DTU Vet
National Veterinary Institute

Treatment of wastewater from fish slaugtherhouses

Evaluation and recommendations for hyginisation methods

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Introduction

Prevention of fish diseases is essential for profitable operation of aquaculture facilities. Historically, pathogens (disease-causing bacteria, viruses, parasites or fungi) derived from fish processing companies have been involved in transferring infection. Not just the processing of Danish fish (mainly aquaculture fish) pose a significant risk, also increased globalization with escalating transport of fishery products enlarge the risk of transfer of pathogenic micoorganisms, which ae a risk not only for aquaculture fish but just as much to wild fish. In Denmark, especially infection with the highly loss-causing fish disease VHS has been crucial. Several disease outbreaks could be associated with release of infectious waste from cutting plants that had slaughtered/processed VHS infected fish. Based on this, the National Veterinary and Food Administration in 2005 introduced requirements for either the sanitisation or percolation of wastewater from fish processing plants. The claim was however introduced without that there was a final decision on whether the proposed methods were effective under Danish conditions and without assessing the business economics of the claim. The requirement would apply to existing companies from September 2008. It was, however, difficult to implement the required methods, as no one in the industry knew what methods were most successful based on financial, operational and disease prevention rationale.
The Danish Veterinary and Food Administration has per August 2008 amended the order requiring that all fish processing companies now base their wastewater treatment of on percolation. This is far from possible at many of the existing Danish fish processing companies because of location and soil conditions. Based on this the order opens the possibility to apply for dispensation to sanitize the wastewater instead. However, there are no pre-approved methods, and it is therefore imposed on the industry to generating knowledge in the field. All companies must by the end of 2010 meet the requirements.

Objectives of the project

- To provide knowledge about existing and new methods to sanitize wastewater from cutting plants.
- To evaluate the disinfecting effect of wastewater perculation under laboratory conditions.
- Through the above to achieve the best possible security measures to avoid spread of fish diseases to both aquaculture and wild fish.

Content of the project

- Desribe and evaluate the current methods for disinfection of wastewater from fish cutting plants.
- Recommend methods which are acceptable based on disease transfer risks.
- Assess the disinfecting effect of percolation under laboratory conditions.
- Produce a report, which describes the different methods and recommendations to future requirements taking into account the optimum effectivity, efficiency, reliability and economy.

This report deals with the objective described in the first bullet point and thus do not take solid waste into consideration. Perculation will be described in further details in a following report concerning the second bullet point.

Conclusions

Based on literature studies a number of methods for sanitazion of process wastewater from fish slaughterhouses/cutting plants are acceptable. Most of these methods are described in the historic Danish legislation "Bekendtgørelse nr. 755 af 28/07/2005 om bekæmpelse af visse smitsomme sygdomme hos fisk" (Ministerial orden no. 755 of 28/07/2005 regarding control of certain infectious diseases in fish) annex 1 and are approved according to the present Norwegian legislation "FOR 1997-02-20 nr 192: Forskrift om desinfeksjon av inntaksvann til og avløpsvann fra akvakulturrelatert virksomhet" (Regulation 1997-02-20 no 192: Regulation concerning disinfection of intake water and outlet water from aquaculture related enterprises). The methods are able to reduce the amount of virus 3 log for VHSV, IHNV, and ISAV. IPNV may not necessarily be reduced by 3 log using the recommended methods. For the pathogenic bacteria *Yersinia ruckeri*, *Aeromonas salmonicida* and *Vibrio anguillarum* the methods are also acceptable.

pH treatment:

a) Mechanic separation (≤ 300 µm filter) followed by acid treatment to pH ≤ 3.0 for ≥ 8 hours.

b) Mechanic separation (≤ 300 µm filter) followed by basic treatment to pH ≥ 12.0 for ≥ 24 hours.

Chlorination:

a) Mechanic separation (≤ 300 µm filter) or chemical precipitation (Fe- and/or Al-salts) followed by chlorination of the supernatant using an initial concentration of ≥ 50 mg/l residual chlorine and ≥ 10 mg/l residual chlorine after 15 minutes treatment.

b) Mechanic separation (≤ 300 µm filter) or chemical precipitation (Fe- and/or Al-salts) followed by chlorination of the supernatant using an initial concentration of ≥ 50 mg/l residual chlorine and ≥ 2 mg/l residual chlorine after 25 minutes treatment.

Heat treatment:

a) 65°C for 10 minutes.
b) 70°C for 5 minutes.
c) 75°C for 4 minutes.
d) 80°C for 3 minutes.
e) 85°C for 2 minutes.
f) 90°C for 1 minute.
g) 95°C for 45 seconds.
h) 100°C for 30 seconds.

N.B. Proper stirring is necessary to make certain that no pockets with inappropriate heating exist.

UV-irradiation:

For wastewater treatment the method cannot at present be recommended as sanitizing method, as wastewater will be too organic polluted without a significant clarification before irradiation.

Ozone:

Mechanic separation (≤ 300 µm filter) or chemical precipitation (Fe- and/or Al-salts) followed by ozone treatment
a) fresh water: ≥ 0,15 mg/l residual ozone after 15 minutes treatment.
b) salt water: ≥ 0,2 mg/l TRO (total residual oxidants) after 15 minutes treatment.

Percolation	Although generally considered a safe method for wastewater sanitation it has not been possible to find any references describing the decimating effect of percolation on fish pathogenic viruses. As a substitute for IPNV, it has not been possible to find publications describing the effect of percolation on other birnaviruses. The effect of percolation on other viruses has not been looked into. It is therefore not possible in this report to validate if the procedure is safe to use.

Legislation

Danish legislation

In the historic legislation "Bekendtgørelse nr. 755 af 28/07/2005 om bekæmpelse af visse smitsomme sygdomme hos fisk" (Ministerial orden no. 755 of 28/07/2005 regarding control of certain infectious diseases in fish) annex 1 describes different disinfection methods that, at that time, were allowed to use. These are:

Formic acid (HCOOH):	Mechanic separation (≤ 300 µm filter) followed by treatment using formic acid to a) pH ≤ 4.0 for ≥ 24 hours, or b) pH ≤ 3.5 in ≥ 8 hours.
NaOH:	Mechanic separation (≤ 300 µm filter) followed by treatment using NaOH to pH ≥ 12.0 for ≥ 24 hours.
UV-irradiation:	a) chemical precipitation (Fe- and/or Al-salts) followed by UV irradiation of the supernatant using an UV-dose ≥ 25 mWs/cm^2. b) Mechanic separation (≤ 40 µm filter) followed by UV irradiation of the supernatant using an UV-dose ≥ 25 mWs/cm^2.
Chlorination:	a) mechanic separation (≤ 300 µm filter) or chemical precipitation (Fe- and/or Al-salts) followed by chlorination of the supernatant using an initial concentration of ≥ 50 mg/l residual chlorine and ≥ 10 mg/l residual chlorine after 15 minutes treatment. b) mechanic separation (≤ 300 µl filter) or chemical precipitation (Fe- and/or Al-salts) followed by chlorination of the supernatant using an initial concentration of ≥ 50 mg/l residual chlorine and ≥ 2 mg/l residual chlorine after 25 minutes treatment.
Heat treatment:	a) 65°C for 10 minutes. b) 70°C for 5 minutes. c) 75°C for 4 minutes. d) 80°C for 3 minutes. e) 85°C for 2 minutes. f) 90°C for 1 minute. g) 95°C for 45 seconds. h) 100°C for 30 seconds.

Percolation

In the present legislation "Bekendtgørelse nr. 755 af 08/07/2008 om autorisation og drift af akvakulturbrug og –virksomheder" (Ministerial order no. 755 of 08/07/2008 regarding authorisation and operation of aquaculture farms and – enterprises) fish cutting plants are according to § 14 obliged to percolate process wastewater. Wastewater may, after permission from the Danish Veterinary and Food Administration, also be discharged to seawater. Dispensation from percolation of wastewater can, according to § 15, be permitted if the wastewater is disinfected and the chosen method result in a complete inactivation of infectious matters.

Legislation in the USA

Dr. P. Gary Egrie from the USDA APHIS Veterinary Services, informed that the Environmental Protection Agency (EPA) has regulatory authority for effluents into public waterways, however they have not developed regulations or recommended methods to address the discharge of aquatic animal pathogens from fish slaughterhouses.

Legislation in Norway

In Norway the legislation "FOR 1997-02-20 nr 192: Forskrift om desinfeksjon av inntaksvann til og avløpsvann fra akvakulturrelatert virksomhet" (Regulation 1997-02-20 no 192: Regulation concerning disinfection of intake water and outlet water from aquaculture related enterprises) regulates the effluents from fish slaugtherhouses. In this legislation it is described in § 9 that outlet water from fish slaugtherhouses/fish cutting plants has to be filtered through a grating before further treatment. The size of the grating has be ≤ 1 mm. In § 10 hourshe demands for the methods for desinfection of the outlet water after filtration are described. The metods have to be documented through scientific documentation based on relevant experimental test designs (water quality, Temperature etc.) to induce at least 3 log (99,9%) inactivation of *Aeromonas salmonicida* subsp. *salmonicida* and ISAV, or based on a dose-repons curve for IPNV it is likely that ISAV is inactivated likewise. In § 11 on demands to the technical equipment it is described that approved technical equipment shall at least be equipped with security measures which guaranties that the disinfectant's/method's "concentration" (mg/l, mWs/cm2, °C etc.) and time are kept. Furthermore a safety device against malfunction and a recording unit has to be installed.
According to § 8 the National Veterinary Institute (Veterinærinstituttet) is responsible for approval of methods. The approved methods can be found on the Norwegian Food Safety Authority (Mattilsynet) homepage and are as follows:

Formic acid (HCOOH):	a) pH ≤ 4.0 for ≥ 24 hours, or b) pH ≤ 3.5 in ≥ 8 hours.
NaOH:	≥ 12.0 for ≥ 24 hours.
UV-irradiation:	Chemical precipitation followed by UV irradiation of the supernatant using an UV-dose ≥ 25 mWs/cm^2.
Chlorination:	a) mechanic separation or chemical precipitation followed by chlorination of the supernatant using an initial concentration of ≥ 50 mg/l residual chlorine and ≥ 10 mg/l residual chlorine after 15 minutes treatment. b) mechanic separation or chemical precipitation followed by chlorination of the supernatant using an initial concentration of ≥ 50 mg/l residual chlorine and ≥ 2 mg/l residual chlorine after 25 minutes treatment.

Heat treatment:	a) 65°C for 10 minutes. b) 70°C for 5 minutes. c) 75°C for 4 minutes. d) 80°C for 3 minutes. e) 85°C for 2 minutes. f) 90°C for 1 minute. g) 95°C for 45 seconds. h) 100°C for 30 seconds.

These methods are basically the same as the methods in the former Danish legislation.

Ozone is not on the list for disinfection methods for wastewater from fish slaugherhourses or cutting plants. This method is approved for disinfection of wastewater from infection trial facilities handling A-, B- and C diseases, exotic and unknown pathogens. In facilities like this the following methods are approved:

Heat treatment:	d) 80°C for 4 minutes. e) 85°C for 3 minutes. f) 90°C for 2 minute. g) 95°C for 1 minut. h) 100°C for 30 seconds.
Chlorination:	a) freshwater: ≥ 25 mg/l residual chlorine after 30 minutes treatment. b) sea water: ≥ 35 mg/l residual chlorine after 30 minutes treatment.
Ozonation:	a) freshwater: ≥ 0,15 mg/l residual ozone after 15 minutes treatment (corresponds to a C T value of 135 mg*s/l). b) sea water: ≥ 0,2 mg/l TRO (total residual oxidants) after 15 minutes treatment (corresponds to a C T value of 180 mg*s/l).

Slaugther offals, which are not to be used as feed/food, shall be treated in accordance with the provisions laid down in regulation on animal by-products. This also applies to the organic sludge produced in conjunction with treatment of wastewater.

Legislation in UK

In England the solid waste from fish slaugtherhouses/cutting plants is regulated by the Animal By-products regulations. The Animal By-Products legislation dictates how different categories of solid waste are disposed of, including tissues from diseased animals. The latter would be Category 2 waste, and waste from apparently healthy animals would be Category 3 waste.

Assuming a fish processing plant is processing category 3 animal by-product/material then all waste/wash water is controlled under waste/environmental legislation and the operator needs to contact the Environment Agency (EA) regarding controls on this. If it is processing category 2 animal by-product/ material then it needs to have a pre-treatment process - essentially a 6 mm mesh with all material caught in the drain trap disposed of as category 2. However again once the liquid has passed through the trap it is a matter for environmental regulation to control it.

The EA would expect that the wash water would go to a foul sewer under a Trade Effluent Agreement with the sewerage undertaker (local water company). The sewerage undertaking might require some filtering or

other treatment to be done before discharge to sewer. The wash water should not be sent to surface water drainage or be directly discharged to a river. However, if the premises were 'in the middle of no-where' with no sewerage links then the company would need a discharge consent from the Environment Agency; they would probably require some pre treatment dependent upon analysis of the proposed discharge. The alternative would be to tanker off site to a sewage works. There does not seem to be any requirements to treat the liquid on site regarding inactivation of pathogens (personal communication from Peter Dixon, CEFAS).

Materials and Methods

These procedures in the former Danish legislation will be evaluated, based on a literature review, together with potential other procedures for their capability to decimate fish pathogens. The underlying basis will be the non exotic fish pathogens listed in "Council Directive 2006/88/EC of 24 October 2006 on animal health requirements for aquaculture animals and products thereof, and on the prevention and control of certain diseases in aquatic animals". These diseases are viral haemorrhagic septicaemia (VHS) caused by VHS virus, infectious haematopoietic necrosis (IHN) caused by IHN virus, koi herpes virus (KHV) disease caused by KHV and infectious salmon anaemia (ISA) caused by ISA virus.

For the Danish aquaculture industry there are a number of other important pathogens such as e.g. infectious pancreatic necrosis virus (IPNV) causing IPN, *Renibacterium salmoninarum* causing bacterial kidney disease, *Aeromonas salmonicida* causing furunculosis, *Yersinia ruckeri* causing enteric redmouth disease and *Flavobacterium psychrophilum* causing rainbow trout fry syndrome.

Some of these diseases are furthermore listed in the Danish "Bekendtgørelse nr. 975 af 13/08/2010 om lister over smitsomme sygdomme til lov om hold af dyr" (Ministerial order no 975 of 13/08/2010 concerning listing of infectious diseses in relation to legislation regarding keeping of animals).

Different kinds of methods for desinfection

Acid

Lowering of the pH to an unfavourable niveau for microorganisms can be done by using organic acids and inorganic acids. For the inorganic acid the effect is solely based on the pH denaturing the proteins. Beside the pH effect the organic acids will enter the fish cells more easily than inorganic acids and thereby enhance the speed of which autolysis of the cells occur, whereby e.g. viral particles within the cells will be reached.

An example of an often used organic acid is formic acid, HCOOH. Formic acid is the simplest carboxylic acid, named after the Latin word for ant, formica, as this is the acid produced by the ant. Formic acid has an acid dissociation constant at the logarithmic scale (pK_a) of 3,7 and is a week acid.

An example of an inorganic acid that often is used to lower pH is hydrochloric acid, HCl. Depending on the source the pK_a for HCl is stated as -7 to -3 which means that in water the HCl will be completely dissociated into H^+ and Cl^-.

If the wastewater is pretreated for example by filtration so lumps of waste (e.g. fish flesh) are not present, there will probably not be much difference in the effect whether an organic or inorganic acid is used to lower the pH.

Base

A high pH is unfavourable for microorganisms. To raise the pH sodium hydroxide, NaOH, can be used. NaOH is a strong base with a pK_a of approximately 13. NaOH is very soluble in water with liberation of heat. NaOH does not react with iron, but it will react with transition metals such as e.g. aluminium.

UV irradiation

UV light is divided into three ranges UV-A (320 – 400 nm), UV-B (280 – 320 nm) and UV-C (190 – 280 nm). The highest capacity to damage microorganisms is found in the UV-C band. The damaging effect of UV light is caused by the altering effect the UV-light has on nucleic acids. When the light is absorbed by the DNA/RNA molecule dimerization of two pyrimidine molecules can occur. This will lead to blocking of the replication (reviewed in 68).

Different kinds of microorganisms are more or less susceptible to UV light. Generally speaking, the suscpetibilty is higher for growing bacteria than for viruses and bacterial spores.

The intensity of the UV light and the time of irradiation are important factors for the ability of the light to inactivate the microorganism. The UV dose is the multiplication of the intensity and the time and is a measure for the amount of energy which reaches a surface. The dose is often expressed as mWs/cm^2.

As UV light is not killing the microorganism there is a possibility for the microorganism to repair the damages of the DNA by photoreactivation. Light in the visible spectrum is able to activate enzymes which can repair the damages induced by the UV light (reviewed in 68). Keeping bacteria in the dark after UV irradiation for 15 hours will inhibit the photoractivation (72). There are, though, also different processes that may occur in the dark in bacterias that are able to repair damages. There is as such a possibility for bacterias to regain the ability to multiply after being exposed to UV light. Increasing the UV dose will decrease the ability for the bacteria to repair itself (72).

Chlorination

Chlorine is a well known disinfectant used for decades both in the industry as well as in the household. The effectivity of chlorine is dependent on factors such as pH, temperature, suspended solids, organic compounds and nitrogen containing compounds. Low pH, high temperature, and no suspended solids, organic compounds etc will enhance the disinfecting effect.

Chlorine kills pathogens such as bacteria and viruses by replacement of hydrogen atoms by chlorine breaking the chemical bonds in their molecules. The molecule will the change shape or fall apart. As the enzymes are destroyed the pathogen will eventually die.

When chlorine is added to water, underchloric acids form and depending on the pH value, underchloric acid

partly expires to hypochlorite ions:
$Cl_2 + H_2O \rightarrow HOCl + H^+ + Cl^-$
$HOCl + H_2O \rightarrow H_3O^+ + OCl^-$

This falls apart to chlorine and oxygen atoms:
$OCl^- \rightarrow Cl^- + O$

Underchloric acid (HOCl) is more reactive and is a stronger disinfectant than hypochlorite (OCl^-). HOCl is split into hydrochloric acid (HCl) and atomar oxygen (O). So the disinfecting properties of chlorine in water are based on the oxidising power of free oxygen atoms and on chlorine substitution reactions.

The cell wall of pathogenic microorganisms is negatively charged by nature. As such, it can be penetrated by the neutral underchloric acid, rather than by the negatively charged hypochlorite ion. Underchloric acid can penetrate slime layers, cell walls and protective layers of microorganisms and effectively kills pathogens as a result. The microorganisms will either die or suffer from reproductive failure.

HOCl reacts faster and is more effective than OCl^-. The level of HOCl will decrease as the pH value goes up. The optimal pH for using chlorine with be at pH 5,5-7,5 (2).

Heat

Different combinations of temperture and time are able to inactivate microorganisms. When proteins are heated their three-dimensional structure will be destroyed as the weak hydrogen bonds dissociate due to the vibrations caused by heating. With destroyed proteins the microorganisms will not function properly.

Iodine

Iodine comes from the Greek word iodes meaning violet or purple. Elemental iodine, iodide or iodine from iodophors (iodine complexed with a solubilising agent that releases free iodine when in solution) are used for disinfection. The disinfecting ability of iodine is less influenced by the pH than chlorine as long as the pH is below 8-9. Iodine is widely used in the aquaculture industry for disinfection of eggs.

Ozonation

Ozone is a potent oxidant with bactericidal and virucidal abilities. Ozone decomposes rapidly to oxygen limiting the ability to maintain a sufficient residual ozone concentration for the necessary time period. Compared to freshwater more longlived reaction products are formed when brackish and seawater are ozoneated. The damaging effect of ozone is probably caused by changes in the membrane structure causing leakage of proteins and nucleic acids, as well as lipid oxidation (reviewed in 68).

Percolation

Percolation concerns the movement of fluids through porous materials, here the movement of wastewater through underground earth. The hope is, that this transport will withheld pathogenic microorganisms and in this way “disinfect” the wastewater.

Discussion

In the present Danish legislation "Bekendtgørelse nr. 755 af 08/07/2008 om autorisation og drift af akvakulturbrug og –virksomheder" (Ministerial order no. 755 of 08/07/2008 regarding authorisation and operation of aquaculture farms and – enterprises) fish cutting plants are obliged to percolate process wastewater. Dispensation from percolation of wastewater can be permitted if the wastewater is disinfected and the chosen method results in complete inactivation of infectious matters. A complete inactivation of pathogens will not be a realistic goal as this will require sterilization of the wastewater, which is not economical feasible for the industry. In order to reduce the risk of transfer of diseases to a tolerable level a lower intensity of inactivation is acceptable. In Norway the requirement is a 3 log reduction for the pathogens *Aeromonas salmonicida* subsp. s*almonicida* and ISAV. Under Danish conditions a 3 log reduction will probably also be appropriate in order to reduce the risks to an acceptable level.

In the scientific literature numbers are available to give an indication of the amount of virus that may be present in process wastewater and in fish offals and how little virus that can initiate an outbreak.

In seawater from Pacific herring confined for the production of spawn-on-kelp 700 pfu/ml VHSV was observed (38). In infection trials using Pacific herring up to $10^{7,7}$ pfu/g herring was detected at 6-8 days after infection. In the water in the flow-through aquarias at day 4-5, $10^{2,5}$ pfu/ml was obtained. When the water flow was turned off for 3 hours the water reached $10^{3,5}$ pfu/ml water. Virus shed by infected herring was on avereage > $10^{6,5}$ pfu/h/fish (62).
When groups of wild herring were confined in the laboratory, they experienced severe mortality, occasionally exceeding 50%, with the prevalence of VHSV reaching 100% by 14 d postcapture. At 7-21 d postcapture, VHSV titers peaked in excess of 10^8 pfu/g of tissue (63).

In rainbow trout infected with the freshwater isolate DK-3592B, the fish were positive at a low titer (7.1 x 10^2 $TCID_{50}$/g of tissue) by day 2 postchallenge, and the titer reached a peak (1.3 x 10^8 $TCID_{50}$/g of tissue) by day 7 (13).
Another infection trial reported mean titres of 5,3 x 10^6 $TCID_{50}$/g of tissue (29).

In experimentally infected rainbow trout challenged with VHSV by bath with 10^2, $10^{3,7}$, and 10^5 $TCID_{50}$/ml of the cumulative mortality was 44, 64, and 96%, respectively, at 14 d post infection (26).
In an experimental infection trial using the isolate J167 from the English outbreak in 2006, an infection dose as low as 10^1 $TCID_{50}$/ml water resulted in an accumulated mortality of 65% at day 21 in rainbow trout fry (19).
Vestergaard Jørgensen & Olesen reported that at the time when VHSV koncentration is highest in the fish (10^8 pfu/g of tissue), the amount of virus particles (pfu) in the water can be as high as 10^3 per ml of water (50). In infection trials at 10°C, the incubation phase was 1½ week when using a viral dose of 50 pfu/ml water. When the dose was lowered to 25 pfu/ml of water the incubation phase was extended to 6 weeks and at a dose of 10 pfu/ml, VHS was not observed during the next 6 months. The authorms comments this results by noting that 10 pfu/ml may be to low a dose under the circumstances used in the infection trial or that the incubation period may be longer than the 6 months, but that under other circumstances such a low dose will be able to initiate an outbreak (50).

These results show that the amount of VHSV can be quite high in tissue from VHSV infected fish during an outbreak, and a dose of virus as low as 10 $TCID_{50}$/ml water may be able to initiate an outbreak. The amount

of virus that can be found in water during an outbreak is 10^3-10^4 $TCID_{50}$/ml water. A 3 log reduction of virus will reduce the amount of VHSV to 0-10 $TCID_{50}$/ml water, a dose that probably only very seldom will be able to initiate a VHS outbreak.

In 11 of 15 wild-caught sockeye salmon in prespawning conditions IHNV was isolated from the following organs at a mean level among the positive organs (min – max) in pfu/g tissue of:
Gills 5,8 x 10^3 (3,0 x 10^2 - 5,5 x 10^5, 10 positive), Kidney 5,8 x 10^3 (1 positive), spleen 5,2 x 10^2 (1,0 x 10^2 – 1,3 x 10^3, 3 positive), pyloric caeca 5,1 x 10^2 (2,5 x 10^{1-} 1,4 x 10^4, 4 positive), Brain 5,0 x 10^1 (1 positive) and eggs 4,0 x 10^2 (1 positive). From fish in spawning conditions IHNV was isolated from nil to 100% of the fish within 2 weeks and virus incidens was high in all organs and fluids except brain and serum (77).
In a study of the possible role of waterborne IHNV in transmission of the disease among spawning sockeye salmon both infection rates and virus titres were higher in fish held at high density in a side channel than in fish in the adjacent river. Virus was never isolated from river water, but was found in water from the side channel at levels ranging from 32.5 to 1600 pfu/ml (78).
In rainbow trout the amount of IHNV i ovarian fluid ranged from 10^1 – $10^{6,5}$ $TCID_{50}$/ml (7).
In an infection trial in rainbow trout using IHNV mean titres of 5,1 x 10^5 $TCID_{50}$/g of tissue was reported (29).
As these values are correspondable to the VHSV values a 3 log reduction will also be acceptable for IHNV.

