



Connect & Discover

Athlone Institute of Technology
Bioscience Research Institute

An Ecotoxicological Investigation on the Effects of Pulsed Ultraviolet Light on Selected Aquatic Chemical Disinfectants

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The logo for 'environ 2017' features a green leaf icon to the left of the word 'environ' in a green sans-serif font, followed by '2017' in a lighter green sans-serif font. The entire logo is enclosed in a thin black rectangular border.

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NUI Galway
OÉ Gaillimh



Department of
Agriculture,
Food and the Marine
An Roinn
Talmhaíochta,
Bia agus Mara

MOREFISH

“Enhancing Production & Sustainability in Irish Aquaculture”

➤ Innovation



➤ Sustainability

➤ Improved Efficiencies

- Multidisciplinary Project
- Worldwide achievement & novel innovations to Irish Aquaculture
 - I. Enhanced production efficiency & sustainability – **Long term onsite studies**
 - II. ↓ Environmental impact – **LCA analysis**
 - III. ↑ Fish health & ↓ disease/mortalities – **Pulsed UV light**

Project Justification

- Intensification of aquaculture practices
 - Lower fishing capacity worldwide
 - ↑ Consumption rates *per capita*
- Irish Aquaculture industry:
 - €149 million
 - Total Employment - 1841
 - Freshwater sector €9.5 million
- Operational Set up:
 - Traditional Flow Through (FT) systems



Figure 1. Typical FT pond system



Advancements Towards Increased Productivity & Efficiency

Recirculating aquaculture systems (RAS)

- Water source is entirely/partially treated water within the farm

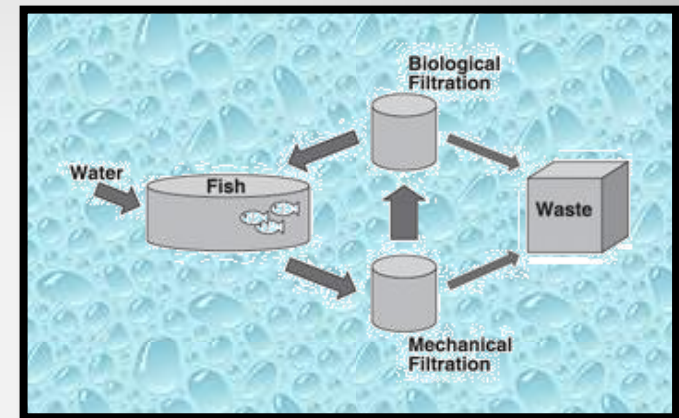
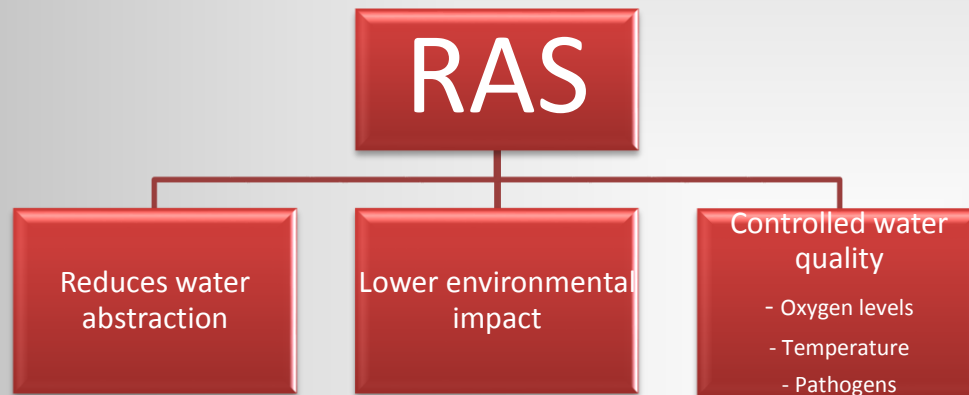


Figure 2. Basic RAS system



- Increased disinfection measures
 - Non-toxic to fish
 - Environmentally friendly
 - Sustainable – cost

Current Disinfection Methods

- Mainly chemical
 - Infected fish/eggs – baths
 - Withdrawal times
 - Disadvantages:
 - Accumulation, toxicity, resistance
- Non-chemical methods
 - Ultraviolet light (static)
 - Ozonation

