

Water Technology Markets 2010

Key opportunities and emerging trends

By Sze Chai Kwok, Heather Lang and Paul O'Callaghan, with contributions from Christopher Gasson, Ankit Patel, Matthew Stiff and Jablanka Uzelac.



Global
Water Intelligence

A Global Water Intelligence publication
www.globalwaterintel.com

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O₂ Environmental Inc
Water Technology Market Experts

BlueTechTracker™ Webinar
www.bluetechtracker.com

Sludge to Energy

Emerging Trends and Technologies

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BlueTech Tracker™ Webinar Series

O2 ENVIRONMENTAL Inc is running a series of BlueTech Tracker™ webinars to highlight key opportunities and emerging trends in water technologies. Each webinar will bring together leading experts and water technology companies. For more information, and to sign up for updates and access to the BlueTech Tracker™ click [here](#) or check out www.bluetechtracker.com

1. **Osmotic Power** – *salinity gradient energy using Forward Osmosis*
2. **Mineral & Resource Recovery from Wastewater** - *turning waste into a profit centre*
3. **Microbial Fuel Cells** - *generating electricity, hydrogen and chemicals from wastewater*
4. **Advanced Oxidation** – *impact of emerging contaminant and shale gas regulations on AOP Markets*
5. **Sludge to Energy** – *emerging trends and technologies*
6. **Ceramic Membranes for Water Treatment** - *Technical Status and Economic Updates*
7. **Ballast Water Treatment** – *market size and growth rate & impact on technology markets.*
8. **Forward Osmosis** – *current state of the art, applications,*
5. **Decentralised Treatment & Re-use**
8. **Electrochemical Technologies**
10. **Low Energy Desalination**
11. **Water Technologies for the Oil & Gas Industry**
12. **How to Reduce the Water footprint of Energy**

Webinar to cover:

- An overview of the size of the Biosolids use and sludge disposal market and current management practices
- Discussion of market and regulatory trends in Europe and North America
- A review of emerging treatment technologies such as Gasification, Torrefaction, Carbonization and Supercritical water oxidation
- A perspective on future trends in this market and adoption of sludge to energy technology.
- An opportunity for you to engage in a discussion and have your questions answered and answers questioned



Moderator: Paul O'Callaghan



- Paul is CEO of [O2 Environmental Inc.](#) and an industry expert on emerging water technologies. He is co-author of the Global Water Intelligence report 'Water Technology Markets 2010 – key opportunities and emerging trends'. He is an industry expert reviewer for both [Sustainable Development Canada](#) and the Innovative Clean Energy (ICE) Fund.
- Paul has carried out market analysis and technology assessment work for broad range of water technology companies and has provided advice to a number of investment funds such as the Renaissance Fund, Frog Capital & the Four Winds Aqua Fund.
- Masters Degree in Water Resource Management and is an active member of the WEF Residuals & Biosolids Committee Literature Review, IWA Water Re-use Committee and developed the BlueTech Tracker™ database of emerging water technology.

Panelists

- Moderator:
- **Paul O'Callaghan**, *CEO*, O₂ Environmental Inc .



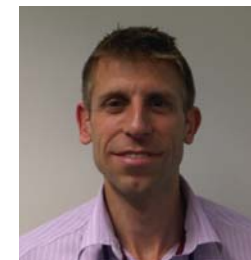
- Panelists:
- **Joe Zuback**, **President and Founder**, **GLOBAL WATER ADVISORS, INC.**



- **Todd O. Williams, P.E., BCEE**,
Principal Technologist, CH2M HILL



- **Peter Vale**, **Senior Asset Strategist**,
Wastewater R&D, SEVERN TRENT WATER, UK



- **Rafael Simons**, **Partner**,
VANTAGE POINT VENTURE PARTNERS

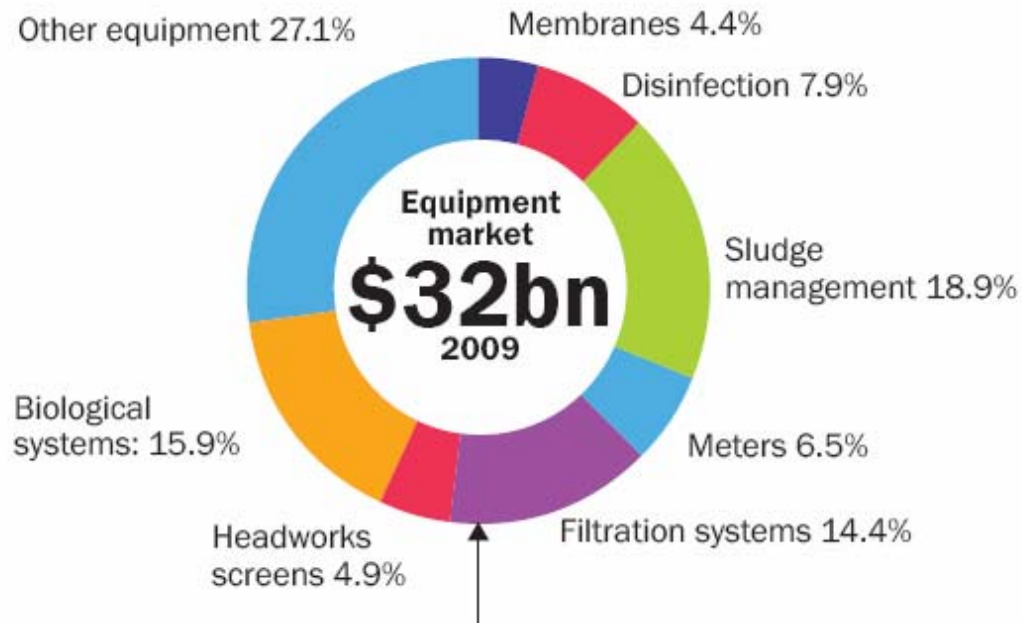


Why the interest in sludge to energy technologies?