For IPNV Wolf & Quimby (unpublished, in 101) reported average IPNV titer in five adult carrier brook trout in $TCID_{50}$/g tissue ranging from $10^{0,3}$ in muscle to $10^{6,7}$ in kidney. In an IPNV infection trial in brook trout virus was shedded in the feces 8 weeks post infection at a mean titre of $10^{3,5-4}$ $TCID_{50}$/g (12). In another infection trial using IPNV Sp, moribund rainbow trout alevins kept at 16°C had a titer of 10^4 – 10^6 pfu/g fish, whereas alevins kept at 10°C which had a titer up to 10^8 pfu/g (21).
In a hatchery outbreak, a level of $10^{4,4}$ infective particles per ml in a tank supplied with 88 l/min of water was measured (101). Desautels & MacKelvie (17) titrated water from three troughs of trout fry during a serious IPN epizootic in a commercial rearing establishment at found an excess of 10^5 $TCID_{50}$/ml.
It is assumed that the amount of virus in process water will be less that the amount found in water during an IPN outbreak, and as such a 3 log reduction will also for this virus reduce the amount to an acceptable risk, regarded the water is not released to watersheds where IPNV free farms are situated downstream.

In Norway at present and in the historic Danish legislation a number of different methods are/were approved for sanitazion of wastewater. These included treatment with

pH (acidic):
Mechanic separation (≤ 300 µm filter) followed by acid treatment to pH ≤ 3.0 for ≥ 8 hours.

The literature review showed that VHSV, IHNV and several other viruses are not inactivated by treatment at a pH of 4 for 24 hours. In order to decimate VHSV and IHNV to a non detectable level a treatment of pH 3 for 3-4 hours is needed. This will also inactivate *Aeromonas salmonicida* and probably also salmonid alphavirus and ISAV. *Yersinia ruckeri* will be decimated to some degree by this treatment, but not necessarily 3 log. Nodavirus is extremely acid stable and will not be inactivated by acid conditions. IPNV is also very stable at low pH, but pH < 2 should be able to inactivate IPNV (as well as *Yersinia* ruckeri) although survival for 35 days at pH 2 has been reported. Ranavirus has been recorded to both survive and be inactivated at pH 4.

pH (basic):
Mechanic separation (≤ 300 µm filter) followed by basic treatment to pH ≥ 12.0 for ≥ 24 hours.

VHSV, IHNV, IPNV, SVCV, PFRV, SAV and *Aeromonas salmonicida* are inactivated at pH 12 for 24 hours. Nodavirus has been reported inactivated at that pH but also to survive. *Yersinia ruckeri* is also difficult to inactivate at pH 12, but will be decimated.
Ranavirus has been recorded to both survive and be inactivated at pH 12.

UV-irradiation:
a) chemical precipitation (Fe- and/or Al-salts) followed by UV irradiation of the supernatant using an UV-dose ≥ 25 mWs/cm^2.
b) Mechanic separation (≤ 40 µm filter) followed by UV irradiation of the supernatant using an UV-dose ≥ 25 mWs/cm^2.

In laboratory trials a dose of 25 mWs/cm^2 (254 nm) induces satisfactory decimations of VHSV, IHNV and ISAV. In laboratory trial using wastewater from a fish cutting plant 3,1 mWs/cm^2 was needed to decimate VHSV 3 log. For IHNV 4 mWs/cm^2 was needed for a 3 log reduction in laboratory trials. For ISAV the needed dose for a 3 log reduction was 7,5 mWs/cm^2. In infection trial using tissue homogenate from ISA infected fish, a dose of 20 mWs/cm^2 was needed to decimate the virus so much that ISA was not induced in the IP injected fish. The bacteria *Aeromonas hydrophila*, *A. salmonicida*, *Vibrio anguillarum* and *Yersinia ruckeri* a 3 log decimation was obtained using a dose of 5 – 25 mWs/cm^2 in laboratory trials. For *Y. ruckeri*, in full scale trials using wastewater from fish slaugtherhouses a dose of 250 mWs/cm^2 gave a reduction of only 1 log despite precipitation with ferrichlorid; 2½ log was obtained using a dose of 1200 mWs/cm^2 and prefiltration with a 20 µm filter.
IPNV is far more resistant to UV light than VHSV and IHNV. In laboratory trials a dose of 200 – 250 mWs/cm^2 was required to obtain a 3 log reduction, and 800 mWs/cm^2 was needed for a 6 log reduction. In full scale trials using wastewater from fish slaugtherhouses a dose of 250 mWs/cm^2 produced only a ½ - 1 log reduction in virus titer. In order not to detect IPNV anymore a dose of 1500 mWs/cm^2 was needed.
Nodavirus also seems to be quite resistant to UV irradiation. In laboratory trials a dose of 100 – 211 mWs/cm^2 has been reported to induce a 3 log reduction. In an infection trial a dose of 100 mWs/cm^2 of the virus was reported to inhibit disease in the fish.
The results from the full scale trials suggest that even though UV irradiation in laboratory trials is effective it may not be possible to use this method on process wastewater in fish slaugtherhouses/cutting plants, despite pretreatment of the water by filtration or chemical precipitation. The authors conclude though that the ineffectual pretreatment probably was due to operating problems and inadequate optimisation of the process. Further full-scale tests showed that the quality of the wastewater was improved by chemical precipitation, and the best result was obtained by first adding ferrichlorid to pH 3,9 followed by addition of NaOH to pH 6,4, polymerisation and flotation. This treatment reduced the amount of organic matter with 65% measured as COD (chemical oxygen demand) and reduced the amount of total nitrogen with 73%. Furthermore was fat and floating material separated in the flotation tank (28). Whether UV irradiation after this treatment whould provide an acceptable reduction of the pathogens is unknown but probable.

Chlorination:

a) mechanic separation (≤ 300 µm filter) or chemical precipitation (Fe- and/or Al-salts) followed by chlorination of the supernatant using an initial concentration of ≥ 50 mg/l residual chlorine and ≥ 10 mg/l residual chlorine after 15 minutes treatment.

b) mechanic separation (≤ 300 µm filter) or chemical precipitation (Fe- and/or Al-salts) followed by chlorination of the supernatant using an initial concentration of ≥ 50 mg/l residual chlorine and ≥ 2 mg/l residual chlorine after 25 minutes treatment.

Generally speaking the amount of chlorine needed depends on the temperature, the pH, the degree of organic contamination and the titer of the pathogen. The necessary amount will rise if the temperature fall, the pH rise, more dirty conditions prevail and the titer of the pathogen goes up. The dose mentioned in the Danish ministerial order no 755 of 28/07/2005 and in the Norwegian list of approved methods (50 mg/l free chlorine (10 mg/l residual chlorine efter 15 min or 2 mg/l residual chlorine after 25 min) is probably acceptable for a 3 log reduction under clean conditions for VHSV, IHNV and bacterial pathogens, and also for the more resistant viruses such as IPNV and nodavirus. But for the conditions that prevail in wastewater from fish cutting plants this dose will not be acceptable without a proper pretreatment of the water. For *Yersinia ruckeri* the dose to induce a 3 log reduction is 250 mg/l for more than 2 hours in full-scale tests using wastewater from fish cutting plants. In a full-scale test using NaOCl IPNV was stable at the same dose administered for 1 hour, whereas when the dose was administered as chloramine-T a 4 log reduction was obtained.

In a full-scale trial where the wastewater was pretreated by adding NaOH to pH 12 followed by addition of ferrichlorid to pH 6,5-7,5 *Y. ruckeri* was inactivated using 48 mg/l chlorine for half an hour. This result shows that chemical precipitation of the wastewater will reduce the amount of chlorine needed to disinfect the wastewater. Mechanical separation was not tested.

Pretreatment of the wastewater was obligatory in the historic Danish ministerial order either as mechanic separation using a filter or as chemical precipitation.

A few papers have reported on the use of chlorine produced by electrolyzation of the water, which seems a usable method.

Heat treatment:

a) 65°C for 10 minutes.
b) 70°C for 5 minutes.
c) 75°C for 4 minutes.
d) 80°C for 3 minutes.
e) 85°C for 2 minutes.
f) 90°C for 1 minute.
g) 95°C for 45 seconds.
h) 100°C for 30 seconds.

Despite the conflicting results reported by different authors or obtained from different experiments the combinations of time and temperature stated in the Danish ministerial order no 755 of 28/07/2005 and in the Norwegian list of approved methods will probably be acceptable for fish pathogenic bacteria and viruses for at least a 3 log reduction if a proper stirring of the wastewater is secured to avoid pockets of water not reaching the desired temperature for the stated amount of time.

Percolation

It has not been possible to find any references describing the decimating effect of percolating of fish pathogenic viruses. Furthermore it has not been possible to find publications describing the effect of percolating other birnaviruses. It is therefore not possible to validate if this procedure is safe to use.

Iodine products

Iodine based disinfection products are useful for disinfection of virus and bacterias but less suitable for use when parasites and fungi are the microorganism in question. IPNV and nodavirus seems to be a bit more resistant that VHSV and IHNV. It has not been possible to find published tests on the efficiency of iodine using wastewater from fish slaugtherhourse or cutting plants. Iodine is sensitive towards titer of pathogen, Temperature, pH and organic contamination, with more iodine needed as the titer of the pathogen goes up, temperature goes down, pH ≥ 8 and organic contamination goes up. Recommeded dose: ≥ 150 ppm for 10 min at pH < 8.

Ozone

Ozone seems to be an effective product to decimate the concentration of fish viral and bacterial pathogens. None of the papers papers covered in this report has tested ozone under circumstances comparable to the conditions prevailing in wastewater from fish cutting plants and it is as such unknown how usable the method will be for this specific purpose. In Norway ozone is not listed as an approved method for disinfection of wastewater from fish slaugtherhouses/cutting plants, but the method is approved for use in infection trial facilities with the following doses:

a) freshwater: ≥ 15 mg/l residual ozone after 15 minutes treatment (corresponds to a C T value of 135 mg*s/l).
b) sea water: ≥ 0,2 mg/l TRO (total residual oxidants) after 15 minutes treatment (corresponds to a C T value of 180 mg*s/l).

If these doses are adopted, and the water is pretreated, all fish pathogenic bacteria and viruses should be inactivated.

Pretreatment of water

Regardless of the method chosen for disinfection of the wastewater from fish processing plants the effect will be better the cleaner the water is. It is therefore very important the the water is treated to reduce the amount of organic matter in the water. The results from the full scale trials in Norway referred to under the headline "Chlorination" in this paragraph shows the importancy of pretreatment of the water before disinfection. There are several ways of pretreating the water of which mechanical separation and chemical precipitation was accepted in the historical Danish legislation.

Tables

pH

Virus

VHSV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
4,0 x 10^7 pfu/ml	HCl	10 min		2,5	8-10	Survival		52	Final concentration 1,5 x 10^4
4,0 x 10^7 pfu/ml	HCl	60 min		2,5	8-10	”inactivated”		52	Final concentration < 10
$10^{5,2}$ $TCID_{50}$/ml	pH	60 min		3		Survival		4	$10^{2,2}$ $TCID_{50}$/ml after 60 min
$10^{5,2}$ $TCID_{50}$/ml	pH	180 min		3		”inactivated”		4	
$10^{5,8}$ $TCID_{50}$/ml	pH	60 min		3		99,9 % reduction	5 % calf serum added	4	<1
$10^{5,8}$ $TCID_{50}$/ml	pH	180 min		3		”inactivated”	5 % calf serum added	4	
$10^{5,1}$ $TCID_{50}$/ml	HCl	24 hours		4	4	Not detectable	Pathogen mixed into minced herring	47	Detection limit: $10^{2,2}$ $TCID_{50}$/ml
	pH	7 days		4		Survival		20, Dixon (pers. com.)	
$10^{6,2}$ $TCID_{50}$/ml	pH	60 min		9	10	Stable		4	
$10^{5,7}$ $TCID_{50}$/ml	KOH	48 hours		11	4	Stable	Pathogen mixed into minced herring	47	
$10^{5,7}$ $TCID_{50}$/ml	KOH	1 t		12	4	Not detectable	Pathogen mixed into minced herring	47	Detection limit: $10^{2,2}$ $TCID_{50}$/ml
	pH	6 hours		12		inaktiveret		20, Dixon (pers. com.)	
1,5 x 10^7 pfu/ml	NaOH	120 min		12,2	8-10	Survival		52	Final concentration 1,8 x 10^4
$10^{6,5}$ $TCID_{50}$/ml	NaOH	5 min	2%	11,85-11,90		> 99,99 % reduction	10 % calf serum added	5, 4	Survival
$10^{5,8}$ $TCID_{50}$/ml	NaOH	5 min	2%	11,85-11,90		”inactivated”		4	
$10^{5,8}$ $TCID_{50}$/ml	NaOH	10 min	2%	11,85-11,90		”inactivated”	10 % calf serum added	4	
$10^{6,5}$ $TCID_{50}$/ml	NaOH	10 min	2%	11,85-11,90		”inactivated”		4	

Conclusion: VHSV is inactivated at pH 3 and pH 12 after 3 hours contact time. For 3 log inactivation pH 3 or pH 12 for 10 minuts is suitable.

IHNV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
$10^6 TCID_{50}$/ml	pH	4 hours		3	4	Not detectable	Virus in MEM	79	
	citrate/phos-phate buffer	7 hours		4,0	22	Survival		100	
	pH	7 days		4		Survival		20, Dixon (pers. com.)	
	pH	6 hours		12		”inactivated”		20, Dixon (pers. com.)	

Conclusion: IHNV is inactivated at pH 3 for 4 hours, but not at pH 4. At pH 12, tested after 6 hours contact time, IHNV is inactivated.

ISAV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	Formic acid	8 hours	-	4	-	”inactivated”	Tissue homogenate of liver, kidney and spleen from moribund ISA-fish, treated and IP-injected in fish.	94	Testet at pH 3,5, 4,0 and 4,5 at 8 hours and 24 hours.
	pH	7 days		4		”inactivated”		20, Dixon (pers. com.)	
	pH	30 min		4		Not detectable	Addition of HCl or NaOH to virus in L15 medium to pH 3, 4, 5, 7, 9 or 11.	27	
	pH	30 min		5-9		Stable	Addition of HCl or NaOH to virus in L15 medium to pH 3, 4, 5, 7, 9 or 11.	27	
	pH	30 min		11		> 90% reduction	Addition of HCl or NaOH to virus in L15 medium to pH 3, 4, 5, 7, 9 or 11.	27	
	NaOH	48 hours	-	11,5	-	”inactivated”	Tissue homogenate of liver, kidney and spleen from moribund ISA-fish, treated and IP-injected in fish.	94	Testet at pH 11,0, 11,5 and 12,0 at 8, 12, 24 and 48 hours.
	NaOH	24 hours	-	12	-	”inactivated”	Tissue homogenate of liver, kidney and spleen from moribund ISA-fish, treated and IP-injected in fish.	94	Testet at pH 11,0, 11,5 and 12,0 at 8, 12, 24 and 48 hours.
	pH	24 hours		12		Survival		20, Dixon (pers. com.)	

Conclusion: ISAV is inactivated at pH 4, but the contact time has to be relative long. There is disagreement among the references regarding inactivation at pH 12.

IPNV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
$10^{6,6}$ $TCID_{50}$/ml	Formic acid (HCOOH)	6 min		1,5	7	Not detectable (> 5 log reduction)	Laboratory trial, 1 part process water + 2 parts "bløggevand" from fish slaugtherhouse.	28	
$10^{5,5}$ $TCID_{50}$/ml	Formic acid (HCOOH)	1 t		2,0		Not detectable (> 4 log reduction)	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, "bløggevand" (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{7,0}$ $TCID_{50}$/ml	pH	35 days		2	4	5 log reduction		74	Isolate VR-299
$10^{7,0}$ $TCID_{50}$/ml	pH	20 days		2	4	3 log reduction		74	Isolate VR-299. Result read on a graph.
6,7 x 10^{6} pfu/ml	HCl	60 min		2,5	8-10	Stable		52	Type Sp. Final concentration 5,3 x 10^{6}
$10^{5,5}$ $TCID_{50}$/ml	Formic acid (HCOOH)	24 hours		2,5		1-2 log reduction	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, "bløggevand" (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{6,6}$ $TCID_{50}$/ml	Formic acid (HCOOH)	10 hours		2,5	7	2 log reduction	Laboratory trial, 1 part process water + 2 parts "bløggevand" from fish slaugtherhouse.	28	
$10^{5,5}$ $TCID_{50}$/ml	Formic acid (HCOOH)	24 hours		3		Stable	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, "bløggevand" (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{7,5}$ $TCID_{50}$/ml	pH	4 hours		3	4	Stable	Virus in MEM	171	
$10^{6,5}$ $TCID_{50}$/ml	pH	360 min		3		Stable		4	
$10^{6,8}$ $TCID_{50}$/ml	pH	360 min		3		Stable	5 % calf serum added	4	
$10^{6,6}$ $TCID_{50}$/ml	Formic acid (HCOOH)	10 hours		3,5	7	3 log reduction	Laboratory trial, 1 part process water + 2 parts "bløggevand" from fish slaugtherhouse.	28	
	Citrate/phos-phate buffer	14 days		4,0	22	Survival		100	
	pH	28 days		4		Survival		20, Dixon (pers. com.)	

$10^{7,0}$ $TCID_{50}$/ml	pH	35 days		7	4	Stable		74	Isolate VR-299
$10^{6,5-7,0}$ $TCID_{50}$/ml	PBS	109 uger			4	Survival		74	Isolate VR-299
$10^{5,8}$ $TCID_{50}$/ml	pH	60 min		9	10	Stable		4	
$10^{7,0}$ $TCID_{50}$/ml	pH	35 days		9	4	5 log reduction		74	Isolate VR-299
$10^{7,0}$ $TCID_{50}$/ml	pH	26 days		9	4	3 log reduction		74	Isolate VR-299. Result Read off a graph.
$10^{5,3}$ $TCID_{50}$/ml	KOH	48 hours		10	4	Stable	Pathogen mixed into minced herring	47	
$10^{5,3}$ $TCID_{50}$/ml	KOH	24 hours		11	4	Survival	Pathogen mixed into minced herring	47	
$10^{5,3}$ $TCID_{50}$/ml	KOH	48 hours		11	4	Not detectable	Pathogen mixed into minced herring	47	Detection limit: 10^2 $TCID_{50}$/ml
$10^{5,5}$ $TCID_{50}$/ml	NaOH	24 hours		11,6		3½ log reduction	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{4,5}$ $TCID_{50}$/ml	NaOH	5 min	2%	11,85-11,90		”inactivated”	10 % calf serum added	4	
$10^{4,8}$ $TCID_{50}$/ml	NaOH	5 min	2%	11,85-11,90		”inactivated”		4, 5	
$10^{4,5}$ $TCID_{50}$/ml	NaOH	10 min	2%	11,85-11,90		”inactivated”	10 % calf serum added	4	
$10^{4,8}$ $TCID_{50}$/ml	NaOH	10 min	2%	11,85-11,90		”inactivated”		4	
$10^{5,5}$ $TCID_{50}$/ml	NaOH	24 hours		12.0		3½ log reduction	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{5,3}$ $TCID_{50}$/ml	KOH	16 hours		12	4	Not detectable	Pathogen mixed into minced herring	47	Detection limit: 10^2 $TCID_{50}$/ml
$10^{6,6}$ $TCID_{50}$/ml	NaOH	6 min		12,0	7	Not detectable (> 5 log reduction)	Laboratory trial, 1 part process water + 2 parts ”bløggevand” from fish slaugtherhouse.	28	
	pH	20 min		12		”inactivated”		20, Dixon (pers. com.)	
2,2 x 10^4 pfu/ml	NaOH	10 min		12,2	8-10	”inactivated”		52	Final concentration < 10
$10^{5,5}$ $TCID_{50}$/ml	NaOH	1 hour		12,4		Not detectable (> 4 log reduction)	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.

Conslution: In order to secure inactivation of IPNV, the pH has to as low as 2 or high as 12 with a contact time for at least 1 hour. There are reports stating surval time of several weeks at pH 2, but in full scale trials using wastewater containing blood, slime and skin scrapings in saltwater 1 hour contact time was sufficient to inactivate IPNV.

Nodavirus

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
$10^{6,5}$ $TCID_{50}$/ml	HCl	7 days		2	15	Stable	Grown virus diluted 1:100 in distilled water. Tested after 1 hour and 1, 3, 7, 15, 21 and 42 days.	30	Isolate: sea bass nodavirus
$10^{6,5}$ $TCID_{50}$/ml	HCl	21 days		2	15	Survival (5 log reduction)	Grown virus diluted 1:100 in distilled water. Tested after 1 hour and 1, 3, 7, 15, 21 and 42 days.	30	Isolate: sea bass nodavirus
$10^{6,5}$ $TCID_{50}$/ml	HCl	42 days		2	15	Not detectable	Grown virus diluted 1:100 in distilled water. Tested after 1 hour and 1, 3, 7, 15, 21 and 42 days.	30	Isolate: sea bass nodavirus
10 µg purified virus	HCl	10 min		3	20	Not inactivated(0/800 larvae survived, control 472/800)	Diluted in 1 ml PBS. Used for infection trial in day old striped jack larvae.	9	Isolate: SJNNV
$10^{6,5}$ $TCID_{50}$/ml	HCl	42 days		3	15	Stable	Grown virus diluted 1:100 in distilled water. Tested after 1 hour and 1, 3, 7, 15, 21 and 42 days.	30	Isolate: sea bass nodavirus
	pH	7 days		4		Survival		20, Dixon (pers. com.)	
10 µg purified virus	PBS	10 min		7	20	Not inactivated(0/800 larvae survived, control 472/800)	Diluted in 1 ml PBS. Used for infection trial in day old striped jack larvae.	9	Isolate: SJNNV
$10^{6,5}$ $TCID_{50}$/ml	NaOH	42 days		9	15	Stable	Grown virus diluted 1:100 in distilled water. Tested after 1 hour and 1, 3, 7, 15, 21 and 42 days.	30	Isolate: sea bass nodavirus
$10^{6,0}$ $TCID_{50}$/ml	KOH	48 hours		10	4	Stable	Pathogen mixed into minced herring	47	
$10^{6,0}$ $TCID_{50}$/ml	KOH	24 hours		11	4	Survival	Pathogen mixed into minced herring	47	

$10^{6,0}$ $TCID_{50}$/ml	KOH	48 hours		11	4	Not detectable	Pathogen mixed into minced herring	47	Detection limit: 10^2 $TCID_{50}$/ml
$10^{6,5}$ $TCID_{50}$/ml	NaOH	7 days		11	15	Survival (2-3 log reduction)	Grown virus diluted 1:100 in distilled water. Tested after 1 hour and 1, 3, 7, 15, 21 and 42 days.	30	Isolate: sea bass nodavirus
$10^{6,5}$ $TCID_{50}$/ml	NaOH	15 days		11	15	Not detectable	Grown virus diluted 1:100 in distilled water. Tested after 1 hour and 1, 3, 7, 15, 21 and 42 days.	30	Isolate: sea bass nodavirus
$10^{6,5}$ $TCID_{50}$/ml	NaOH	15 days		11	15	Not detectable	Grown virus diluted 1:100 in distilled water. Tested after 1 hour and 1, 3, 7, 15, 21 and 42 days.	30	Isolate: sea bass nodavirus
$10^{6,0}$ $TCID_{50}$/ml	KOH	12 hours		12	4	Not detectable	Pathogen mixed into minced herring	47	Detection limit: 10^2 $TCID_{50}$/ml
10 µg purified virus	NaOH	10 min		12	20	”Effective” (238/800 larvae survived, antigen ELISA negativ - control 472/800)	Diluted in 1 ml PBS. Used for infection trial in day old striped jack larvae.	9	Isolate: SJNNV
	pH	24 hours		12		Survival		20, Dixon (pers. com.)	

Conclusion: Nodavirus seemingly is able to withstand low pH. There are disagreements conserning the ability of the virus to withstand pH 12.

PFRV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
6,5 log10 $TCID_{50}$/ml	pH	60 min		9	10	Stable		4	
6,5 log10 $TCID_{50}$/ml	NaOH	5 min	2%	11,85-11,90		”inactivated”	10 % calf serum added	4	
6,8 log10 $TCID_{50}$/ml	NaOH	5 min	2%	11,85-11,90		”inactivated”		4, 5	
6,8 log10 $TCID_{50}$/ml	NaOH	10 min	2%	11,85-11,90		”inactivated”	10 % calf serum added	4	
6,2 log10 $TCID_{50}$/ml	NaOH	10 min	2%	11,85-11,90		”inactivated”		4	

Conclusion: PFRV is inactivated at pH 12 for 5 minuts.

