The Benefits of Research and Innovation in Nuclear and Defence Decommissioning

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The Arvia Process for Oil Waste Destruction

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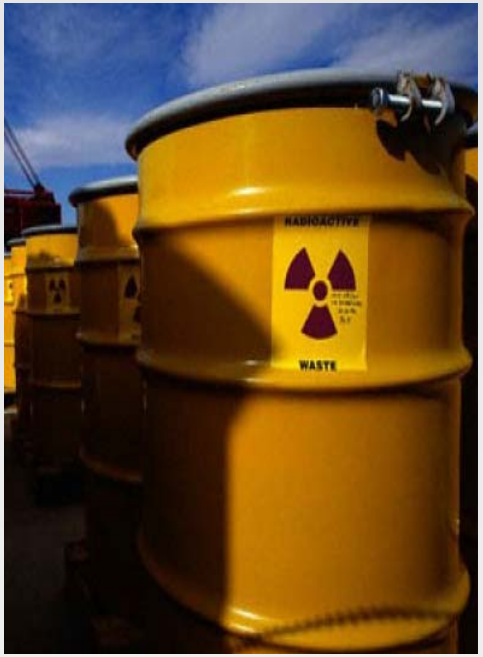
The Problem

The treatment and disposal of Highly radioactive oils is a Magnox and industry wide problem, e.g.,



Trawsfynydd:
High Alpha & ILW Oils that **exceed** UK incinerator limits

Chapelcross
Tritiated ILW **orphan** oil waste

Hunterston A:
Oil from contaminated pond sludge
Oil from cleaning contaminated pipe-work

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Baseline Solution

Incineration:

Energy **Intensive** (high carbon cost)

Only one **Licensed** Incinerator in the UK

With **LIMITED** discharge authorisations

SO EXPENSIVE & SLOW!

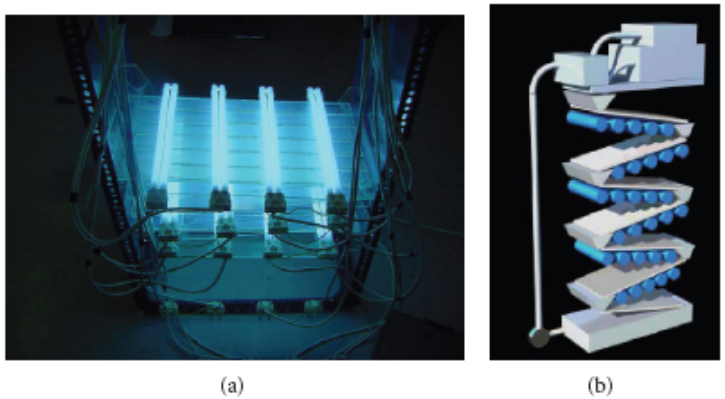
Cannot be employed in some cases – “Orphan” Wastes

A “Smarter” Solution was Required

Candidate Technologies (1)

Photo-Catalytic Techniques (UV-TiO_2 Systems)

Only applicable to trace organics in water, not the treatment of "raw oil waste"



(a) (b)

FIGURE 2: Multiple thin film plate reactor stack (a) lab-based unit, (b) concept design for scaled-up unit.

"…the processes has been developed as "polishing" units and is a complimentary technology to existing techniques.."

"Novel Photocatalytic Reactor Developments for Removal of Hydrocarbons from Water" – M Adams etal, Robert Gordon University , Aberdeen, Int. Journal of Photoenergy, Article 67453, 2008.

Candidate Technologies (2)

Classical Electrochemical Oxidation Techniques

Difficult (expensive) to scale-up to enable an “industrial “ process, i.e., complicated apparatus, expensive specialist materials (e.g., boron-doped diamond wafers), limited component lifetime.

“Assessment of Electrodes from Wafers of Boron-Doped Diamond for the Electrochemical Oxidation of Waste Lubricants – G T Taylor eta, AWE, presented at WM2006, Tucson, AZ

Candidate Technologies (3a)

Chemical Oxidation, e.g., ModulOx ™

Employs Fentons Reagent & proven for resin wastes, but safety concerns when dealing with solvent/oil wastes (highly exothermic reaction)

Not 100% effective - chemical waste/by-products can be produced that require further treatment (e.g., benzene from TBP)

