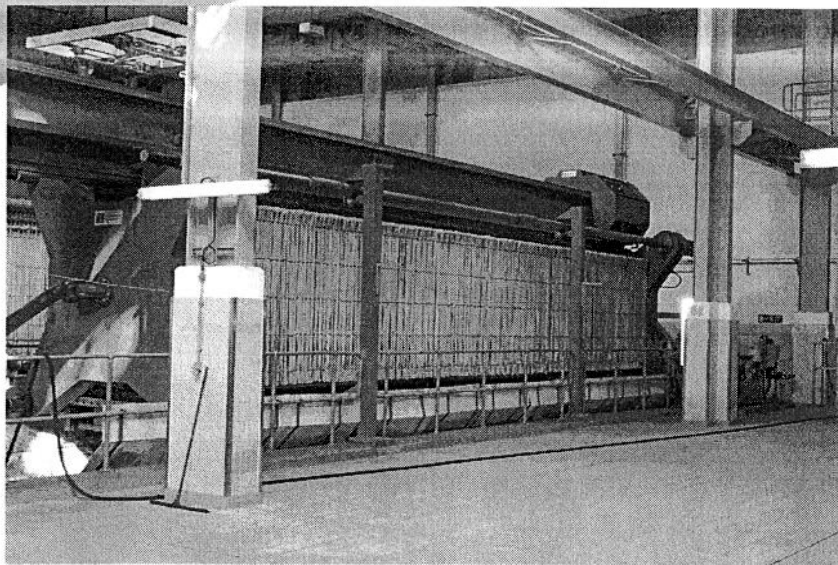
Belt press

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Filter press

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Stirred sludge volume index (SSVI)

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- A crude measure of sludge settleability
- Obtained by allowing a sludge sample to settle under standardised conditions

$$\text{SSVI (ml/g)} = \frac{\text{Volume of settled sludge per litre (ml/l)}}{\text{Mixed sample solids concentration (mg/l)}} \times 1000$$

SSVI > 120 poor; <100 good, <50 very good

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Stabilisation

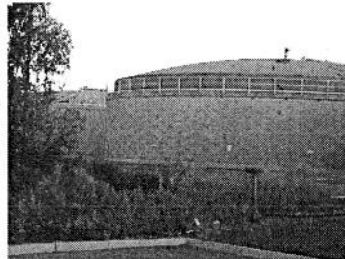
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Common methods

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- Digestion
- Composting

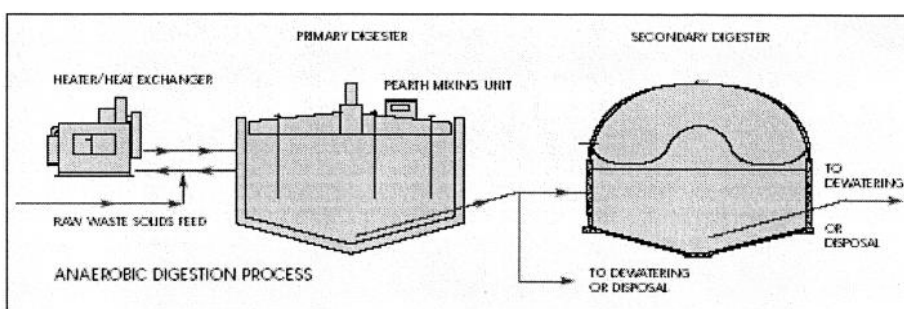


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Digestion

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Two-stage digester



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Primary and secondary digesters

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Picture from Asaadi and Marsh