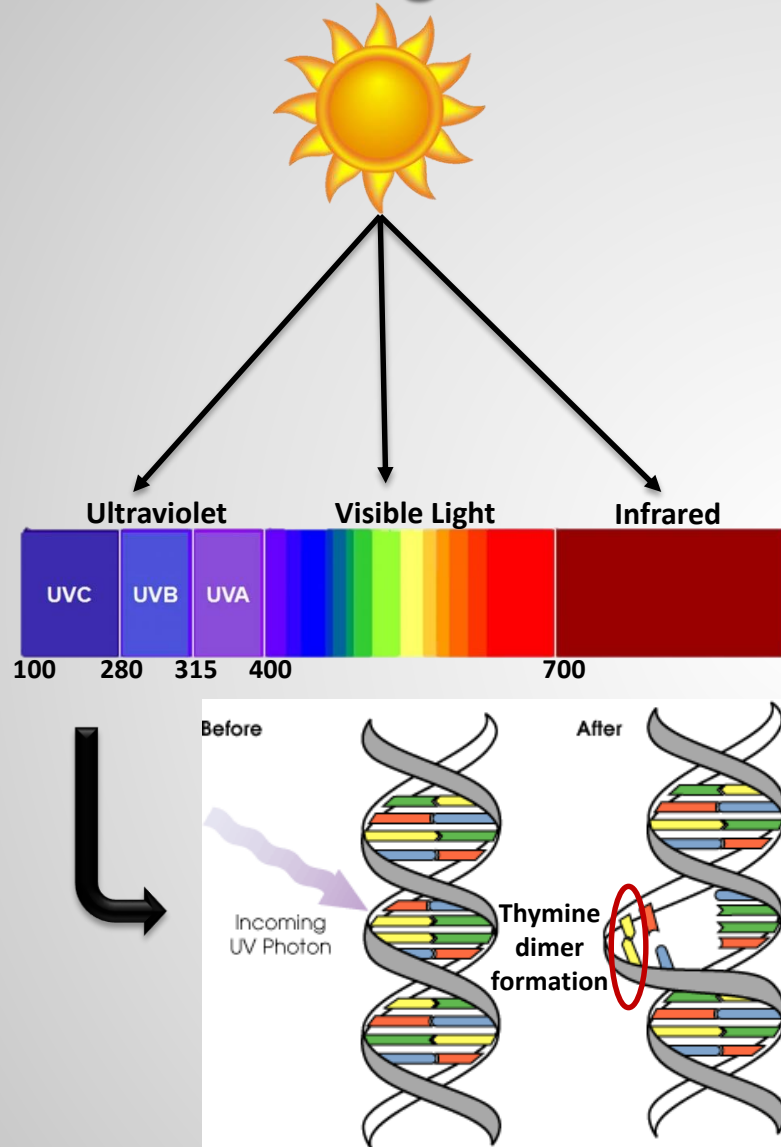


Figure 3. Filling Egg Trough with Disinfectant Solution, (Lake Huron Fishing Club, 2010)

Table 1. Treatment dose of chemical pathogenic disinfectants for use in aquaculture in Ireland.

| Formalin | Chloramine T | Pyceze |
|--|----------------------|--|
| 150-250ppm – 30-60mins (37-39% active ingredient) | 2-20ppm up to 60mins | 20ppm – 30mins (fish) 50ppm – 30mins (eggs) |

Ultraviolet Light Disinfection



- UVC – germicidal λ – 220 to 280nm
 - Micro-organisms have high absorbance @ 254nm
- Conventional static UV
 - Low/high pressure
 - Mercury based bulbs
- Bulb replacement