Ranavirus

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	pH	28 days		4		Survival		20, Dixon (pers. com.)	
	pH	1 hour		4		Not detectable	Virus in cell culture medium.	67	Isolat: EHNV
	pH	6 hours		12		Survival		20, Dixon (pers. com.)	
	pH	1 hour		12		Not detectable	Virus in cell culture medium.	67	Isolat: EHNV

Conclusion: the literature does not agree on the inactivation of ranavirus at pH 4 and 12.

SAV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^7 $TCID_{50}$/ml	pH	4 hours		3	4	Not detectable	Virus in MEM	79	Salmon pancreas disease virus (SPDV)
	HCl	mixing		4	4	”inactivated”		33	SAV1
	Formic acid	5 min		4	4	Survival. 99,99 % reduction		33	SAV1
	Formic acid	1 dag		4	4	”inactivated”	Tested after 5 min, 1 day and 7 days.	33	SAV1
	Formic acid	7 days		5	4	”inactivated”	Tested after 5 min, 1 day and 7 days.	33	SAV1
	Formic acid	7 days		6	4	Stable	Tested after 5 min, 1 day and 7 days.	33	SAV1
	Formic acid	7 days		7,2	4	Stable	Tested after 5 min, 1 day and 7 days.	33	SAV1
	NaOH	mixing		12	4	”inactivated”		33	SAV1

Conclusion: SAV can be inactivated at pH 4 using a contact time of 24 hours or > 3 log reduction after a contact time of 5 min. At pH 3 or 12 hourshe virus is inactivated immediately.

SVCV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
$10^{7,2}$ $TCID_{50}$/ml	pH	30 min		3	room temp.	> 3 log reduction	Titrated after 30, 60 and 120 minuts.	3	
$10^{7,2}$ $TCID_{50}$/ml	pH	120 min		3	room temp.	6 log reduction	Titrated after 30, 60 and 120 minuts.	3	
	pH	28 days		4		Survival		20, Dixon (pers. com.)	
$10^{6,5}$ $TCID_{50}$/ml	pH	60 min		9	10	Stable		4	

	pH	6 days				Survival		64	
$10^{7,2}$ $TCID_{50}$/ml	NaOH	5 min	2%	11,85-11,90		”inactivated”	10 % calf serum added	4	
$10^{6,8}$ $TCID_{50}$/ml	NaOH	5 min	2%	11,85-11,90		> 99,99 % reduction		4, 5	Survival
$10^{7,5}$ $TCID_{50}$/ml	NaOH	10 min	2%	11,85-11,90		”inactivated”	10 % calf serum added	4	
$10^{7,5}$ $TCID_{50}$/ml	NaOH	10 min	2%	11,85-11,90		”inactivated”		4	
	pH	6 hours		12		Survival/”inactivated”		20, Dixon (pers. com.)	

Conclusion: SVCV kan inaktiveres ved pH 3 (3 log, 30 min) og pH 12.

Bacteria

Aeromonas salmonicida

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
1,4 x 10^7 cfu/ml	citrate/phos-phate buffer	90 min		4,0	22	”inactivated”		100	
	pH	2 hours		4		”inactivated”		20, Dixon (pers. com.)	
5 x 10^8 cfu/ml	KOH	12 hours		10	22	”inactivated”	Pathogen mixed into minced herring	47	Testet efter 12 hours, 24 hours og 48 hours
	pH	10 min		12		”inactivated”		20, Dixon (pers. com.)	

Conclusion: *A. salmonicida* is inactivated at pH 4 (testet at 90 min contact time) and pH 12 (10 min contact time).

Lactococcus garviae

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	pH	7 days		4		Survival		20, Dixon (pers. com.)	
	pH	14 days		12		Survival		20, Dixon (pers. com.)	

Conclusion: According to this experiment *L. garviae* can withstand both pH 4 and 12.

Listonella (Vibrio) anguillarum

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	pH	24 hours		4		Survival		20, Dixon (pers. com.)	
	pH	30 min		12		”inactivated”		20, Dixon (pers. com.)	

Conclusion: *V. anguillarum* can withstand pH 4, but is inactivated at pH 12 using a contact time of 30 min.

Mycobacterium chelonae

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
1,4 x 10^7 cfu/ml	Citrate/phos-phate buffer	> 14 days		4,0	22	”inactivated”		100	
	pH	2 days		4		Survival		20, Dixon (pers. com.)	
	pH	48 hours		12		Survival		20, Dixon (pers. com.)	

Conclusion: *M. chelonae* can withstand both pH 4 and 12.

Photobacterium damselae

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	pH	24 hours		4		Survival		20, Dixon (pers. com.)	
	pH	10 min		12		”inactivated”		20, Dixon (pers. com.)	

Conclusion: *P. damselae* survives pH 4, but is inactivated at pH 12 for 10 min.

Renibacterium salmoninarum

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
1,4 x 10^7 cfu/ml	Citrate/phos-phate buffer	4 hours		4,0	22	Survival		100	
	pH	24 hours		4		”inactivated”		20, Dixon (pers. com.)	
	pH	6 hours		12		”inactivated”		20, Dixon (pers. com.)	

Conclusion: *R. salmoninarum* survives pH 4 for at least 4 hours, but is inactivated after 24 hours. Can be inactivated at pH 12 using a contact time of 6 hours.

Streptococcus iniae

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	pH	24 hours		4		”inactivated”		20, Dixon (pers. com.)	
	pH	30 min		12		”inactivated”		20, Dixon (pers. com.)	

Conclusion: *S. iniae* can be inactivated at pH 4 (24 hours contact time) og pH 12 (30 min contact time).

Yersinia ruckeri

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
$10^{8,28}$ cfu/ml	Formic acid (HCOOH)	1 hour		1,5	7	Not detectable (> 8 log reduction)	Laboratory trial, 1 part process water + 2 parts ”bløggevand” from fish slaugtherhouse.	28	
$10^{8,28}$ cfu/ml	Formic acid (HCOOH)	6 min		1,5	7	7 log reduction	Laboratory trial, 1 part process water + 2 parts ”bløggevand” from fish slaugtherhouse.	28	
$10^{4,69}$ cfu/ml	Formic acid (HCOOH)	10 hours		1,98	7	Not detectable (≥ 4 log reduction)	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	Salinity 14-15 ‰
$10^{6,77}$ cfu/ml	Formic acid (HCOOH)	0,1 hour		2		Not detectable (> 6 log reduction)	Full-scale trial, wastewater from fish slaugtherhouses.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{6,77}$ cfu/ml	Formic acid (HCOOH)	1 hour		2,5		Not detectable (> 6 log reduction)	Full-scale trial, wastewater from fish slaugtherhouses.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{4,69}$ cfu/ml	Formic acid (HCOOH)	10 hours		2,5	7	Not detectable (≥ 4 log reduction)	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	Salinity 14-15 ‰
$10^{8,28}$ cfu/ml	Formic acid (HCOOH)	5 hours		2,5	7	Not detectable (> 8 log reduction)	Laboratory trial, 1 part process water + 2 parts ”bløggevand” from fish slaugtherhouse.	28	

$10^{6,77}$ cfu/ml	Formic acid (HCOOH)	24 hours		3		4 log reduction	Full-scale trial, wastewater from fish slaugtherhouses.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{8,28}$ cfu/ml	Formic acid (HCOOH)	10 hours		3,5	7	3 log reduction	Laboratory trial, 1 part process water + 2 parts ”bløggevand” from fish slaugtherhouse.	28	
$10^{4,69}$ cfu/ml	Formic acid (HCOOH)	10 hours		3,98	7	Not detectable (≥ 4 log reduction)	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	Salinity 14-15 ‰
	pH	24 hours		4		Survival		20, Dixon (pers. com.)	
$10^{6,77}$ cfu/ml	NaOH	24 hours		11,6		2-3 log reduction	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{6,77}$ cfu/ml	NaOH	5 hours		12,0		Not detectable (> 6 log reduction)	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{8,28}$ cfu/ml	NaOH	10 hours		12,0	7	Stable? Survival.	Laboratory trial, 1 part process water + 2 parts ”bløggevand” from fish slaugtherhouse.	28	
	pH	10 min		12		”inactivated”		20, Dixon (pers. com.)	
$10^{6,77}$ cfu/ml	NaOH	1 hour		12,4		Not detectable (> 6 log reduction)	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{4,69}$ cfu/ml	NaOH	24 hours		12,44	7	2 log reduction	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	Salinity 14-15 ‰
$10^{8,28}$ cfu/ml	NaOH	10 hours		12,5	7	2-3 log reduction	Laboratory trial, 1 part process water + 2 parts ”bløggevand” from fish slaugtherhouse.	28	
$10^{4,69}$ cfu/ml	NaOH	5 hours		12,70	7	Not detectable (≥ 4 log reduction)	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	Salinity 14-15 ‰
$10^{4,69}$ cfu/ml	NaOH	10 hours		12,81	7	Not detectable (≥ 4 log reduction)	Full-scale trial (Norskagfisk), blood water from fish	28	Salinity 14-15 ‰

							slaugtherhouse.		
$10^{8,28}$ cfu/ml	NaOH	10 hours		13,0	7	3-4 log reduction	Laboratory trial, 1 part process water + 2 parts "bløggevand" from fish slaugtherhouse.	28	

Conclusion: *Y. ruckeri* can be inactivated at pH 2.5 (contact time 1-10 hours). There are reports of 3 log inactivation at pH 3.5 and a contact time of 10 hours. There are conflicting data with regard to high alkaline pH, in full scale trials using wastewater from slaughterhouses complete inactivation at pH> 12 as well as only 2-4 log reduction is shown. This may be due to lacking proper stirring in the full-scale experiments so pockets where the bacteria have not been treated have occurred.

Parasites

Pathogen	Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
Trichodina jadranica	2,1	HCl	24 hours		5	25	Stable (2,4)	*In vivo*, eel	75	Categorisation (category/number of parasites): 0/0, 1/1-10, 2/11-100, 3/100-1000, 4/>1000
Gyrodactylus salaris		pH	Few days		< 5		Dies		1	No reference stated!
Myxosoma cerebralis		KOH	2 days	0,5%		22	All dead	*In vitro* - spores	42	Tested at 0,01, 0,1 and 1%

UV

Virus

VHSV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^{4-5} $TCID_{50}$/ml	UV		0,79 ± 0,15 mWs/cm^2			99,9% reduction	Virus in fresh water.	81	UV-C
10^{4-5} $TCID_{50}$/ml	UV		app. 1,5 mWs/cm^2			"inactivated"	Virus in fresh water.	81	Read off a graph.
app. 6 log TCID	UV		1,8 mWs/cm^2			99,9% reduction		46	UV-C
$10^{7,2}$ $TCID_{50}$/ml	UV	10 min	254 nm, 5 cm afstand		20	"inactivated"		4	
10^{4-5} $TCID_{50}$/ml	UV		3,1 ± 0,18 mWs/cm^2			99,9% reduction	Virus in wastewater from fish cutting plant.	81	UV-C
app. 6 log TCID	UV		4,0 mWs/cm^2			"inactivated"		46	UV-C
10^{4-5} $TCID_{50}$/ml	UV		app. 4 mWs/cm^2			"inactivated"	Virus in wastewater from	81	Read off a graph.

							fish cutting plant.		
	UV		10 mWs/cm^2			LD90		76	

Conclusion: VHSV is susceptible to UV irradiation with ≥ 3 log reduction when exposed to 4 mWs/cm^2. It has been reported though, that 10 mWs/cm^2 is needed for a 2 log reduction.

IHNV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	UV		1 mWs/cm^2			99% infectivity reduction		102	
$10^{4,8-6,3}$ $TCID_{50}$/ml	UV		1,0 - 2,0 mWs/cm^2			ID_{99}	UV intensity: 100 µW/cm^2	103	strain CHAB
$10^{6,8-7,8}$ $TCID_{50}$/ml	UV		1,5 - 3,0 mWs/cm^2			ID_{99}	UV intensity: 200 µW/cm^2	103	strain RTTO
	UV		2 - 3 mWs/cm^2			99% reduction		104	
	UV		2 mWs/cm^2			3 log reduction		86	
$10^{4,8-6,3}$ $TCID_{50}$/ml	UV	30 sec	3 mWs/cm^2			>2-4 log reduction	UV intensity: 100 µW/cm^2	103	strain CHAB
$10^{6,8-7,8}$ $TCID_{50}$/ml	UV	30 sec	4 mWs/cm^2			>3 log reduction	UV intensity: 200 µW/cm^2	103	strain RTTO

Conclusion: IHNV is susceptible to UV irradiation with 3 log reduction when exposed to 4 mWs/cm^2.

ISAV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^{4-5} $TCID_{50}$/ml	UV		3,3 ± 0,35 mWs/cm^2			99,9% reduction	Virus in fresh water.	81	UV-C
10^{4-5} $TCID_{50}$/ml	UV		5,1 ± 1,3 mWs/cm^2			99,9% reduction	virus i havvand	81	UV-C
10^{4-5} $TCID_{50}$/ml	UV		app. 5,5 mWs/cm^2			”inactivated”	Virus in fresh water.	81	Read off a graph.
10^{4-5} $TCID_{50}$/ml	UV		app. 6,5 mWs/cm^2			”inactivated”	virus i havvand	81	Read off a graph.
10^{4-5} $TCID_{50}$/ml	UV		7,2 ± 1,6 mWs/cm^2			99,9% reduction	Virus in wastewater from fish cutting plant.	81	UV-C
	UV		7,5 mWs/cm^2	7,9	5	99,9% reduction	Sea water, sterile filtered.	73	UV-C
10^{4-5} $TCID_{50}$/ml	UV		app. 8 mWs/cm^2			”inactivated”	Virus in wastewater from fish cutting plant.	81	Read off a graph.
	UV	-	20 mWs/cm^2	-	-	”inactivated”	Tissue homogenate of liver, kidney and spleen from moribund ISA-fish, treated and IP-injected in fish.	94	Tested at UV-doses 0,5 - 50 mWs/cm^2.

Conclusion: ISAV is susceptible to UV irradiation with ≥ 3 log reduction when exposed to 8 mWs/cm^2.

IPNV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
$10^{7,3-8,3}$ $TCID_{50}$/ml	UV		100 - 150 mWs/cm^2			ID_{99}	UV intensity: 1000 µW/cm^2	103	serotype Buhl
	UV		100 mWs/cm^2			99% infectivity reduction		102	
$10^{6,7}$ $TCID_{50}$/ml	UV		118,8 ± 5,7 mWs/cm^2			99,9% reduction	Virus in fresh water.	81	UV-C
	UV		150 mWs/cm^2			99% reduction		104	Type buhl
$10^{6,7}$ $TCID_{50}$/ml	UV		app. 170 mWs/cm^2			”inactivated”	Virus in fresh water.	81	Read off a graph.
$10^{7,3-8,3}$ $TCID_{50}$/ml	UV	3 min 20 sec	200 mWs/cm^2			3 log reduction	UV intensity: 1000 µW/cm^2	103	serotype Buhl
	UV		200 mWs/cm^2			3 log reduction		86	
	UV		246 mWs/cm^2	7,9	5	99,9% reduction	Sea water, sterile filtered.	73	UV-C
$10^{4,5}$ $TCID_{50}$/ml	UV, after ferrichlorid-precipitation		250 mWs/cm^2		75	½-1 log reduction	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{8,2}$ $TCID_{50}$/ml	UV	60 min	254 nm, 5 cm afstand		20	”inactivated”		4	
	UV		330 mWs/cm^2			LD80		76	
10^{3-4} $TCID_{50}$/ml	UV		336,7 ± 27,5 mWs/cm^2			99,9% reduction	Virus in wastewater from fish cutting plant.	81	UV-C
$10^{7,0}$ $TCID_{50}$/ml	UV	6-15 min	720 – 1800 mWs/cm^2			6 log reduction	2000 µW/cm^2	74	Isolate VR-299. Result read off a graph.
$10^{7,0}$ $TCID_{50}$/ml	UV	30 min	792 mWs/cm^2			5,8 log reduction	440 µW/cm^2	74	Isolate VR-299. Result read off a graph.
10^{3-4} $TCID_{50}$/ml	UV		app. 1500 mWs/cm^2			”inactivated”	Virus in wastewater from fish cutting plant.	81	Read off a graph.

Conclusion: IPNV is susceptible to UV irradiation with 3 log reduction when exposed to 250-350 mWs/cm^2.

Nodavirus

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10 µg purified virus	UV		10 mWs/cm^2	7	20	Not inactivated(0/800 larvae survived, control 326/800)	Diluted in 1 ml PBS. Used for infection trial in day old striped jack larvae.	9	Isolate: SJNNV
	UV		100 mWs/cm^2			99% infectivity reduction		102	Tvivl om referencens pålidelighed
10 µg purified virus	UV		100 mWs/cm^2	7	20	"Effective" (222/800 larvae survived, antigen ELISA negative - control 326/800)	Diluted in 1 ml PBS. Used for infection trial in day old striped jack larvae.	9	Isolate: SJNNV
	UV		104 mWs/cm^2	7,9	5	99,9% reduction	Sea water, sterile filtered.	73	UV-C
	UV	8 min	211,2 mWs/cm^2			3 log reduction	440 µW/cm2	30	Isolate: sea bass nodavirus
	UV	10 min	264 mWs/cm^2			Not detectable	440 µW/cm2	30	Isolate: sea bass nodavirus

Conclusion: Nodavirus is susceptible to UV irradiation with 3 log reduction when exposed to 100-200 mWs/cm^2.

PFRV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	UV		1 mWs/cm^2			99% infectivity reduction		102	
$10^{5,3}$ $TCID_{50}$/ml	UV	10 min	254 nm, 5 cm afstand		20	”inactivated”		4	

SVCV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	UV		1 mWs/cm^2			99% infectivity reduction		102	Tvivl om referencens pålidelighed
$10^{5,2}$ $TCID_{50}$/ml	UV	10 min	254 nm, 5 cm afstand		20	”inactivated”		4	

Viruses from eel

Pathogen	Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
EVA		UV		1 mWs/cm^2			99% infectivity reduction		102	
EVEX		UV		1 mWs/cm^2			99% infectivity reduction		102	

Conclusion: EVA and EVEX are susceptible to UV irradiation with 2 log reduction when exposed to 1 mWs/cm^2.

Channel catfish virus

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	UV		2 mWs/cm^2			99% reduction		104	
$10^{6,55\text{-}7,05}$ $TCID_{50}$/ml	UV		1,8 - 2,0 mWs/cm^2			ID_{99}	UV intensity: 100 µW/cm^2	103	

Conclusion: CCV is susceptible to UV irradiation with 2 log reduction when exposed to 2 mWs/cm^2.

OMV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	UV		2 mWs/cm^2			99% reduction		104	
$10^{3,05}$-$10^{6,55}$ $TCID_{50}$/ml	UV		1,0-2,0 mWs/cm^2			ID_{99}	UV intensity: 100 µW/cm^2	103	
	UV		1,4 mWs/cm^2			3 log reduction		86	

Conclusion: OMV is susceptible to UV irradiation with 2 log reduction when exposed to 2 mWs/cm^2.

Chum salmon virus

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
$10^{4,3}$-$10^{5,05}$ $TCID_{50}$/ml	UV		100 mWs/cm^2			99% reduction	UV intensity: 1000 µW/cm^2	103, 104	

Herpesvirus salmonis

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
$10^{4,05}$-$10^{4,30}$ $TCID_{50}$/ml	UV		2 mWs/cm^2			99% reduction	UV intensity: 100 µW/cm^2	104, 103	

Bacteria

Aeromonas hydrophila

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^4-10^5 cfu/ml	UV	3,2 sec	3,3 – 5,3 mWs/cm^2		12,5	> 99.0% reduction	Water with dissolved organic matter without filtration.	15	
10^4-10^5 cfu/ml	UV	3,2 sec	4,0 – 4,75 mWs/cm^2		12,5	> 99.3% reduction	Water with dissolved organic matter with filtration.	15	
10^4-10^5 cfu/ml	UV	3,2 sec	4,5 mWs/cm^2		12,5	> 99.8% reduction	Spring water, 25 nm filtration before UV irradiation.	15	
10^3 cfu	UV		5 mWs/cm^2			≥ 99,9% reduction	Spreadning on agar plate followed by UV irradiation.	104, 59	
10^4-10^5 cfu/ml	UV	3,2 sec	12 - 30 mWs/cm^2		12,5	> 99.9% reduction	Water with dissolved organic matter without filtration.	15	
10^4-10^5 cfu/ml	UV	3,2 sec	13 - 29 mWs/cm^2		12,5	> 99.9% reduction	Water with dissolved organic matter with filtration.	15	
10^4-10^5 cfu/ml	UV	3,2 sec	21 - 24 mWs/cm^2		12,5	> 99.9% reduction	Spring water, 25 nm filtration before UV irradiation.	15	
1,3 x10^7 $TCID_{50}$/ml	UV		23,1 mWs/cm^2			> 4 log reduction		60	

Conclusion: *A. hydrophila* is susceptible to UV irradiation with 3 log reduction when exposed to 5-25 mWs/cm^2.

Aeromonas punctata

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^3 cfu	UV		4 mWs/cm^2			≥ 99,9% reduction	Spreadning on agar plate followed by UV irradiation.	104, 59	
2,2 x10^5 $TCID_{50}$/ml	UV		23,1 mWs/cm^2			99,97% reduction		60	

Aeromonas salmonicida

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^7 CFU/ml	UV		0,05 mW/cm^2	7,2	7	99,9% reduction	PBS	71	Reduction rate: 0,15/sec
10^7 CFU/ml	UV		0,05 mW/cm^2	7,8	7	99,9% reduction	Wastewater from aquaculture (15,7 ‰ salinity).	71	Reduction rate: 0,14/sec

10^7 CFU/ml	UV	48 sec	2,34 mWs/cm^2	7,2	7	99,9 % reduction	PBS	71	
10^7 CFU/ml	UV	50 sec	2,38 mWs/cm^2	7,8	7	99,9 % reduction	Wastewater from aquaculture (15,7 ‰ salinity).	71	
10^4-10^5 cfu/ml	UV	3,2 sec	3,3 – 5,3 mWs/cm^2		12,5	> 99.0% reduction	Water with dissolved organic matter without filtration.	15	
	UV		3,4 mWs/cm^2			3 log reduction		86	
10^3 cfu	UV		4 mWs/cm^2			≥ 99,9% reduction	Spreadning on agar plate followed by UV irradiation.	104, 59	
10^4-10^5 cfu/ml	UV	3,2 sec	4,0 – 4,75 mWs/cm^2		12,5	> 99.3% reduction	Water with dissolved organic matter with filtration.	15	
10^4-10^5 cfu/ml	UV	3,2 sec	4,5 mWs/cm^2		12,5	> 99.8% reduction	Spring water, 25 nm filtration before UV irradiation.	15	
10^4-10^5 cfu/ml	UV	3,2 sec	12 - 30 mWs/cm^2		12,5	> 99.9% reduction	Water with dissolved organic matter without filtration.	15	
10^4-10^5 cfu/ml	UV	3,2 sec	13 - 29 mWs/cm^2		12,5	> 99.9% reduction	Water with dissolved organic matter with filtration.	15	
	UV		13 mWs/cm^2		12,5	”inactivated”	Infection trial in water filtratrated with 25 nm filter followed by UV irradiation.	15	98,5% mortality in control group.
10^4-10^5 cfu/ml	UV	3,2 sec	21 - 24 mWs/cm^2		12,5	> 99.9% reduction	Spring water, 25 nm filtration before UV irradiation.	15	
5,6 x10^6 $TCID_{50}$/ml	UV		23,1 mWs/cm^2		18,3	> 4 log reduction		60	

Conclusion: *A. salmonicida* is susceptible to UV irradiation with ≥ 3 log reduction when exposed to 5-25 mWs/cm^2.

