HIGH RATE ALGAL PONDS FOR COMMUNITY WASTEWATER MANAGEMENT SCHEMES

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Wastewater management in rural communities

- Typically depend upon on site wastewater treatment e.g. septic tank
  - Suspended solids settled
  - BOD removed

- Clay & sandy soils maybe unsuitable for on-site disposal, risk to:
  - public health
  - surface & groundwater contamination

- Solution: Community wastewater management schemes
Advantages of retaining septic tanks on site:

- Solids retained in tank, permits use of small diameter pipework & infrastructure (lowering cost)
- Local Council maintains septic tanks.
- Very consistent effluent composition from system.

Disadvantages of current lagoon design:

- Long retention times (66d).
- Large surface area requirement
- High evaporative water loss
An opportunity for high rate algal ponds (HRAPs):

High rate algal ponds:

• Shallow depth (0.3 – 0.5 m)

• Baffled channel design to improve hydrodynamics

• Mixed by paddlewheel (~12 rpm; mean surface velocity ~ 0.2m/s)

• Homogeneous reaction environment; no thermal stratification

• Increased exposure of bulk water to disinfecting wavelengths – UV, UVA

• Increased exposure to photosynthetically active radiation – increased algal growth, photosynthetic oxygen production and pH.

• All contributing to shorter retention times (4 – 10d) for effective treatment
The Kingston on Murray Project
(Constructed 2008)

- On the southern bank of the Murray River within the District Council of Loxton Waikerie
- 220km north of Adelaide, situated within a citrus and wine grape growing area.
- The community has a population of approximately 250-300 residents and comprises residential properties, a school and a back-packers hostel accommodating tourists & seasonal fruit pickers.
Kingston on Murray
200 – 250m² high rate algal pond (HRAP)
Research Objective
(2008 – 2012)

To determine if wastewater from a South Australian rural community treated using a high rate algal pond (HRAP) can be safely used for irrigation of non-food crops.

{If an HRAP can ‘safely’ replace a 5 cell WSP system used in CWMS}
Percentage removal of BOD$_5$, total inorganic nitrogen (TIN) and soluble reactive phosphate (PO$_4$-P) and the log$_{10}$ reduction value (LRV) of *E.coli* from effluent *pre-treated in septic tanks* followed by treatment in the HRAP at Kingston on Murray (KoM) and from the facultative pond at Lyndoch. \( n \) = number of samples analysed.

<table>
<thead>
<tr>
<th>Removal</th>
<th>BOD$_5$ %</th>
<th>TIN %</th>
<th>PO$_4$-P %</th>
<th>E. coli LRV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>KoM</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>THRT 5d</td>
<td>92.3</td>
<td>60.5</td>
<td></td>
<td>1.6</td>
</tr>
<tr>
<td>( n )</td>
<td>124</td>
<td>75</td>
<td>11.8</td>
<td>124</td>
</tr>
<tr>
<td><strong>Lyndoch</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>THRT 30d</td>
<td>93.2</td>
<td>78</td>
<td>13.4</td>
<td>2.1</td>
</tr>
<tr>
<td>( n )</td>
<td>74</td>
<td>62</td>
<td>78</td>
<td>82</td>
</tr>
</tbody>
</table>

Independent review accepted Flinders data; proceeded to independent validation 2012.
Independent Validation  
(2013 – 2016)

- Designed in consultation with SA Dept Health.

- Winter sampling & analysis (worse case scenario), Monday & Thursday over 10 weeks – performed by NATA accredited lab (AWQC).

- 20 samples in, 20 samples out.

- Indicator organisms of pathogenic bacteria, viruses and protozoa measured – log removal value determined (log in – log out).