Figure 4. Conventional UV lamp

Pulsed Ultraviolet Light (PUV) Technology

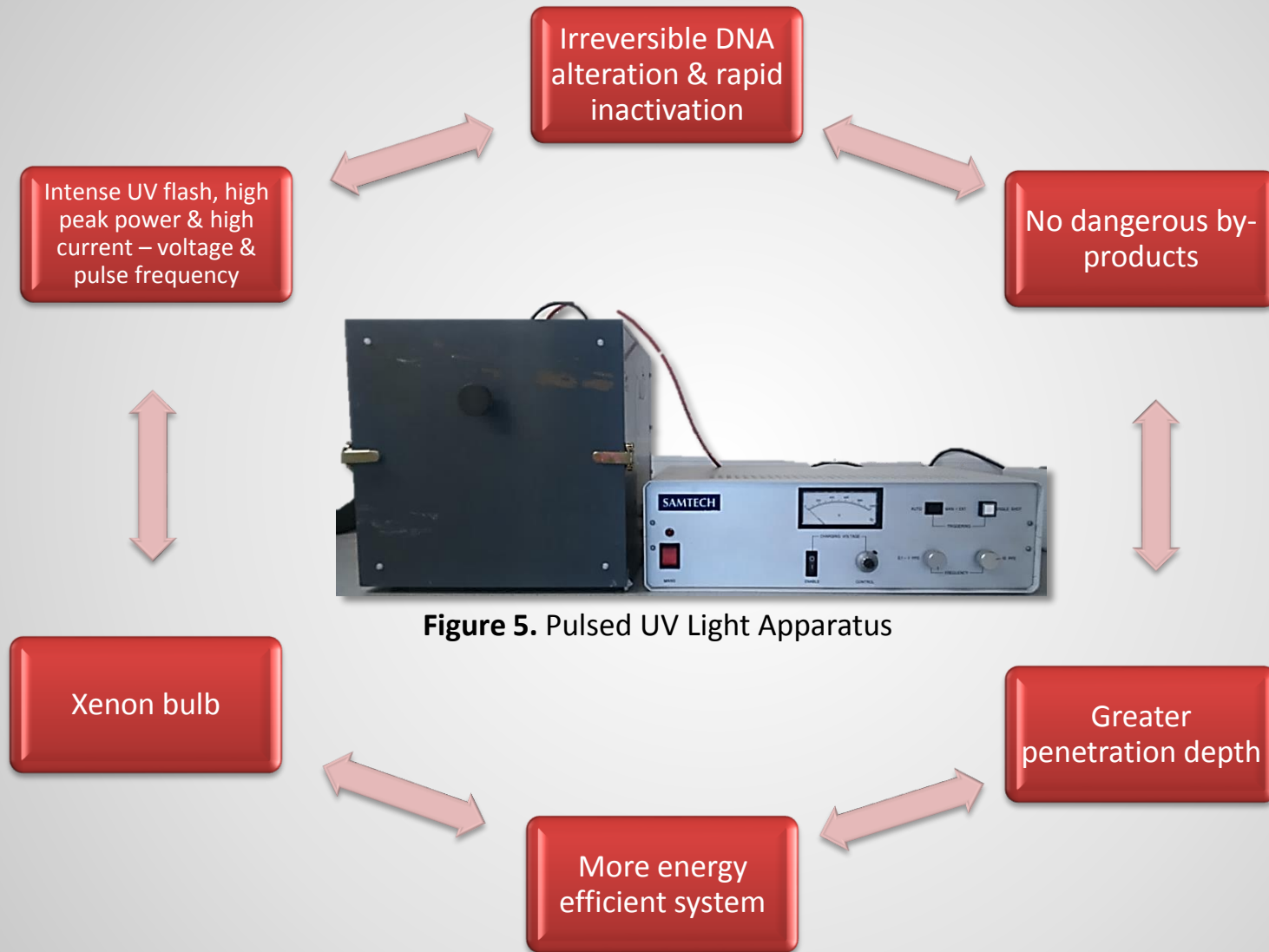


Figure 5. Pulsed UV Light Apparatus

Uses of PUV in Aquaculture

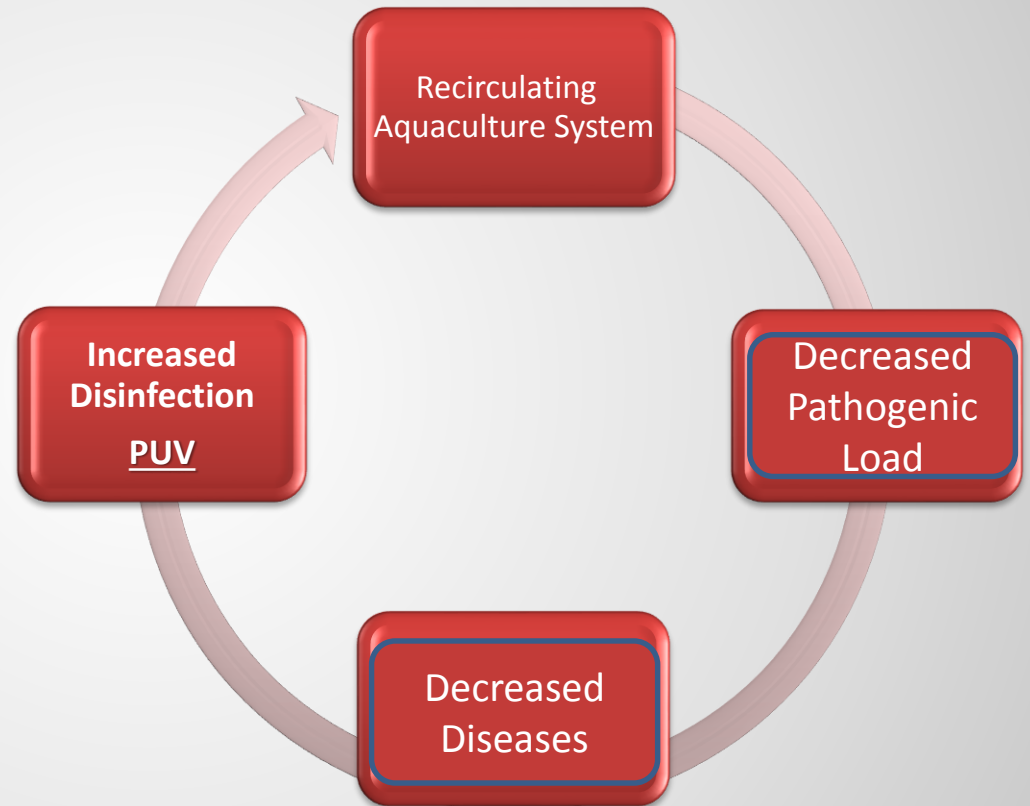
Influent



Main Farm Process

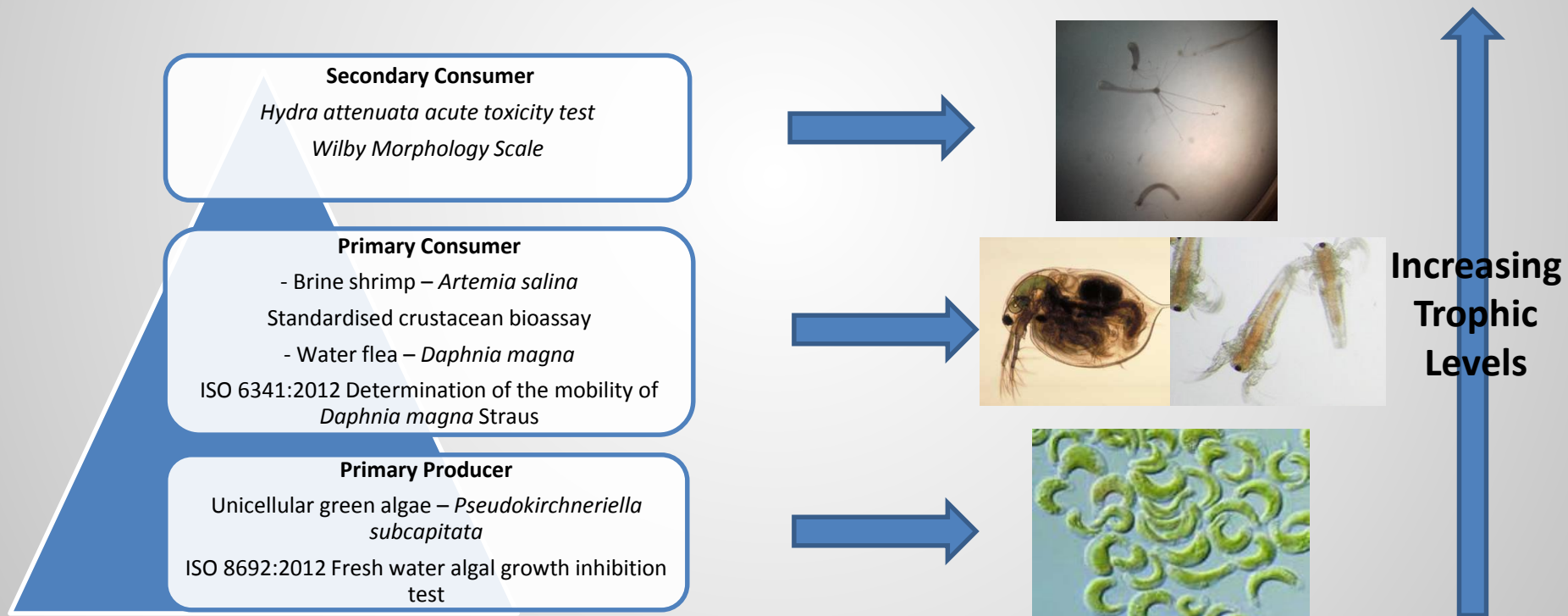


Discharge



Objectives

- Investigate the effects of Pulsed Ultraviolet Light (PUV) on finfish pathogens ✓