Escherichia coli

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^3 cfu	UV		4 mWs/cm^2			≥ 99,9% reduction	Spreadning on agar plate followed by UV irradiation.	104, 59	

Natural flora (heterothrophic bacteria)

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
$10^{3,5}$ cfu/ml	UV					93,6% reduction	flowrate 4 l/m	53	Sea water, filtrated (10 µm)
7,4 x 10^5 cfu/ml	UV		10 mWs/cm^2		5	2,5 log reduction	Sea water, Artemia added.	69	
7,4 x 10^5 cfu/ml	UV		13 mWs/cm^2		5	2,5 log reduction	Sea water, Artemia added.	69	The artemia protects the bacteria.
7,4 x 10^5 cfu/ml	UV		22 mWs/cm^2		5	2,5 log reduction	Sea water, Artemia added.	69	The artemia protects the bacteria.
7,4 x 10^5 cfu/ml	UV med præfiltrering		22 mWS/cm^2		5	> 5 log reduction	Sea water, Artemia added, filtration through 50 µm	69	cfu after filtration app. The same as before filtration.
4,7 x 10^4 cfu/ml	UV		150 mWs/cm^2			4 log reduction	flowrate 2,0 m^3	56	Natural flora in wastewater from hathing facility.
app. 9000 cfu/ml	UV		app. 1800 mWs/cm^2	7,5		1,7 log reduction	Fish farm, recirculation.	88	

Conclusion: there are conflicting results concerning the resistance of the natural flora towards UV irradiation. The composition of the natural flora will depend on a lot of different variables, which will influence the effect of UV irradiation.

Pseudomonas flourescens

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^4-10^5 cfu/ml	UV	3,2 sec	3,3 – 5,3 mWs/cm^2		12,5	> 99.0% reduction	Water with dissolved organic matter without filtration.	15	
10^4-10^5 cfu/ml	UV	3,2 sec	4,0 – 4,75 mWs/cm^2		12,5	> 99.3% reduction	Water with dissolved organic matter with filtration.	15	
10^4-10^5 cfu/ml	UV	3,2 sec	4,5 mWs/cm^2		12,5	> 99.8% reduction	Spring water, 25 nm filtration before UV irradiation.	15	
10^3 cfu	UV		5 mWs/cm^2			≥ 99,9% reduction	Spreadning on agar plate followed by UV irradiation.	104, 59	
10^4-10^5 cfu/ml	UV	3,2 sec	12 - 30 mWs/cm^2		12,5	> 99.9% reduction	Water with dissolved organic matter without filtration.	15	
10^4-10^5 cfu/ml	UV	3,2 sec	13 - 29 mWs/cm^2		12,5	> 99.9% reduction	Water with dissolved organic matter with filtration.	15	
10^4-10^5 cfu/ml	UV	3,2 sec	21 - 24 mWs/cm^2		12,5	> 99.9% reduction	Spring water, 25 nm filtration before UV irradiation.	15	
1,5 x10^7 $TCID_{50}$/ml	UV		23,1 mWs/cm^2		20,4	4 log reduction		60	

Conclusion: *P. flourescens* is susceptible to UV irradiation with ≥ 3 log reduction when exposed to 5-25 mWs/cm^2.

Vibrio anguillarum

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	UV		2,9 mWs/cm^2			3 log reduction		86	
10^4-10^5 cfu/ml	UV	3,2 sec	3,3 – 5,3 mWs/cm^2		12,5	> 99.0% reduction	Water with dissolved organic matter without filtration.	15	
10^3 cfu	UV		4 mWs/cm^2			≥ 99,9% reduction	Spreadning on agar plate followed by UV irradiation.	104, 59	
10^4-10^5 cfu/ml	UV	3,2 sec	4,0 – 4,75 mWs/cm^2		12,5	> 99.3% reduction	Water with dissolved organic matter with filtration.	15	
10^4-10^5 cfu/ml	UV	3,2 sec	4,5 mWs/cm^2		12,5	> 99.8% reduction	Spring water, 25 nm filtration before UV irradiation.	15	
10^4-10^5 cfu/ml	UV	3,2 sec	12 – 30 mWs/cm^2		12,5	> 99.9% reduction	Water with dissolved organic matter without filtration.	15	
10^4-10^5 cfu/ml	UV	3,2 sec	13 - 29 mWs/cm^2		12,5	> 99.9% reduction	Water with dissolved organic matter with filtration.	15	
10^4-10^5 cfu/ml	UV	3,2 sec	21 – 24 mWs/cm^2		12,5	> 99.9% reduction	Spring water, 25 nm filtration before UV irradiation.	15	
1,9 x10^6 $TCID_{50}$/ml	UV		23,1 mWs/cm^2		20,3	> 5 log reduction		60	

Conclusion: *V. anguillarum* is susceptible to UV irradiation with ≥ 3 log reduction when exposed to 5-25 mWs/cm^2.

Vibrio ordalii

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	UV		5,5 mWs/cm^2			3 log reduction		86	

Yersinia ruckeri

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^4-10^5 cfu/ml	UV	3,2 sec	3,3 – 5,3 mWs/cm^2		12,5	> 99.0% reduction	Water with dissolved organic matter without filtration.	15	
10^4-10^5 cfu/ml	UV	3,2 sec	4 – 4,75 mWs/cm^2		12,5	> 99.3% reduction	Water with dissolved organic matter with filtration.	15	

10^4-10^5 cfu/ml	UV	3,2 sec	4,5 mWs/cm^2		12,5	> 99.8% reduction	Spring water, 25 nm filtration before UV irradiation.	15	
10^4-10^5 cfu/ml	UV	3,2 sec	12 - 30 mWs/cm^2		12,5	> 99.9% reduction	Water with dissolved organic matter without filtration.	15	
10^4-10^5 cfu/ml	UV	3,2 sec	13 – 29 mWs/cm^2		12,5	> 99.9% reduction	Water with dissolved organic matter with filtration.	15	
10^4-10^5 cfu/ml	UV	3,2 sec	21 – 24 mWs/cm^2		12,5	> 99.9% reduction	Spring water, 25 nm filtration before UV irradiation.	15	
$10^{5,21}$ cfu/ml	UV, after ferrichlorid precipitation		250 mWs/cm^2		65	1 log reduction	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
	UV		1200 mWs/cm^2			2½ log reduction	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	forfilter 20 µm

Conclusion: In laboratory trials *Y. ruckeri* is susceptible to UV irradiation with ≥ 3 log reduction when exposed to 5-25 mWs/cm^2. In full scale trials, after precipitation using ferrichlorid only 1 log reduction was obtained after a dose of 250 mWs/cm^2, and it was not possible to obtain a 3 log reduction using a dose of 1200 mWs/cm^2 despite prefiltration through a 20 µm filter.

Parasites

Ichthyophthirius multifiliis

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	UV		92 mWs/cm^2	6,1-7,3		Transmission prevented	Transmission of Ich from infected to free fish.	34	1 UV lamp.

Myxosoma cerebralis

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	UV		4 mWs/cm^2			> 5 log reduction	Infectivity of myxospores in tubifex.	37	Myxospore suspension
	UV, pre filtration of water		28 mWs/cm^2			86-100% reduction af infektivitet	25 µm filter, UV irradiation of contaminated water, fish added, clinic and % spores registered.	41	Ingen klinik, ingen spores i det ene forsøg, 14% spores i det andet forsøg. Kontrolfisk 100% spores og klinik.

	UV		35 mWs/cm^2			”inactivated”	Infection trial wiht UV irradiated spores (UV-doses 35000, 43000 and 112000 µWs/cm2)	40	
2 x 10^4 TAM	UV		40 mWS/cm^2			”inactivated”	Smitteforsøg med UV-behandlede triactinomyxoner (1000/fisk)	36	
	UV		48 mWs/cm^2			4,75 log reduction	Infektivitet af myxospores i tubifex	37	Myxospore suspension
	UV		1700 mWs/cm^2			alle døde	myxospores i suspension	44	

Fungae and oomycetes

Achlya flagellata

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	UV		220 mWs/cm^2			”inactivated”		59	

Aphanomyces laevis

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	UV		210 mWs/cm^2			”inactivated”		59	

Saprolegnia

Pathogen	Concentration pathogen	Disin-fectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
Saprolegnia anispora		UV		150 mWs/cm^2			”inactivated”	Punched agar disk with hyphae irradiated.	104, 59	
Saprolegnia parasitica		UV		200 – 230 mWs/cm^2			”inactivated”	Punched agar disk with hyphae irradiated.	104, 59	
Saproglegnia sp.		UV		210 – 250 mWs/cm^2			”inactivated”	Punched agar disk with hyphae irradiated.	104, 59	

UV in combination with other treatments

IPNV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	UV/ozone		161 mWs/cm^2 + ozone			Survival		86	

Aeromonas salmonicida

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^7 CFU/ml	UV/NaOCl		0,05 mW/cm^2 / 0,2 mg/l added	7,2	7	99,9% reduction	PBS	71	Reduction rate: 0,32/sec
10^7 CFU/ml	UV/NaOCl		0,05 mW/cm^2 / 2,0 mg/l added	7,8	7	99,9% reduction	Wastewater from aquaculture (15,7 ‰ salinity).	71	Reduction rate: 0,26/sec
10^7 CFU/ml	UV/I_2		0,05 mW/cm^2 / 1,0 mg/l added	7,2	7	99,9 % reduction	PBS	71	Reduction rate: 0,42/sec
10^7 CFU/ml	UV/I_2		0,05 mW/cm^2 / 1,3 mg/l added	7,8	7	99,9 % reduction	Wastewater from aquaculture (15,7 ‰ salinity).	71	Reduction rate: 0,28/sec
10^7 CFU/ml	UV/ozone		0,05 mW/cm^2 / 0,1 mg/l	7,2	7	99,9 % reduction	PBS	71	Reduction rate: 0,32/sec

Natural flora (heterothrophic bacteria)

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
116 ± 25 cfu/ml	ozone/UV		0,21 mg/l, 54,7 mJ/cm^2	7,5	14,3	1,81 log reduction	fish farm, recirculation	87	

Miscellaneous chlorine compounds

NB: It it not always stated if the concentration of the disinfectant is as free chlorine or as the disinfectant itself.

Virus

VHSV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
$10^{7,8}$ $TCID_{50}$/ml	Benzalkonium chlorid	6 hours	1%			Stable	10 % calf serum added	4, 5	
10^{8} $TCID_{50}$/ml	Benzalkonium chlorid	30 min	1:1000		15	Not detectable	10% (w/v) dilution in PBS. 1% fetal calf serum.	65	Strain JF00Ehi1. Benzalkoniumklorid 10% (w/v). Dilution scale 1:1000.
10^{8} $TCID_{50}$/ml	Benzalkonium chlorid	5 min	1:1000		15	Not detectable	10% (w/v) dilution in artificail sea water. 1% fetal calf serum.	65	Strain JF00Ehi1. Benzalkoniumklorid 10% (w/v). Dilution scale 1:1000.
$10^{7,2}$ $TCID_{50}$/ml	NaOCl	10 min	7,6 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
$10^{6,8}$ $TCID_{50}$/ml	NaOCl	60 min	7,6 mg/ml Cl_2	7,07-7,49	10	Stable	2,5 % calf serum added	4	
$10^{6,2}$ $TCID_{50}$/ml	NaOCl	5 min	25 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
$10^{6,5}$ $TCID_{50}$/ml	NaOCl	10 min	25 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction	2,5 % calf serum added	4	
$10^{6,5}$ $TCID_{50}$/ml	NaOCl	2 min	36 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
$10^{6,5}$ $TCID_{50}$/ml	NaOCl	10 min	36 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction	2,5 % calf serum added	4	
$10^{6,5}$ $TCID_{50}$/ml	NaOCl	5 min	54 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
$10^{6,8}$ $TCID_{50}$/ml	NaOCl	5 min	54 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction	2,5 % calf serum added	4	
$10^{7,8}$ $TCID_{50}$/ml	NaOCl	2 min	98 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
$10^{7,2}$ $TCID_{50}$/ml	NaOCl	10 min	98 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction	2,5 % calf serum added	4	
$10^{6,5}$ $TCID_{50}$/ml	NaOCl	< 2 min	515 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
$10^{6,8}$ $TCID_{50}$/ml	NaOCl	< 2 min	515 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction	2,5 % calf serum added	4	
10^{7} $TCIID_{50}$/ml	NaOCl	1 min	50 ppm		15	Not detectable	Diluted in PBS. 1% fetal calf serum.	65	Isolat JF00EHi1. Dilution scale 1:50.
10^{7} $TCID_{50}$/ml	NaOCl	1 min	50 ppm		15	Ineffective.	Diluted in artifical sea water. 1% fetal calf serum.	65	Isolat JF00EHi1. Dilution scale 1:50.
10^{7} $TCID_{50}$/ml	NaOCl	5 min	100 ppm		15	Not detectable	Diluted in artifical sea water. 1% fetal calf serum.	65	Isolat JF00EHi1. Dilution scale 1:50
10^{7} $TCID_{50}$/ml	NaOCl	1 min	200 ppm		15	Not detectable	Diluted in artifical sea water. 1% fetal calf serum.	65	Isolat JF00EHi1. Dilution scale 1:50

Conclusion: In laboratory experiements under dirty conditions (addition of 1% calf serum) it was possible to decimate VHSV to non detectable by use of 100 mg/l chlorine for 5 min. Another experiment showed that using the same dose it takes 2 min to decimate VHSV ≥ 2 log under clean conditions but 10 min under dirty conditions (2,5% calf serum). It is not possible to validate the dose to decimate VHSV 3 log based on these figures.

IHNV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^4 - $10^5$$TCID_{50}$/ml	NaOCl	30 sec	0,1 mg/l residual	6,9	10	”inactivated”	Distilled water.	99, 98	
10^4 - $10^5$$TCID_{50}$/ml	NaOCl	5 min	0,5 mg/l residual	6,9	10	”inactivated”	Soft lake water., 30 mg/l $CaCO_3$	99, 98	
10^4 - $10^5$$TCID_{50}$/ml	NaOCl	10 min	0,5 mg/l residual	8,2	10	”inactivated”	Hard lake water., 120 mg/l $CaCO_3$	99, 98	
10^4 - $10^5$$TCID_{50}$/ml	NaOCl	30 sec	1,0 mg/l residual	8,2	10	”inactivated”	Hard lake water., 120 mg/l $CaCO_3$	99, 98	
	NaOCl	30 min	10 ppm Cl_2			”inactivated”		8	

Conclusion: Chlorine is effective to inactive IHNV at low cencentrations of short contact time. The tests are performed under fairly clean conditions and not under conditions comparable to wastewater from fish cutting plants.

ISAV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
6,8 log10 ffu/ml	chloramine-T	5 min	0,25%		4	> 6,5 log reduction	Hard water, 342 ppm total hardness.	89	Buffodine
6,2 log10 ffu/ml	ClO_2	5 min	25 ppm		4	1,2 log reduction	Hard water, 342 ppm total hardness, no addition of serum.	89	Zydox AD-05
5,1 log10 ffu/ml	ClO_2	5 min	50 ppm		4	1,4 log reduction	Hard water, 342 ppm total hardness, addition of serum.	89	Zydox AD-05
5,1 log10 ffu/ml	ClO_2	5 min	50 ppm		4	> 4,8 log reduction	Hard water, 342 ppm total hardness, addition of serum.	89	Zydox AD-05
6,2 log10 ffu/ml	ClO_2	5 min	50 ppm		4	5,3 log reduction	Hard water, 342 ppm total hardness, no addition of serum.	89	Zydox AD-05
5,5 log10 ffu/ml	OCl^-	5 min	100 ppm		4	> 5,2 log reduction	Hard water, 342 ppm total hardness, with and without addition of serum.	89	

	NaOCl	15 min	100 mg/l	-	-	"inactivated"	Tissue homogenate of liver, kidney and spleen from moribund ISA-fish, treated and IP-injected in fish.	94	Testet ved konc. 5, 10, 20, 50 og 100 mg/l med kontakttid 15 min og 30 min.

Conclusion: Under laboratory conditions it is possible to obtain 5 log reduction of ISAV using 100 mg/l chlorine for 5 minuts.

KHV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
1 - 1,5 x 10^4 $TCID_{50}$/ml	Benzalkonium chloride	30 sec	60 mg/l		0	Not detectable	Virus and disinfectant mixed 1:1, tested after 30 sek and 20 min. Diluted 1:10 using L15 medium og inoculated 200 µl.	55	Strain KHV-I. The method cannot detect a 3 log reduction.
1 - 1,5 x 10^4 $TCID_{50}$/ml	Benzalkonium chloride	30 sec	30 mg/l		25	Not detectable	Virus and disinfectant mixed 1:1, tested after 30 sek and 20 min. Diluted 1:10 using L15 medium og inoculated 200 µl.	55	Strain KHV-I. The method cannot detect a 3 log reduction.
	NaOCl	20 min	0,3 mg/l residual			98,5% reduction		55	Strain KHV-I.
1 - 1,5 x 10^4 $TCID_{50}$/ml	NaOCl	20 min	200 mg/l		0	"inactivated"	Virus and disinfectant mixed 1:1, tested after 30 sec and 20 min. Diluted 1:10 using L15 medium og inoculated 200 µl.	99, 98	Strain KHV-I. The method cannot detect a 3 log reduction.
1 - 1,5 x 10^4 $TCID_{50}$/ml	NaOCl	20 min	250 mg/l		25	"inactivated"	Virus and disinfectant mixed 1:1, tested after 30 sec and 20 min. Diluted 1:10 using L15 medium og inoculated 200 µl.	99, 98	Strain KHV-I. The method cannot detect a 3 log reduction.

Conclusion: It does seem as if KHV is susceptible to chlorine. It is difficult to assess the dose to reduce the titer 3 log for KHV, as the methods used are not able to detect such a reduction.

IPNV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
$10^{7,5}$ $TCID_{50}$/ml	Benzalkonium chlorid	6 hours	1%			Stable	10 % calf serum added	4, 5	Trade name Mefarol.
	chloramine-T	30 min	3,2%		4	> 4 log reduction	Clean conditions.	49	

$10^{5,5}$ $TCID_{50}$/ml	chloramine-T (SETAX)	24 hours	50 mg/l	7,5		Stable	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{5,5}$ $TCID_{50}$/ml	chloramine-T (SETAX)	24 hours	100 mg/l	7,5		2 log reduction	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{5,5}$ $TCID_{50}$/ml	chloramine-T (SETAX)	1 hour	250 mg/l	7,5		4 log reduction	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
10^{6} infectious units/ml	chloramine-T (SETAX)	30 min	3 g/l		4	1 log reduction	Sea water added 10% salmon blood.	22	
10^{6} infectious units/ml	chloramine-T (SETAX)	30 min	10 g/l		4	2 log reduction	Sea water added 10% salmon blood.	22	
10^{5} $TCID_{50}$/ml	Cl_2	30 min	25 ppm (=25 mg/l)		room temp.	”inactivated”	Tap water.	17	Chlorine concentration after correction for medium and diluent addition.
10^{5} $TCID_{50}$/ml	Cl_2	30 min	25 ppm		room temp.	”inactivated”	PBS	17	Chlorine concentration after correction for medium and diluent addition.
$10^{7,5}$ $TCID_{50}$/ml	Cl_2	30 min	40 ppm		room temp.	”inactivated”	Salt water.	17	Chlorine concentration after correction for medium and diluent addition.
10^{5} $TCID_{50}$/ml	NaOCl	1 min	0,1 mg/l clorine residual	6,9	10	”inactivated”	Distilled water.	99	
10^{5} $TCID_{50}$/ml	NaOCl	10 min	0,2 mg/l clorine residual	8,2	10	Stable	Hard lake water.	99	
10^{5} $TCID_{50}$/ml	NaOCl	2 min	0,7 mg/l clorine residual	8,2	10	”inactivated”	Hard lake water.	99	
10^{5} $TCID_{50}$/ml	NaOCl	10 min	0,2 mg/l clorine residual	8,2	10	”inactivated”	Soft lake water.	99	
$10^{3,8}$ $TCID_{50}$/ml	NaOCl	60 min	7,5 mg/ml Cl_2	7,07-7,49	10	Stable		4	
$10^{4,2}$ $TCID_{50}$/ml	NaOCl	60 min	7,5 mg/ml Cl_2	7,07-7,49	10	Stable	2,5 % calf serum added	4	
$10^{5,5}$ $TCID_{50}$/ml	NaOCl	2 min	30 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	

$10^{6,2}$ $TCID_{50}$/ml	NaOCl	30 min	30 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction	2,5 % calf serum added	4	
$10^{6,2}$ $TCID_{50}$/ml	NaOCl	2 min	36 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
$10^{6,2}$ $TCID_{50}$/ml	NaOCl	20 min	36 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction	2,5 % calf serum added	4	
$10^{5,5}$ $TCID_{50}$/ml	NaOCl	2 min	56 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
$10^{5,2}$ $TCID_{50}$/ml	NaOCl	20 min	56 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction	2,5 % calf serum added	4	
$10^{6,5}$ $TCID_{50}$/ml	NaOCl	2 min	106 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
$10^{6,2}$ $TCID_{50}$/ml	NaOCl	20 min	106 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction	2,5 % calf serum added	4	
$10^{5,2}$ $TCID_{50}$/ml	NaOCl	< 2 min	520 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
$10^{5,5}$ $TCID_{50}$/ml	NaOCl	< 2 min	520 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
10^{4} - 10^{5} $TCID_{50}$/ml	NaOCl	60 sec	0,1 mg/l residual	6,9	10	”inactivated”	Distilled water.	98	
10^{4} - 10^{5} $TCID_{50}$/ml	NaOCl	10 min	0,2 mg/l residual	6,9	10	”inactivated”	Soft lake water., 30 mg/l $CaCO_3$	98	
10^{4} - 10^{5} $TCID_{50}$/ml	NaOCl	2 min	0,7 mg/l residual	8,2	10	”inactivated”	Hard lake water., 120 mg/l $CaCO_3$	98	
10^{4} - 10^{5} $TCID_{50}$/ml	NaOCl	10 min	0,2 mg/l residual	8,2	10	Stable	Hard lake water., 120 mg/l $CaCO_3$	98	
$10^{3,9}$ $TCID_{50}$/ml	NaOCl	5 min	1 mg/l clorine residual		21	”inactivated”	Tested using 0,13, 0,25, 0,5, 1, 2, 4, 8 and 16 mg/l residual. Distilled water..	23	IPNV: Serotype Buhl.
$10^{4,5}$ $TCID_{50}$/ml	NaOCl	5 min	4 mg/l clorine residual	6,6-8,9	21	”inactivated”	Tested using 0,13, 0,25, 0,5, 1, 2, 4, 8 and 16 mg/l residual. Distilled water..	23	IPNV: Serotype Buhl.
$10^{4,3}$ $TCID_{50}$/ml	NaOCl	15 sec	5 mg/l clorine residual		21	”inactivated”	Ttested at time 0, 15, 30, 60, 120 s. Distilled water.	23	IPNV: Serotype Buhl.
$10^{4,5}$ $TCID_{50}$/ml	NaOCl	5 min	16 mg/l clorine residual	9,0-10,0	21	”inactivated”	Tested using 0,25, 0,5, 1, 2, 4, 8 and 16 mg/l residual. Distilled water.	23	IPNV: Serotype Buhl.
$10^{5,5}$ $TCID_{50}$/ml	NaOCl	24 hours	50 mg/l	7,5		Stable	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{5,5}$ $TCID_{50}$/ml	NaOCl	24 hours	100 mg/l	7,5		Stable	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{5,5}$ $TCID_{50}$/ml	NaOCl	1 hour	250 mg/l	7,5		Stable	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.

$10^{6,6}$ $TCID_{50}$/ml	NaOCl	10 hours	43 mg/l		7	1 log reduction	Laboratory trial, 1 part process water + 2 parts ”bløggevand” from fish slaugtherhouse.	28	
$10^{6,6}$ $TCID_{50}$/ml	NaOCl	10 hours	130 mg/l		7	5 log reduction	Laboratory trial, 1 part process water + 2 parts ”bløggevand” from fish slaugtherhouse.	28	
$10^{6,6}$ $TCID_{50}$/ml	NaOCl	10 hours	260 mg/l		7	4 log reduction	Laboratory trial, 1 part process water + 2 parts ”bløggevand” from fish slaugtherhouse.	28	
$10^{6,6}$ $TCID_{50}$/ml	NaOCl	5 hours	130 mg/l		7	3 log reduction	Laboratory trial, 1 part process water + 2 parts ”bløggevand” from fish slaugtherhouse.	28	
$10^{6,6}$ $TCID_{50}$/ml	NaOCl	5 hours	260 mg/l		7	3½ log reduction	Laboratory trial, 1 part process water + 2 parts ”bløggevand” from fish slaugtherhouse.	28	

Conclusion: In laboratory experiments under highly contaminated conditions that exist in process and wastewater from fish slaughterhouses chlorine in a dose of 130 mg/l with a contact time of 10 hours gave 5 log reduction in titer. During full-scale trials it has not been possible to achieve these results. It was, for example, not possible in a full-scale test to inactivate IPNV using NaOCl at a concentration of 250 mg/l chlorine and a contact time of 1 hour. Using Chloramine-T has it been possible with a contact time of 1 hour and concentration of 250 mg/l chlorine to achieve a 4 log inactivation in a full-scale trials. In the full-scale trials no continous stirring was performed and pockets of non /low treated areas may have occurred and/or the virus may have been protected by different aggregations.