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More of them

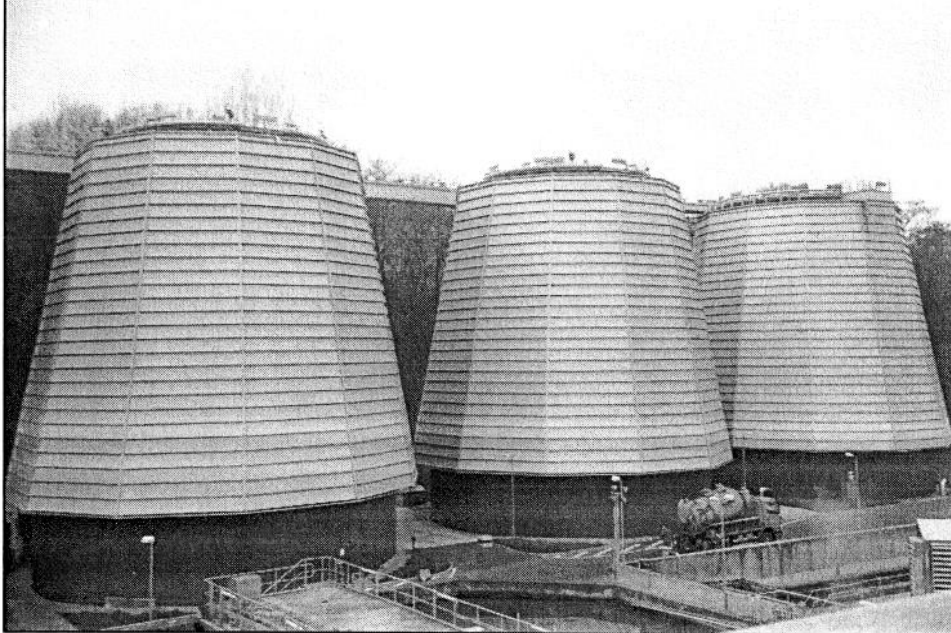
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And more

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And more

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BAUW CRANFIELD AG UK

OK that's enough

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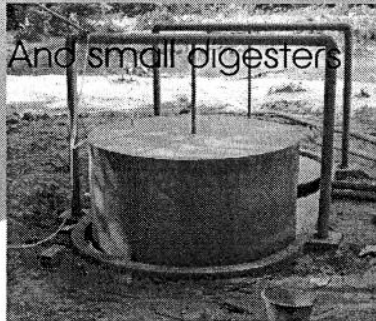
However, there are egg
digesters

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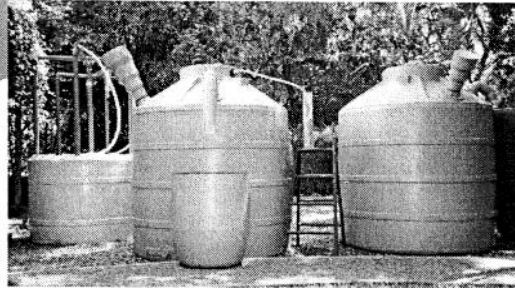


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And small digesters



Cambodia



Argentina



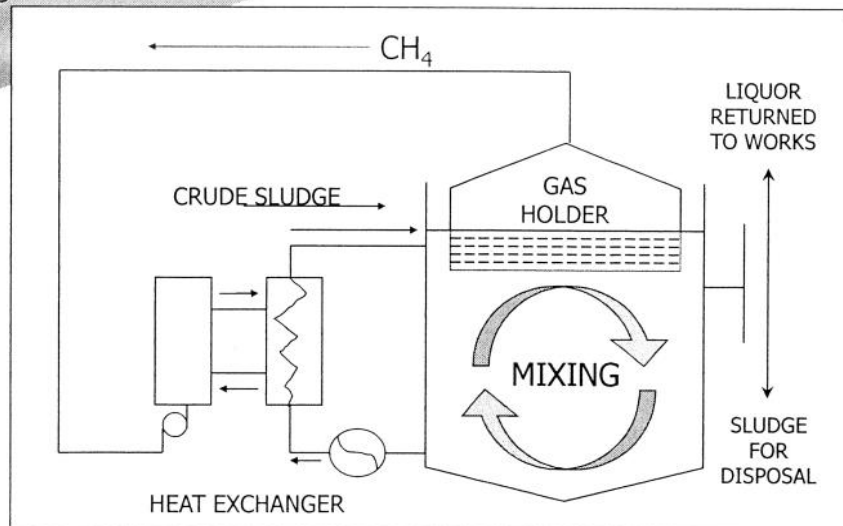
Lao



Venezuela & Brazil

Schematic diagram of
an anaerobic
digester

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Tanks

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- Grit removal
- Minimum 1:1 aspect ratio
- 25° floor slope
- Bottom draw off with twin isolating valves
- Man entry provision