- 5th percentile value was used for determining the validated LRV (20 samples, 1 ‘errant’ result = 5th percentile)
Independent validation of $\log_{10}$ reduction values

250km

Sampled in Winter (worse case scenario); Monday & Thursday; 10 weeks; 20 inlet and 20 outlet samples

Independent microbiological analysis by National Association of Testing Authorities (NATA) accredited laboratory (AWQC)
<table>
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<tr>
<th></th>
<th>F-RNA bacteriophage $\log_{10}$ reduction values</th>
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<tbody>
<tr>
<td></td>
<td>($\log_{10}$ PFU 100 ml$^{-1}$)</td>
</tr>
<tr>
<td></td>
<td>HRAP1                HRAP2                In series</td>
</tr>
<tr>
<td>Mean</td>
<td>1.17                  1.16                  2.32</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.38                  0.73                  0.74</td>
</tr>
<tr>
<td>Median</td>
<td>1.30                  0.88                  2.08</td>
</tr>
<tr>
<td>5th percentile</td>
<td>0.62                  0.35                  1.61</td>
</tr>
<tr>
<td>n</td>
<td>20                    20                    20</td>
</tr>
</tbody>
</table>

Data collected by the *Australian Water Quality Centre*: Mean, standard deviation, median, 5th percentile and number of samples analysed (n) of the $\log_{10}$ reduction values for F-RNA bacteriophage ($\log_{10}$ PFU 100 ml$^{-1}$) for HRAP1, HRAP2 and in series at Kingston on Murray, (1 August and 10 October 2013).
• The HRAP achieved satisfactory winter, 5th percentile $\log_{10}$ reduction values for the specified faecal indicators organisms, specifically viruses.
Operational Recommendations

Treatment:
- HRAP treatment time of 10d, with an additional 15 days storage time where helminths are considered a hazard.
- Continuous inlet flows are preferable, however, where this unrealistic management of inlet flow rates to prevent shock loading is desirable; not more than 4% of the pond volume should be introduced over a period shorter than 4% of the hydraulic residence time.

Restrictive measures:
- Preferably, effluent should be discharged via sub-surface irrigation.
- When using spray irrigation suitable buffer zones should be established. The irrigation area should be fenced and the public excluded.
- Design and operational guidelines for HRAPs for wastewater treatment were promulgated.
Design Guideline for a High Rate Algal Pond (HRAP) - as an element in Wastewater Treatment Trains

November 2016

Culmination of a Research Project
Conducted by:
- Professor Howard Fallowfield
- Professor Nancy Croser
- Dr Neil Buchanan

School of the Environment
Flinders University
Adelaide, South Australia
2010 to 2015

High Rate Algal Pond Design
Guideline for Inclusion in SA Community Wastewater Management Schemes

“each design must be engineered to suit the particular application, and each completed design is subject to approval by the Department for Health and Ageing”.
Beneficial outcomes for rural SA communities of adopting HRAPs

– use 40% less surface area than the ‘traditional’ 5 cell WSP
  • the technology can be employed in locations were insufficient land is available for larger WSP systems.
  • alternative to energy intensive electro-mechanical wastewater treatment systems which are often considered for application where there is insufficient land for traditional WSP.

– with only 40% of the earthworks of CWMS lagoon system

– construction cost of the in series HRAP system is estimated to be 40 – 55% that of a conventional CWMS lagoon system.

– significantly reduces evaporative losses, 12-17% loss compared with 30% for CWMS lagoon system,
HRAP assumptions; 30\% area of WSP and 10\% of the retention time i.e.~7d. Equivalent treatment performance. Reuse water $71c \text{ kL}^{-1}$ (Neil Buchanan, pers. com.)
Further developments at Kingston on Murray
System replication in South Australia
Interstate replication
Smart Water – Melbourne Water Study
Flinders University’s high rate algal ponds at Melbourne Water’s Western Treatment Plant, Werribee.
International Engagement
SANITATION SAFETY PLANNING
MANUAL FOR SAFE USE AND DISPOSAL OF WASTEWATER, GREYWATER AND EXCRETA

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Adoption of high rate algal ponds for inclusion in wastewater management schemes for rural communities in South Australia
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Dr Neil Buchanan
(30th Dec 1954 – 2nd July 2015)