- Sludge arises as a by-product of the wastewater treatment process
- Despite representing approximately 1% of total flow, Sludge handling accounts for up to 50% of Total Operating Costs
- The sludge treatment equipment market represents at least 20% of the total water equipment market

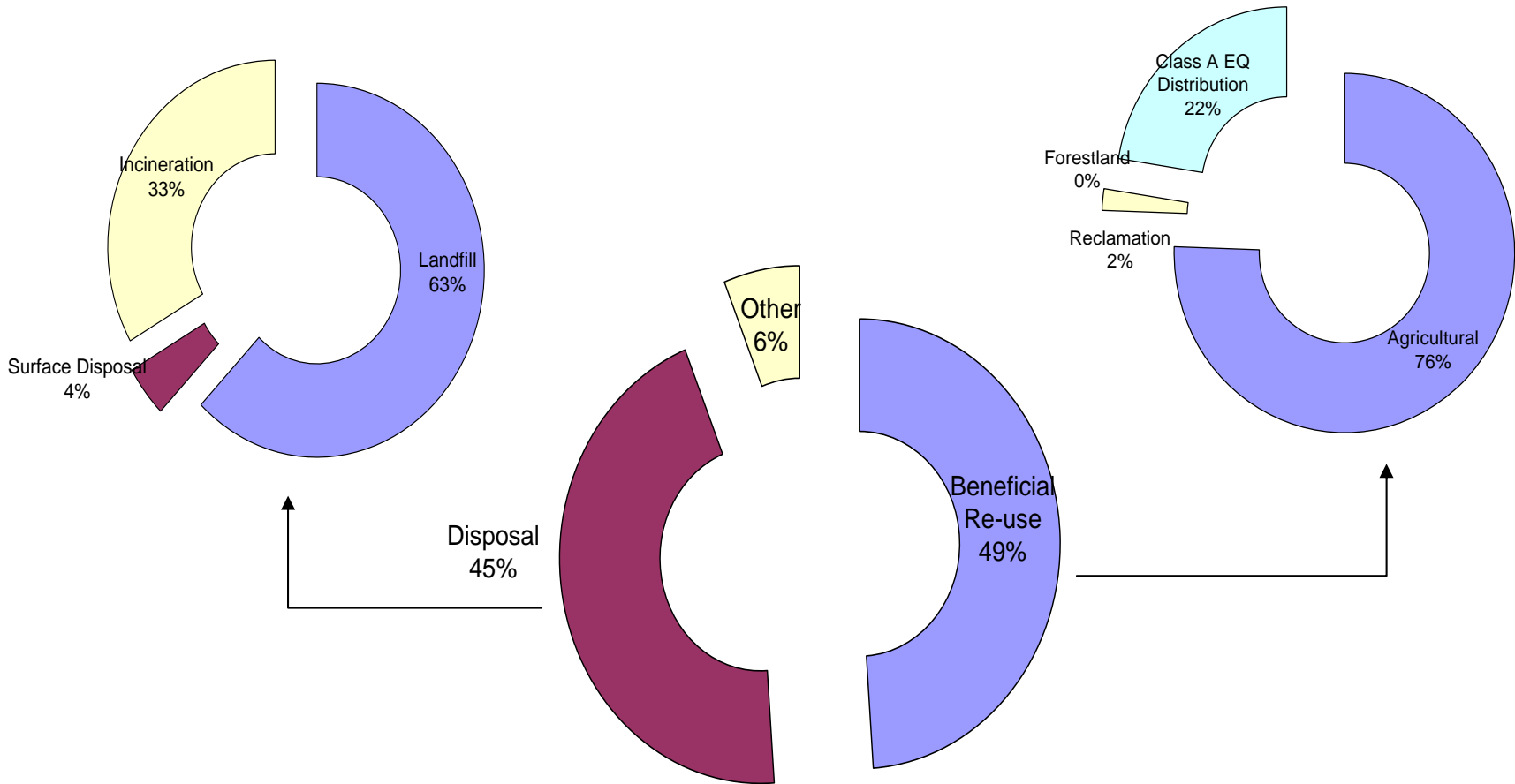
Sludge Management Equipment Market

- Globally estimated to be worth \$6Bn in 2009 (GWI)
 - Note - Includes just: Drying / Digestion / Dewatering



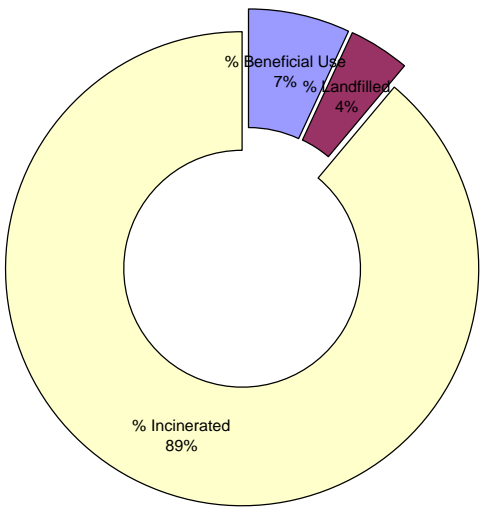
Sludge Management in U.S.