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Tanks

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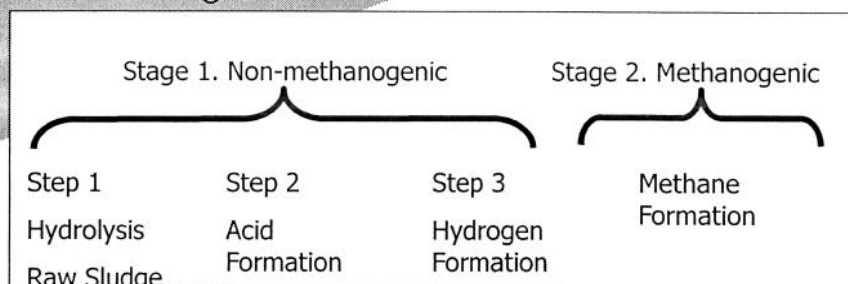
- Tank volume concrete/steel
- Life 60 / 20 years
- Fixed roof
- Pressure monitoring
- Relief valves
- Insulation / heat loss

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Process Mechanism

- Biological Process
- 35°C no air 15 days (mesophilic)
- Thermophilic 45 - 55°C
- 30-50% organic reduction
- Pleasant tarry odour
- Org nitrogen to ammonia
- Methane production
- 6 – 8 % solid feed

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Biochemistry of
anaerobic digestion

0.8 - 1.1 m³ kg⁻¹ VS destroyed net CV 23 MJ m⁻³

0.9 – 1.1 m³ kg⁻¹ VS destroyed - primary

0.7 – 0.8 m³ kg⁻¹ VS destroyed – secondary

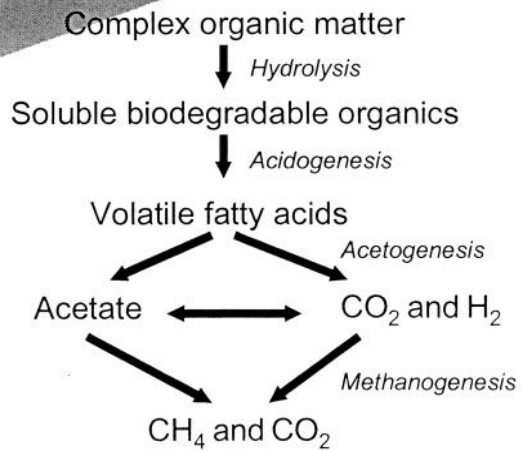
Theoretical max 1.87 m³ kg⁻¹ VS destroyed