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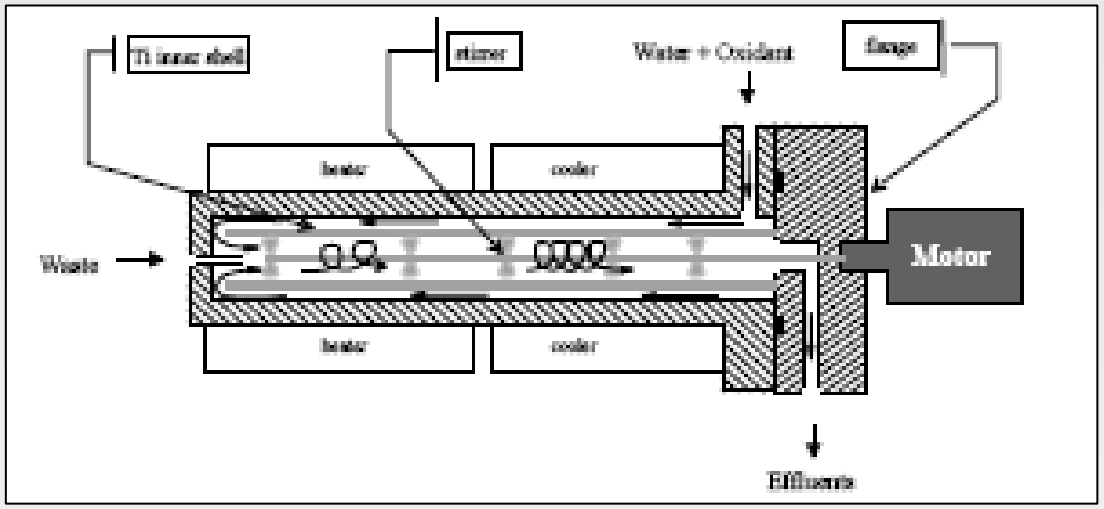
Candidate Technologies (3b)

“CEA Delos” Process: Supercritical Water Oxidation at ~500C at 300 Bar – developed for treating liquid effluent (with high salt loadings)



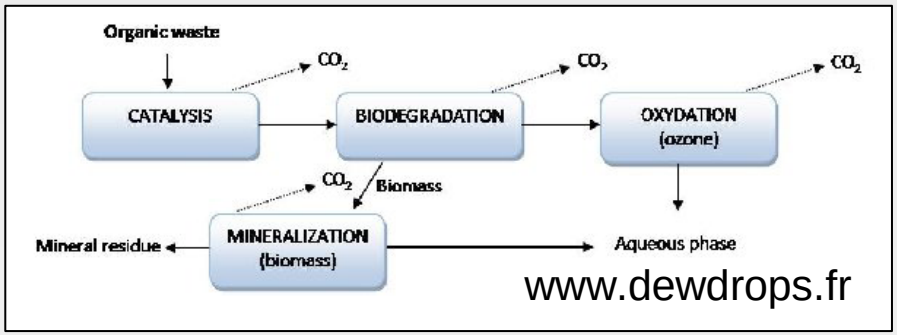
Effective, but energy intensive and complicated plant (safety issues?)

www.cea-technologies.com/articles/article/600/en

Candidate Technologies (4)

Microbial Digestion, e.g., DewDrops™ process

Bio-reactor destroys the oil, where the contaminated bio-mass is then “mineralised” using Fentons reagent



Bio-reactor very sensitive to waste composition, complicated plant

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Candidate Technologies (5)

Plasma Arc Technology – **energy intensive, extensive off-gas clean-up, complicated plant**

Physical Disposal:

Encapsulation in cementitious grouts: limited to 5-10% oil before seepage

Adsorption onto an Inert Substrate for Encapsulation, i.e., “No-Char” – oil released upon compression, no net advantage over direct encapsulation in grout

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No “ideal” alternative to Incineration

What do we do now?

New alternative – Arvia?

- “Spin-out” from the Manchester University
- Technology is an “Organic Destruction Cell” which destroys aqueous organics
- Based on adsorption coupled with electrochemical regeneration
- Patented “Arvia” Process
  - 8 patents filed
  - Patents granted in UK, Aus. Japan & US

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Arvia's Technology

• **Nyex™** is a graphite flake which adsorbs organics	• Proprietary material • IPR in place • Nyex™ adsorbs organics/oils/micro-organisms
• **Arvia™ Process** a single unit in which the adsorption, separation and destruction of the organics takes place	• No moving parts • Batch & continuous processes available • Nyex™ regenerated in-situ • Organics/oils destroyed in-situ • Produces water & trivial gases

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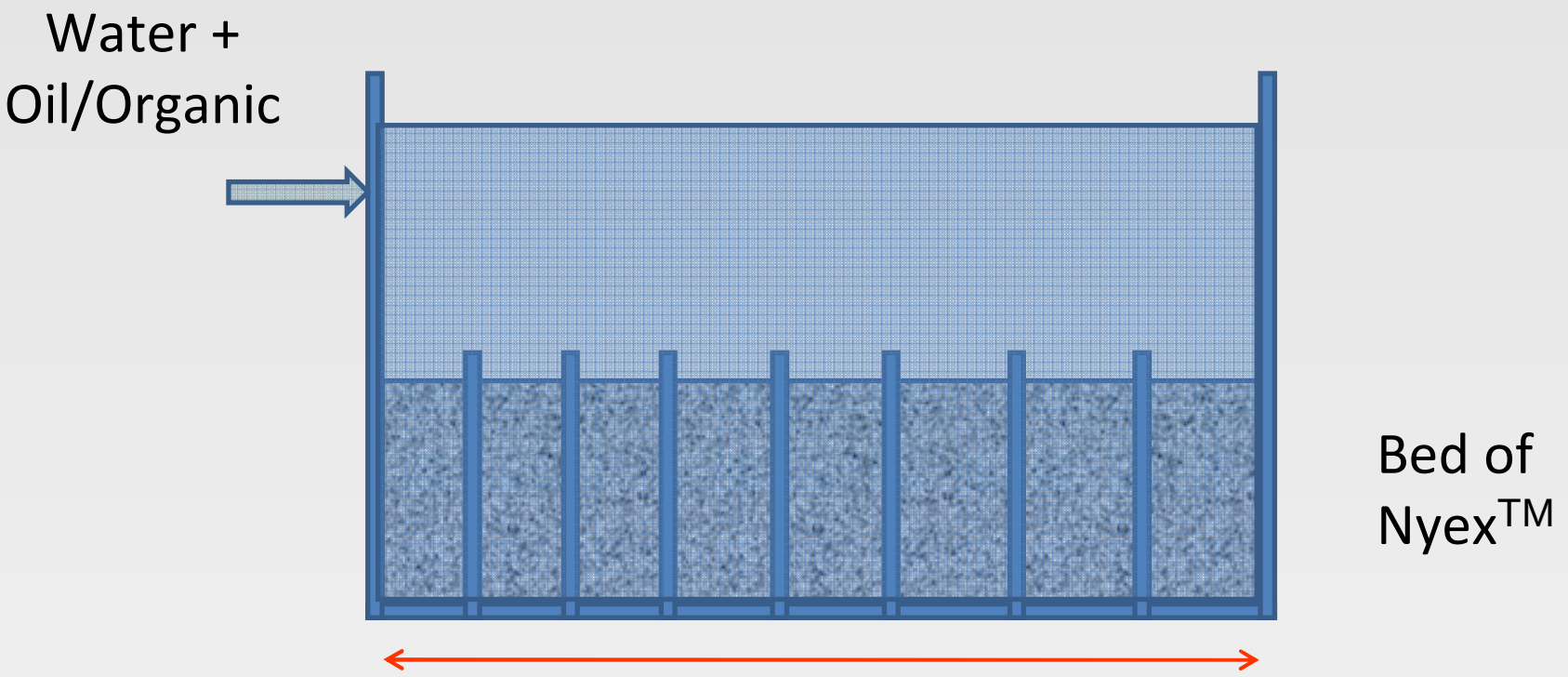
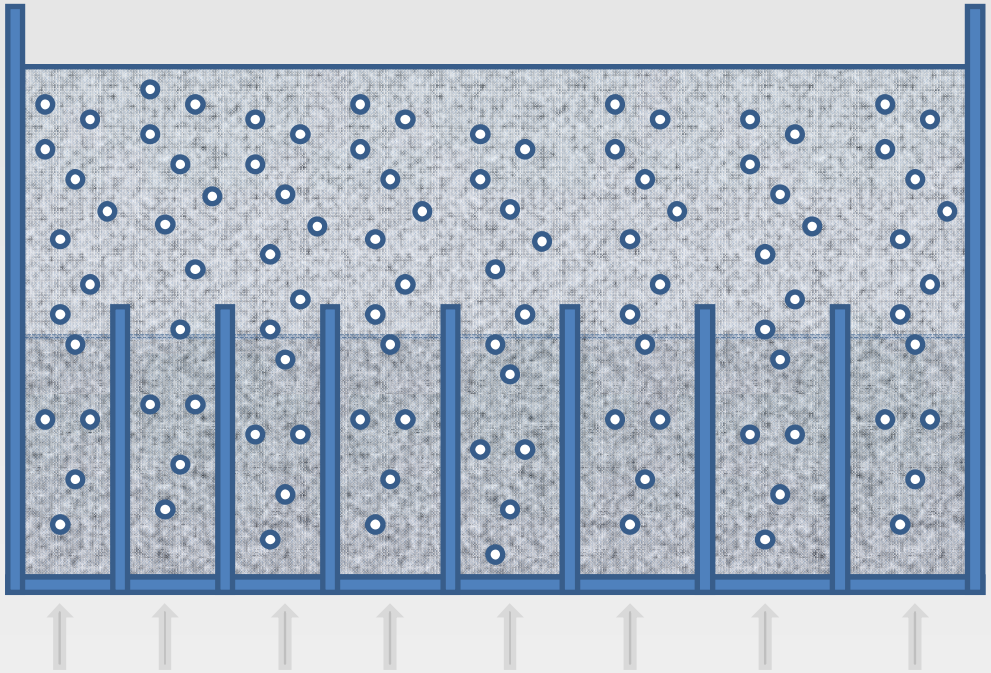
ODC*- Batch Operation