- 7.1 Million Dry Tons per annum

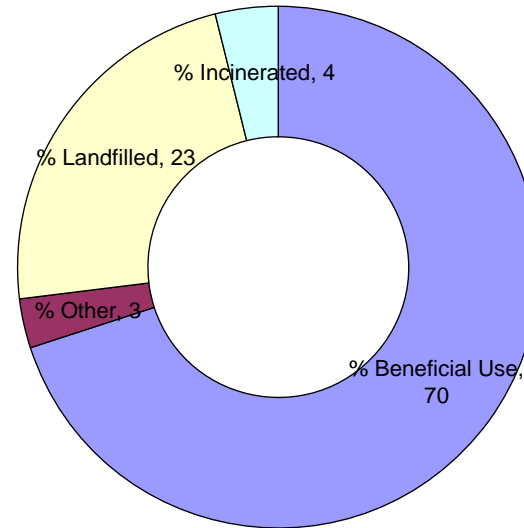


Management Practices Vary Enormously by State

Rhode Island



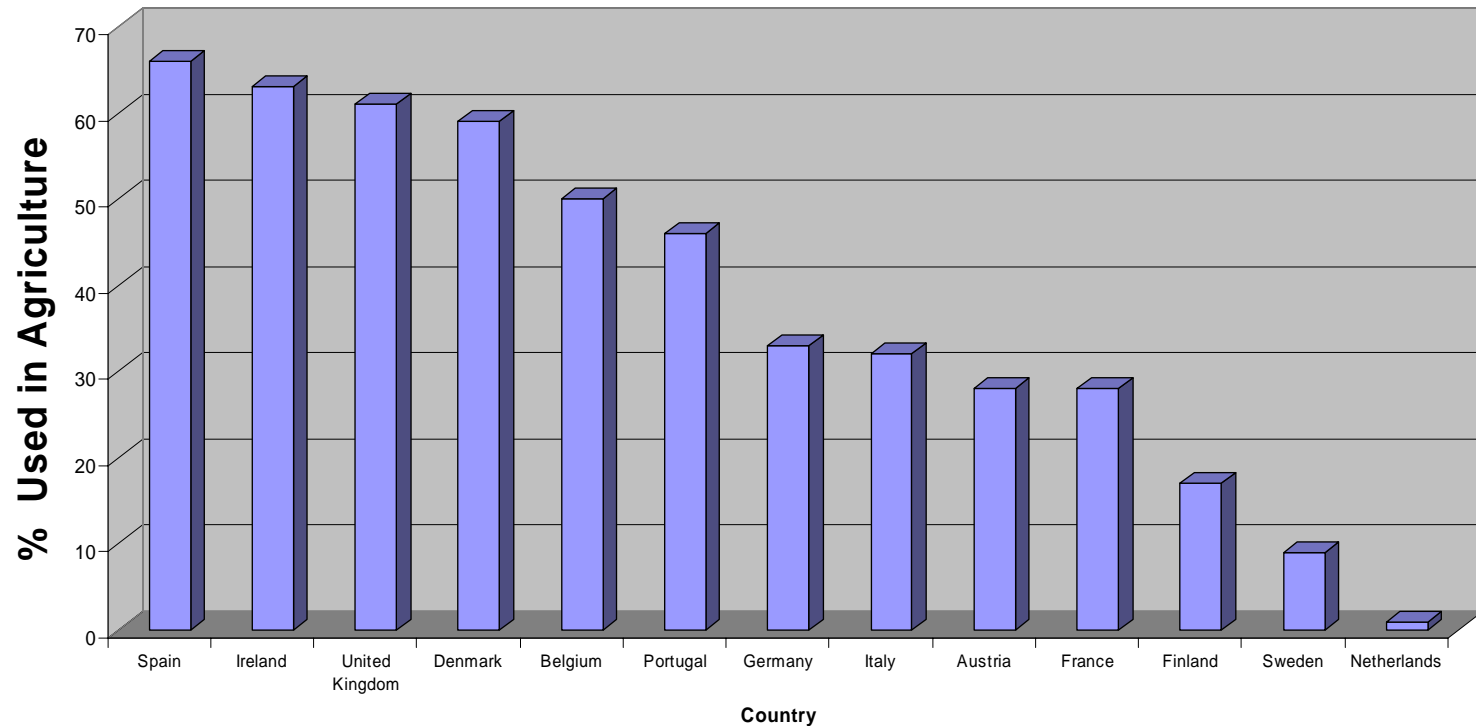
California



Sludge Management in Western Europe

- 7 million dry tonnes per annum

Western Europe: Percentage of Sludge Converted to Biosolids and Beneficially Used in
Agriculture (2003)



There is Energy in Sludge

- Sewage sludge typically contains between 6,000 – 10,000 BTU's per lb of **DRY** Solids (DS), with 7,000 BTU's per lb DS being a reasonable average number.
- There is a challenge in accessing this energy.... Sewage sludge is a **Wet** material....
- Theoretical minimum energy to produce 1 lb of Dry solids from a sludge with 80% moisture content = circa 3,600 BTU's / lb.

Sludge to Energy Technologies

- Sludge to Gas
 - Sludge Pre-treatment
 - Anaerobic Digestion
 - Gasification
- Sludge to Solid Fuel
 - Carbonization
 - Torrefaction
- Sludge to Oil
 - Pyrolysis
- Supercritical water oxidation
- Incineration

Sludge Pre-Treatment Technologies

Technology Area	Company	Technology Offering
Sludge Pre-Treatment		
<i>Thermal Hydrolysis</i>	CAMBI	Thermal Hydrolysis
	Veolia	Biothelys™
<i>Mechanical Disintegration</i>	Lysatec	Lysate Centrifuge
	Microsludge	Microsludge™ High Pressure Homogenisation
	Biogest	Crown™
<i>Ultrasonic Technologies</i>	Sonico	Sonix
	VTA Technology	VTA GSD
	Ultrawaves	Ultrasonic reactor
<i>Chemical Treatment</i>	PMC Biotec	AFC Process / ChemTreat/ Mechanical Chemical Grinding
	Kurita Water Industries	Bioleader Ozonation Process
	PraxAir	Lyso™ Ozonation Process
<i>Electroporation</i>	OpenCell	
<i>Two phase Anaerobic Digestion</i>	United Utilities	Enhanced Enzymic Hydrolysis