 - Successful at eliminating pathogens e.g. *Aeromonas salmonicida*
- Investigate the effects of Pulsed Ultraviolet Light (PUV) on chemical disinfectants
 - Multi-trophic Ecotoxicological Test Battery – Acute Toxicity Testing



Algal Bioassay – Bronopol pre & post PUV treatment



- Results indicate similar ErC_{50} values prior to & post PUV for 72hrs
- Results indicate similar ErC_{50} values prior to & post PUV for 96hrs
 - T-test indicates no significant difference before and after PUV treatment at 95% confidence level {72hrs $p=0.9019$; 96hrs $p=0.8881$ }

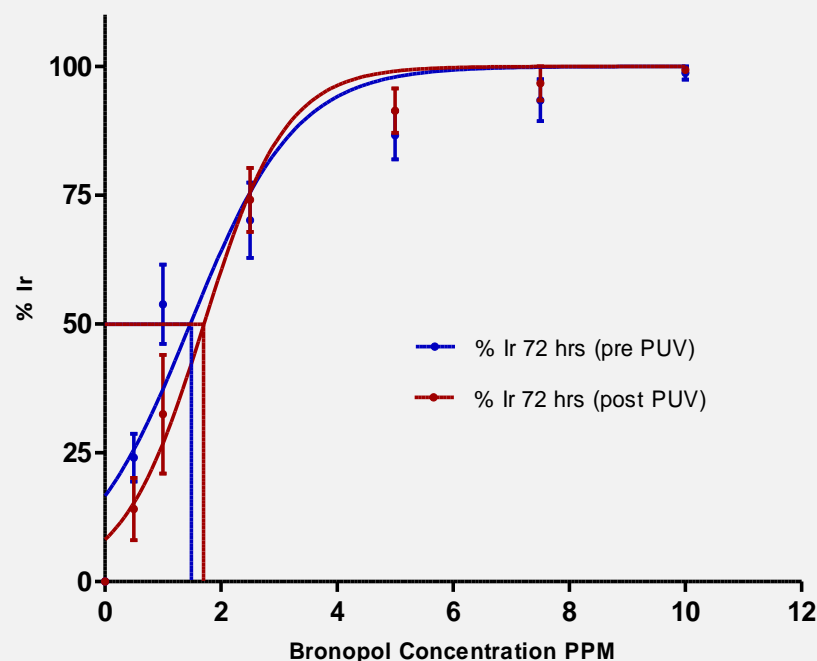


Figure 6. Dose response curve for *Pseudokirchneriella subcapitata* exposed to Bronopol for 72 hrs pre and post pulsed ultraviolet light exposure.

Pre PUV ErC_{50} = 1.470ppm [95% C.I = 1.162 – 1.778]
Post PUV ErC_{50} = 1.705ppm [95% C.I = 1.420 – 1.991]