***Organic Destruction Cell**

ODC - Adsorption

Nyex™ Bed is Lifted & Fluidised



Nyex™ Adsorbs & Concentrates Oil/Organics

Air

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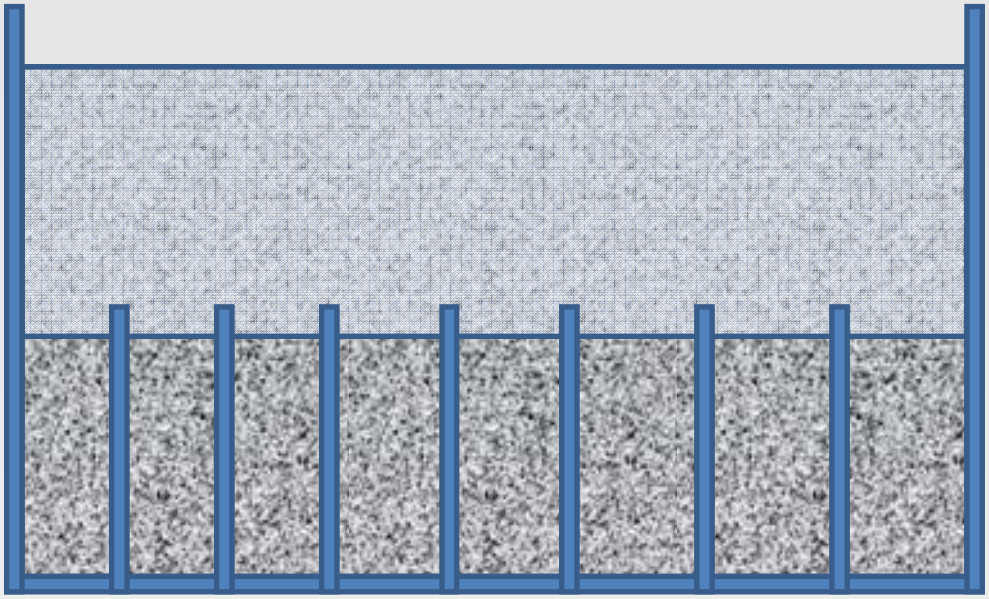
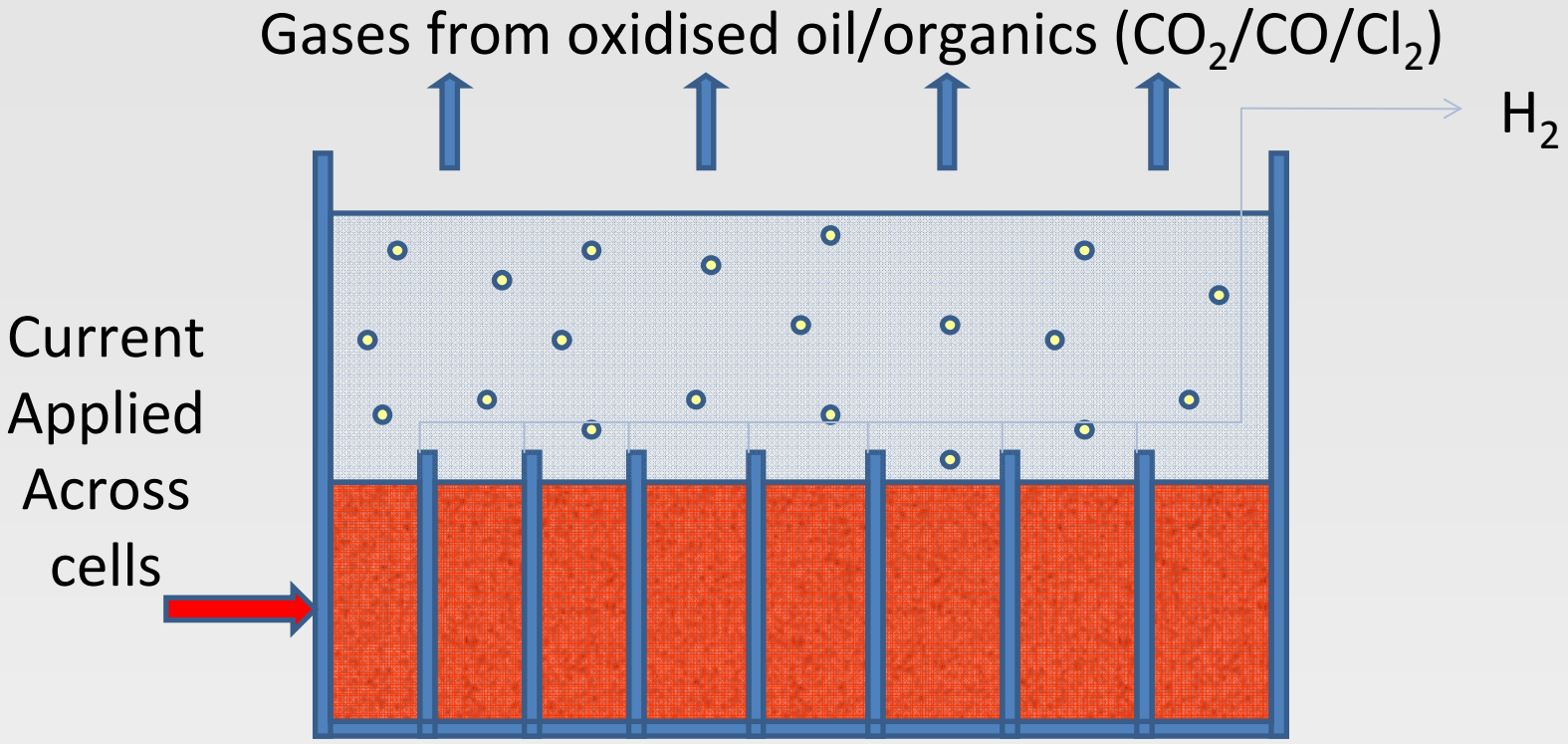
ODC - Settlement