Sludge Gasification

Company	Technology Offering
MaxWest	Gasification Process
Nexterra	Gasification Process
Kopf	Gasification Process
Eisenmann	Gasification Process
CMI Industry	Thermline



MaxWest System – Sanford, Florida

Supercritical Water Oxidation



Aquacritox, Cork, Ireland

Company	Technology	Reference Sites
SCFI	Aquacritox	Ringaskiddy, Cork, Ireland
SuperWater	SuperWater Process	Ironbridge WWTP, Florida

Sludge to Solid Fuel

Technology Area	Company	Technology Offering
Sludge to Solid Fuel		
<i>Carbonization</i>	EnerTech	SlurryCarb™ Process
<i>Torrefaction</i>	New Earth	ECO Pyro-Torrefaction (EPT)
	Thermo Energy	ThermoFuel Process

DEAN OF INVENTION

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By Team Planet Green
Sun Oct 10, 2010 14:12



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All organic waste—human and animal—is bad for the environment. In fact, cows generate a jaw-dropping 20 percent of the world's greenhouse gas emissions. Specifically, their waste emits methane, and that gas is pure poison for the ozone layer. And don't think your own stool doesn't stink where the environment is concerned.

An astounding 5 percent of America's energy consumption is spent simply on processing our own human waste. If you could take just one day's excrement from all the humans and cows in the world and harness the energy locked inside, you'd have enough electricity to power New York City for seven years. Until recently, all that waste was just going to waste. But now, DEAN OF INVENTION unveils how the race is on to develop processing plants that can harness this previously poo-hooped waste into power.



Planet Green

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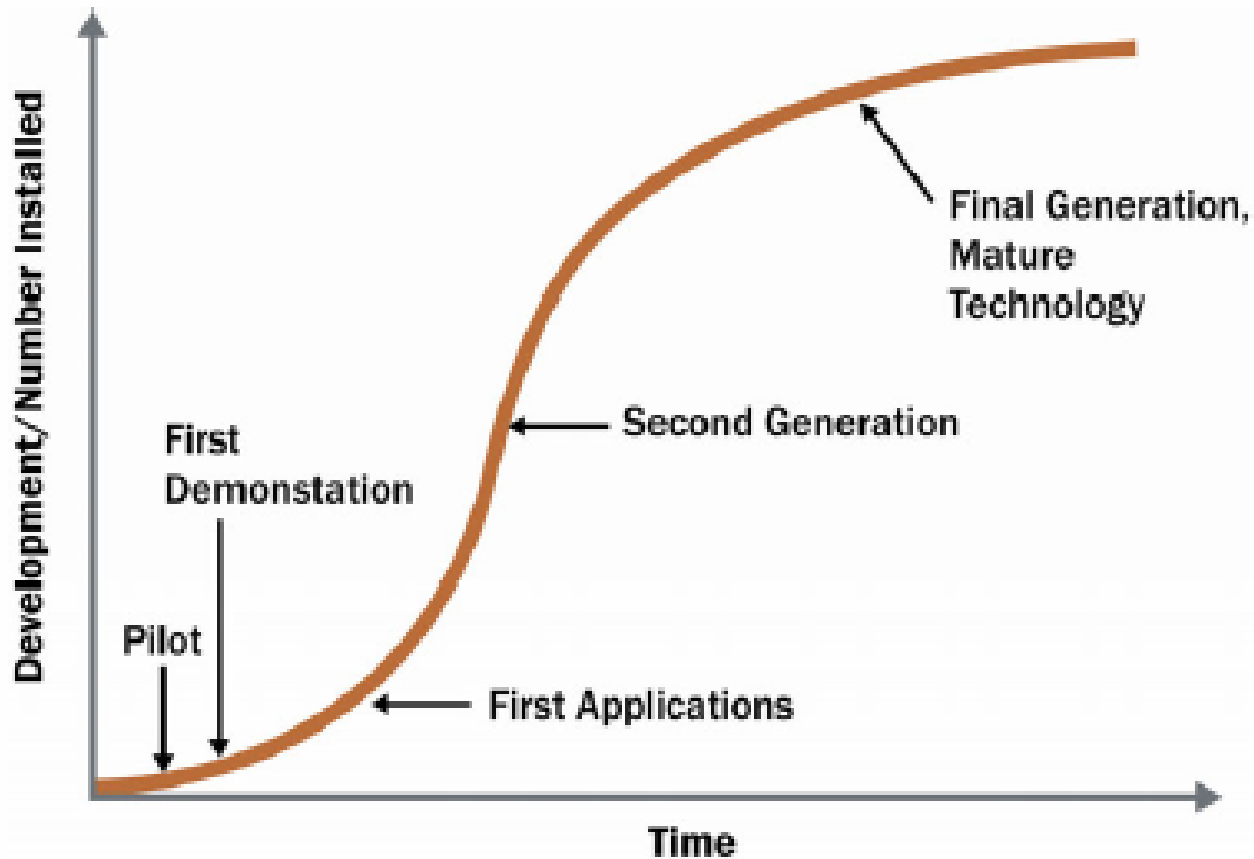


Figure 1. S curve for life cycle of new process introduction showing development and cumulative number of installations versus time.

Joe Zuback, President and Founder, GLOBAL WATER ADVISORS, INC.



- Joseph E. Zuback is the President and Founder of Global Water Advisors, Inc., a firm that specializes in providing support to global water managers, solution providers, and investors for optimization of performance, development, and commercialization of advanced water technology products and systems.
- Mr. Zuback's thirty-five years experience in the water industry spans the spectrum of municipal, industrial, commercial, marine, and residential water and wastewater treatment markets around the world. He retired at the end of 2008 from Siemens Water Technologies Corp (formerly USFilter), where he served as Chief Technology Officer, Senior Vice President, and a member of the Executive Council management team. His management responsibilities included new product rationalization and development processes, intellectual property, technology risk assessment, new venture commercialization strategies, and coordination with Siemens' global network of water technology research partners.