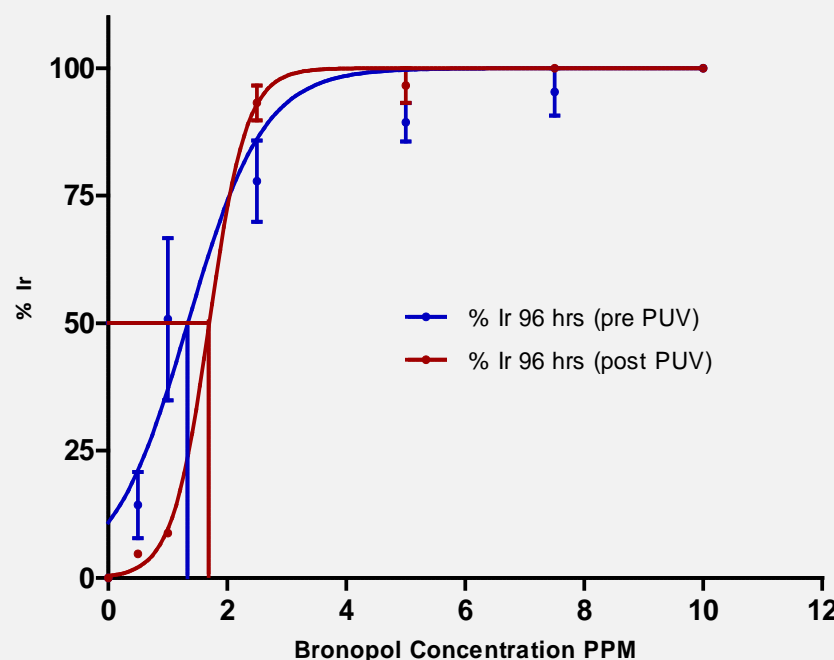


Figure 7. Dose response curve for *Pseudokirchneriella subcapitata* exposed to Bronopol for 96 hrs pre and post pulsed ultraviolet light exposure.

Pre PUV ErC_{50} = 1.338ppm [95% C.I = 1.119 – 1.557]
Post PUV ErC_{50} = 1.698ppm [95% C.I = 1.585 – 1.812]

Artemia salina – Bronopol pre & post PUV treatment

- Results indicate similar ErC_{50} values prior to & post PUV for 24hrs
- Results indicate similar ErC_{50} values prior to & post PUV for 48hrs
 - Less toxic – t-test indicates no significant difference before and after PUV treatment at 95% confidence level {24hrs $p=0.9401$; 48hrs $p=0.9994$ }

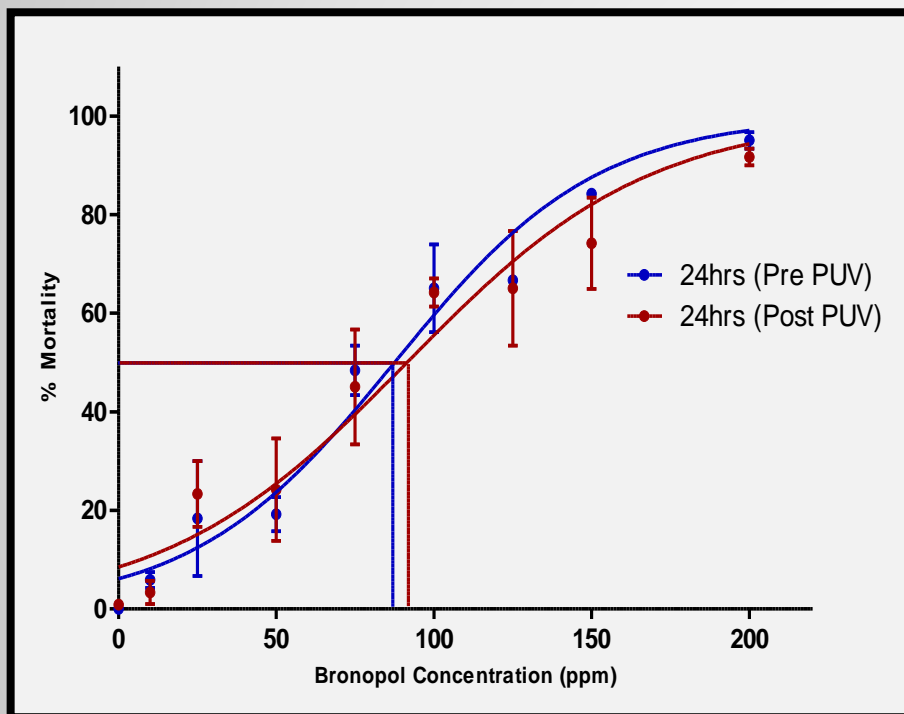


Figure 8. Dose response curve for *Artemia salina* exposed to Bronopol for 24hrs pre and post pulsed ultraviolet light exposure. (N=3)

Pre PUV $LC_{50} = 87.49\text{ppm}$ [95% C.I = 79.86 – 95.13]
Post PUV $LC_{50} = 91.45\text{ppm}$ [95% C.I = 79.60 – 103.30]