Nyex™ Settles Between Cells



ODC - Electrochemical Oxidation



Electrochemical oxidation destroys oil/organics

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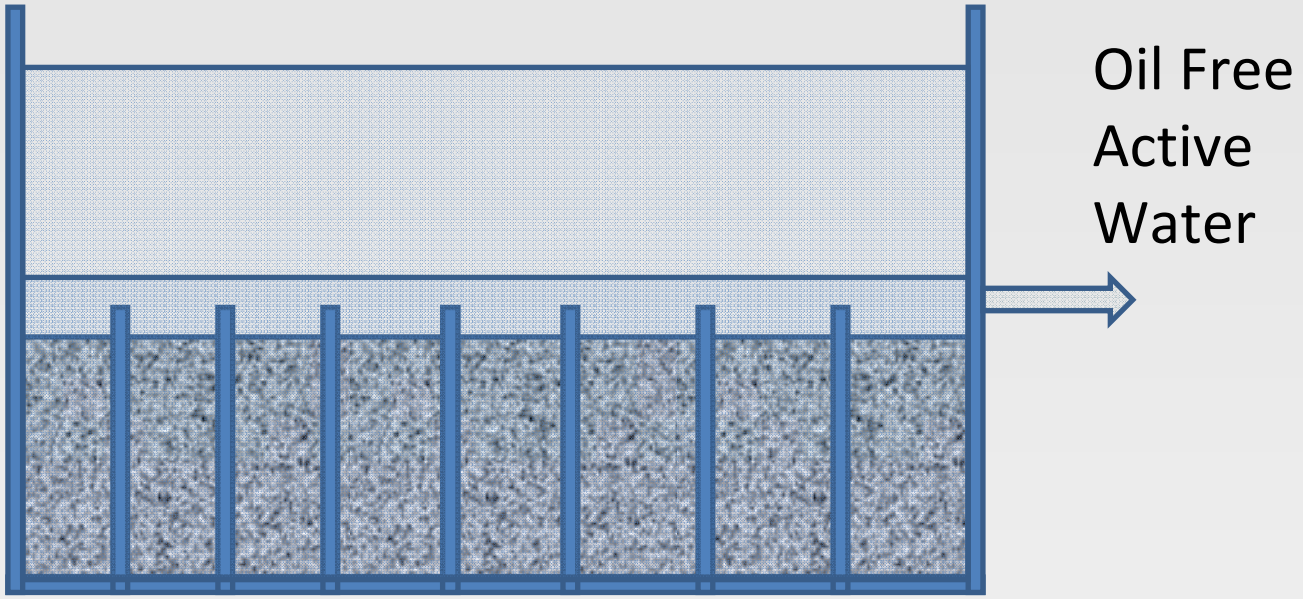
ODC - Finish