Typically achieve nearly 60 % primary sludge VS destruction

But only 30 – 35 % secondary sludge VS destruction

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Anaerobic digestion

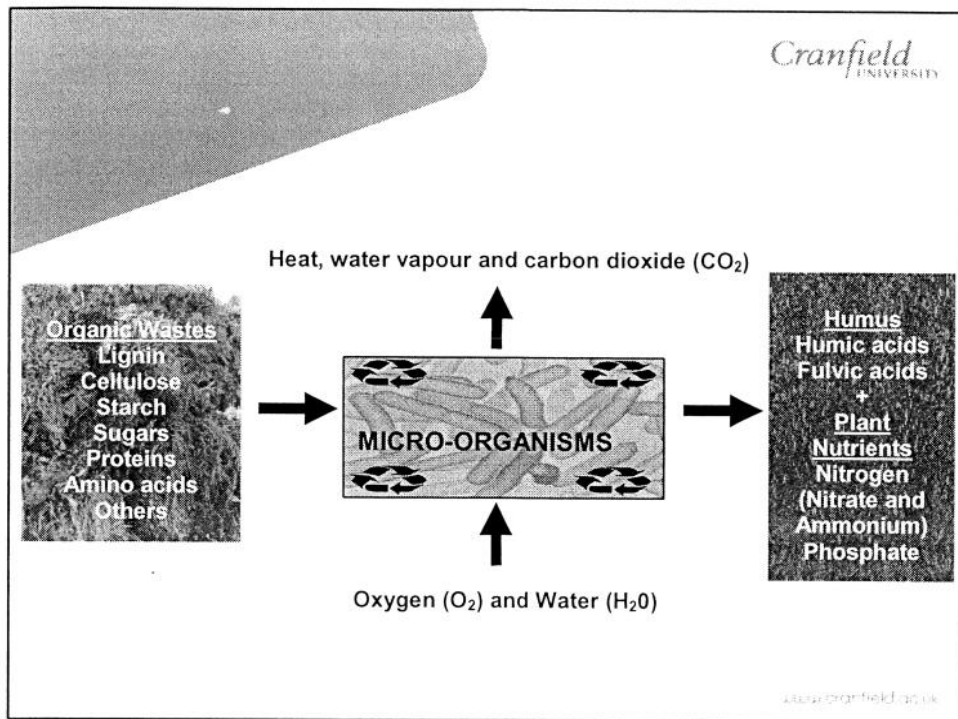


- Complex interaction between different microorganisms
- Every biochemical step occurs under specific conditions
- Proper balance must be ensured

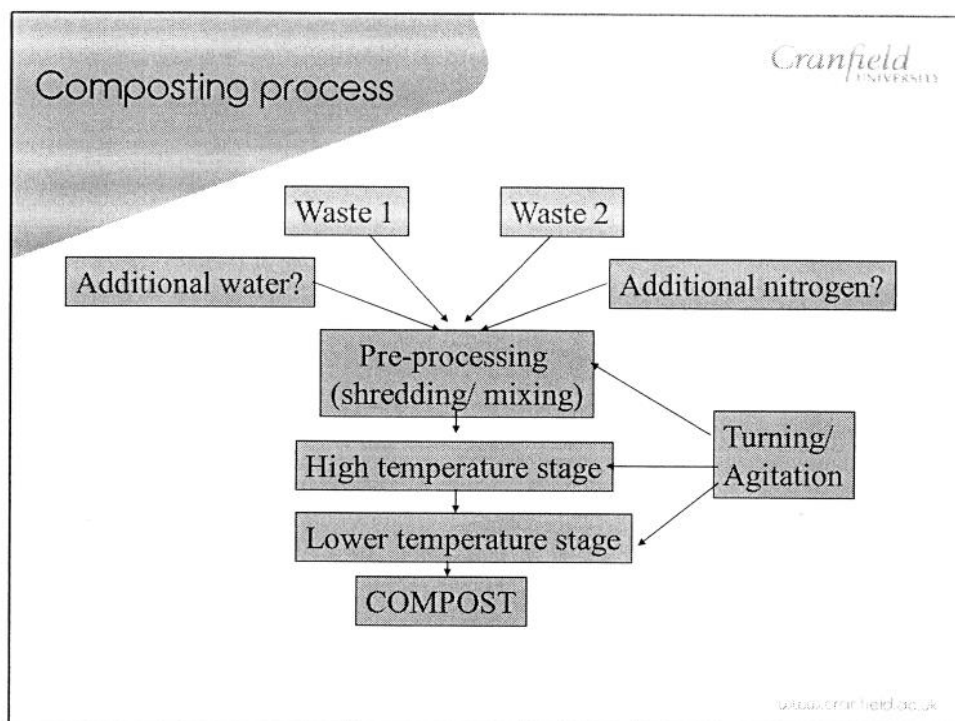
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Composting