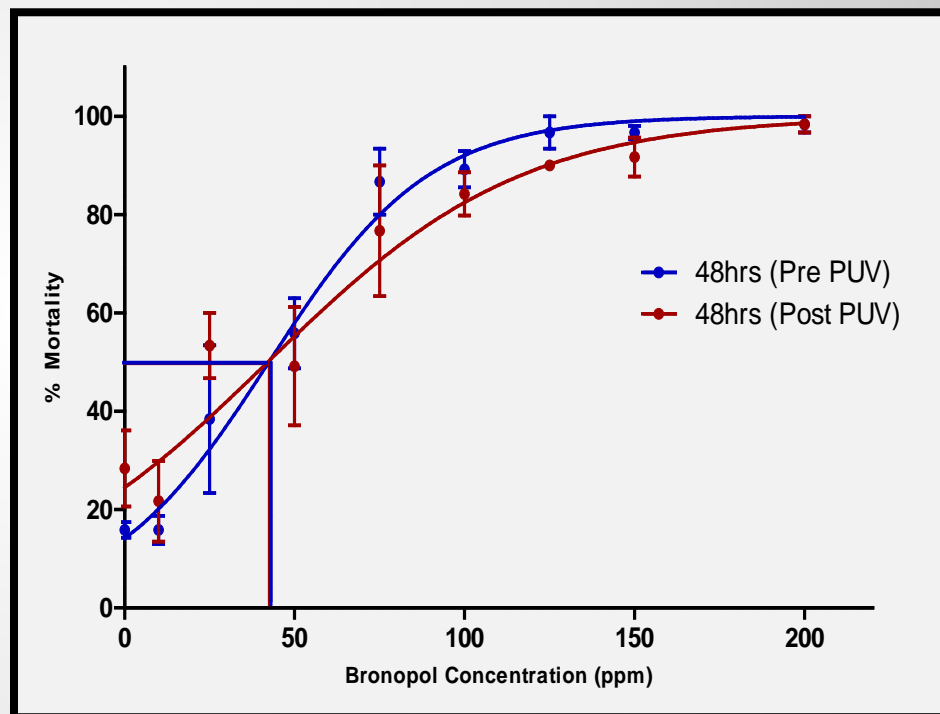


Figure 9. Dose response curve for *Artemia salina* exposed to Bronopol for 48hrs pre and post pulsed ultraviolet light exposure. (N=3)

Pre PUV $LC_{50} = 42.46\text{ppm}$ [95% C.I = 37.03 – 47.90]
Post PUV $LC_{50} = 42.15\text{ppm}$ [95% C.I = 30.50 – 53.80]

Daphnia magna Assay– Bronopol pre & post PUV treatment



- Results indicate similar ErC_{50} values prior to & post PUV for 24hrs
- Results indicate similar ErC_{50} values prior to & post PUV for 48hrs
 - Less toxic – t-test indicates no significant difference before and after PUV treatment at 95% confidence level {24hrs $p=0.5229$; 48hrs $p=0.6015$ }