Regenerated Nyex®

Project Timeline

A Partnering approach with Arvia Technology was adopted to rapidly assess, develop, and implement

Laboratory study

300 L Prototype

January 2011 – active trials at Trawsfynydd

TRL2 → **8**

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Trawsfynydd Titan Unit

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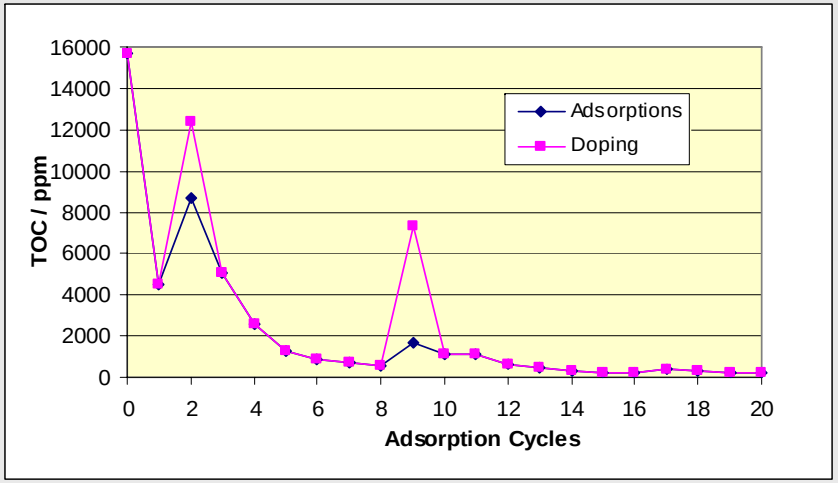
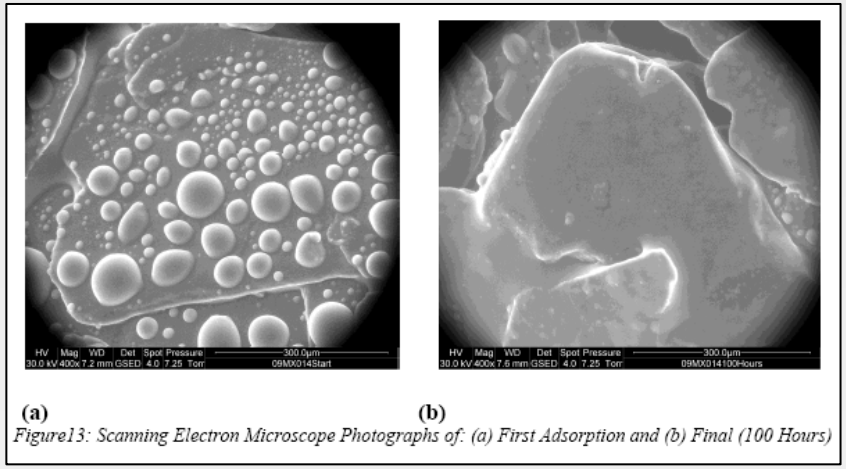
Results (1)



Over 99.9% oil destruction

Titan Trial: Calculated initial COD 70,000 mg/l
Final COD – 0 mg/l (LoD 20 mg/l)



(a) (b)

Figure13: Scanning Electron Microscope Photographs of: (a) First Adsorption and (b) Final (100 Hours)