Questions

– Economics

- Is Sludge to Energy an Economically viable management option under current market conditions?

– Impact of Future Legislation / Public Opinion

- Europe/ US / Rest of World

– Technology Status

- are the technologies waiting for the right market conditions, or is the market waiting for the right technologies?

NEXT WEBINAR

Ceramic Membranes for Water Treatment - *Technical Status and Economic Updates*

www.bluetechtracker.com

- **Date: November 18th 2010 11am Eastern Standard Time**
- For a number of years ceramic membranes have been used in niche applications, but have not been able to compete with polymeric membranes for main-stream applications such as ultrafiltration for drinking water treatment and membrane bio-reactors'. Recently however there are signs that this may be changing with a number of companies coming to market with solutions incorporating ceramic membranes. Will this be a game –changer in the industry?
- This BlueTech Tracker™ webinar will include presentations from international technology experts and market leaders from the Canada , US , Germany and the UK. The Webinar will provide insights into the current status of ceramic membranes, where they are being used and will include a Q&A session to address specific questions from participants.
- **Moderator:**
- **Graeme Pearce** Membrane Technology Associates and O2 TAG Partner
- **Panelists:**
- Enrico Vonghia, GE Water, EA&P - Competitive Intelligence, ES Leader, Canada
- Stefan Panglisch, IWW, Germany
- Scott Freeman, Black and Veatch, USA

The view of “Big Water” on Sludge Treatment



SIEMENS



OVIVO

How are major water technology providers viewing this market?

Equipment/component business

- Mixers, pumps, dewatering equipment
- Sludge minimization, treatment, and enhanced methane generation processes
- Biogas auxiliary equipment
- Gas-fired engines (GE, Siemens)
- Monitors and controls
- Polymers

Operations Contracts (Suez and Veolia)

State-of-the-Art and Emerging Sludge Technologies

Sludge Centrifuge



Rotary Drum Dryer



Fluidized Bed Incinerator



Emerging Technologies Focus on Reducing Energy and Waste Sludge Disposal Costs

- Cell lysis (ultrasound, pulsed electricity)
- Recycle digested sludge to WWTP (Cannibal, WASAC)
- Dryer alternatives (electrodewatering)
- Increased gas production (increased methanization, sludge gasification)
- Beneficial use of sludge (Fuel, carbon source)
- Beneficial use of waste heat (Oasys)
- Increased electricity efficiency (fuel cells)
- Performance contracts

Criteria for success: Significant reduction in 20 year life cycle costs compared to status quo

If your company wants to enter this market....

...here are a few suggestions to maximize your odds of success

1. Know thy competition! (and criteria for technology selection)
2. Be certain that you have > 30% life cycle cost advantage for new “disruptive” technology
3. Remember that this is a “global multi-local” market
4. Focus on key niches where advantages are easiest to validate
5. Plan beta site test validation strategy early

Todd O. Williams, Principal Technologist, CH2M HILL



- Todd has a 30-year career in environmental engineering with experience and specific emphasis in residuals and biosolids management.
- Mr. Williams has made numerous presentations specific to residuals management and is a contributing author for several articles and books significant to residuals management, composting, and odor control including *Odor Control in Wastewater Treatment Plants*



Sludge Pretreatment and FOG Wastes Use for Improving Anaerobic Digestion Performance and Overview of EPA Sewage Sludge Incinerator Proposed Rulemaking

By

Todd O. Williams, P.E., BCEE
CH2M HILL Richmond, Virginia

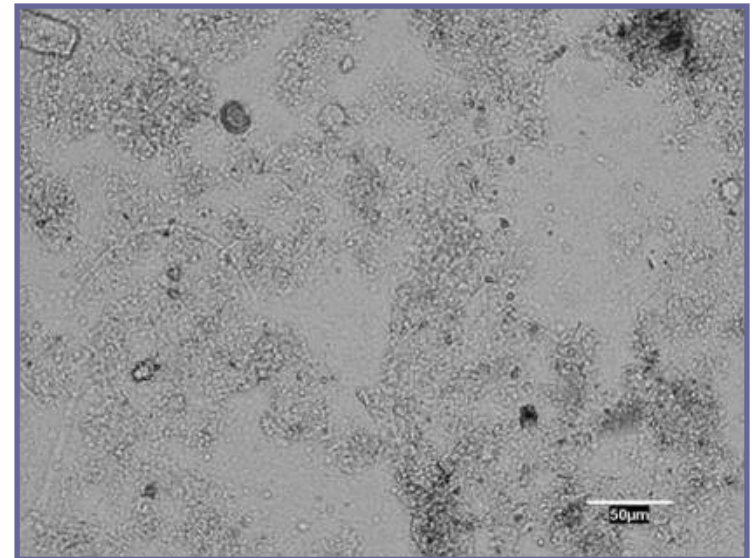
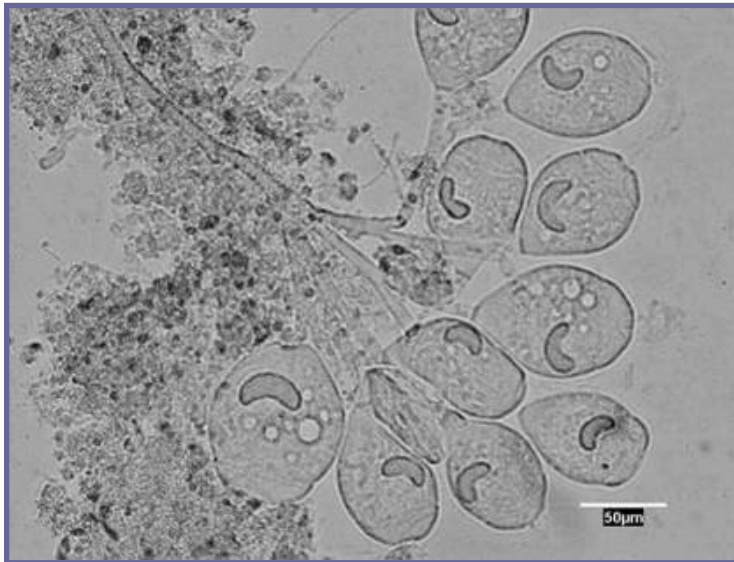
October 21, 2010