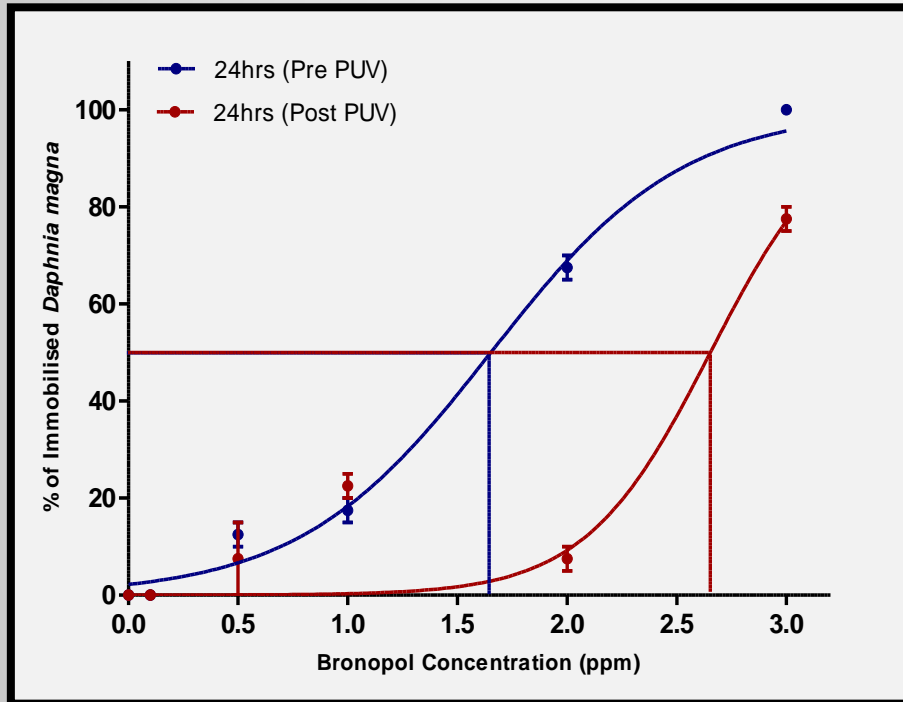


Figure 10. Dose response curve for *Daphnia magna* exposed to Bronopol for 24 hours pre and post pulsed ultraviolet light exposure.

Pre PUV $EC_{50} = \underline{1.653ppm}$ [95% C.I = 1.584 – 1.758]
Post PUV $EC_{50} = \underline{2.653ppm}$ [95% C.I = 2.374 – 2.933]

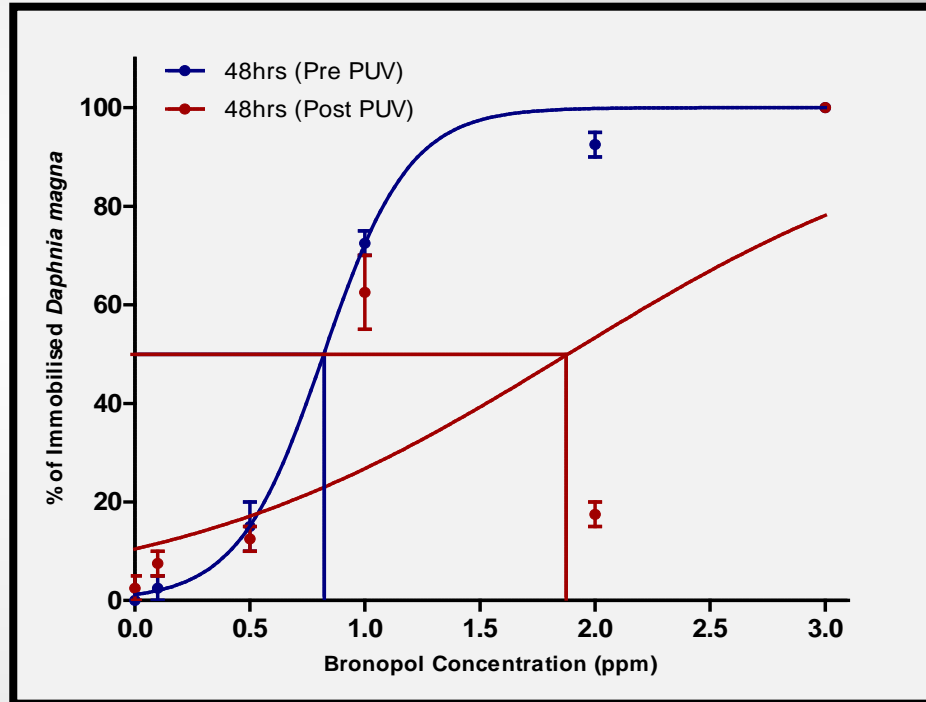


Figure 11. Dose response curve for *Daphnia magna* exposed to Bronopol for 48 hours pre and post pulsed ultraviolet light exposure.

Pre PUV $EC_{50} = \underline{0.821ppm}$ [95% C.I = 0.766 – 0.876]
Post PUV $EC_{50} = \underline{1.883ppm}$ [95% C.I = 0.977 – 2.789]

Summary & Future Work

- Pulsed ultraviolet light is safe to use in combination with Bronopol
- No statistically significant difference at this level of experimentation pre and post PUV
 - Bronopol is still less toxic following PUV exposure
 - Possibly greater significance at a magnified level in real setting
- Investigate these findings in pilot study on fish farm
- Ongoing investigations with other common disinfectants used in aquaculture
- Investigate if the response evoked in *Artemia salina* bioassay at approx. 2ppm Bronopol following PUV exposure

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Thank You All For Listening!!