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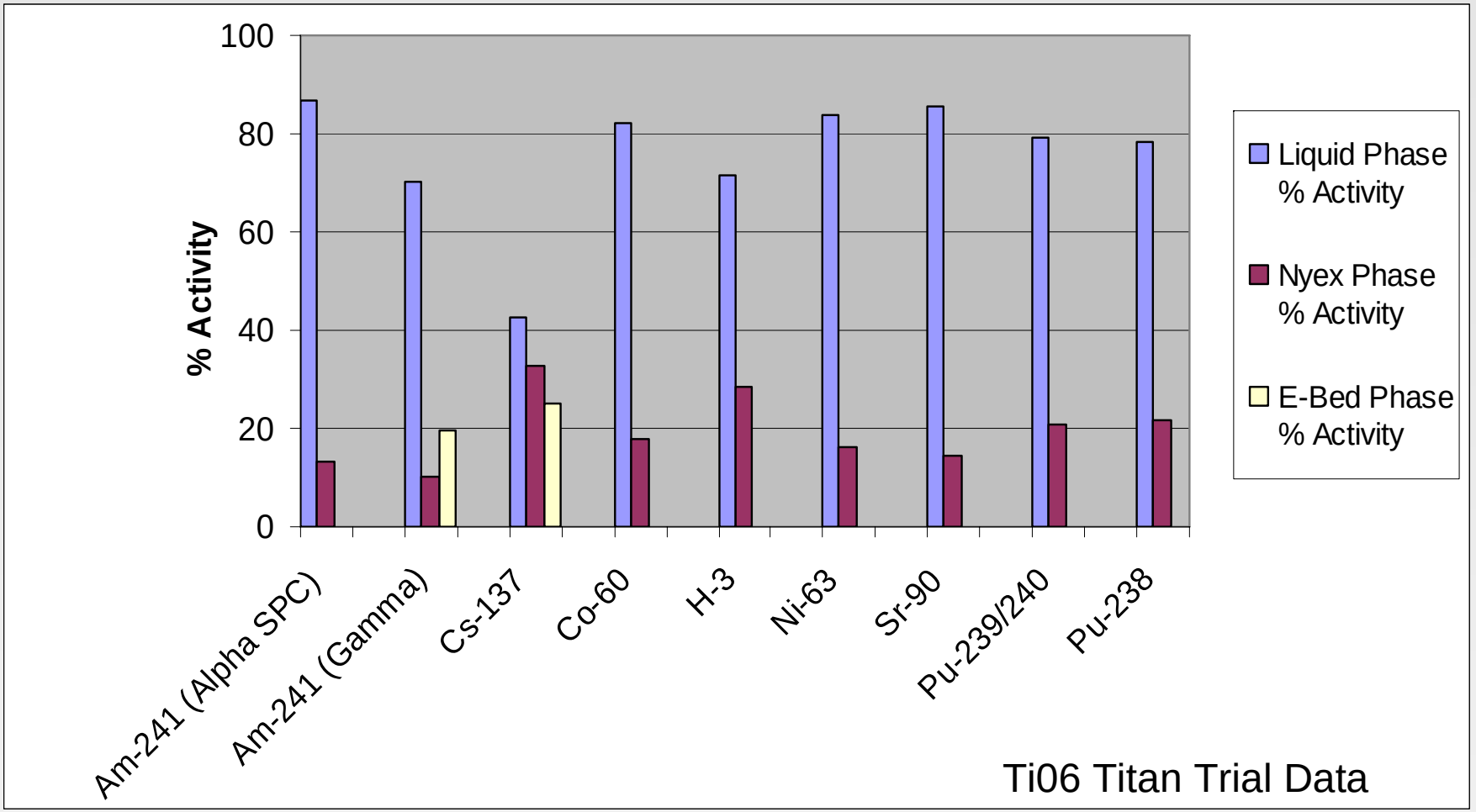
Results (2) – Radioactivity Distribution



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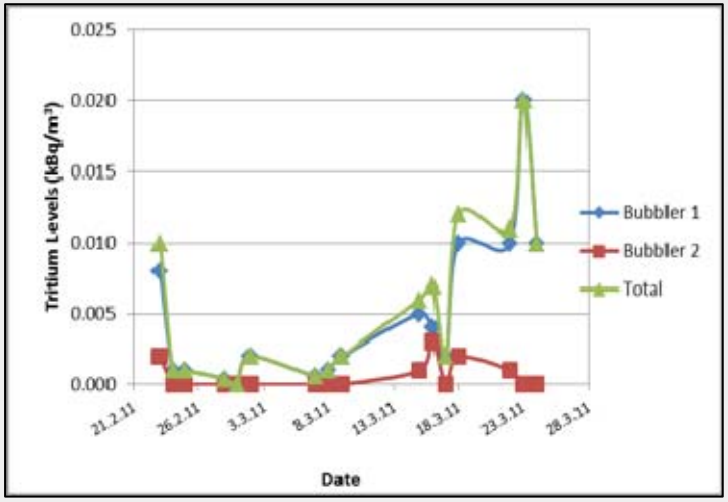
Aerial Tritium Discharge?

- Concern that gaseous H-3 could be vented
- Tested on laboratory scale
- Only low levels of activity detected
- Confidence that off-gas from full scale plant could go for direct discharge (via HEPA filter)



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Principal Secondary Wastes

Sentenced under existing nuclear site licence conditions:

- Supernatant and cell washings processed by the site Active Effluent Treatment Plant (AETP) prior to discharge
- LLW Graphite Wastes (Spent Nyex™, electrode material) sentenced to the UK LLW repository
- Gaseous waste discharged after HEPA filtration

Benefits of Arvia ODC (2)

Satisfies the Environment Agency Environmental Sector Plan for the UK Nuclear Industry:

‘Minimise the amount of natural resources used’

‘Recognise the impact of climate change’

‘Minimise discharges to air and water’

‘Minimise and manage solid waste’

‘Demonstrate sound environmental management and leadership’.

