The impact of glyphosate-containing herbicide (GCH) on pollution attenuation in a model pervious paving system (PPS)

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Submitted to Chemosphere
Structure

1. Why glyphosate containing herbicides and what are they?
2. Why could GCHs be a problem?
3. Pervious paving (PPS) and the role of the geotextile
4. The experiments
5. Results
6. Conclusions
Why glyphosate-containing herbicide? (GCH)

- Background:
- Most widely used herbicide for weed control in amenity areas by Local Authorities
- Reclassified April 2012 as R53 ‘May cause long term adverse effects in the aquatic environment’.
Water UK’s Review Group on Flooding: Lessons Learned from Summer Floods 2007:

"Bigger pipes are not the solution to bigger storms. The water industry can build extra resilience into the sewer network at a cost but sewers and drains are not flood defences. There will be occasions when the network will not be able to deal with the volumes of water associated with extreme floods.

Looking forward, new designs need to consider overland flow routes, sustainable drainage and sacrificial areas for flooding as an alternative to piped sewerage systems for the disposal of surface water."
PPS structure and the focus of the experiments

- PPS at Act UK, Technocentre, Coventry

![Diagram of PPS structure]

- Paving units
- 50mm depth of washed, clean 3 – 10 mm gravel bedding layer
- Polypropylene geotextiles
- 300 – 500mm depth of washed, clean 5 – 40mm granite sub-base

Permeable fabric
Function of the geotextile

- To separate different sizes of aggregate to avoid blocking
- Allows hydraulic head to build up: settlement of particulate associated pollutants
- Provides a substrate for biofilm to grow on

Surface of new geotextile fibre
Pits = 3-12 µm

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Development of biofilm on geotextile after 6 months

- Biofilm
- Individual geotextile fibres
- Fungal hyphae
Fungal spores and bacteria

Supporting geotextile
Why would GCH be a problem?

- Herbicidal efficacy of enhanced by a surfactant
- GCH readily broken down in soils:
  - soil adsorption
  - microbial degradation
- BUT: Coupe et al., 2006

Project aims
- To investigate whether commonly used GCHs affect water quality in the test rig effluent;
The experiments

gotextile
aggregate
Tap and tubing
Sample bottles

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Experimental protocols

• 4 test rigs, 3 replicates:
  • GCH only
  • Oil only
  • GCH + oil
  • Control (no additions)
• NB *used* motor oil

• Application rate of contaminants:
  • Oil: 1.2g/week – worst case scenario
  • GCH: 10ml/week
  • @7.2g glyphosate/ litre
Experimental protocols

- Rainfall simulation: 13mm = “typical” rainfall event
- Effluent collected and analysed for:
  1. Physical appearance:
  2. Hydrocarbons:
  3. Metals:

- Tray with holes
  1. Cloudiness, formation of foaming
  2. IR spectroscopy
  3. ICP-OES
1. Cloudiness/foaming

Samples of effluent from test rigs to show cloudiness and foam with herbicide added.

Herbicide + oil
Herbicide
control
oil

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2. Hydrocarbon content

- **Concentration (mg/l)**
  - Oil + Gly
  - Oil only
  - Control
  - Gly only

**Weekly contaminant addition**

**Background**

**Contaminants added**

**Below limits of detection**

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3. Metals in effluent: rates of dissolution

<table>
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<th>Solvent</th>
<th>Oil added</th>
<th>Average concentration (mg/l) n=6</th>
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<tr>
<td></td>
<td></td>
<td><strong>Cd</strong></td>
<td><strong>Cu</strong></td>
<td><strong>Pb</strong></td>
<td><strong>Zn</strong></td>
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</table>

0.3g oil made up to 100ml with deionised water

Or: 0.3g oil added to 5ml of 7.2g/l glyphosate made up to 100ml with deionised water

Red indicates close to, or exceeding, WHO potable water limits
3. Metals in effluent

**Zn**

- **Oil + Gly**
- **Oil only**
- **Control**
- **Gly only**

**WHO, 2011 potable water guideline:**

- Zn = 3.0 mg/l
- Pb = 0.025 mg/l

**Pb**
3. Metals in effluent

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<tr>
<th>Date</th>
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<td>0.04</td>
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<tr>
<td>28/07/2011</td>
<td>0.02</td>
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</tbody>
</table>

WHO, 2011 potable water guideline: 2.0 mg/l
Conclusions

- Addition of GCH impacted on the oil retention capability of the PPS rigs. The surfactant may be forming an emulsion with the oil thus allowing oil to pass through the PPS.
- The addition of GCH also impacted the capability of the PPS to retain heavy metals.
- Intimately tied up with the microbiology since: