Water Related Research at Flinders University
A (brief) Overview

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Application of high rate algal ponds for wastewater treatment and biomass energy production
High rate algal ponds (HRAPs) for wastewater treatment and renewable energy production

- Adoption of HRAPs by Community Wastewater Management Schemes (ex STEDS) (Fallowfield, Buchanan – SA Local Government Association)

- Algae to Energy – Smart Water Fund/Melbourne Water (Fallowfield, Taylor, Buchanan)
SA: Community wastewater management schemes

High rate algal pond (HRAP)
Kingston on Murray HRAP: Overview

Township
• Population 150 – 300
• Effluent treated 12 m³/d

Climate
• Irradiance 8.3 MJm⁻² (June – winter) to 28.1 MJm⁻² (January – summer)
• 3.8°C minimum July to 31.8°C maximum in January,

HRAP
• Surface area 200m²
• Operated at 0.32 – 0.55m depth
• THRT 5d
• Mixing 0.2m/s
## Kingston on Murray HRAP wastewater treatment performance & biomass production

<table>
<thead>
<tr>
<th></th>
<th>Inlet (pre-treated in septic tanks)</th>
<th>% Removal</th>
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<tbody>
<tr>
<td>BOD$_5$ (mg/L)</td>
<td>204</td>
<td>92.3</td>
</tr>
<tr>
<td>NH$_4$-N (mg/L)</td>
<td>89.9</td>
<td>69.1</td>
</tr>
<tr>
<td>TN (mg/L)</td>
<td>91.2</td>
<td>53.5</td>
</tr>
<tr>
<td>PO$_4$-P (mg/L)</td>
<td>15.6</td>
<td>16.4</td>
</tr>
<tr>
<td><em>E. Coli</em> (MPN/100ml)</td>
<td>6.36</td>
<td>1.74*</td>
</tr>
<tr>
<td>Algal biomass production for renewable energy (g/m$^2$/d)</td>
<td>-</td>
<td>25.0 – 49.0</td>
</tr>
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</table>

*Log$_{10}$ reduction value; (n=120)
Benefits of incorporating HRAP technology in CWMS

1. Two HRAPs in series provides the same degree of treatment:
   – in 8 -18 days compared with 66 days required by the 5 cell CWMS lagoon system
   – using 40 – 50% less surface area
   – with only 11- 30% of the earthworks of CWMS lagoon system

2. The construction cost 40 – 55% that of a conventional CWMS lagoon system.

3. An in series HRAP system reduces evaporative loss of the treated wastewater to 12 – 17% compared with 30% for the conventional CWMS; resulting in more water being available for beneficial reuse in rural communities.

4. Final stages of system approval by the Dept of Health and SA LGA; independent microbiological assessment conducted by AWQC.
Melbourne Water Corporation &
Smart Water Fund
Victoria
Wastewater + CO₂
Research objectives

• Determine wastewater treatment potential
  – BOD$_5$, N & P removal
  – *E.coli* removal

• Determine
  – biomass productivity
  – species
  – proximate composition

• Compare performance ± CO$_2$ addition

• Provide data for LCA
High rate algal ponds (HRAPs) for wastewater treatment and renewable energy production

- Pilot scale integrated aerobic – algal treatment of piggery slurry (Fallowfield, Buchanan; Pork CRC)

- Co-digestion of organic wastes and wastewater grown algal biomass (Fallowfield, Cheng; Pork CRC)

- Aerobic pre-treatment of piggery slurry for the growth of algae. (Fallowfield, Hawley; Pork CRC)
Nitrification – denitrification

- Application of high rate nitrifying filter for management of ammonia driven chlorine demand (Fallowfield, Lei Mai, van den Akker)

- Removal of chemicals of concern (EDCs, herbicides, personal care products) by high rate nitrifying filter (Fallowfield, Lei Mai, van den Akker, Kookana)

- Denitrification of water using agricultural residues as carbon sources (Fallowfield, Mark Zhang, collaboration with China University of Geosciences).
Disinfection & pathogen survival

- UVB inactivation of *E. coli*, aerobic spore forming bacteria and F-RNA ‘phages. (Cromar, Fallowfield, Lian, Young, Bolton, Williams)

- Improved QMRA for wastewater irrigated salad crops in SE Asia (Cromar, Fallowfield, Makkaew, Miller)

- Adsorption of ‘phages by surface modified zeolites (Fallowfield, Reeves, Guan)
• Modelling responses of the Coorong, Lower Lakes & Murray Mouth to environmental flows: (Deakin University, DEWNR and MDBA), developing the Environment Flows Response Tool

• Assessments of impacts on beaches of waters from different sources (amongst many other anthropogenic influences like beach nourishment): ecological impact assessment of stormwater, groundwater, wastewater etc.