RUSHLIGHT AWARDS WINNER 2010

Clean Environment Award

Next Steps?

- Magnox – Full scale production plant planned for Trawsfynnydd site
  - Designed to destroy 1l of oil per hr.
  - 24/7 operation
- The wider UK nuclear estate interested testing technology for other organic wastes
- Significant international interest generated from WM12

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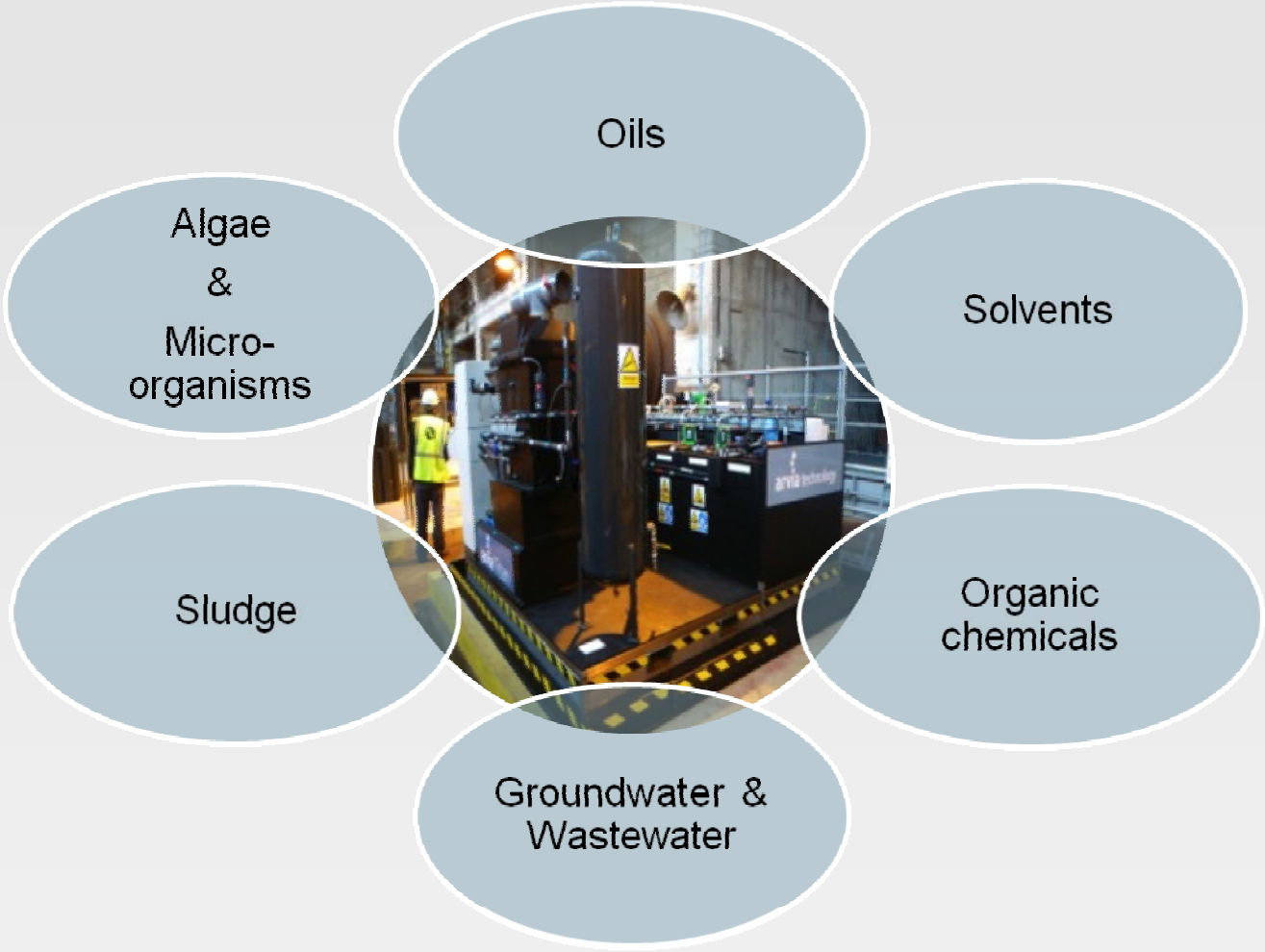
Opportunities



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"A number of other decommissioning projects are now investigating whether this approach could be applied to some of their more challenging wastes. The benefits of sharing this success could be considerable"

Dr. Darrell Morris,
Research Manager- Nuclear Decommissioning Authority

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