Cemaes Bay - Quantitative Microbial Source Apportionment
November 2017
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Supporting Organizations

Dŵr Cymru
Welsh Water

CYNGOR SIR YNYSG MÔN
ISLE OF ANGLESEY
COUNTY COUNCIL

Cyfoeth Naturiol Cymru
Natural Resources Wales

Acclimatize
Cemaes Bay

- Poor water quality classification
- The only one in Wales
- Infrastructure improvement 30th April 2015 – “Step Change”
- UV disinfection of effluent discharging to the local river
Data Sources

- Operational data
  - Llanfechell STW effluent – FIO concentrations and discharge
  - Overflow event duration monitoring (EDM) data

- Coastal hydrodynamic modelling initiative
  - Discharge and FIO concentrations in rivers and streams
  - FIO concentrations in STW effluent at Anglesey STWs
  - Storm inlet and storm tank overflow FIO concentrations
  - Targeted dry and wet weather event sampling

- River and stream FIO concentration data

- Bathing water compliance data
- Dry weather: 58.48% of total discharge
- Wet weather event: 41.52% of total discharge (duration: 28.56% of study)
River/stream catchment areas
Llanfechell STW: Discharge

- Dry weather: 59.80% of total discharge
- Wet weather event: 40.20% of total discharge
Llanfechell SPS Overflow: Discharge

- EDM data 7 overflows, 5 in bathing season
- Duration: 0.35% of study, 1.22% of event
Afon Wygyr: Sampling

- Samples categorized according to flow condition
- 37 dry weather samples, 24 wet weather event samples
**E. coli: rivers and streams**

![Graph showing concentration of E. coli in different streams](image)

- **A. E. coli**
  - Traeth Bach Stream
  - Afon Wygyr Site
  - Pig-y-Barcud

† - statistically significant difference

![Diagram legend](image)
Intestinal Enterococci: rivers and streams

† - statistically significant difference
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Discharge: $9.75 \times 10^5$ m$^3$

- Storm overflow: 0.04% of total
- Dominated by rivers and streams: 97.49% of total
**E. coli:** $6.32 \times 10^{13}$ organisms

- Llanfechell effluent: 0.02% of total
- Wet weather event conditions dominate the load and rivers_streams are the dominant inputs – 86.09% of event load
- High proportion from Traeth Bach stream *cf.* discharge in dry weather
- High proportion from storm overflow *cf.* discharge in wet weather
Intestinal enterococci: $2.47 \times 10^{13}$ organisms

- Llanfechell effluent: 0.06% of total
- Wet weather event conditions dominate the load and rivers/streams are the dominant inputs – 95.3% of event load
- High proportion from Traeth Bach stream *cf.* discharge in dry weather
- High proportion from storm overflow *cf.* discharge in wet weather
No UV *E. coli*: $7.94 \times 10^{13}$ organisms

2016 FIO data from five biofiltration STWs on Anglesey

- Dry weather input from Pig-y-Barcud: 0.72%
- UV reduces the Llanfechell effluent *E. coli* load by > 99%
- Wet weather event conditions still dominate - with rivers and streams generating 70.68% of the event load
No UV IE: $2.82 \times 10^{13}$ organisms

- 2016 FIO data from five biofiltration STWs on Anglesey
- Dry weather input from Pig-y-Barcud: 1.02%
- UV reduces the Llanfechell effluent *E. coli* load by > 99%
- Wet weather event conditions still dominate - with rivers and streams generating 88.16% of the event load
Afon Wygyr: event conditions
Cemaes Bay: event

- Cemaes Bay – during the same event (30 – 40 NTU)
### Microbial load reduction from “Step Change”

<table>
<thead>
<tr>
<th></th>
<th>Dry Weather (%)</th>
<th>Event (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>E. coli</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduction</td>
<td>28.06</td>
<td>18.69</td>
<td>20.49</td>
</tr>
<tr>
<td>Remaining†</td>
<td>71.94</td>
<td>81.31</td>
<td>79.51</td>
</tr>
<tr>
<td><strong>Intestinal enterococci</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduction</td>
<td>25.90</td>
<td>7.48</td>
<td>11.53</td>
</tr>
<tr>
<td>Remaining†</td>
<td>74.10</td>
<td>92.52</td>
<td>88.47</td>
</tr>
</tbody>
</table>

† - load from catchment sources
Any effect at the DSP?

- ANOVA - No statistically significant difference between annual GMs
Any effect at the DSP?

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Any effect at the DSP?

- 2-tailed t-test – no statistically significant difference in GMs
- 1-tailed t-test – Post UV GM significantly lower than Pre UV GM for *E. coli* only
Cemaes Bay compliance

<table>
<thead>
<tr>
<th>Year</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>Poor</td>
</tr>
<tr>
<td>2016</td>
<td>Poor</td>
</tr>
<tr>
<td>2015</td>
<td>Sufficient</td>
</tr>
<tr>
<td>2014-projected</td>
<td>Sufficient</td>
</tr>
</tbody>
</table>

- The step change has not had the desired effect on compliance
- Enterococci is the driving compliance parameter – the step change did not produce a large enough reduction in the enterococci load
- Robust prediction and discounting is required whilst actions to reduce enterococci loading in the catchment are sought and implemented
Cemaes Bay - Acclimatize

- Detailed sampling - 30 min interval 07:00 – 19:00 GMT on 61 days during 2017
- Detailed hydrological monitoring of river and stream inputs
- Meteorological monitoring – including solar radiation, wind
- Goal => prediction system in place by 2018 bathing season
DSP results – enterococci

- Large variation ≈ 2 orders in each day (max: 3.6 orders)
- Elevation in response to event conditions – even relatively small events
DSP results Swansea 2011

- Large variation ≈ 1.4 orders in each day (max: 3.1 orders)
- Similar pattern to Cemaes
Within-day variability

- Two beaches sampled similarly to characterize water quality in the “bathing day”:
  - Swansea – urban beach, complex inputs
  - Cemaes – rural beach, relatively simple inputs

- Sampling at Bray (Ireland) and Aberafan has also shown within-day variability

- Prediction systems – with a public health outcome - need to take this into account

- Questions the suitability of compliance data (now < 1 sample per week) for prediction systems…