Trends in Wastewater Treatment

E30: AAEE/AIDIS/WEF Breakfast

James L Barnard
Contents

- Discovery of the Activated Sludge Process
- Major trends in wastewater treatment
- Drivers for Research and Development
- Wastewater as a Resource
- Possible Future Scenarios
1914 - Arden & Lockett Publish Activated Sludge Process
The Activated Sludge Process
Physical/Chemical Treatment

Tertiary High Lime and Ammonia Stripping

- Lake Tahoe – Right and Pretoria Left
Ion Exchange for ammonia removal
Trends in Independent Physical/Chemical

- CEPT
- High Lime
- Ammonia Stripping
- Recalcination
- GAC

Relative Popularity

Goudkoppies plant completed - 1975

60th Birthday of the activated sludge process

85% N removal
90% P Removal

Anaerobic Zones added 1974
Dublin Bay – View towards City

11.3 m³/s  260 mgd

Figure 3  Overall concept of SBR operation to achieve the required conditions for nutrient removal
Nitrogen Removal in Attached Growth systems

- Carbon
- Nitrification
- Denitrification
- Hi Rate AS
- CEPT
- BAF
- MBBR
- BAF
- Fluidized bed
- MBBR
- BAF
- Denite Filter
- Carbon Source
Davyhulme plant, Manchester – Biological Aerated Filters

Nitrification

Denitrification with Methanol
The Activated Sludge Process #2
IFAS Example Schematic

Influent -> Anoxic (No Media) -> Aerobic (20-65% Media) -> Aerobic (20-65% Media) -> Clarifier

RAS -> WAS

Effluent
Biological phosphorus removal still possible
Application of Membranes to Wastewater - 1968
MBR Lay-out with media in 2nd AX Zone

- Influent
- Anoxic
- Aerobic Lower DO
- Carbon
- Second Anoxic
- Membranes
- Effluent

Waste Sludge and Scum
Drivers for Development of New Technology

- Population Growth
- Eutrophication – Reduce N and P to lowest possible level
- Reduce energy cost and recovery of energy
- Reduce EDC and PCP
- Reduce GHG
- Recovery of resources
Urbanization in the world

Within 2035 60% of the global population will live in cities.

World Watch Institute 2007: > 50% is already living in urban areas.
Drive for Limits of Technology (LOT)

- LOT is meaningless and should not be used
- What is Sustainable
- What is economically justifiable
- LCA studies
- Nitrogen limits 2.5 mg/L? What is the role of the rDON? How is it removed?
- Phosphorus limits down to 0.01 mg/L.
- Should we apply strict nutrient limits when the impact is negligent or it is evident that it may harm the receiving water
In inland freshwater, it was proven that phosphorus leads to algal growth.
Upper Occoquan Plant
Unaddressed Violations Damage Waterways and Send the Wrong Message to Citizens, Developers and Neighboring Localities

In 1989, 60% all streams in the Occoquan Watershed were classified as high-quality streams

Up to 85% of the flow to the reservoir comes from Water Purification plants
Energy
Global Cooling or Global Warming

1968

2009
## Comparative Energy Costs

<table>
<thead>
<tr>
<th>Energy used for</th>
<th>kWh/c/a</th>
</tr>
</thead>
<tbody>
<tr>
<td>BNR Wastewater Treatment</td>
<td>40</td>
</tr>
<tr>
<td>Switching one lamp to low energy fixtures</td>
<td>102</td>
</tr>
<tr>
<td>Pumping water from north to south of California</td>
<td>355</td>
</tr>
<tr>
<td>Household per person (2 persons)</td>
<td>14,000</td>
</tr>
</tbody>
</table>

Most of the Energy in WWTP required for Nitrification
FAD or FUTURE?
An expert evaluates whether digester-gas-fed fuel cells and microturbines are cost-effective sources of power

Nicholas Mignone WE&T November 2008
Green-House Gases
GHG Emissions from three plants –
(Dr Katie Third – W2W Alliance Perth)

Annual GHG Emissions (tonnes CO2)

- MLE
- MLE
- SBR

- Chemicals used
- Purchased power-other
- Purchased power-aeration
- Sludge processing-mineralisation
- Sludge processing-trucking
- Sludge processing-biogas
- Biotreatment

All fine bubble aeration
Sources of green house gases

- 85 - 95% from water vapor
- 13% of remaining GHG caused by nitrous oxide (by effect)
- 12% of N$_2$O from anthropogenic sources
- 65% of that from domesticated animals
- 20% from industry including vehicles
- That leaves 15% for others including agriculture which would put wastewater treatment plants at most (guess) 0.1% of the remaining 15%. (from Foley et al 2008)
- The net effect of reducing N$_2$O at all WWTP may be a reduction of 0.000006% of GHG
Treatment of Emerging Contaminants
Biological Treatment

Preliminary Comparison of six Arizona WWTPs

Overall estrogenic activity removal (%)

- Oxidation ditch: 97%
- Membrane bioreactor: 97%
- Nitrification/denitrification: 99%
- Activated sludge: 65%
- Biotower #1: 26%
- Biotower #2: 54%
Possible Resource Recovery

- Urine Separation
- Influent
- Protein Recovery
- Fertilizer
- Digester
- Power
- Composting
- Cooling Towers
- Potable Water
- Irrigation
- Heat Recovery
Phosphorus Removal and Recovery
THE DISAPPEARING NUTRIENT

Phosphate-based fertilizers have helped spur agricultural gains in the past century, but the world may soon run out of them. **Natasha Gilbert** investigates the potential phosphate crisis.
Renewed Interest in Biological Phosphorus Removal

- Cost of chemicals.
- Better understanding of the mechanism
- Better overall economics in getting to really low levels
- Phosphorus recovery while still applying chemicals for polishing
Global Reserves of Phosphorus

Brazil
USA
Other Countries
South Africa
Russia
Morocco
Jordan
Israel
China
Phosphorus recovery

Struvite
Mg.NH$_4$.PO$_4$·6 H$_2$O

Also recovers up to 20% of nitrogen
Water Re-use
Water reclamation for Potable use
Windhoek Water Reclamation
Singapore - New Water
Will the activated sludge plant be around for another 30 years? 50 years? 100 years?
Very Likely

- As MBR for low footprint
- With Membrane Filtration - Nanotechnology
- With maximum power recovery
- High removal rate of ammonia
- Relatively low GHG
- High removal rate of PCP&EDC
- Opportunity to recover phosphorus
Or in other forms - Anammox
Granular Activated Sludge

Influent → Decant

NEREDA®
Granular Activated sludge - Gansbaai RSA

COD in 800-10,000 ppm → COD out < 100 ppm / N in 150-200 ppm → N out < 10 ppm
P(dissolved) in 15-25 ppm → P out < 1.0 ppm / SS out < 20 ppm
Urine in Wastewater

Volume of Wastewater

- Yellow-water (Urine+flushwater) - 80%
- Brownwater (Faeces+flushwater) - 20%
- Greywater (shower, kitchen, etc) - 1%

"N" Content

- 15%
- 5%
- 80%

"P" Content

- 10%
- 50%

Reference
Andre Mbya UCT
Summary

- Expect to see the activated sludge process around for some time in some form – as, IFAS, MBR or with membrane filtration for water re-use
- More emphasis on resource recovery N and P
- More emphasis on saving water as the main driver for reducing energy cost – indigenous living
- Urine separation as a means of sustainability in countries that are catching up and in new developments
- Greatly improved membranes for solids liquid separation and water recovery
If you are still awake
Thank you for coming