Nodavirus

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10 µg purified virus	Benzalkonium chlorid	10 min	50 µg/ml		20	”Effective”	Diluted in 1 ml PBS. Used for infection trial in day old striped jack larvae. Concentration testet: 2,5 - 100 µg/ml.	9	Isolate: SJNNV
10 µg purified virus	CaOCl	10 min	50 µg/ml		20	”Effective”	Diluted in 1 ml PBS. Used for infection trial in day old striped jack larvae. Concentration testet: 2,5 - 100 µg/ml.	9	Isolate: SJNNV

$10^{7,25\ TCID}{}_{50}$/ml	Cl_2	5 min	50 ppm		15	Not detectable	Distilled water.. Tested after 5, 15 and 30 min.	30	Isolate: sea bass nodavirus
$10^{7,25\ TCID}{}_{50}$/ml	Cl_2	30 min	25 ppm		15	Not detectable	Distilled water.. Tested after 5, 15 and 30 min.	30	Isolate: sea bass nodavirus
$10^{7,25\ TCID}{}_{50}$/ml	Cl_2	30 min	100 ppm		15	2 log reduction	HBSS + calf serum. Tested after 5, 15 and 30 min.	30	Isolate: sea bass nodavirus
10 µg purified virus	NaOCl	10 min	50 µg/ml		20	”Effective”	Diluted in 1 ml PBS. Used for infection trial in day old striped jack larvae. Concentration testet: 2,5 - 100 µg/ml.	9	Isolate: SJNNV

Conclusion: Under laboratory settings and clean conditions nodavirus is easily incativated using a dose of 50 mg/l for 5 minuts. When adding calf serum it was only possible to obtain a 2 log reduction using a concentration of 100 mg/l for 30 minuts.

Hirame rhabdovirus

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	OCl^-	1 min	0,42 mg/l			>99% reduction		57	Hypoclorite produced by use of batch electrolytic system.
$10^{4,5\ TCID}{}_{50}$/ml	OCl^-	1 min	0,34 mg/l			3 log reduction	flowrate 3,5 m^3/t, el. 1,5 A	54	Electrolyzed salt water.
$10^{4,5\ TCID}{}_{50}$/ml	OCl^-	2,5 min	0,49 mg/l			> 4 log reduction	flowrate 3,5 m^3/t, el. 2 A	54	Electrolyzed salt water.

Conclusion: Electrolysation of saltwater to produce chlorine seem to be an effective method to inactivate hirame rhabovirus using a dose of 0,5 mg/l and a contact time of 2,5 minuts. There has not been tested under dirty conditions, which may reduce the effect of chlorine.

oncorhynchus masou virus

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	Benzalkonium chlorid	30 sec	100 ppm		0	”inactivated”		35	
	Benzalkonium chlorid	30 sec	100 ppm		25	”inactivated”		35	
	Benzalkonium chlorid	20 min	100 ppm		0	”inactivated”		35	
	Benzalkonium chlorid	20 min	100 ppm		15	”inactivated”		35	

	NaOCl	30 sec	100 ppm		0	”inactivated”		35	
	NaOCl	30 sec	100 ppm		25	”inactivated”		35	
	NaOCl	20 min	50 ppm		0	”inactivated”		35	
	NaOCl	20 min	50 ppm		15	”inactivated”		35	

Conclusion: Under laboratory conditions *O. masou* virus is inactivated using a dose of 100 mg/l for 30 sec, or 50 mg/l for 20 min.

PFRV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
6,2 log10 $TCID_{50}$/ml	Benzalkonium chlorid	6 hours	1%			Stable	10 % calf serum added	4	Trade name Mefarol.
6,5 log10 $TCID_{50}$/ml	NaOCl	20 min	7,6 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
5,8 log10 $TCID_{50}$/ml	NaOCl	60 min	7,6 mg/ml Cl_2	7,07-7,49	10	Stable	2,5 % calf serum added	4	
6,5 log10 $TCID_{50}$/ml	NaOCl	20 min	25 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
6,2 log10 $TCID_{50}$/ml	NaOCl	20 min	25 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction	2,5 % calf serum added	4	
6,8 log10 $TCID_{50}$/ml	NaOCl	20 min	36 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
6,8 log10 $TCID_{50}$/ml	NaOCl	20 min	36 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction	2,5 % calf serum added	4	
6,8 log10 $TCID_{50}$/ml	NaOCl	5 min	54 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
6,5 log10 $TCID_{50}$/ml	NaOCl	10 min	54 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction	2,5 % calf serum added	4	
6,8 log10 $TCID_{50}$/ml	NaOCl	5 min	101 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
7,2 log10 $TCID_{50}$/ml	NaOCl	10 min	101 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction	2,5 % calf serum added	4	
6,5 log10 $TCID_{50}$/ml	NaOCl	< 2 min	540 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
6,5 log10 $TCID_{50}$/ml	NaOCl	2 min	540 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction	2,5 % calf serum added	4	

Conclusion: As the author has not noted the precise reduction it is difficult to evalute which dose to use to inactivate PFRV. It does seem, though, as PFRV is susceptible to chlorine when using the right dose for the right time.

Ranavirus

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
1 x 10^7 PFU/ml	Chlorhexidine	1 min	0,005%		22	1,7 log reduction	Novalsan 0,25%	14	Isolate from American bullfrog
1 x 10^7 PFU/ml	Chlorhexidine	5 min	0,005%		22	2,6 log reduction	Novalsan 0,25%	14	Isolate from American bullfrog
1 x 10^7 PFU/ml	Chlorhexidine	1 min	0,015%		22	3,25 log reduction	Novalsan 0,75%	14	Isolate from American bullfrog
1 x 10^7 PFU/ml	Chlorhexidine	1 min	0,040%		22	3,75 log reduction	Novalsan 2,0%	14	Isolate from American bullfrog
1 x 10^7 PFU/ml	NaOCl	1 min	0,012%		22	0,5 log reduction		14	Isolate from American bullfrog
1 x 10^7 PFU/ml	NaOCl	5 min	0,012%		22	0,5 log reduction		14	Isolate from American bullfrog
1 x 10^7 PFU/ml	NaOCl	1 min	0,060%		22	0,9 log reduction		14	Isolate from American bullfrog
1 x 10^7 PFU/ml	NaOCl	5 min	0,060%		22	1,8 log reduction		14	Isolate from American bullfrog
1 x 10^7 PFU/ml	NaOCl	1 min	0,18% (1,8 g/l)		22	”inactivated”		14	Isolate from American bullfrog
	NaOCl	5 hours	400 mg/l			Survival	Virus i udtørret cellekulturmedium overhældt med NaOCl. Testet efter 2 og 5 hours.	67	ENV
	NaOCl	2 hours	200 mg/l			”inactivated”	Virus in cell culture medium.. Kun testet efter 2 hours og ved denne dosis.	67	EHNV

Conclusion: It seems as if ranavirus is quite resistant to chlorine.

SVCV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
6,5 log10 $TCID_{50}$/ml	Benzalkonium chlorid	6 hours	1%			Stable	10 % calf serum added	4, 5	
$10^{7,1}$ $TCID_{50}$/ml	Benzalkonium chlorid	20 min	100 ppm		22	> 4 log reduction	Diluted in PBS. Contact time 30 sec or 20 min. 1%	61	Isolate S30

							calf serum.		
6,2 log10 $TCID_{50}$/ml	NaOCl	20 min	7,6 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
6,8 log10 $TCID_{50}$/ml	NaOCl	60 min	7,6 mg/ml Cl_2	7,07-7,49	10	Stable	2,5 % calf serum added	4	
6,5 log10 $TCID_{50}$/ml	NaOCl	10 min	27 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
6,5 log10 $TCID_{50}$/ml	NaOCl	10 min	27 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction	2,5 % calf serum added	4	
7,5 log10 $TCID_{50}$/ml	NaOCl	2 min	36 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
7,2 log10 $TCID_{50}$/ml	NaOCl	10 min	36 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction	2,5 % calf serum added	4	
5,8 log10 $TCID_{50}$/ml	NaOCl	2 min	55 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
5,5 log10 $TCID_{50}$/ml	NaOCl	5 min	55 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction	2,5 % calf serum added	4	
5,5 log10 $TCID_{50}$/ml	NaOCl	< 2 min	101 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
5,8 log10 $TCID_{50}$/ml	NaOCl	2 min	101 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction	2,5 % calf serum added	4	
6,2 log10 $TCID_{50}$/ml	NaOCl	< 2 min	506 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction		4	
6,5 log10 $TCID_{50}$/ml	NaOCl	2 min	506 mg/ml Cl_2	7,07-7,49	10	≥ 99 % reduction	2,5 % calf serum added	4	

Conclusion: As the author has not noted the precise reduction it is difficult to evalute which dose to use to inactivate PFRV. It does seem, though, as PFRV is susceptible to chlorine when using the right dose for the right time.

Yellowtail ascites virus

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	OCl^-	1 min	0,42 mg/l			>99% reduction		57	Hypoclorite produced by use of batch electrolytic system.
$10^{4,5}$ $TCID_{50}$/ml	OCl^-	1 min	0,58 mg/l			> 4 logi naktivering	flowrate 3,5 m^3/t, el. 2.5 A	54	Electrolyzed salt water.
$10^{4,5}$ $TCID_{50}$/ml	OCl^-	1 min	0,45 mg/l			3 log reduction	flowrate 3,5 m^3/t, el. 2 A	97	Electrolyzed salt water.

Bacteria

Aeromonas salmonicida

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
$10^{5,5}$ cfu/ml	Benzalkonium chlorid	3 min	0,02%		5	Stable	Test of effect of Temperature.	85	
$10^{5,5}$ cfu/ml	Benzalkonium chlorid	3 min	0,02%		15	3 log reduction	Test of effect of Temperature.	85	
$10^{5,5}$ cfu/ml	Benzalkonium chlorid	3 min	0,02%		25	> 4½ log reduction	Test of effect of Temperature.	85	
$10^{5,5}$ cfu/ml	Benzalkonium chlorid	3 min	0,02%		15	2 log reduction	Artificial sea water.	85	
$10^{5,5}$ cfu/ml	Benzalkonium chlorid	3 min	0,02%		15	3 log reduction	Hard water (300 ppm $CaCO_3$)	85	
$10^{5,5}$ cfu/ml	Benzalkonium chlorid	3 min	0,02%		15	4½ log reduction	Distilled water.	85	
10^{5} cfu/ml	Benzalkonium chlorid	5 min	0,03%		20	> 4 log reduction		85	Concentration of commercial product.
10^{8} cfu/ml	Benzalkonium chlorid	4 min	0,03%		20	> 7 log reduction	Test of effect of bacteria titer.	85	
$10^{6,5}$ cfu/ml	Benzalkonium chlorid	2 min	0,03%		20	> 5½ log reduction	Test of effect of bacteria titer.	85	
10^{5} cfu/ml	Benzalkonium chlorid	1 min	0,03%		20	> 4 log reduction	Test of effect of bacteria titer.	85	
$10^{5,5}$ cfu/ml	Benzalkonium chlorid	1 min	0,03%		20	3½ log reduction	300 ppm calf serum added.	85	
$10^{5,5}$ cfu/ml	Benzalkonium chlorid	1 min	0,03%		20	4½ log reduction	0 ppm calf serum added.	85	
10^{5} cfu/ml	Benzalkonium chlorid	1 min	0,1%		20	> 4 log reduction		85	Concentration of commercial product.
	chloramine-T	30 min	0,08 - 0,5 % (v/v)		4	> 5 log reduction	Tested at 0,001, 0,01, 0,05, 0,08, 0,1, 0,5, 0,7 and 1%. Hard water, organic loaded.	49	
10^{8}-10^{9} CFU/ml	chloramine-T (SETAX)	1 min	1 g/l		4	≥ 6 log reduction	Sea water added 10% salmon blood.	22	
10^{3} cells/ml	NaOCl	10 min	0,01 mg/l residual	6,9	20	Stable	Distilled water.	97, 98	Samples tested after ½, 1, 2, 5, 10, 20 and 30 min.
10^{3} cells/ml	NaOCl	1 min	0,01 mg/l residual	6,9	20	2 log reduction	Distilled water.	97, 98	Samples tested after ½, 1, 2, 5, 10, 20 and 30 min.
10^{3} cells/ml	NaOCl	10 min	0,05 mg/l residual	6,9	20	Stable	Soft lake water., 30 mg/l $CaCO_3$	97, 98	

10^3 cells/ml	NaOCl	10 min	0,05 mg/l residual	8,2	20	Stable	Hard lake water., 120 mg/l $CaCO_3$	97, 98	
10^3 cells/ml	NaOCl	30 sec	0,1 mg/l residual	6,9	20	”inactivated”	Distilled water.	97, 98	Samples tested after ½, 1, 2, 5, 10, 20 and 30 min.
10^3 cells/ml	NaOCl	30 sec	0,1 mg/l residual	6,9	20	”inactivated”	Soft lake water., 30 mg/l $CaCO_3$	97, 98	
10^3 cells/ml	NaOCl	30 sec	0,2 mg/l residual	8,2	20	”inactivated”	Hard lake water., 120 mg/l $CaCO_3$	97, 98	
10^7 CFU/ml	NaOCl	1 min	0,2 mg/l added	7,2	7	4 log reduction	PBS	71	Read off a graph.
10^7 CFU/ml	NaOCl	36 sec	0,2 mg/l added	7,2	7	99,9 % reduction	PBS	71	
10^7 CFU/ml	NaOCl		0,2 mg/l added	7,2	7	99,9% reduction	PBS	71	Reduction rate: 0,20/sec
10^7 CFU/ml	NaOCl	1 min	2 mg/l added	7,8	7	4 log reduction	Wastewater from aquaculture (15,7 ‰ salinity).	71	Read off a graph.
10^7 CFU/ml	NaOCl		2,0 mg/l added	7,8	7	99,9% reduction	Wastewater from aquaculture (15,7 ‰ salinity).	71	Reduction rate: 0,19/sec
10^7 CFU/ml	NaOCl		4,0 mg/l added	7,8	7	99,9% reduction	Wastewater from aquaculture (15,7 ‰ salinity).	71	Reduction rate: 0,30/sec
$10^{5,5}$ cfu/ml	NaOCl	5 min	4 ppm		15	> 4½ log reduction	Artificial sea water.	85	
$10^{5,5}$ cfu/ml	NaOCl	1 min	4 ppm		15	4½ log reduction	Hard water (300 ppm $CaCO_3$)	85	
$10^{5,5}$ cfu/ml	NaOCl	1 min	4 ppm		15	> 4½ log reduction	Distilled water.	85	
10^8 cfu/ml	NaOCl	5 min	5 ppm		20	Stable	Test of effect of bacteria titer.	85	Concentration of commercial product. (Purelox)
10^6 cfu/ml	NaOCl	5 min	5 ppm		20	> 5 log reduction	Test of effect of bacteria titer.	85	Concentration of commercial product. (Purelox)
10^4 cfu/ml	NaOCl	3 min	5 ppm		20	> 3 log reduction	Test of effect of bacteria titer.	85	Concentration of commercial product. (Purelox)
$10^{5,5}$ cfu/ml	NaOCl	1 min	5 ppm		20	Stable	300 ppm calf serum added.	85	
$10^{5,5}$ cfu/ml	NaOCl	1 min	5 ppm		20	3 log reduction	10 ppm calf serum added.	85	
$10^{5,5}$ cfu/ml	NaOCl	1 min	5 ppm		20	4½ log reduction	0 ppm calf serum added.	85	
$10^{5,5}$ cfu/ml	NaOCl	1 min	5 ppm		5	4 log reduction	Test of effect of Temperature.	85	
$10^{5,5}$ cfu/ml	NaOCl	1 min	5 ppm		15	4½ log reduction	Test of effect of Temperature.	85	
$10^{5,5}$ cfu/ml	NaOCl	1 min	5 ppm		25	> 4½ log reduction	Test of effect of Temperature.	85	

10^5 cfu/ml	NaOCl	1 min	10 ppm		20	> 4 log reduction		85	Concentration of commercial product. (Purelox)
3,8 x 10^6 cfu/ml	OCl^-	1 min	0,11 mg/l			4 log reduction	flowrate 3,0 m^3/t, el. 0,5 A	54	Electrolyzed salt water.
3,8 x 10^6 cfu/ml	OCl^-	1 min	0.06 mg/l			3 log reduction	flowrate 3,5 m^3/t, el. 0,5 A	54	Electrolyzed salt water.

Conclusion: Under laboratory condtions *Aeromonas salmonicida* is sensitive to chlorine.

Carnobacterium piscicola

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	chloramine-T	30 min	0,1 - 0,5 % (v/v)		4	> 5 log reduction	Tested at 0,001, 0,01, 0,05, 0,08, 0,1, 0,5, 0,7 and 1%. Hard water, organic loaded.	49	

Edwardsiella tarda

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^7 CFU/ml	NaOCl	20 min	400 ppm		20	4 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.
10^7 CFU/ml	NaOCl	60 min	400 ppm		20	5 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.
10^7 CFU/ml	ClO_2	20 min	3200 ppm		20	4 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary

							hours.		concentration for disinfection in this paper is much higher than published in other papers.
10^7 CFU/ml	ClO_2	60 min	3200 ppm		20	4 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.
10^7 CFU/ml	Quartenary ammonium	20 min	400 ppm		20	> 5 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.
10^7 CFU/ml	Quartenary ammonium	60 min	200 ppm		20	4 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.

Conclusion: According to this paper *E. tarda* is quite resistant to chlorine!

Indigenious flora (heterothophic bacteria)

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	OCl^-	1 min	0,54 mg/l			>99% reduction	Hypoclorite produced by use of batch electrolytic system.	57	hatchery inlet water
	OCl^-	1 min	0,64 mg/l			>99% reduction	Hypoclorite produced by use of batch electrolytic system.	57	waste-seawater
$4,7 \times 10^4$ cfu/ml	OCl^-	1 min	1,28 mg/l			3 log reduction	flowrate 2,0 m^3/t, el. 2,5 A (Electrolyzed salt water)	56	Natural flora in wastewater from hathing

									facility.
$10^{3,5}$ cfu/ml	OCl^-			8,2		Stable	flowrate 4 l/min, el. 0,1 A (Electrolyzed salt water)	53	Sea water, filtrated (10 µm).
$10^{3,5}$ cfu/ml	OCl^-			8,2		99,4% reduction	flowrate 4 l/min, el. 1,2 A. (Electrolyzed salt water)	53	Sea water, filtrated (10 µm).
$10^{3,5}$ cfu/ml	OCl^-		2,13 mg Cl/l	8,2		”inactivated”	flowrate 4 l/min, el. 1,3 A. (Electrolyzed salt water)	53	Sea water, filtrated (10 µm).

Conclustion: When electrolysing saltwater it seems possible to obtain a 3 log reduction of the natural flora. Wether this will also be the case in wastewater from fish cutting plants is unknown.

Lactococcus garviae

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	chloramine-T	30 min	0,08 - 0,5 % (v/v)		4	> 5 log reduction	Tested at 0,001, 0,01, 0,05, 0,08, 0,1, 0,5, 0,7 and 1%. Hard water, organic loaded.	49	

Renibacterium salmoninarum

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
3×10^4 - 2×10^6 bacteria/ml	NaOCl	26 sec	0,05 mg/l free chlorine	7	15	3 log reduction	in vitro in PBS	82	Read off a graph.
3×10^4 - 2×10^6 bacteria/ml	NaOCl	42 sec	0,6 mg/l free chlorine	7	15	5 log reduction	in vitro in PBS	82	Read off a graph.
5×10^4 bacteria/ml	NaOCl	20 sec	0,06 mg/l free chlorine	7	15	3 log reduction	in vitro in PBS	82	Read off a graph.
5×10^4 bacteria/ml	NaOCl	120 sec	0,07 mg/l free chlorine	7	7,5	3 log reduction	in vitro in PBS	82	Read off a graph.
5×10^4 bacteria/ml	NaOCl	54 sec	0,41 - 0,53 mg/l free chlorine	6	15	3 log reduction	in vitro in PBS	82	Read off a graph.
5×10^4 bacteria/ml	NaOCl	≥ 60 sec	0,41 - 0,53 mg/l free chlorine	7	15	3 log reduction	in vitro in PBS	82	Read off a graph., at t=120 sec 2,7 log reduction
5×10^4 bacteria/ml	NaOCl	92 sec	0,41 - 0,53 mg/l free chlorine	8	15	1 log reduction	in vitro in PBS	82	Read off a graph.
5×10^6 cfu/ml	NaOCl	15 min	10 mg/l free chlorine	10,3	15	”inactivated”	Autoclaved tank water, pH measured after addition of NaOCl.	39	Growth tested on KDM2 agar plate.
5×10^6 cfu/ml	NaOCl	15 min	10 mg/l free	6,3	15	”inactivated”	Distilled water, pH	39	Growth tested on KDM2

			chlorine				measurement after adding NaOCl.		agar plate.
5 x 10^6 cfu/ml	NaOCl	5 min	200 mg/l free chlorine	11,8	15	”inactivated”	Autoclaved tank water, pH measured after addition of NaOCl.	39	Growth tested on KDM2 agar plate.
5 x 10^6 cfu/ml	NaOCl	5 min	200 mg/l free chlorine	12,0	15	”inactivated”	Distilled water, pH measurement after adding NaOCl.	39	Growth tested on KDM2 agar plate.
5 x 10^6 cfu/ml	NaOCl	24 hours	200 mg/l free chlorine	11,8	15	Few survivors.	Autoclaved tank water, pH measured after addition of NaOCl.	39	Growth tested on KDM2 and SKDM agar plates after culture in KDM2 buillon.
5 x 10^6 cfu/ml	NaOCl	15 min	200 mg/l free chlorine	12,0	15	Few survivors.	Distilled water, pH measurement after adding NaOCl.	39	Growth tested on KDM2 and SKDM agar plates after culture in KDM2 buillon.

Conclusion: Under clean condtions in PBS *R. salmoninarum* seem very sensitive to chlorine. In autoclaved tank water 10 mg/l for 15 min or 200 mg/l for 5 min was able to reduce the titer > 3 log.

Streptococcus iniae

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	NaOCl	≥ 15 min	3-5 ppm			"powerfull disinfectants"		93	
	Chlorhexidine	≥ 15 min	3-5 ppm			"powerfull disinfectants"		93	

Streptococcus sp.

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^7 CFU/ml	NaOCl	20 min	1600 ppm		20	> 5 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other

									papers.
10^7 CFU/ml	NaOCl	60 min	1600 ppm		20	> 5 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.
10^7 CFU/ml	ClO_2	20 min	3200 ppm		20	Stable	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.
10^7 CFU/ml	ClO_2	60 min	3200 ppm		20	Stable	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.
10^7 CFU/ml	Quartenary ammonium	20 min	200 ppm		20	4 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.
10^7 CFU/ml	Quartenary ammonium	60 min	200 ppm		20	5 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200,	58	The actual concentration of disinfectant probably

							400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.		only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.

Conclusion: According to this paper *Streptococcus* is quite resistant to chlorine!

Vibrio anguillarum

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^5 cfu/ml	Benzalkonium chlorid	4 min	0,01%		20	> 4 log reduction		85	Concentration of commercial product.
10^5 cfu/ml	Benzalkonium chloride	1 min	0,03%		20	> 4 log reduction		85	Concentration of commercial product.
10^8-10^9 CFU/ml	chloramine-T (SETAX)	1 min	2 g/l		4	≥ 6 log reduction	Sea water added 10% salmon blood.	22	
1,1 x 10^6 CFU/ml	NaOCl	60 min	150 mg/l added			”inactivated”	Test medium: sterilized wastewater from fish slaughterhouse.	48	Tested only at this dose/time combination.
10^5 cfu/ml	NaOCl	2 min	3 ppm		20	> 4 log reduction		85	Concentration of commercial product. (Purelox)
10^5 cfu/ml	NaOCl	1 min	10 ppm		20	> 4 log reduction		85	Concentration of commercial product. (Purelox)
	OCl^-	1 min	0,21 mg/l			>99% reduction		57	Hypoclorite produced by use of batch electrolytic system.
4,5 x 10^6 cfu/ml	OCl^-	1 min	0,07 mg/l			> 4 log reduction	flowrate 3,5 m^3/t, el. 0,5 A	54	Electrolyzed salt water.
5 x 10^4 cfu/ml	OCl^-			8,2		”inactivated”	Sea water, filtrated (10 µm). Flowrate 4 l/min, el. 1,3 A	53	Electrolyzed salt water.

Conclusion: Under loboratory condtions *V. anguillarum* is sensitive to chlorine. In steriliset wastewater from a fish slaugtherhouse 150 mg/l for 60 min was able to reduce the titer to undetectable. No other dose/time combinations were testet.