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Composting process



Composting Systems

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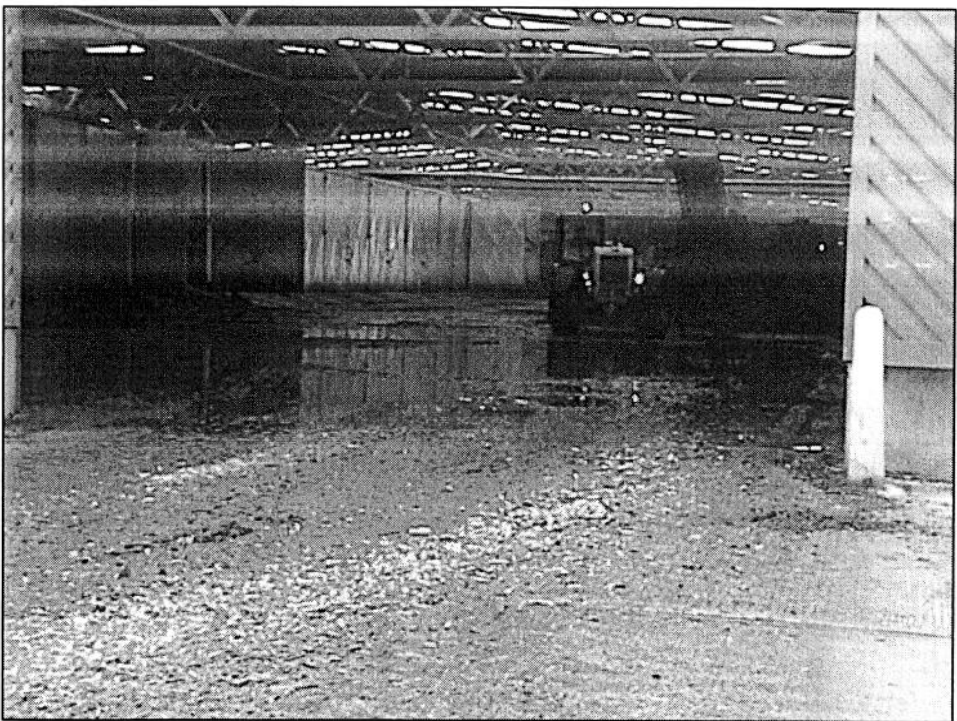
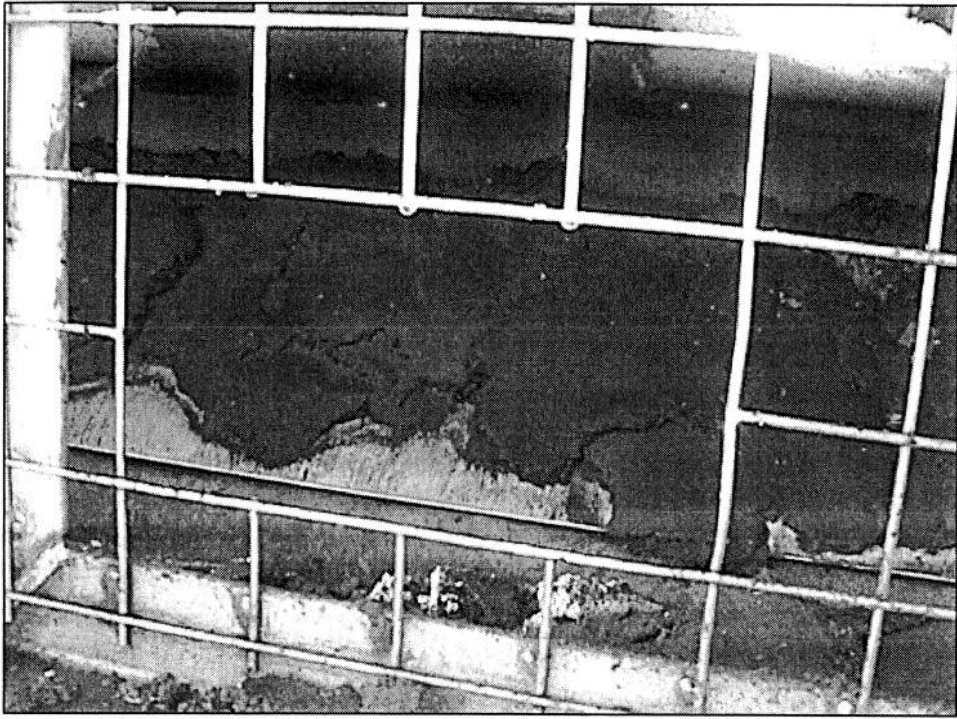
Closed Systems

