Water decontamination of pharmaceuticals after sea lice bath treatments

Claudia Croton[1], Simen Østnæs[1], Stephanie Delacroix[2], Marit Rode[1]
[1]Pharmaq AS, 0275 Oslo, NO; [2]Norwegian Institute for Water Research, 0579 Oslo, NO

Introduction

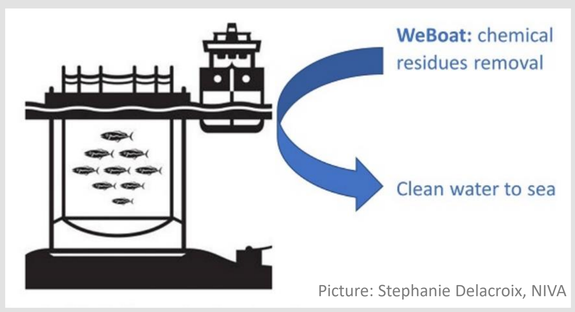
The bath product Alpha Flux (active pharmaceutical ingredient (API) hexaflumuron (HEX)) is used to treat infestations of Atlantic salmon by the parasitic sea louse *Caligus rogercresseyi*.

Photo: Rachmilla Andersen, Pharmaq

It is desirable to limit API discharge into the sea. This can be achieved by ozonation, chlorination, and ultraviolet (UV) radiation. Ozonation and chlorination in seawater lead to the formation of oxidants, commonly expressed as total residual oxidants (TRO), which can degrade various compounds[1]. UV radiation can initiate photodegradation of chemicals due to its high photon energy[2].

Objective

The MarTERA project "WeBoat" aims to create an eco-friendly water decontamination technology to remove sea lice pharmaceuticals.



Picture: Stephanie Delacroix, NIVA

Lab experiments were conducted to investigate the degradation of HEX by ozonation, UV radiation, and chlorination.

Material & Methods

In three experiments using 10 L seawater from a wellboat, Alpha Flux was administered at 2 mg/L HEX. The water was continuously stirred for 1 h to simulate a delousing treatment. Subsequently, ozonation, UV irradiation, and chlorination were performed.

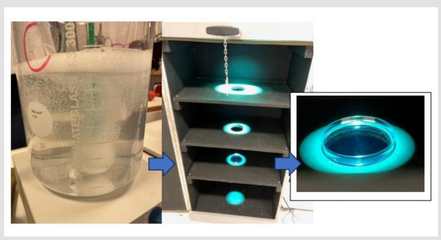
Three treatment combinations were tested:

(1) Ozonation: One single and two consecutive ozonations to TRO concentration (conc.) 5 mg/L at pH 10, with an intermediate incubation to TRO conc. 4 mg/L.

(2) Ozonation & UV: Ozonation to TRO conc. 5 mg/L at pH 10, followed by UV treatment at 900 mJ/cm^2 after varying intermediate incubation periods.

(3) Chlorination: Administration of hypochlorite to TRO concentrations 10, 100, and 1000 mg/L at unadjusted pH and pH 10.

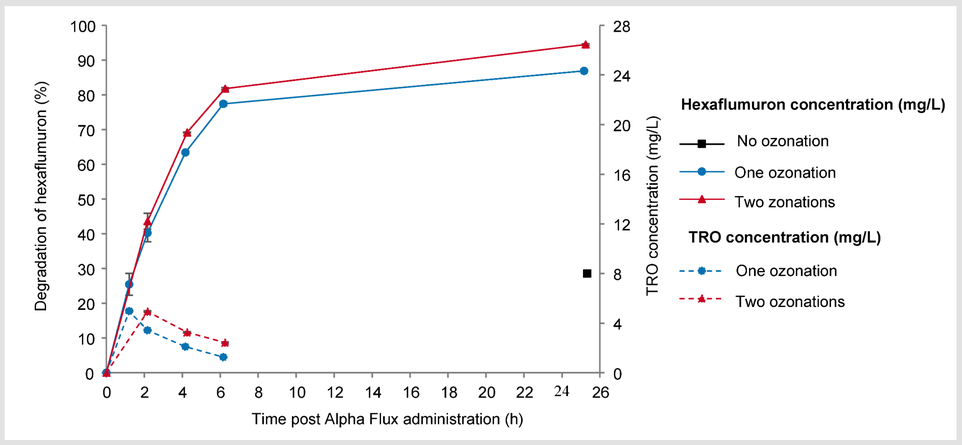
→ After each treatment, the water was incubated for 24 h. Prior to sample collection, excess oxidants were neutralized using sodium thiosulfate.



Picture: Stephanie Delacroix, NIVA

Results

Ozonation

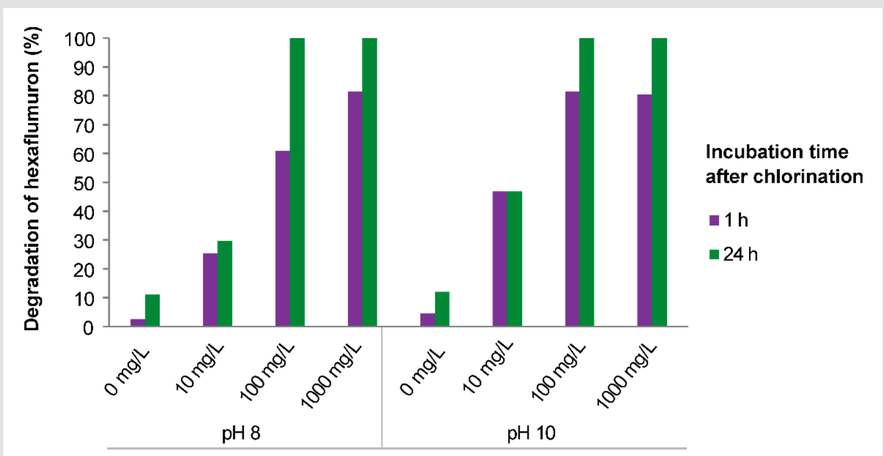


- Two successive ozonations and a subsequent 23-h incubation period resulted in 94% degradation of the initial 2 mg/L HEX.
- A single ozonation led to 4-7% less HEX degradation.

Ozonation & UV

- Incubation following ozonation was more effective in degrading HEX than UV treatment.
- UV as a final treatment after ozonation and 24-h incubation increased HEX degradation by 2.6%.

Chlorination



- Chlorination at pH 10 led to a higher HEX removal rate compared to unadjusted pH.
- At a TRO conc. 10 mg/L and pH 10, 47% degradation was achieved after 24 h of incubation
- To achieve a 99.9% degradation, TRO conc. 100 mg/L and 24 h incubation were required.

Discusion

- In seawater, ozone and free chlorine react with bromide ions to form reactive oxidants, which can react with HEX and lead to its degradation. They persist in water, leading to further degradation.
- The highest HEX degradation (99.98%) occurred with chlorination to 100 mg/L TRO. However, higher TRO conc. accelerate corrosion of wellboat equipment[3]. Therefore, the TRO during ballastwater treatment usually stays below 10 mg/L TRO.
- UV treatment after ozonation was less effective in degrading HEX than incubation. UV light breaks oxidative bonds, forming less reactive species. Consequently, UV radiation decreased the TRO conc., which diminished degradation reactions with HEX.

Conclusion

The highest realistically achievable HEX degradation occurred with two consecutive ozonations at 5 mg/L TRO and pH 10.

23 hours after ozonation, 94% of the initial 2 mg/L HEX in the treatment water were degraded.

References

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Claudia Croton
E-Mail: claudia.croton@zoetis.com