Vibrio ordalii

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^5 cfu/ml	NaOCl	2 min	3 ppm		20	> 4 log reduction		85	Concentration of commercial product. (Purelox)
10^5 cfu/ml	NaOCl	1 min	10 ppm		20	> 4 log reduction		85	Concentration of commercial product. (Purelox)
10^5 cfu/ml	Benzalkonium chlorid	2 min	0,03%		20	> 4 log reduction		85	Concentration af kommercielt product
10^5 cfu/ml	Benzalkonium chlorid	1 min	0,1%		20	> 4 log reduction		85	Concentration af kommercielt product

Conclusion: Under clean conditions *V. ordalii* is sensitive to chlorine in a low dose.

Vibrio salmonicida

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^8-10^9 CFU/ml	chloramine-T (SETAX)	1 min	3 g/l		4	6 log reduction	Sea water added 10% salmon blood.	22	

Vibrio sp.

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^7 CFU/ml	NaOCl	20 min	800 ppm		20	5 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.
10^7 CFU/ml	NaOCl	60 min	400 ppm		20	4 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm).	58	The actual concentration of disinfectant probably only half of stated in

							Growht at 20°C and counting already after 24 hours.		article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.
10^7 CFU/ml	ClO_2	20 min	3200 ppm		20	3 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.
10^7 CFU/ml	ClO_2	60 min	3200 ppm		20	3 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.
10^7 CFU/ml	Quartenary ammonium	20 min	400 ppm		20	4 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.
10^7 CFU/ml	Quartenary ammonium	60 min	400 ppm		20	> 5 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for

									disinfection in this paper is much higher than published in other papers.

Conclusion: According to this paper *Vibrio* is quite resistant to chlorine!

Yersinia ruckeri

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	chloramine-T	30 min	0,08 - 0,5 % (v/v)		4	> 5 log reduction	Tested at 0,001, 0,01, 0,05, 0,08, 0,1, 0,5, 0,7 and 1%. Hard water, organic loaded.	49	
$10^{6,77}$ cfu/ml	chloramine-T (SETAX)	24 hours	50 mg/l	7,5		Stable	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{4,69}$ cfu/ml	chloramine-T (SETAX)	24 hours	50 mg/l	8,96	7	1½ log reduction	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	Salinity 14-15 ‰
$10^{6,77}$ cfu/ml	chloramine-T (SETAX)	24 hours	100 mg/l	7,5		Stable	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{4,69}$ cfu/ml	chloramine-T (SETAX)	24 hours	200 mg/l	8,96	7	3 log reduction	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	Salinity 14-15 ‰
$10^{6,77}$ cfu/ml	chloramine-T (SETAX)	24 hours	250 mg/l	7,5		Not detectable (> 6 log reduction)	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{4,69}$ cfu/ml	chloramine-T (SETAX)	24 hours	1000 mg/l	8,96	7	4 log reduction	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	Salinity 14-15 ‰
10^{8}-10^{9} CFU/ml	chloramine-T (SETAX)	1 min	2 g/l		4	6 log reduction	Sea water added 10% salmon blood.	22	
10^{3} cells/ml	NaOCl	10 min	0,01 mg/l residual	6,9	20	Stable	Distilled water.	97, 98	Samples tested after ½, 1, 2, 5, 10, 20 and 30 min.
10^{3} cells/ml	NaOCl	30 sec	0,05 mg/l	6,9	20	”inactivated”	Distilled water.	97, 98	Samples tested after ½,

			residual						1, 2, 5, 10, 20 and 30 min.
10^3 cells/ml	NaOCl	10 min	0,05 mg/l residual	6,9	20	Stable	Soft lake water., 30 mg/l $CaCO_3$	97, 98	
10^3 cells/ml	NaOCl	10 min	0,05 mg/l residual	8,2	20	Stable	Hard lake water., 120 mg/l $CaCO_3$	97, 98	
10^3 cells/ml	NaOCl	2 min	0,1 mg/l residual	6,9	20	”inactivated”	Soft lake water., 30 mg/l $CaCO_3$	97, 98	
10^3 cells/ml	NaOCl	2 min	0,1 mg/l residual	8,2	20	”inactivated”	Hard lake water., 120 mg/l $CaCO_3$	97, 98	
$10^{8,28}$ cfu/ml	NaOCl	10 hours	43 mg/l		7	> 3 log reduction	Laboratory trial, 1 part process water + 2 parts ”bløggevand” from fish slaugtherhouse.	28	
	NaOCl	0,5 hours	48 mg/l			”inactivated”	Fuldskalaforsøg. Kemisk fældet blodvand (Hævning til pH 12, derefter fældning med jernklorid til pH 6,5-7,5)	28	
$10^{6,77}$ cfu/ml	NaOCl	24 hours	50 mg/l	7,5		Stable	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{6,77}$ cfu/ml	NaOCl	24 hours	100 mg/l	7,5		Stable	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{4,69}$ cfu/ml	NaOCl	30 min	100 mg/l	8,96	7	Not detectable (≥ 4 log reduction)	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	Salinity 14-15 ‰
$10^{8,28}$ cfu/ml	NaOCl	10 hours	130 mg/l		7	> 3 log reduction	Laboratory trial, 1 part process water + 2 parts ”bløggevand” from fish slaugtherhouse.	28	
6 x 10^6 CFU/ml	NaOCl	60 min	200 mg/l added			Vækst		48	Test medium: sterilized wastewater from fish slaughterhouse.
2 x 10^7 CFU/ml	NaOCl	24 hours	200 mg/l added			Vækst		48	Test medium: unsterilized wastewater from fish slaughterhouse, frozen before use.

6×10^6 CFU/ml	NaOCl	60 min	250 mg/l added			”inactivated”		48	Test medium: sterilized wastewater from fish slaughterhouse.
$10^{6,77}$ cfu/ml	NaOCl	2 t	250 mg/l	7,5		> 3 log reduction	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{6,77}$ cfu/ml	NaOCl	24 hours	250 mg/l	7,5		> 4 log reduction	Full-scale trial (Vikan Akvavet), wastewater from fish slaugtherhouse.	28	Salinity 20 ‰, ”bløggevand” (blood, fish slime and epithelial cells in salt water) diluted with fresh water.
$10^{4,69}$ cfu/ml	NaOCl	2 t	250 mg/l	8,96	7	3 log reduction	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	Salinity 14-15 ‰
2×10^7 CFU/ml	NaOCl	24 hours	250 mg/l added			”inactivated”		48	Test medium: unsterilized wastewater from fish slaughterhouse, frozen before use.
$10^{4,69}$ cfu/ml	NaOCl	24 hours	250 mg/l	8,96	7	Not detectable (≥ 4 log reduction)	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	Salinity 14-15 ‰
$10^{8,28}$ cfu/ml	NaOCl	10 hours	260 mg/l		7	5 log reduction	Laboratory trial, 1 part process water + 2 parts ”bløggevand” from fish slaugtherhouse.	28	
$6,5 \times 10^7$ CFU/ml	NaOCl	30 min	280 mg/l added			Vækst		48	Testmedium: usteriliseret spildevand fra fiskeslagteri
$6,5 \times 10^7$ CFU/ml	NaOCl	60 min	280 mg/l added			Vækst		48	Testmedium: usteriliseret spildevand fra fiskeslagteri
$6,5 \times 10^7$ CFU/ml	NaOCl	30 min	350 mg/l added			”inactivated”		48	Testmedium: usteriliseret spildevand fra fiskeslagteri
$6,5 \times 10^7$ CFU/ml	NaOCl	60 min	350 mg/l added			”inactivated”		48	Testmedium: usteriliseret spildevand fra fiskeslagteri
$10^{4,69}$ cfu/ml	NaOCl	30 min	350 mg/l	8,96	7	4 log reduction	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	Salinity 14-15 ‰
$10^{4,69}$ cfu/ml	NaOCl	2 t	350 mg/l	8,96	7	Not detectable	Full-scale trial (Norskagfisk),	28	Salinity 14-15 ‰

						(≥ 4 log reduction)	blood water from fish slaugtherhouse.		

Conclusion: In full-scale trials under highly contaminated conditions as is found in process wastewater from fish slaugtherhouses 250 mg/l chlorine (administered) as NaOCl for 2 hours were able to decimate *Y. ruckeri* 2 log and after 24 hours to inactivate the bacterium. If the water was pretreated with first pH 12 followed by precipitation with ferrichlorid to pH 6,5 only 50 mg/l chlorine was needed to decimate > 3 log.
When using chloramines-T it was necessary to use a dose of 250-1000 mg/l chlorine for 24 hours to obtain the same degree of inactivation (no pre-treatment of water).

Parasites

Gyrodactylus salaris

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	chlor					følsom		1	From OIE diagnostic manual. No reference stated!

Myxosoma cerebralis

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	$Ca(ClO)_2$	14 days	400 ppm		22	Survival	In vitro – spores	42	
	CaOCl	18 hours	1200 ppm			28% of fish infected	Infected mud, chlorine added to water.	44	Control fish 100% infected.
	CaOCl	30 min	10 ppm		12	No spores in fish	Myxosoma cerebralis free in water, fish added after disinfection	44	Control fish 100% infected.
	Cl	14 days	200 ppm		22	Survival	In vitro – spores	42	
	NaOCl	15 min	200 mg/l		15	1 log reduction	Infectivity of myxospores in tubifex.	37	Myxospore suspension
	NaOCl	15 min	500 mg/l		15	5 log reduction	Infectivity of myxospores in tubifex.	37	Myxospore suspension
	NaOCl	15 min	2500 mg/l	8,1	15	100% reduction	Infectivity of myxospores in tubifex.	37	Myxospore suspension
	NaOCl	1 min	131 ppm		room temp.	All dead	in vitro. Triactinomyxon spores	96	

	Quartenary ammonium	14 days	0,1%		22	Survival	In vitro – spores	42	
	Quartenary ammonium	10 min	1000 mg/l		22	1 log reduction	Infectivity of myxospores in tubifex.	37	alkyl dimethyl benzyl ammonium chlorid
	Quartenary ammonium	10 min	1500 mg/l		22	ingen infektion i tubifex	Infectivity of myxospores in tubifex.	37	alkyl dimethyl benzyl ammonium chlorid

Conclusion: Using a concentration of 500-2500 mg/l it will likely be possible to use chlorine for desinfection of *M. cerebralis*.

Trichodina jadranica

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
2,2	chloramine-T	24 hours	50 ppm		25	Survival (0,5)	In vivo, ål	75	Catergorization (category/number of parasites on ell): 0/0, 1/1-10, 2/11-100, 3/100-1000, 4/>1000

Conclusion: It seems as if it will be possible to use chlorine for desinfection of Trichodina but the dose has to be bigger than the one used here.

Temperature

Virus

VHSV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^6 $TCID_{50}$/ml	Heating	3 days			20	> 4 log reduction	MEM without serum	51	Read off a graph.
10^6 $TCID_{50}$/ml	Heating	2½ uge			20	app. 4 log reduction	MEM with serum	51	Read off a graph.
10^6 $TCID_{50}$/ml	Heating	3 hours			30	Survival	MEM with serum	51	
10^6 $TCID_{50}$/ml	Heating	24 hours			30	Not detectable	MEM with serum	51	
10^6 $TCID_{50}$/ml	Heating	5 min			50	Survival	MEM with serum	51	
10^6 $TCID_{50}$/ml	Heating	10 min			50	Not detectable	MEM with serum	51	
	Heating	1 hour			60	”inactivated”		20, Dixon (pers. com.)	
10^6 $TCID_{50}$/ml	Heating	1 min			70	Not detectable	MEM with serum	51	

Conclusion: VHSV is heat sensitive and is inactivated at 60°C for 10 min to 1 hour.

IHNV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^7 $TCID_{50}$/ml	Heating	5 hours		7,2	8	Stable	MEM-1 medium	32	
10^7 $TCID_{50}$/ml	Heating	5 hours		7,2	22	Stable	MEM-1 medium	32	
	Heating	8 hours			32	”inactivated”	MEM medium	83	
2,5 x 10^7 $TCID_{50}$/ml	Heating	1 døgn		7,2	32	”inactivated”	MEM-1 medium	32	Karluk Lake isolat
1,5 x 10^7 $TCID_{50}$/ml	Heating	1 døgn		7,2	32	”inactivated”	MEM-1 medium	32	Cedar River isolat
10^7 $TCID_{50}$/ml	Heating	7,3 hours		7,2	32	4 log reduction	MEM-1 medium	32	
	Heating	5 hours		7	35	”inactivated”		100	
2,5 x 10^7 $TCID_{50}$/ml	Heating	140 min		7,2	38	”inactivated”	MEM-1 medium	32	Karluk Lake isolat
1,5 x 10^7 $TCID_{50}$/ml	Heating	140 min		7,2	38	”inactivated”	MEM-1 medium	32	Cedar River isolat
	Heating	20 min		7	40	”inactivated”		100	
	Heating	10 min		7	45	”inactivated”		100	
	Heating	90 sec		7	50	”inactivated”		100	
	Heating	30 sec		7	55	”inactivated”		100	
	Heating	1 hour			60	”inactivated”		20, Dixon (pers. com.)	

Conclusion: IHNV is heat sensitive and is reported inactivated at 55°C for 30 sec and 60°C for 1 hour.

IPNV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	Heating	20 t		7,2	37,5	1 log reduction	MEM-1 medium	32’32	Read off a graph.
	Heating	20 t		7,2	50	2 log reduction	MEM-1 medium	32’32	Read off a graph.
	Heating	< 20 min		7,2	60	95 % reduction		32’32	
$10^{7,2}$ $TCID_{50}$/ml	Heating	30 min		6,8	60	99,9% reduction		74’74	Isolate VR-299
$10^{7,2}$ $TCID_{50}$/ml	Heating	1 hour		3	60	6 log reduction	virus in EMEM with serum	74’74	Isolate VR-299. Result Read off a graph.
$10^{7,2}$ $TCID_{50}$/ml	Heating	4 hours		9	60	6 log reduction	virus in EMEM with serum	74’74	Isolate VR-299. Result Read off a graph.
$10^{7,2}$ $TCID_{50}$/ml	Heating	5 hours		6,8-7	60	6 log reduction	virus in EMEM with and without serum	74’74	Isolate VR-299
	Heating	8 hours		7	60	”inactivated”		100’100	Isolate VR-299
	Heating	16 hours		7,2	60	”inactivated”		32’32	
	Heating	24 hours			60	Survival		20, Dixon (pers. com.)	
	Heating	48 hours			60	”inactivated”		20, Dixon (pers. com.)	
$10^{6,6}$ $TCID_{50}$/ml		1 min			65	Not detectable (> 5 log reduction)	Laboratory trial, 1 part process water + 2 parts	28	

							”bløggevand” from fish slaugtherhouse.		
$10^{5,9}$ $TCID_{50}$/ml	Heating	5 min			65	1½ log reduction	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	
	Heating	3,5 hours		7	65	”inactivated”		100˝100	Type VR-299
$10^{5,9}$ $TCID_{50}$/ml	Heating	5 min			70	1,9 log reduction	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	
	Heating	2 t		7	70	”inactivated”		100˝100	Type VR-299
$10^{5,9}$ $TCID_{50}$/ml	Heating	3 min			75	2,3 log reduction	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	
	Heating	10 min		7	80	”inactivated”		100˝100	Type VR-299

Conclusion: IPNV is more heat resistant the VHSV and IHNV. The virus is reported to be reduced by 3 log when heated to 60°C for 30 min. Another author reports survival after 24 h at 60°C. In laboratory trials using process water including fish slime, skin scrapings and blood > 5 log reduction were achieved after heating to 65°C for 1 min. In full-scale trials using blood water, 2,3 log reduction were achieved after treatment of IPNV for 3 min.

ISAV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
1 x 10^6 $TCID_{50}$/ml	Temperature	14 days			4	Stable	Virus in L15-medium	27	
1 x 10^6 $TCID_{50}$/ml	Temperature	10 days			15	Stable	Virus in L15-medium	27	
1 x 10^6 $TCID_{50}$/ml	Temperature	2 days			37	Survival. 4-5 log reduction	Virus in L15-medium	27	3,2 x 10^1 TCID50/ml på dag 2.
	Heating	2 min			50	”inactivated”	Tissue homogenate of liver, kidney and spleen from moribund ISA-fish, treated and IP-injected in fish.	94	Tested at 45-60°C in 1, 2 and 5 min.
	Heating	1 min			55	”inactivated”	Tissue homogenate of liver, kidney and spleen from moribund ISA-fish, treated and IP-injected in fish.	94	Tested at 45-60°C in 1, 2 and 5 min.
2,5 x 10^6 $TCID_{50}$/ml	Heating	5 min			56	Not detectable	Virus in L15-medium	27	
	Heating	1 hour			60	”inactivated”		20, Dixon (pers. com.)	

Conclusion: ISAV is heat sensitive with reported inactivation times of 56°C for 5 min and 60°C for 1 hour.

KHV

Concentration	Disinfectant	Contact	Concentration	pH	Temp.	Result	Method	Reference	Comments

pathogen		time	disinfectant						
1,6 x 10^4 PFU/ml	Heating	1 min			> 50	Not detectable	Tested at 40, 50, 60 og 70°C i ½, 1, 3 and 5 min.	55	Strain KHV-I

Nodavirus

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	Temperature	1 year			-20	Stable	Grown virus. Tested after 4 weeks, 3 and 6 months and 1 year.	30	Isolate: sea bass nodavirus
	Temperature	6 months			4	Stable	Grown virus. Tested after 1, 4 and 7 days, 4 weeks, 3 and 6 months and 1 year.	30	Isolate: sea bass nodavirus
	Temperature	1 year			4	Survival (4-5 log reduction)	Grown virus. Tested after 1, 4 and 7 days, 4 weeks, 3 and 6 months and 1 year.	30	Isolate: sea bass nodavirus
	Temperature	4 uger			25	Survival (2-3 log reduction)	Grown virus. Tested after 1, 4 and 7 days, 4 weeks, 3 and 6 months and 1 year.	30	Isolate: sea bass nodavirus
	Temperature	3 months			25	Not detectable	Grown virus. Tested after 1, 4 and 7 days, 4 weeks, 3 and 6 months and 1 year.	30	Isolate: sea bass nodavirus
	Temperature	1 day			37	Survival (2-3 log reduction)	Grown virus. Tested after 1, 4 and 7 days, 4 weeks, 3 and 6 months and 1 year.	30	Isolate: sea bass nodavirus
	Temperature	4 days			37	Not detectable	Grown virus. Tested after 1, 4 and 7 days, 4 weeks, 3 and 6 months and 1 year.	30	Isolate: sea bass nodavirus
10 µg purified virus	Heating	30 min		7	50	Not inactivated (0/800 larvae survived, control 230/800)	Diluted in 1 ml PBS. Used for infection trial in day old striped jack larvae.	9	Isolate: SJNNV
10 µg purified virus	Heating	30 min		7	60	”Effective” (390/800 larvae survived, antigen ELISA negativ - control 230/800)	Diluted in 1 ml PBS. Used for infection trial in day old striped jack larvae.	9	Isolate: SJNNV
10^7 $TCID_{50}$/ml	Heating	30 min			60	Not detectable	Hanks balanced salt solution	30	Isolate: sea bass nodavirus
$10^{8\ TCID}{}_{50}$/ml	Heating	30 min			60	6½ log reduction	Hanks balanced salt solution	30	Isolate: sea bass

							med serum		nodavirus
$10^{8\ TCID}{}_{50}$/ml	Heating	1 hour			60	Not detectable	Hanks balanced salt solution med serum	30	Isolate: sea bass nodavirus
	Heating	24 hours			60	”inactivated”		20, Dixon (pers. com.)	

Conclusion: nodavirus is heat sensitive although more resistant than VHSV and IPNV, with reported inactivation times of 1-24 hours at 60°C. Treatment of virus for 30 min at 50°C was not sufficient inhibit disease in an infection trial using day-old striped jack larvae. Increasing the Temperature to 60°C for 30 min was effective in inhibiting disease.

Ranavirus

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	Temperature	2 years			-70	Survival	Virus in cell culture medium.	67	EHNV. CPE development slow, 8-10 days
	Temperature	2 years			-70	Survival	Virus in fish tissue.	67	EHNV. CPE development slow, 8-10 days
	Temperature	2 years			-20	Survival	Virus in cell culture medium.	67	EHNV. CPE development slow, 8-10 days
	Temperature	2 years			-20	Survival	Virus in fish tissue.	67	EHNV. CPE development slow, 8-10 days
	Temperature	300 days			4	Survival	Virus in RTG-2 celler	67	EHNV. CPE development slow, 8-10 days
	Heating	24 hours			40	”inactivated”	Virus in cell culture medium.	67	EHNV
	Heating	15 min			60	”inactivated”	Virus in cell culture medium.	67	EHNV
	Heating	24 hours			60	”inactivated”		20, Dixon (pers. com.)	

Conclusion: Ranavirus is reported inactivated by heat treatment for 15 min to 24 hours at 60°C.

Salmonid alphavirus

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	Temperature	30 min			4-25	Stable	Heating to 15, 25, 37, 45, 50, 55 and 60°C in 15 min followed by cooling in ice.	79	Salmon pancreas disease virus (SPDV)
	Heating	30 min			37-45	reduced	Heating to 15, 25, 37, 45, 50, 55 and 60°C in 15 min followed by cooling in ice.	79	Salmon pancreas disease virus (SPDV)
	Heating	30 min			50	Not detectable	Heating to 15, 25, 37, 45, 50, 55 and 60°C in 15 min followed by cooling in ice.	79	Salmon pancreas disease virus (SPDV)
	Heating	1 hour			60	”inactivated”		33	SAV1

Conclusion: SAV is reported inactivated at 50°C for 30 min and 60°C for 1 hour.

SVCV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
$10^{6,5}$ $TCID_{50}$/ml	Temperature	180 days			-74	2 log reduction	Cell culture medium without serum. Titrated day 3, 7, 14, 21, 28, 75, 110 and 180.	3	
$10^{7,8}$ $TCID_{50}$/ml	Temperature	180 days			-74	Stable	Cellekulturmedium med 5% serum. Titreret day 3, 7, 14, 21, 28, 75, 110 og 180 days	3	
$10^{6,5}$ $TCID_{50}$/ml	Temperature	180 days			-20	> 3½ log reduction	Cell culture medium without serum. Titrated day 3, 7, 14, 21, 28, 75, 110 and 180.	3	
$10^{7,8}$ $TCID_{50}$/ml	Temperature	180 days			-20	2 log reduction	Cellekulturmedium med 5% serum. Titreret day 3, 7, 14, 21, 28, 75, 110 og 180 days	3	
$10^{6,5}$ $TCID_{50}$/ml	Temperature	110 days			4	> 4 log reduction	Cell culture medium without serum. Titrated day 3, 7, 14, 21, 28, 75, 110 and 180.	3	
$10^{6,5}$ $TCID_{50}$/ml	Temperature	180 days			4	”inactivated”	Cell culture medium without serum. Titrated day 3, 7, 14, 21, 28, 75, 110 and 180.	3	
$10^{7,8}$ $TCID_{50}$/ml	Temperature	180 days			4	> 3 log reduction	Cellekulturmedium med 5% serum. Titreret day 3, 7, 14, 21, 28, 75, 110 og 180 days	3	
$10^{6,5}$ $TCID_{50}$/ml	Temperature	7 days			22-24	2 log reduction	Cell culture medium without serum. Titrated day 3, 7, 14, 21, 28, 75, 110 and 180.	3	
$10^{6,5}$ $TCID_{50}$/ml	Temperature	14 days			22-24	”inactivated”	Cell culture medium without serum. Titrated day 3, 7, 14, 21, 28, 75, 110 and 180.	3	
$10^{7,8}$ $TCID_{50}$/ml	Temperature	21 days			22-24	> 3 log reduction	Cellekulturmedium med 5% serum. Titreret day 3, 7, 14, 21, 28, 75, 110 og 180 days	3	
$10^{7,8}$ $TCID_{50}$/ml	Temperature	75 days			22-24	”inactivated”	Cellekulturmedium med 5% serum. Titreret day 3, 7, 14, 21, 28, 75, 110 og 180 days	3	
$10^{7,5}$ $TCID_{50}$/ml	Heating	480 min			30	½ log reduction	Cell cultur medium with 5% serum. Titrated after 5, 10, 20, 30, 60, 120, 240 and 480 min.	3	

$10^{7,5}$ $TCID_{50}$/ml	Heating	480 min			35	1 log reduction	Cell cultur medium with 5% serum. Titrated after 5, 10, 20, 30, 60, 120, 240 and 480 min.	3	
$10^{7,5}$ $TCID_{50}$/ml	Heating	240 min			40	3 log reduction	Cell cultur medium with 5% serum. Titrated after 5, 10, 20, 30, 60, 120, 240 and 480 min.	3	
$10^{7,5}$ $TCID_{50}$/ml	Heating	480 min			40	> 4 log reduction	Cell cultur medium with 5% serum. Titrated after 5, 10, 20, 30, 60, 120, 240 and 480 min.	3	
$10^{7,5}$ $TCID_{50}$/ml	Heating	60 min			45	3 log reduction	Cell cultur medium with 5% serum. Titrated after 5, 10, 20, 30, 60, 120, 240 and 480 min.	3	
$10^{7,5}$ $TCID_{50}$/ml	Heating	180 min			45	> 5 log reduction	Cell cultur medium with 5% serum. Titrated after 5, 10, 20, 30, 60, 120, 240 and 480 min.	3	
$10^{7,5}$ $TCID_{50}$/ml	Heating	60 min			50	”inactivated”	Cell cultur medium with 5% serum. Titrated after 5, 10, 20, 30, 60, 120, 240 and 480 min.	3	
	Heating	1 hour			60	”inactivated”		20, Dixon (pers. com.)	