• Fish assemblage responses to different impacts, including the desalination plant and wastewater disposal (PhD project, this part done in conjunction with SA Water etc.)
National Centre of Excellence in Desalination (NCED) / membrane biofouling

Membrane biofouling

- “The effects of salinity on diatoms: Chemical characterisation of potential biofouling compounds produced”) 2011 NCED Honours Scholarship Fund (Ellis; La Vars (student)

- “Assessing the biofouling role of microbes in the desalination system; from the intake pipe to the reverse osmosis membranes” (NCED Grant (NCED) (Leterme, Brown, Ellis, Dixon, Kildea, Drikas, Chow, Winters)

- “Development of universally applicable coatings and additives for state-of-the-art reverse osmosis and pretreatment membranes: non-leaching, antimicrobial, low-biofouling, chlorine resistant and improved compaction properties” NCED Grant (Ellis, Ginic-Markovic, Clarke, Constantopoulos, Markovic, Groth, Dickson, Dickson, Pelekani, Dixon)

- “Nanostructure of Diatoms: A predictive model for species sustainability” NCED Grant (Leterme, Ellis, Brown, Mitchell)

- “The influence of a zwitterionic amino-sulfobetaine compound (the Technology) on the surface morphology, separation and biofouling resistance of polyamide thin film composite water filtration membranes” SA Clevergreen Grant (Ellis)
Water quality, resource recovery

• “Surface engineered microfluidic devices for the detection of Norovirus” Flinders Collaborative Research Grant Scheme (FCRGS) (Ellis, Khodakov, Brown/Callaghan Innovations, NZ),

• “Primary producers’ morphological flexibility under environmental constraints” ARC Discovery Grant (DP110101679) (Leterme, Ellis, Brown, Romero, Rohwer)

• “Sensors Systems for Analysis of Aquatic Environments” (CSIRO Collaboration Cluster Fund (Shapter, Ellis, Voelcker)

• “Reclamation of copper from natural Australian zeolites post-water treatment” Australian Institute of Nuclear Science and Engineering (AINSE) award (Ellis, Shapter, Yu, Popelka-Filcoff)
Groundwater Research

National Centre for Groundwater Research and Training

Prof. Okke Batelaan; Prof. Adrian Werner; Prof. Peter Cook;
(okke.batelann@flinders.edu.au; adrian.werner@flinders.edu.au; peter.g.cook@csiro.au)

• Groundwater resource management
  – Uley South Aquifer source water for Eyre Peninsula; PhD study (Matt Knowling) modelling relative importance of climate, pumping on the status of the aquifer, to assess whether recharge to the aquifer can be informed from the numerical model and the available groundwater data.
  – Adelaide groundwater project, model simulations re impacts of managed aquifer recharge on the water balance of the Adelaide groundwater.

• Pathogen removal - transport within aquifers
  – Attachment-block removal of viruses in MAR. MSc groundwater hydrology student (Claire Thomas) in collaboration with CSIRO field test with the Aldinga Waste Water Treatment Plant.
  – PhD student working with CSIRO on removal of ‘phages
  – Virus transport in Willunga area (near the current MAR setup) – planning stage
Groundwater Research

School of Biological Sciences
Prof. Jim Mitchell (Jim.mitchell@flinder.edu.au)

Groundwater ecology

• Subterranean invertebrate communities of arid zone Western Australia: diversity, assessment and food-web dynamics (Austin, Cooper, Humphreys, Blyth, Mitchell) – ARC Linkage Grant

• Quantitative metrics for determining aquifer ecosystem state: (Hose & Seymour) – ARC Linkage Grant

• Quantitative metrics for determining aquifer ecosystem state: (Goonan, Cooper, Humphries, Choy, Westbury) – ARC Linkage Grant
Biodiversity – marine and freshwater
Prof. Luciano Beheregaray
luciano.beheregaray@flinders.edu.au

• "Evolution, adaptation and resilience of Australian freshwater fishes" (Beheregaray) - ARC Future Fellowship.

• "Comparative Evolutionary Genomics of Australian Rainbowfishes" (Beheregaray & Bernatchez) - ARC Discovery.

• "History, transport, or temperature: solving the riddle of Australia's temperate marine biodiversity" (Beheregaray, Moller & Waters) - ARC Discovery.

• "Restoration Genetics of Five Endangered Fish Species from the Murray-Darling Basin" (Beheregaray, Harris & Adams) - ARC Linkage

• "Genomics for Persistence of Australian Freshwater Fish" (Sunnucks, Sgro, Lintermans, Beheregaray, Allendorf, Lyon & Luikart) ARC Linkage.

• "Developing a Genomic Approach for Environmental Condition Indicators in the Lake Eyre Basin" (Beheregaray) - Goyder Project:
And more…….

School of Health Sciences

• Governance options for outback water supply in South Australia; Goyder Funded research (Dr Meryl Pearce, John Martin, Brad Jorgensen (La Trobe) and Prof. Eileen Willis)

Department of Medical Biotechnology & SA Water/AWQC

• How do particles in recycled water protect pathogens from disinfection? Dr Fiona Young, Dr Paul Monis