Solids Pretreatment Prior to Digestion to Enhance Digester Gas Production

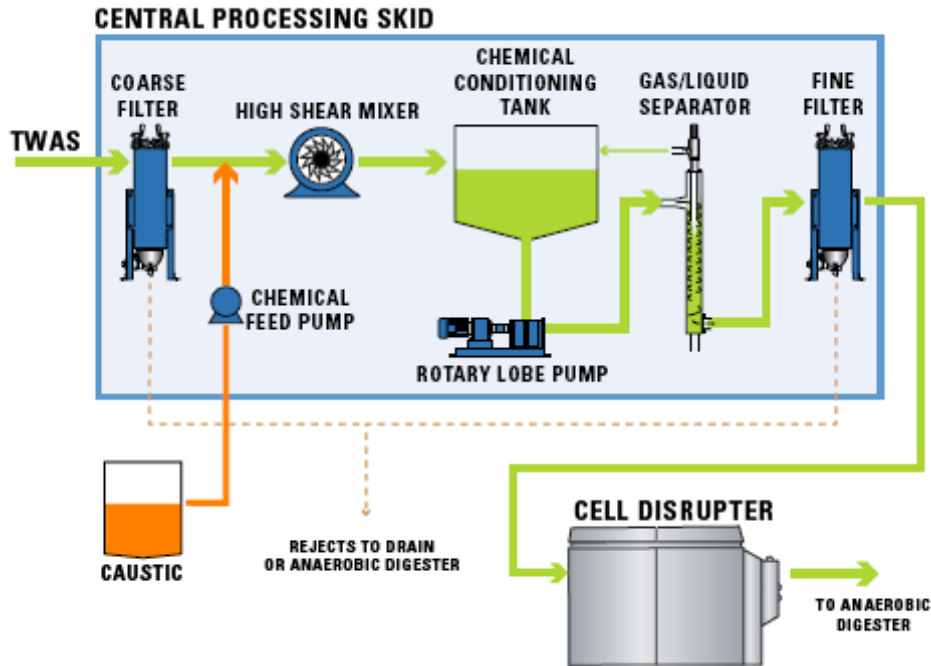
- Many technologies in the market to lyse cells and enhance anaerobic digestion
 - Biological processes
 - Chemical processes
 - Physical processes
- Many technologies are “embryonic”; some are ready for full-scale consideration
- Highlight a few examples

Cell Lysis Processes – Key Mechanisms

- Focused on floc disintegration and cell lysis
- From cell wall damage to full cell disruption depending on energy intensity
- Sized on volume basis – Thicker sludge is better
- Several mechanisms: cavitation, temperature, pressure release, shear, pulsed electric fields



Homogenization: MicroSludge™



- NaOH to weaken cell membranes and reduce viscosity (pH 9 to 10)
- Chopper pump to break up agglomerates
- Screen to 800 μm to remove non-cellular debris
- Homogenizer pressure 82,700 kPa (12,000 psig) for cell lysis
- Bench scale and full scale installations in service



Pressure Release: Crown Disintegrator

- Macerate sludge to homogenize
- Increase pressure (175 psig) with PD pump
- High pressure mixer, flow into disintegration nozzle
- Flow exits the nozzle, cavitation ruptures cell

Vendor claims

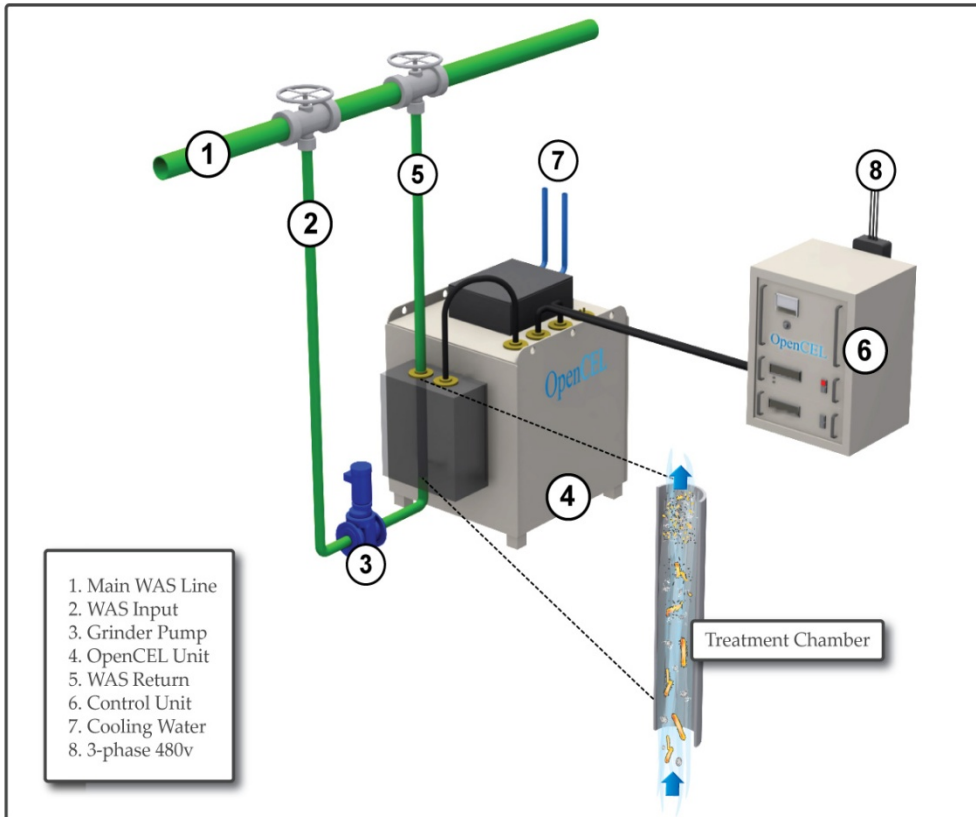
- > 20% increase in Biogas
- >15% reduction in dehydrated sludge volume
- Carbon augmentation for BNR
- Installations in Germany and New Zealand