Conclusion: SVCV is inactivated at ≤ 60°C after 1 h.

Channel catfish virus

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	Heating	24 hours			60	”inactivated”		20, Dixon (pers. com.)	

Bacteria

Aeromonas salmonicida

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
1,4 x 10^6 cfu/ml	Heating	48 hours		7	35	”inactivated”		100	

1,4 x 10^6 cfu/ml	Heating	3 hours		7	40	”inactivated”		100	
1,4 x 10^6 cfu/ml	Heating	10 min		7	45	”inactivated”		100	
1,4 x 10^6 cfu/ml	Heating	2 min		7	50	”inactivated”		100	
	Heating	1 hour			60	Survival		20, Dixon (pers. com.)	

Conclusion: *A. salmonicida* is reported inactivated after heat treatment for 2 min at 50°C. This is disputed by another report stating survival after 1 hour at 60°C.

Lactococcus garviae

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	Heating	24 hours			60	Survival		20, Dixon (pers. com.)	
	Heating	48 hours			60	”inactivated”		20, Dixon (pers. com.)	

Vibrio anguillarum

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^6 CFU/ml	Heating	1 min			60	”inactivated”		48	Test medium: sterilized wastewater from fish slaughterhouse.
10^7 CFU/ml	Heating	2 min			60	Growth		48	Test medium: unsterilized wastewater from fish slaughterhouse.
	Heating	1 hour			60	Survival		20, Dixon (pers. com.)	
10^6 CFU/ml	Heating	15 sec			72	”inactivated”		48	Test medium: sterilized wastewater from fish slaughterhouse.
10^7 CFU/ml	Heating	15 sec			72	”inactivated”		48	Test medium: unsterilized wastewater from fish slaughterhouse.

Mycobacterium chelonei

Concentration	Disinfectant	Contact	Concentration	pH	Temp.	Result	Method	Reference	Comments

pathogen		time	disinfectant						
7,5 x 10^6 cfu/ml	Heating	24 hours		7	40	”inactivated”		100	
7,5 x 10^6 cfu/ml	Heating	4 hours		7	45	”inactivated”		100	
7,5 x 10^6 cfu/ml	Heating	60 min		7	50	”inactivated”		100	
7,5 x 10^6 cfu/ml	Heating	15 min		7	55	”inactivated”		100	
7,5 x 10^6 cfu/ml	Heating	2,5 min		7	60	”inactivated”		100	
	Heating	6 hours			60	”inactivated”		20, Dixon (pers. com.)	
7,5 x 10^6 cfu/ml	Heating	< 30 sec		7	65	”inactivated”		100	

Photobacterium damselae

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	Heating	1 hour			60	Survival		20, Dixon (pers. com.)	

Renibacterium salmoninarum

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
≥ 10^5 cfu/ml	Heating	> 2 t		7	40	”inactivated”		100	
≥ 10^5 cfu/ml	Heating	> 6 t		7	45	”inactivated”		100	
≥ 10^5 cfu/ml	Heating	> 4 hours		7	50	”inactivated”		100	
≥ 10^5 cfu/ml	Heating	> 3 hours		7	55	”inactivated”		100	
	Heating	1 hour			60	”inactivated”		20, Dixon (pers. com.)	
≥ 10^5 cfu/ml	Heating	> 15 min		7	65	”inactivated”		100	

Streptococcus iniae

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	Heating	5 min			60	”inactivated”		20, Dixon (pers. com.)	

Yersinia ruckeri

Concentration	Disinfectant	Contact	Concentration	pH	Temp.	Result	Method	Reference	Comments

pathogen		time	disinfectant						
6,6 x 10^7 CFU/ml	Heating	1 min			60	”inactivated”		48	Test medium: sterilized wastewater from fish slaughterhouse.
6,5 x 10^7 CFU/ml	Heating	2 min			60	”inactivated”		48	Test medium: unsterilized wastewater from fish slaughterhouse.
	Heating	1 hour			60	Survival		20, Dixon (pers. com.)	
$10^{8,28}$ cfu/ml	Heating	1 min			65	5 log reduction	Laboratory trial, 1 part process water + 2 parts ”bløggevand” from fish slaugtherhouse.	28	
$10^{4,69}$ cfu/ml	Heating	3 min		8,96	65	Not detectable (≥ 4 log reduction)	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	Salinity 14-15 ‰
$10^{8,28}$ cfu/ml	Heating	5 min			65	7½ log reduction	Laboratory trial, 1 part process water + 2 parts ”bløggevand” from fish slaugtherhouse.	28	
$10^{5,04}$ cfu/ml	Heating	24 hours			65	Stable	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	
$10^{4,69}$ cfu/ml	Heating	1 min		8,96	70	4 log reduction	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	Salinity 14-15 ‰
$10^{5,04}$ cfu/ml	Heating	24 hours			70	Stable	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	
6,6 x 10^7 CFU/ml	Heating	15 seconds			72	”inactivated”		48	Test medium: sterilized wastewater from fish slaughterhouse.
6,5 x 10^7 CFU/ml	Heating	15 sec			72	”inactivated”		48	Test medium: unsterilized wastewater from fish slaughterhouse.
$10^{4,69}$ cfu/ml	Heating	1 min		8,96	75	3½ log reduction	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	Salinity 14-15 ‰
$10^{4,69}$ cfu/ml	Heating	2 min		8,96	75	Not detectable (≥ 4 log reduction)	Full-scale trial (Norskagfisk), blood water from fish slaugtherhouse.	28	Salinity 14-15 ‰
$10^{5,04}$ cfu/ml	Heating	24 hours			75	Not detectable (> 6 log reduction)	Full-scale trial (Norskagfisk), blood water from fish	28	

							slaugtherhouse.		

Parasites

Gyrodactylus salaris

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
75	Temperature	60 hours			3	All dead	Free, without host.	80	
422	Temperature	365 hours			3	All dead	On dead host.	80	
88	Temperature	45 hours			12	All dead	Free, without host.	80	
315	Temperature	142 hours			12	All dead	On dead host.	80	
65	Temperature	27 hours			18	All dead	Free, without host.	80	
204	Temperature	72 t			18	All dead	On dead host.	80	

Myxosoma cerebralis

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	Temperature	7 days			-80	No infection in tubifex.	Infectivity of myxospores in tubifex.	37	Myxospore suspension
	Temperature	2 months			-80	No infection in tubifex.	Infectivity of myxospores in tubifex.	37	Myxospore in head tissue from fish.
	Temperature	7 days			-20	No infection in tubifex.	Infectivity of myxospores in tubifex.	37	Myxospore suspension
	Temperature	2 months			-20	No infection in tubifex.	Infectivity of myxospores in tubifex.	37	Myxospore in head tissue from fish.
96-192	Temperature	105 min			-20	Survival?	in vitro. Triactinomyxon spores	96	1,0 ± 0.8% probably alive, remaining dead.
	Temperature	2 months			4	Active infection in tubifex.	Infectivity of myxospores in tubifex.	37	Myxospore in head tissue from fish.
	Temperature	7 days			5	Active infection in tubifex.	Infectivity of myxospores in tubifex.	37	Myxospore suspension
45-131	Temperature	105 min			7	Alive 31%, dead 46%	in vitro. Triactinomyxon spores	96	
51-124	Temperature	60 min			19-21	Alive 72%, dead 5%	in vitro. Triactinomyxon spores	96	
	Temperature	2 months			20	No infection in tubifex.	Infectivity of myxospores in tubifex.	37	Myxospore in head tissue from fish.
	Temperature	7 days			22	Active infection in	Infectivity of myxospores in	37	Myxospore suspension

						tubifex.	tubifex.		
	Heating	5 min			58	Survival	in vitro. Triactinomyxon spores	96	
100 spores talt	Heating	10 min			70	60% dead	In vitro - spores farvet med methylenblå som tegn på død (skal eftervises)	43	
	Heating	5 min			75	All dead	in vitro. Triactinomyxon spores	96	
100 spores talt	Heating	10 min			80	98% dead	In vitro - spores farvet med methylenblå som tegn på død (skal eftervises)	43	4 trials where all dead, 1 trial where 88% dead.
100 spores talt	Heating	10 min			90	All dead	In vitro - spores farvet med methylenblå som tegn på død (skal eftervises)	43	

Percolation

It has not been possible to find any references describing the decimating effect of percolating of fish pathogenic viruses. Furthermore it has not been possible to find publications describing the effect of percolating other birnaviruses. It is therefore not possible to validate if this procedure is safe to use.

Other procedures:

Iodine based disinfectants

Virus

IHNV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
$10^{4,53}$ - $10^{5,18}$ pfu/ml	Povidon iodine	7,5 seconds	0,10 mg/l free iodide			99,49 → 99,99% reduction	Distilled water.	11	6 isolates representing 5 types.
$10^{4,62}$ pfu/ml	Povidon iodine	5 min	0,4 mg/l residual free iodide	6		> 99,99% reduction		11	Testing of effect of pH.
$10^{4,66}$ pfu/ml	Povidon iodine	5 min	0,4 mg/l residual free iodide	7		> 99,99% reduction		11	Testing of effect of pH.
$10^{4,74}$ pfu/ml	Povidon iodine	5 min	0,4 mg/l residual	8		99,89% reduction		11	Testing of effect of pH.

			free iodide						
$10^{4,71}$ pfu/ml	Povidon iodine	5 min	0,4 mg/l residual free iodide	9		90,78% reduction		11	Testing of effect of pH.
	Povidon iodine	5 min	0,4 mg/l residual free iodide			> 4 log reduction for alle saliniteter	Natural seawater containg 0, 4, 7½, 15½ and 32 ‰ salte.	11	Effect of BSA (dirty conditions).
$10^{5,04}$ pfu/ml	Povidon iodine	5 min	0,4 mg/l residual free iodide			> 4 log reduction for alle saliniteter	Dirty conditions: iodide + calf serum(0,002%) mixed before virus added	11	Effect of BSA (dirty conditions).
$10^{5,04}$ pfu/ml	Povidon iodine	5 min	0,4 mg/l residual free iodide			Stable	Dirty conditions: iodide + calf serum(0,016%) mixed before virus added	11	Effect of BSA (dirty conditions).
$10^{4,81}$ pfu/ml	Povidon iodine	5 min	0,4 mg/l residual free iodide			> 4 log reduction for alle saliniteter	Dirty conditions: virus + calf serum (0,002%) mixed before iodide added	11	Effect of BSA (dirty conditions).
$10^{4,81}$ pfu/ml	Povidon iodine	5 min	0,4 mg/l residual free iodide			99,96% reduction	Dirty conditions: virus + calf serum (0,016%) mixed before iodide added	11	Effect of BSA (dirty conditions).
$10^{4,81}$ pfu/ml	Povidon iodine	5 min	0,4 mg/l residual free iodide			66,67% reduction	Dirty conditions: virus + calf serum (0,064%) mixed before iodide added	11	Effect of BSA (dirty conditions).
$10^{4,41}$ - $10^{4,91}$ pfu/ml	Povidon iodine	7,5 sec	0,4 mg/l residual free iodide			Not detectable til Stable	Natural water from 8 different sources (fresh + salt)	11	
$10^{4,41}$ - $10^{4,91}$ pfu/ml	Povidon iodine	7,5 sec	0,8 mg/l residual free iodide			≥ 4 log reduction	Natural water from 8 different sources (fresh + salt)	11	
	Iodophor	5 min	8 ppm	6,0		”inactivated”		8	1 ppm = 1 mg/l
	Iodophor	30 sec	12 ppm	7,0		”inactivated”		8	
	Iodophor	15 sec	25 ppm	7,0		”inactivated”		8	
	Iodophor	5 min	32 ppm	8,6		”inactivated”		8	
10^{6} PFU/ml	Iodophor	10 min	100 mg/l			> 3 log reduction	Green eggs and eyed eggs treated in 10 or 60 min	31	

Conclusion: Under laboratory conditions IHNV is sensitive to disinfection with iodine. The higher the pH and the more organic waste the more iodine is needen to disinfect the same amount of virus. Recommended dose: 100 ppm, 10 min contact time.

IPNV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
$10^{7,41}$ $TCID_{50}$/ml	Iodophor, acid	30 min	0,033% (v/v)		4	> 4 log reduction	Tested at 0,0055, 0,011, 0,022,0,033, 0,044 and 0,055%. Hard water, Dirty	49	

							conditions.		
$10^{3,9}$ $TCID_{50}$/ml	Iodophor	5 min	4 mg/l residual		21	”inactivated”	Testet using ½, 1,2, 4, 8, 16, 32 and 64 mg/l residual. Distilled water.	23	IPNV: Serotype Buhl. Iodophor: Betadine
$10^{3,8\ TCID}_{50}$/ml	Iodophor	15 seconds	12 mg/l residual		21	”inactivated”	Tested at time 0, 15, 30, 60, 120 s. Distilled water.	23	IPNV: Serotype Buhl. Iodophor: Betadine
$10^{3,9}$ $TCID_{50}$/ml	Iodophor	5 min	16 mg/l residual	6-8,6	21	”inactivated”	Testet using ½, 1,2, 4, 8, 16, 32 and 64 mg/l residual. Distilled water.	23	IPNV: Serotype Buhl. Iodophor: Betadine
$10^{5,5\ TCID}_{50}$/ml	Iodophor	5 min	30 ppm iodine		room temp.	”inactivated”	PBS	17	Wescodyne
	Iodophor	5 min	32 ppm	6,9		”inactivated”		8	
$10^{6,6}$ $TCID_{50}$/ml	Iodophor	5 min	35 ppm iodine		room temp.	”inactivated”	PBS	17	Wescodyne
$10^{6,6}$ $TCID_{50}$/ml	Iodophor	3 min	45 ppm iodine		room temp.	Survival	PBS	17	Wescodyne
	Actomar	5 min	0,01%			> 4 log reduction		5	
$10^{5,2}$ $TCID_{50}$/ml	Actomar	20 min	50 ppm			”inactivated”	Without serum	6	Active iodide 50, 100, 150 and 200 ppm testet. Time 2, 4, 5, 6, 8, 10, 20 and 30 min tested.
$10^{5,2}$ $TCID_{50}$/ml	Actomar	2 min →	50 ppm			3 log reduction	With 5 % serum	6	Active iodide 50, 100, 150 and 200 ppm testet. Time 2, 4, 5, 6, 8, 10, 20 and 30 min tested.
$10^{5,8\ TCID}_{50}$/ml	Actomar	6 min	150 ppm			3 log reduction	With 5 % serum	37	Active iodide 50, 100, 150 and 200 ppm testet. Time 2, 4, 5, 6, 8, 10, 20 and 30 min tested.
$10^{5,8\ TCID}_{50}$/ml	Actomar	20 min	150 ppm			”inactivated”	With 5 % serum	6	Active iodide 50, 100, 150 and 200 ppm testet. Time 2, 4, 5, 6, 8, 10, 20 and 30 min tested.
	iodophor	5 min	80-100 ppm		5	> 99,9%	Iodophor added virus	24	FAM (acid iodophor)
	iodophor	5 min	80-100 ppm		5	> 99,9%	Iodophor added virus	24	Buffodine (neutral iodophor)
	iodophor	5 min	80-100 ppm		5	90%	Eggs before hardening, surface infected with virus	24	Buffodine (neutral iodophor)

Conclusion: Under laboratory conditions IPNV is sensitive for iodine. When conditions are dirty more iodine is needed. Recommended dose for 3 log reduction: 150 ppm, 10 min contact time.

ISAV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
5,1 log10 ffu/ml	Iodophor	5 min	50 ppm		4	> 4,8 log reduction	Hard water, 342 ppm total hardness.. Testet with 50, 100 and 200 ppm.	89	Buffodine
5,1 log10 ffu/ml	Iodine	5 min	100 ppm		4	> 4,8 log reduction	Hard water, 342 ppm total hardness, with and without addition of serum.	89	Tegodyne
5,5 log10 ffu/ml	Iodine	5 min	100 ppm		4	> 5,2 log reduction	Hard water, 342 ppm total hardness, with and without addition of serum. Testet with 100, 200 and 400 ppm.	89	FAM 30

Conclusion: Under laboratory conditions ISAV is sensitive for iodine. Recommended dose: 100 ppm, 5 min contact time.

VHSV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	Iodophor	5 min	8 ppm	6,9		”inactivated”		8	
10^7 $TCID_{50}$/ml	Iodophor	1 min	50 ppm		15	Not detectable	Diluted in PBS. 1% fetal calf serum.	65	Isolat JF001Ehi1. Dilution scale 1:50. Isodine.
10^7 $TCID_{50}$/ml	Iodophor	1 min	50 ppm		15	Not detectable	Fortyndet i kunstig havvand. 1% føtalt calf serum.	65	Isolat JF001Ehi1. Dilution scale 1:50. Isodine.
$10^{5,8\ TCID}_{50}$/ml	Actomar	8 min →	50 ppm			3 log reduction	With 5 % serum	6	Active iodide, 50 and 100 ppm tested. Time 2, 4, 5, 6, 8, 10, 20 and 30 min tested.
$10^{5,5\ TCID}_{50}$/ml	Actomar	4 min	50 ppm			”inactivated”	Without serum	6	Active iodide, 50 and 100 ppm tested. Time 2, 4, 5, 6, 8, 10, 20 and 30 min tested.
	Actomar	5 min	100 ppm			”inactivated”		5	Author claim 100% reduction.
$10^{6,5\ TCID}_{50}$/ml	Actomar	2 min	100 ppm			”inactivated”	With 5 % serum	6	Active iodide, 50 and 100 ppm tested. Time 2, 4, 5, 6, 8, 10, 20 and 30 min tested.
10^8 pfu/ml	Iodophor	10 min	100 ppm			Not detectable	fiskeæg added virus	95	genotype IVb
	iodophor	5 min	80-100 ppm		5	> 99,9%	Iodophor added virus	24	Buffodine (neutral

									iodophor)
	iodophor	5 min	80-100 ppm		5	> 99,99%	Nystrøgne, Not hærdede æg overflade inficeret med virus	24	Buffodine (neutral iodophor)
	iodophor	5 min	80-100 ppm		5	> 99,9%	Iodophor added virus	24	FAM (acid iodophor)

Conclusion: Iodophores can inactivate VHSV on fish eggs using a dose of 100 ppm and a contact time of 10 min. The results indicate that iodine will be used under dirty conditions minimizing the disinfecting effect. Recommended dose: 100 ppm, 10 min.

SVCV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	Actomar	5 min	100 ppm			99 % reduction		5	
$10^{7,2}$ $TCID_{50}$/ml	Actomar	10 min	100 ppm			"inactivated"	Without serum	6	Active iodide 100, 150 and 200 ppm tested. Time 2, 4, 5, 6, 8, 10, 20 and 30 min tested.
$10^{7,5\ TCID}_{50}$/ml	Actomar	2 min og fremefter	100 ppm			2 log reduction	With 5 % serum	6	Active iodide 100, 150 and 200 ppm tested. Time 2, 4, 5, 6, 8, 10, 20 and 30 min tested.
$10^{7,8\ TCID}_{50}$/ml	Actomar	4 min	150 ppm			3 log reduction	With 5 % serum	6	Active iodide 100, 150 and 200 ppm tested. Time 2, 4, 5, 6, 8, 10, 20 and 30 min tested.
$10^{7,5\ TCID}_{50}$/ml	Actomar	10 min	200 ppm			"inactivated"	With 5 % serum	6	Active iodide 100, 150 and 200 ppm tested. Time 2, 4, 5, 6, 8, 10, 20 and 30 min tested.

Conclusion: The results indicates that a dose of 100 ppm wil be used under dirty conditions rendering an acceptable disinfection impossible. Recommended dose: 200 ppm, 10 min.

PFRV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	Actomar	5 min	100 ppm			99,99 % reduction		5	
$10^{7,5\ TCID}_{50}$/ml	Actomar	4 min	100 ppm			"inactivated"	Without serum	6	Active iodide 100, 150 and 200 ppm tested. Time 2, 4, 5, 6, 8, 10, 20 and 30 min tested.
$10^{7,5\ TCID}_{50}$/ml	Actomar	4 min og fremefter	100 ppm			6 log reduction	With 5 % serum	6	Active iodide 100, 150 and 200 ppm tested.

									Time 2, 4, 5, 6, 8, 10, 20 and 30 min tested.
$10^{7,2}$ $TCID_{50}$/ml	Actomar	10 min	150 ppm			"inactivated"	With 5 % serum	6	Active iodide 100, 150 and 200 ppm tested. Time 2, 4, 5, 6, 8, 10, 20 and 30 min tested.

Conclusion: The results indicate that a dose of 100 ppm will be used under dirty conditions, but the obtained reduction was still satisfactory.

KHV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
1 - 1,5 x 10^4 PFU/ml	Iodophor	30 seconds	130 mg/l		0	Not detectable	Virus and disinfectant mixed 1:1, tested after 30 sec and 20 min. Diluted 1:10 using L15 medium and 200 µl inoculated .	55	Strain KHV-I. The method cannot detect a 3 log reduction.
1 - 1,5 x 10^4 PFU/ml	Iodophor	30 seconds	200 mg/l		25	Not detectable	testet ved 30 sec og 20 min.	55	Strain KHV-I. The method cannot detect a 3 log reduction.

Conclusion: Although the method used is not capable of detecting a 3 log reduction the results indicate the KHV is sensitive to disinfection using iodophores.

Nodavirus

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	Jod	15 min	40 mg/l			Not inactivated (all larvae dead after 15 days)	Washing of eggs from noda infected ovaries in seawater, followed after hatching.	9	Isolate: SJNNV
10 µg purified virus	Jod	10 min	50 mg/ml		20	"Effective"	Diluted in 1 ml PBS. Used for infection trial in day old striped jack larvae. Concentration testet: 2,5 - 100 mg/ml.	9	Isolate: SJNNV
$10^{6,125}$ $TCID_{50}$/ml	iodophor, buffered	5 min	25 ppm I_2		15	Not detectable	Distilled water. Tested after 5, 15 and 30 min.	30	Isolate: sea bass nodavirus
$10^{6,125}$ $TCID_{50}$/ml	iodophor, buffered	30 min	100 ppm I_2		15	4½ log reduction	HBSS + calf serum. Tested after 5, 15 and 30 min.	30	Isolate: sea bass nodavirus

Conclusion: Under laboratory conditions nodavirus is sensitive to disinfection with iodine products but it seems that nodavirus is a bit more resistant than VHSV and IHNV. Recommended concentration: 100 ppm, 30 min.

Oncorhynchus masou virus

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	Iodophor	30 sec	40 ppm		0	”inactivated”		35	
	Iodophor	30 sec	40 ppm		25	”inactivated”		35	

Bacteria

Aeromonas liquefaciens

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
1 x 10^7/ml	Iodophor	30 sec	25 ppm	7	10-13	> 5 log reduction	Distilled water. 4 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Wescodyne
1 x 10^7/ml	Iodophor	120 sec	25 ppm	7	10-13	Not detectable (> 7 log reduction)	Distilled water. 4 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Wescodyne
1 x 10^6/ml	Iodophor	300 sec	25 ppm	8	10-13	> 5 log reduction	Distilled water. 1 strain tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Wescodyne
1 x 10^7/ml	Povidon iodine	15 sec	25 ppm	7	10-13	≥ 6 log reduction	Distilled water. 4 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Betadine
1 x 10^7/ml	Povidon iodine	120 sec	25 ppm	7	10-13	Not detectable (> 7 log reduction)	Distilled water. 4 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Betadine
1 x 10^7/ml	Povidon iodine	300 sec	25 ppm	8	10-13	> 5 log reduction	Distilled water. 1 strain tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Betadine

Conclusion: Under clean conditions 25 ppm for a few minutes will provide an aceptable reduction.

