Effect of pulsed irradiation by UV-LEDs on water disinfection

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UV-LEDs

- A new UV source

  - Environment-friendly (no mercury)
  - Compact and robust (more durable)
  - Fast start-up time (no warm-up time)
  - Low power requirement
  - Long life time
  - Potential for higher energy efficiency
  - Diversity in emission wavelength
  - Ability to turn on and off with high frequency
Why pulsed irradiation?

- Xenon lamps pulsed light
  - Enhance inactivation
  - Additional mechanisms

Bohrerova et al., 2008. Water Research. 42(12), 2975-2982
Why UV-LEDs pulsed irradiation?

- Ability to turn on and off with high frequency
- Flexibility on pulse patterns
Research question

Xenon lamps
pulsed light

UV-LEDs
pulsed irradiation

Enhance inactivation

Optimal pulse pattern?
Experiments

Apparatus

- 265 nm UV-LED
- Water sample
- Magnetic Stirrer

UV irradiation measurement

- Radiometer
- Chemical actinometry
Microorganisms inactivation

- 265 nm
- UVC-LED

Continuous irradiation
- Frequency:
  - 0.1 Hz
  - 1 Hz
  - 10 Hz
  - 100 Hz
  - 1k Hz
- Duty rate:
  - 10%
  - 25%
  - 50%
  - 75%
  - 90%

Pulsed irradiation

- E. coli
- MS2
- Total coliform in wastewater
- E. coli in wastewater
UV-LEDs pulsed irradiation

- UV fluence determination

Pulsed irradiation at 50% duty rate: double operation time

<table>
<thead>
<tr>
<th>Irradiation mode</th>
<th>UV fluence based on calculated operation time</th>
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<tbody>
<tr>
<td></td>
<td>Time (s)</td>
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<tr>
<td>Continuous</td>
<td>40</td>
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<tr>
<td>Pulsed 0.1 Hz 50%</td>
<td>80</td>
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<tr>
<td>Pulsed 1 Hz 50%</td>
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<tr>
<td>Pulsed 10 Hz 50%</td>
<td>80</td>
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<tr>
<td>Pulsed 100 Hz 50%</td>
<td>80</td>
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<tr>
<td>Pulsed 1k Hz 50%</td>
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Calculated operation time for pulsed irradiation can not guarantee equivalent UV fluence.
UV-LEDs pulsed irradiation

- Waveform of pulsed irradiation

Due to imperfection of pulse waveform, operation time of pulsed irradiation needs to be adjusted in order to get equivalent UV fluence for inactivation comparison.
UV-LEDs pulsed irradiation

- Ensure equivalent UV fluence for pulsed irradiation

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<td>Pulsed 1 Hz 50%</td>
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<td>Pulsed 10 Hz 75%</td>
<td>50</td>
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<tr>
<td>Pulsed 10 Hz 25%</td>
<td>139</td>
</tr>
<tr>
<td>Pulsed 10 Hz 10%</td>
<td>333</td>
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</tbody>
</table>
Microorganisms inactivation

E. coli

Total coliform in wastewater

E. coli in wastewater

MS2

Frequency

Frequency

Frequency

Frequency

Duty rate

Duty rate

Duty rate

Duty rate
UV-LEDs pulsed irradiation

- Clarified the role of pulsed irradiation:

  Applying the **same amount of UV radiation** with the **same UV wavelength and intensity** in repeated pulse always achieves comparable inactivation effect as applying UV radiation continuously.
Discussion

- UV-LED continuous VS pulsed irradiation

![Graph showing comparison between UV-LED continuous and pulsed irradiation.]

Pulsation does not make a difference on inactivation.

- Mercury lamps continuous VS xenon lamps pulsed irradiation

![Graph showing comparison between Mercury lamps continuous and xenon lamps pulsed irradiation.]

High peak intensity might be the key to make a difference on inactivation.
UV-LEDs pulsed irradiation

- Thermal management

Pulsed irradiation can help a better thermal management for UV-LEDs.
Conclusions

- Comparisons of continuous and pulsed irradiation on microorganisms inactivation were based on equivalent UV fluence.

- UV-LED pulsed irradiation with various pulse patterns achieved comparable inactivation as continuous irradiation on various microorganisms.

- Pulsed irradiation can help a better thermal management for high output UV-LEDs application.
Acknowledgements
Thanks for your attention!

Questions?

For more information, please refer to the publication:


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