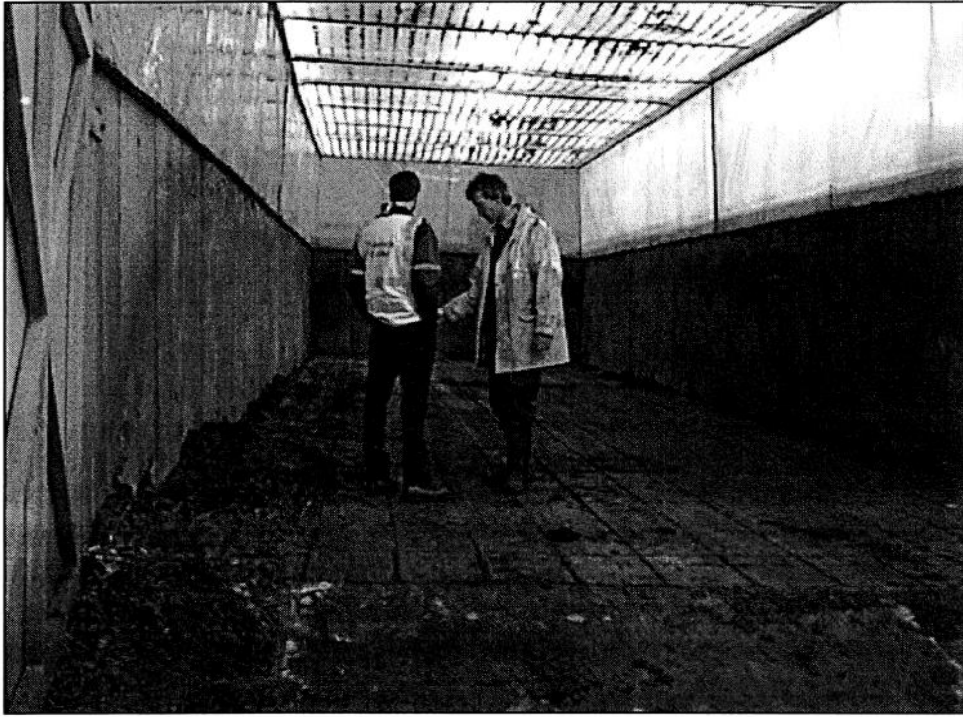
- Rotating horizontal reactors (tube)
- Static vertical reactor (tower)
- In-vessel systems (boxes)

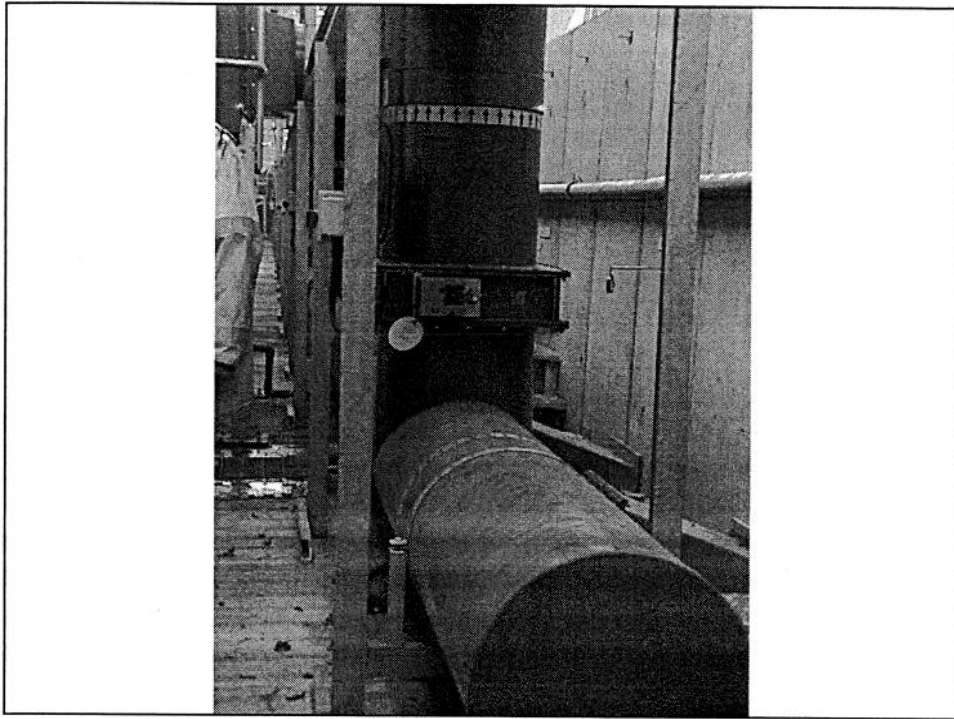
Function continuously or periodically with forced aeration

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Lecture aims

- To be aware of the common methods of sludge treatment
- To appreciate the regulatory drivers for sludge treatment