Siemens Crown Disintegrator
Wiesbaden WWTP - 60m³/hr

Pulse Power - Full-scale installation at the 10 MGD Mesa, AZ NWWRP

Schematic of an OpenCEL installation



- Focus Pulse (FP) system installed downstream of thickened sludge pumps (prior to anaerobic digesters)
- FP system consists of OpenCEL components and ancillary equipment
- OpenCEL components:
 - Modulator
 - Power Supply
 - Control Rack



Thermal Hydrolysis

- High pressure-high temperature process: thermal hydrolysis of dewatered solids under pressure using live steam
- Hydrolyzed and pasteurized solids digested at greater rates (smaller vessels)
- Heat recovery minimizes the energy consumption
- Most installations are on blended solids to get Class A Biosolids
- Two vendors with European Installations Only:
 - Cambi[®] Thermal Hydrolysis Process (THP) [~20 plants]
 - Selected by DC Water to provide the largest Cambi installation in the world
 - *BioThelys*[®] [4 plants] and *Exelys*[®] Thermal Lysis Processes by Veolia

Waste Solids Digestion Pretreatment Key Points

- ◆ Many new products in the market
- ◆ Few full-scale installations; many outside US
- ◆ Many benefits claimed in literature
- ◆ Carbon augmentation potential for BNR
- ◆ Empirical sizing methods
- ◆ Little is known on impact of raw feed characteristics and/or process operational parameters – pilot studies are recommended

Claimed Benefits – Are They Verifiable?

- Increased digestion rates & stability
- Increased volatile solids (VS) reduction
- Increased biogas production
- Reduced solids for dewatering & reuse/disposal
- **Reduced filamentous foaming**
- **Reduced viscosity**
- **Improved dewatering (higher cake solids; lower polymer dosage)**
- Increased hydrolysis of complex organics and production of VFAs – BNR carbon augmentation

Claimed Benefits Should be verified with Pilot Studies!

Digestion Gas Enhancement through High Strength Waste Addition is Gaining Interest

- Fats, Oils and Grease (FOG) wastes have a very high energy content and are highly degradable
- Many utilities are evaluating the addition of FOG wastes to digesters for two main reasons:
 - To eliminate FOG problems in collection systems and treatment facilities
 - To utilize excess digestion capacity to generate more biogas for conversion to energy through combined heat and power (CHP) to offset energy costs
- Utilities building FOG receiving and handling facilities for increasing biogas by as much as 2X and installing CHP facilities
 - Dallas, TX
 - Gwinnett County, GA
 - Johnson County, KS
 - Pinellas County, FL
 - Vancouver, BC
- Many equipment needs with these facilities

EPA Proposed Rule on SSI Emissions (1)

- Proposed Sewage Sludge Incineration (SSI) Rule
Published in The Federal Register on October 14, 2010
 - <http://www.epa.gov/ttn/atw/129/ssi/ssipg.html>
- New Source Performance Standards for new SSI and
Emission Guidelines (EG) for existing SSI
- Emission limits in two categories for existing SSI Units:
 - Multiple Hearth Incinerators (163 existing in US)
 - Fluidized Bed Incinerators (55 existing in US)
- Emission limits proposed for opacity and nine pollutants
 - Cadmium, dioxins/furans, carbon monoxide, hydrogen chloride, lead, mercury, nitrogen oxides, particulate matter and sulfur dioxide

EPA Proposed Rule on SSI Emissions (2)

- Limits for MH incinerators are not as tough as expected, but some retrofits likely
- Limits for FB incinerators may be challenging to meet for some pollutants
- Limits for new incinerators are extremely low
- Units incinerating sewage sludge at other types of facilities (commercial, industrial, institutional) are regulated by other standards

EPA Proposed Rule on SSI Emissions (3) Schedule

- There is a public hearing in Research Triangle Park, NC scheduled October 29th
- 30 day comment period ends November 29th, 2010
- Proposed Rule will be Promulgated in early 2011
- Compliance for New Source Performance Standard (NSPS) required 6 months after Rule Promulgation (applies to any new facilities after October 14, 2010).
- Compliance with Emission Guidelines (EG) for existing facilities required 3 or 5 years after Rule Promulgation depending on State plans for implementing the EG

EPA Proposed Rule on SSI Emissions (4)

- Proposed Standards will likely require majority of existing SSI's to install one or more air pollution control devices to comply including:
 - Activated Carbon Injection
 - Fabric Filters
 - High Efficiency Scrubbers
 - Catalytic Conversion Systems (for NOx control)
 - Granular Activated Carbon Fixed Bed Adsorption
- Additional requirements for testing, monitoring, recordkeeping, reporting and operator training are included in the proposed rule

Peter Vale,
Senior Asset Strategist,
SEVERN TRENT WATER, UK



- ◆ Peter is a Senior Asset Strategist with Severn Trent Water Ltd and manages in-house wastewater research and development projects.
- ◆ Severn Trent Water is one of the second largest water utility in the UK, serving approximately 8 million customers, and operating over 1000 sewage treatment plants.
- ◆ Prior to joining Severn Trent in 2002, Pete worked as Process Engineer in an environmental engineering consultancy.
- ◆ Pete has a an MSc in water and wastewater engineering and is a member of the Chartered Institute of Water and Environmental Management..

Sludge to energy in Severn Trent; current position and strategic direction



Pete Vale
Senior Asset Strategist
Severn Trent Water

peter.vale@severntrent.co.uk

21st October 2010

Severn Trent Water

- **Water and Waste water company :**
 - Supplying over 2 billion litres of drinking water each day
 - Treating the sewage of 8m customers
- **Large Asset Base comprising:**
 - 5170 sites
 - >1000 sewage treatment works
- **High Demand for Electricity**
 - 900GWh per annum



Current utilisation of our bio-solids resource

- **Biosolids management in STW, facts and figures :**
 - 241,000 tonnes/yr (as dry solids) produced & treated
 - All of this sludge undergoes mesophilic anaerobic digestion
 - at 33 sites,
 - each site equipped with CHP
 - a total of 44 CHP engines with an installed base of 32MW
 - Renewable energy is generated from the biogas:
 - 176 GWh per annum (as electrical power)
 - equates to ~20% of our total demand
 - plus 194 GWh per annum as heat (~65% of this is used to heat the digesters)
 - All of the digestate is recycled to agricultural land
 - currently 605,000 wet tonnes per annum generating ~£1.3 million in revenue



Biosolids Strategy – Short Term

- Maximise energy production from existing assets:
 - Digester efficiency, e.g.
 - Thicker feed sludge (maximise retention, minimise heat load)
 - Increase temp set point – more gas at 38°C?
 - Optimum mixing
 - Advanced Digestion
 - Acid phase digestion
 - SAS disintegration



Biosolids Strategy – Longer term

- **Our objective is to achieve both the lowest whole life cost & lowest carbon footprint sludge treatment solution**
- **Our current operation probably delivers the lowest cost, best practicable environmental option, however, there are drivers for change:**
 1. Security of the “land bank”
 - currently we rely 100% on this route
 2. Increasing our renewable energy generation
 - for e.g. to meet our low C commitments by 2015 we aim to generate 30% of our electricity from renewable resources
- **For these reasons we are actively evaluating technologies that:**
 - extract more energy from sludge (AD leaves ~65% behind),
 - offers an alternative outlet for the end product(s) which ideally would be revenue generating, and
 - offer the potential for double “ROC’s” – the UK Government’s renewable energy generation incentive scheme

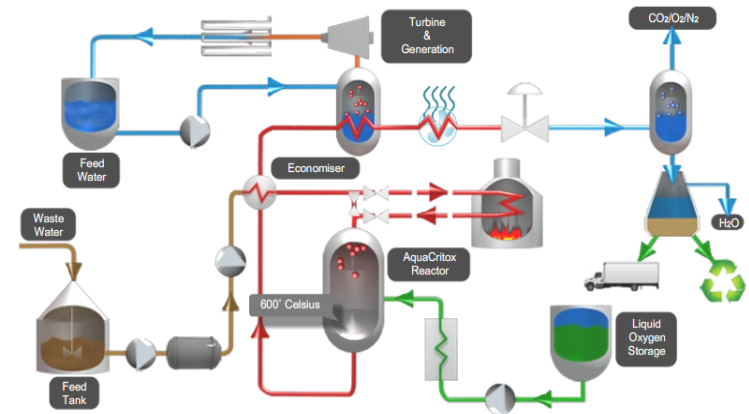
Sludge to Energy R&D - Pyrolysis

- **Working with Aston University's European Bioenergy Research Institute to develop and evaluate the technology:**
 - processing digested dried sewage sludge
- **Preliminary results**
 - Intermediate pyrolysis does not seem to create 'problem' tars
 - Pyrolysis oil with a heating value close to heating oil
- **Next steps/comments**
 - Testing of oil in engines
 - Detailed practical and economic evaluation
 - A demonstration scale plant would be needed
 - an efficient 'medium temp' sludge drying process would help energy balance



Sludge to Energy R&D - SCWO

- **Working with SCFI to evaluate their Aqua Critox process:**
 - The process has the considerable advantage of not requiring upstream drying
 - Potential for phosphorus recovery
 - Small quantity of inert ash left – potential for re-use
 - The cost and carbon cost of oxygen is the critical factor
- **Next Steps**
 - Testing of STW sludge in Cork demonstration plant



Rafael Simons, Partner,

VANTAGE POINT VENTURE PARTNERS



- Rafael joined VantagePoint from Zenon Environmental (acquired by GE), a leading water treatment company, where he was COO, responsible for all aspects of sales, operations, R&D, and manufacturing of membrane-based water treatment technology.
- Prior to Zenon, he was a consultant with McKinsey & Company, focusing on the environment and energy sectors.
- Earlier in his career, Rafael was a researcher at Lawrence Berkeley National Laboratory, where he invented a new technique to access contaminated groundwater for environmental remediation. He is a graduate of University of California, Berkeley (BA, MEng, PhD).

A Venture Capital View of Next Generation Sludge to Energy Technologies

How We View the Market

Business model first, technology second

Where does it fit in the process chain?

- Pre-dewatering
- Pre-digester
- Post-digester
- Centralized off-site

What commodity is produced?

- Biogas
- Biofuel
- Compost
- Fertilizer

How is value Captured?

- Capital sale
- Off-take Agreement
- Value Sharing

Investment Criteria

1. **Cost:** Lifecycle net cost is paramount with a target of as close to net \$0 as possible
2. **Logistics:** Clear strategy for how the resource is stored, handled, and sold?
3. **Contingency:** Minimal impact on the plant operations if the new technology goes down
4. **Capital:** How much capital must be deployed, especially prior to signed sales contracts?

Achilles Heels

Biogas – Consistency

Biofuel – Cost / gallon

Fertilizer – Nutrient value / Distribution