Aeromonas salmonicida

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^7 CFU/ml	I_2		1,0 mg/l added	7,2	7	99,9% reduction	PBS	71	Reduction rate: 0,21/sec
10^7 CFU/ml	I_2	36 sec	1 mg/l added	7,2	7	99,9 % reduction	PBS	71	
10^7 CFU/ml	I_2		1,3 mg/l added	7,8	7	99,9% reduction	Wastewater from aquaculture (15,7 ‰ salinity).	71	Reduction rate: 0,14/sec
10^7 CFU/ml	I_2	1 min	1,3 mg/l added	7,8	7	3½ log reduction	Wastewater from aquaculture	71	Read off a graph.

							(15,7 ‰ salinity).		
10^7 CFU/ml	I_2		2,6 mg/l added	7,8	7	99,9% reduction	Wastewater from aquaculture (15,7 ‰ salinity).	71	Reduction rate: 0,26/sec
10^7 CFU/ml	I_2	40 sec	2,6 mg/l added	7,8	7	4½ log reduction	Wastewater from aquaculture (15,7 ‰ salinity).	71	Read off a graph.
	Iodophor, acid	30 min	0,28 % (v/v)		4	> 5 log reduction	Tested at 0,16, 0,2, 0,28, 0,4, 0,8, 1, 1,6, 2 and 3,2%. Hard water, high organic load.	49	
2,6 x 10^7/ml	Iodophor	15 sec	25 ppm	7	10-13	6 log reduction	Distilled water. 4 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Wescodyne
4 x 10^7/ml	Iodophor	60 sec	25 ppm	8	10-13	Not detectable (> 7 log reduction)	Distilled water. 1 strain tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Wescodyne
2,6 x 10^7/ml	Iodophor	120 sec	25 ppm	7	10-13	Not detectable (> 7 log reduction)	Distilled water. 4 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Wescodyne
10^5 cfu/ml	Povidon iodine	3 min	10 ppm		20	> 4 log reduction		85	Concentration of commercial product. (Isodine)
10^8 cfu/ml	Povidon iodine	5 min	5 ppm		20	Stable	Test of effect of bacteria titer.	85	Concentration of commercial product. (Isodine)
10^6 cfu/ml	Povidon iodine	5 min	5 ppm		20	> 3 log reduction	Test of effect of bacteria titer.	85	Concentration of commercial product. (Isodine)
10^4 cfu/ml	Povidon iodine	1 min	5 ppm		20	> 3 log reduction	Test of effect of bacteria titer.	85	Concentration of commercial product. (Isodine)
$10^{5,5}$ cfu/ml	Povidon iodine	4 min	5 ppm		20	Stable	10 ppm calf serum added.	85	
$10^{5,5}$ cfu/ml	Povidon iodine	4 min	5 ppm		20	4½ log reduction	0 ppm calf serum added.	85	
$10^{5,5}$ cfu/ml	Povidon iodine	3 min	5 ppm		5	3½ log reduction		85	Test of effect of Temperature.
$10^{5,5}$ cfu/ml	Povidon iodine	3 min	5 ppm		25	4½ log reduction		85	Test of effect of Temperature.
$10^{5,5}$ cfu/ml	Povidon iodine	5 min	5 ppm		15	Stable	Artificial sea water.	85	
$10^{5,5}$ cfu/ml	Povidon iodine	1-3 min	5 ppm		15	3½ - 4 log reduction	Hard water (300 ppm $CaCO_3$)	85	
$10^{5,5}$ cfu/ml	Povidon iodine	1-3 min	5 ppm		15	3½ - 4 log reduction	Distilled water.	85	
1 x 10^7/ml	Povidon iodine	15 sec	25 ppm	7	10-13	> 5 log reduction for 3 of 4 strains	Distilled water. 4 strains tested. Time: 15, 30, 60, 120	84	Betadine

							and 300 seconds.		
1 x 10^7/ml	Povidon iodine	300 sec	25 ppm	7	10-13	Not detectable	Distilled water. 4 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Betadine
4 x 10^7/ml	Povidon iodine	300 sec	25 ppm	7	10-13	Not detectable	Distilled water. 1 strain tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Betadine
10^5 cfu/ml	Povidon iodine	1 min	30 ppm		20	> 4 log reduction		85	Concentration of commercial product. (Isodine)

Conclusion: The lower the Temperature, the highter the titer of the pathogen, the more organic dirt, the worse the obtaine disinfection. The results indicate that a dose of 25 ppm for 5 min will provide ≥ 3 log reduction.

Carnobacterium piscicola

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	Iodophor, acid	30 min	0,4 - 1% (v/v)		4	> 5 log reduction	Tested at 0,16, 0,2, 0,28, 0,4, 0,8, 1, 1,6, 2 and 3,2%. Hard water, high organic load.	49	

Flexibacter columnaris

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
1,7 x 10^6/ml	Iodophor	15 sec	25 ppm	7	10-13	> 5 log reduction	Distilled water. 4 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Wescodyne
1,7 x 10^6/ml	Iodophor	300 sec	25 ppm	7	10-13	Not detectable (> 6 log reduction)	Distilled water. 4 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Wescodyne
4 x 10^4/ml	Iodophor	30 sec	25 ppm	8	10-13	Not detectable (> 3 log reduction)	Distilled water. 1 strain tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Wescodyne
2 x 10^6/ml	Povidon iodine	15 sec	25 ppm	7	10-13	Not detectable (> 6 log reduction)	Distilled water. 4 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Betadine
2 x 10^6/ml	Povidon iodine	120 sec	25 ppm	7	10-13	Not detectable (≥ 6 log reduction)	Distilled water. 4 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Betadine
4 x 10^4/ml	Povidon iodine	120 sec	25 ppm	8	10-13	Not detectable (> 3	Distilled water. 1 strain	84	Betadine

						log reduction)	tested. Time: 15, 30, 60, 120 and 300 seconds.		

Conclusion: Under clean conditions 25 ppm for 5 min will inactivate the bacteria.

Cytophaga psychrophila (Flavabacterium psychrophilum)

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
1,4 x 10^6/ml	Iodophor	15 sec	25 ppm	7	10-13	> 5 log reduction	Distilled water. 4 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Wescodyne
1,4 x 10^6/ml	Iodophor	60 sec	25 ppm	7	10-13	Not detectable (> 6 log reduction)	Distilled water. 4 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Wescodyne
5 x 10^3/ml	Iodophor	15 sec	25 ppm	8	10-13	Not detectable (> 3 log reduction)	Distilled water. 1 strain tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Wescodyne
1,4 x 10^6/ml	Povidon iodine	15 sec	25 ppm	7	10-13	5 log reduction	Distilled water. 4 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Betadine
1,4 x 10^6/ml	Povidon iodine	30 sec	25 ppm	7	10-13	≥ 6 log reduction	Distilled water. 4 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Betadine
5 x 10^3/ml	Povidon iodine	30 sec	25 ppm	8	10-13	Not detectable (> 3 log reduction)	Distilled water. 1 strain tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Betadine

Conclusion: Under clean conditions 25 ppm for 5 min will inactivate the bacteria.

Edwardsiella tarda

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^7 CFU/ml	Povidon iodine	20 min	800 ppm		20	5 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.
10^7 CFU/ml	Povidon iodine	60 min	800 ppm		20	5 log reduction	Dilution 1:1 of bacteria and	58	The actual concentration

							disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.		of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.

Conclusion: this paper states that *E. tarda* is much more resistant to iodine that other bacteria!

Kidney disease (Corynebacterium sp. - Renibacterium salmoninarum?)

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
Growth	Iodophor	15 sec	25 ppm	7	10-13	Not detectable	Distilled water. 2 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Wescodyne
Growth	Iodophor	300 sec	25 ppm	8	10-13	Not detectable	Distilled water. 1 strain tested. Time: 300 seconds.	84	Wescodyne
Growth	Povidon iodine	15 sec	25 ppm	7	10-13	Not detectable	Distilled water. 2 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Betadine
Growth	Povidon iodine	300 sec	25 ppm	8	10-13	Not detectable	Distilled water. 1 strain tested. Time: 300 seconds.	84	Betadine

Renibacterium salmoninarum

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
> 1667 Bacteria/æg	Povidon iodine	15 min	500 mg/l		15	166/170 (97,6%) of the eggs sterile on surface	Eggs from infected coho salmon.	25	

Conclusion: Disinfection of salmon egg seems to require a higher amount of iodine to be disinfected that do the bacteria under clean conditions (destilled water). Under clean conditions *R. salmoninarum* is comparable to other fish pathogenic bacteria requiring 25 ppm for 5 min. A dose of 500 mg/l did not completely inactivate *R. salmoniarum* on the surface of the eggs though most of the eggs were rendered sterile.

Lactococcus garviae

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	Iodophor, acid	30 min	0,4 % (v/v)		4	> 5 log reduction	Tested at 0,16, 0,2, 0,28, 0,4,	49	

							0,8, 1, 1,6, 2 and 3,2%. Hard water, high organic load.		

Streptococcus sp

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^7 CFU/ml	Povidon iodine	20 min	3200 ppm		20	> 5 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.
10^7 CFU/ml	Povidon iodine	60 min	1600 ppm		20	4 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.

Conclusion: this paper states that *Streprococcus* is much more resistant to iodine that other bacteria!

Vibrio anguillarum

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^5 cfu/ml	Povidon iodine	1 min	10 ppm		20	> 4 log reduction		85	Concentration of commercial product. (Isodine)
3 x 10^7/ml	Iodophor	15 sec	25 ppm	7	10-13	> 6 log reduction	Distilled water. 4 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Wescodyne
3 x 10^7/ml	Iodophor	120 sec	25 ppm	7	10-13	Not detectable (> 7 log reduction)	Distilled water. 4 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Wescodyne
5 x 10^6/ml	Iodophor	60 sec	25 ppm	8	10-13	Not detectable (> 6 log reduction)	Distilled water. 1 strain tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Wescodyne
1 x 10^5/ml	Povidon iodine	15 sec	25 ppm	7	10-13	Not detectable (> 5 log reduction)	Distilled water. 4 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Betadine

5 x 10^6/ml	Povidon iodine	300 sec	25 ppm	8	10-13	Not detectable (> 6 log reduction)	Distilled water. 1 strain tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Betadine

Conclusion: Under clean conditions 25 ppm for 5 min will inactivate the bacteria.

Vibrio ordalii

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^5 cfu/ml	Povidon iodine	1 min	30 ppm		20	> 4 log reduction		85	Concentration of commercial product. (Isodine)

Conclusion: Under clean conditions 25 ppm for 5 min will inactivate the bacteria.

Vibrio sp.

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^7 CFU/ml	Povidon iodine	20 min	1600 ppm		20	> 5 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.
10^7 CFU/ml	Povidon iodine	60 min	800 ppm		20	4 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.

Conclusion: this paper states that *Vibrio* is much more resistant to iodine than stated in other papers!

Yersinia ruckeri

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
3 x 10^7/ml	Iodophor	15 sec	25 ppm	7	10-13	Not detectable (> 7 log reduction)	Distilled water. 4 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Wescodyne
5 x 10^6/ml	Iodophor	15 sec	25 ppm	8	10-13	Not detectable (> 6 log reduction)	Distilled water. 1 strain tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Wescodyne
	Iodophor, acid	30 min	0,28 % (v/v)		4	> 5 log reduction	Tested at 0,16, 0,2, 0,28, 0,4, 0,8, 1, 1,6, 2 and 3,2%. Hard water, high organic load.	126	
2 x 10^7/ml	Povidon iodine	15 sec	25 ppm	7	10-13	Not detectable (> 7 log reduction)	Distilled water. 4 strains tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Betadine
5 x 10^6/ml	Povidon iodine	15 sec	25 ppm	8	10-13	Not detectable (> 6 log reduction)	Distilled water. 1 strain tested. Time: 15, 30, 60, 120 and 300 seconds.	84	Betadine

Conclusion: Under clean conditions 25 ppm for 5 min will inactivate the bacteria.

Parasites

Gyrodactylus salaris

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	Iodine					Sensitive		1	From OIE diagnostic manual. No reference stated!

Myxosoma cerebralis

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	Povidon iodine	10 min	500 ppm		room temp.	Survival	in vitro. Triactinomyxon spores	96	5% of commercial product.

	Povidon iodine	10 min	5000 ppm		room temp.	Survival	in vitro. Triactinomyxon spores	96	50% of commercial product.

Fungae

Phoma herbarum

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
Growth	Povidon iodine	120 sec	25 ppm	7	10-13	No growth	Distilled water. 1 strain tested (spores). Time: 15, 30, 60, 120 and 300 seconds.	84	Betadine
Growth	Iodophor	120 sec	25 ppm	7	10-13	No growth	Distilled water. 1 strain tested (spores). Time: 15, 30, 60, 120 and 300 seconds.	84	Wescodyne

Saprolegnia parasitica

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
Growth	Povidon iodine	300 sec	25 ppm	7	10-13	Growth	Distilled water.. 1 stamme testet (mycelium). Tid: 15, 30, 60, 120 og 300 seconds.	84	Betadine
Growth	Iodophor	300 sec	25 ppm	7	10-13	Growth	Distilled water.. 1 stamme testet (mycelium). Tid: 15, 30, 60, 120 og 300 seconds.	84	Wescodyne

Ozone

Virus

VHSV

It has not been possible to find any references.

IHNV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^4 - $10^5$$TCID_{50}$/ml	ozone	30 sec	total residual	6,9	10	”inactivated”	Ozone tilført: 70 mg/h/L,	99, 98	C T value: 0,3 mg*s/l

			oxidants 0,01 mg/l				Distilled water.		
	ozone	15 sec	total residual oxidants 0,5 mg/l			99% infectivity reduction		102	C T value: 7,5 mg*s/l
10^4 - 10^5TCID$_{50}$/ml	ozone	10 min	70 mg/h/L	6,9	10	”inactivated”	Not possible to obtain a stable ozone residual. Soft lake water, 30 mg/l $CaCO_3$.	99, 98	
10^4 - 10^5 TCID$_{50}$/ml	ozone	10 min	70 mg/h/L	8,2	10	”inactivated”	Not possible to obtain a stable ozone residual. Hard lake water, 120 mg/l $CaCO_3$.	99, 98	

Conclusion: IHNV is sensitive to treatment with ozone. Based on these figures the dose needed for a 3 log reduction is unknown.

IPNV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^5 TCID$_{50}$/ml	ozone	60 sec	total residual oxidants 0,01 mg/l	6,9	10	”inactivated”	Ozone added: 70 mg/h/L, Distilled water.	99, 98	C T value: 0,6 mg*s/l
$10^{5,5}$ TCID$_{50}$/ml	ozone	60 sec	0,20 mg/l		9-12	> 4 log reduction	Lake water, autoclaved.	70	C T value: 12 mg*s/l
$10^{5,5}$ TCID$_{50}$/ml	ozone	120 sec	0,20 mg/l		9-12	> 5 log reduction	Lake water, autoclaved.	70	C T value: 24 mg*s/l
$10^{5,5}$ TCID$_{50}$/ml	ozone	60 sec	0,20 mg/l		9-12	> 5 log reduction	Brackish water, salinity 15 ‰, autoclaved.	70	C T value: 12 mg*s/l
$10^{5,5}$ TCID$_{50}$/ml	ozone	60 sec	0,20 mg/l		9-12	> 5 log reduction	Sea water, salinity 32 ‰, autoclaved.	70	C T value: 12 mg*s/l
	ozone	1 min	total residual oxidants 0,5 mg/l			99% infectivity reduction		102	C T value: 30 mg*s/l
10^5 TCID$_{50}$/ml	ozone	30 sec	90 mg/h/L	6,9	10	”inactivated”	Not possible to obtain a stable ozone residual. Soft lake water, 30 mg/l $CaCO_3$.	99, 98	
10^5 TCID$_{50}$/ml	ozone	10 min	90 mg/h/L	8,2	10	”inactivated”	Not possible to obtain a stable ozone residual. Hard lake water, 120 mg/l $CaCO_3$.	99, 98	

Conclusion: IPNV is sensitive to treatment with ozone. Based on these figures the dose needed for a 3 log reduction is unknown.

ISAV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	ozone	15 sec	0,33 mg/l TRO	7,9	5	99,0 % reduction	Sea water, sterile filtered.	73	C T value: 5,0 mg*s/l, written in article.
	ozone	31 min	2,5 mg/l TRO	7,9	5	98,4 % reduction	Sea water, sterile filtered.	73	C T value: 4650 mg*s/l, written in article.

	ozone	14 min	6,7 mg/l TRO	7,9	5	98,0 % reduction	Sea water, sterile filtered.	73	C T value: 5628 mg*s/l, written in article.
	ozone	17 min	7,9 mg/l TRO	7,9	5	98,7 % reduction	Sea water, sterile filtered.	73	C T value: 8058 mg*s/, written in article. l

Conclusion: Based on this paper ISAV is sensitive to ozone but it will not be possible to obtain more than a 2 log reduction.

Nodavirus

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10 µg purified virus	ozone	30 sec	0,1 mg/ml TRO		20	Not inactivated (0/800 larvae survived, control 238/800)	Virus added to 1 ml ozone treated sea water. Used for infection trial in day old striped jack larvae.	9	Isolate: SJNNV. C T value: 3 mg*s/l
	ozone	1 min	0,2 mg/ml TRO			”Effective” (136/800 larvae survived, antigen ELISA negative, untreated eggs 0/800 survived, antigen ELISA positive)	Washihng of eggs from noda infected ovaries i sea water, followed after hatching.	9	Isolate: SJNNV C T value: 12 mg*s/l
10 µg purified virus	ozone	2,5 min	0,1 mg/ml TRO		20	”Effective” (334/800 larvae survived, antigen ELISA negativ, control 238/800)	Virus added to 1 ml ozone treated sea water. Used for infection trial in day old striped jack larvae.	9	Isolate: SJNNV. C T value: 15 mg*s/l
10 µg purified virus	ozone	30 sec	0,5 mg/ml TRO		20	”Effective” (150/800 larvae survived, antigen ELISA negativ, control 238/800)	Virus added to 1 ml ozone treated sea water. Used for infection trial in day old striped jack larvae.	9	Isolate: SJNNV. C T value: 15 mg*s/l
	ozone	31,5 min	1,6 mg/l TRO	7,9	5	98,0 % reduction	Sea water, sterile filtered.	73	C T value: 3043 mg*s/l, written in article.

Conclusion: Nodavirus is sensitive towards ozone. One papers state that a dose of 12-15 mg*s/l is effective in prohibiting disease in striped jack larvae. The other paper states that when using a dose of 3000 mg*s/l only a 2 log reduction is obtainable.

Bacteria

Aeromons licquefaciens

Concentration	Disinfectant	Contact	Concentration	pH	Temp.	Result	Method	Reference	Comments

pathogen		time	disinfectant						
10^7/ml	ozone	> 6 min	0,1 mg/l	7		app. 4 log reduction	Distilled water, continous ozonation.	16	Read off a graph. C T value: > 36 mg*s/l
10^7/ml	ozone	3 min	0,15 mg/l	7		app. 4 log reduction	Distilled water, continous ozonation.	16	Read off a graph. C T value: 27 mg*s/l
10^7/ml	ozone	2 min	0,2 mg/l	7		app. 4 log reduction	Distilled water, continous ozonation.	16	Read off a graph. C T value: 24 mg*s/l
10^7/ml	ozone	3½ min	0,2 mg/l	7		"inactivated"	Distilled water, continous ozonation.	16	Read off a graph. C T value: 42 mg*s/l
10^8/ml	ozone	1 min	1 mg/l	7		app. 3 log reduction	Distilled water, ozonation stopped when bacteria added.	16	No further reduction during the next 4 min. Read off a graph.

Conclusion: Based on this paper a dose of 30 mg*s/l is capable of a 4 log reduction of *A. licquefaciens.*

Aeromonas salmonicida

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^3 cells/ml	ozone	10 min	0,01 mg/l residual	6,9	20	"inactivated"	Distilled water.. Samples tested after ½, 1, 2, 5, 10, 20 and 30 min.	98, 97	C T value: 6 mg*s/l
10^3 cells/ml	ozone	30 sec	0,04 mg/l residual	6,9	20	"inactivated"	Distilled water.. Samples tested after ½, 1, 2, 5, 10, 20 and 30 min.	98, 97	C T value: 1,2 mg*s/l
10^7 CFU/ml	ozone	1 min	0,065 mg/l/sec	7,8	7	3½ log reduction	Wastewater from aquaculture (15,7 ‰ salinity).	71	Read off a graph.
10^7 CFU/ml	ozone		0,065 mg/l/sec	7,8	7	99,9 % reduction	Wastewater from aquaculture (15,7 ‰ salinity).	71	Reduction rate: 0,12/sec
10^7/ml	ozone	6 min	0,05 mg/l	7		app. 4 log reduction	Distilled water, continous ozonation.	16	Read off a graph. C T value: 18 mg*s/l
10^7 CFU/ml	ozone		0,1 mg/l/sec	7,2	7	99,9 % reduction	PBS	71	Reduction rate: 0,32/sec
Unknown	ozone		0,1 mg/l residual			Not detectable	Test af laboratoriespildevand	10	A. salm is known to be part of the wastewater, but it has not been tested whether it was possible to re-isolate the bacteria before ozonation.
10^7/ml	ozone	1½ min	0,1 mg/l	7		app. 4 log reduction	Distilled water, continous ozonation.	16	Read off a graph. C T value: 9 mg*s/l
10^7/ml	ozone	2½ min	0,1 mg/l	7		"inactivated"	Distilled water, continous ozonation.	16	Read off a graph. C T value: 15 mg*s/l

3 x 10^6 CFU/ml	ozone	180 sec	0,15 mg/l		9-12	4 log reduction	Sea water, salinity 32 ‰, autoclaved.	70	C T value: 27 mg*s/l
3 x 10^6 CFU/ml	ozone	120 sec	0,15 mg/l		9-12	4 log reduction	Brackish water, salinity 15 ‰, autoclaved.	70	Read off a graph. C T value: 18 mg*s/l
3 x 10^6 CFU/ml	ozone	60 sec	0,20 mg/l		9-12	4 log reduction	Lake water, autoclaved.	70	Read off a graph. C T value: 12 mg*s/l
10^8/ml	ozone	1 min	1 mg/l	7		”inactivated”	Distilled water, ozonation stopped when bacteria added.	16	Read off a graph.
10^3 cells/ml	ozone	30 min	20 mg/h/l	8,2	20	”inactivated”	Hard lake water., 120 mg/l $CaCO_3$ Samples tested after ½, 1, 2, 5, 10, 20 and 30 min.	98, 97	
10^3 cells/ml	ozone	5 min	90 mg/h/l	8,2	20	”inactivated”	Hard lake water., 120 mg/l $CaCO_3$ Samples tested after ½, 1, 2, 5, 10, 20 and 30 min.	98, 97	
10^3 cells/ml	ozone	15 min	90 mg/h/l	6,9	20	”inactivated”	Soft lake water., 30 mg/l $CaCO_3$ Samples tested after ½, 1, 2, 5, 10, 20 and 30 min.	98, 97	

Conclusion: *A. salmonicida* is sensitive to treatment with ozone. Based on these figures the dose needed for a 4 log reduction is 10-30 mg*s/l.

Enterococcus seriolicida

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
$10^{6,5}$ cfu/ml	ozone	6 min	0,018 mg/l TRO			Stable	Sea water, sterile filtered.	92	Read off a graph. C T value: 6,48 mg*s/l
$10^{6,5}$ cfu/ml	ozone	4 min	0,096 mg/l TRO			”inactivated”	Sea water, sterile filtered.	92	Read off a graph. C T value: 23,04 mg*s/l
$10^{6,5}$ cfu/ml	ozone	1 min	0,536 mg/l TRO			”inactivated”	Sea water, sterile filtered.	92	Read off a graph. C T value: 32,16 mg*s/l
	ozone	1 min	0,393 mg/l TRO			6 log reduction	Estimated based on Chick-Watson parametre.	92	C T value: 23,58 mg*s/l

Natural flora (heterotrophic bacteria)

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
116 ± 25 cfu/ml	ozone	8,3 min	0,21 mg/l	7,5	14,3	1,35 log reduction	fish farm, recirculation	87	C T value: 105 mg*s/l
4,7 x 10^4 cfu/ml	ozone	1 min	0,5 mg/l TRO			4 log reduction	flowrate 2,0 m^3	56	Natural flora in wastewater from hathing facility.

									C T value: 30 mg*s/l
$10^{5,5}$ cfu/ml	ozone	3 min	0,773 mg/l TRO			”inactivated”	havvand	92	Read off a graph. C T value: 140 mg*s/l
Unknown	ozone		1,0 mg/l residual			Survival		10	
$10^{5,5}$ cfu/ml	ozone	< 1 min	1,933 mg/l TRO			”inactivated”	havvand	92	Read off a graph. C T value: < 120 mg*s/l

Pasteurella piscicida

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^6 cfu/ml	ozone	6 min	0,018 mg/l TRO			Stable	Sea water, sterile filtered.	92	Read off a graph. C T value: 6,5 mg*s/l
	ozone	1 min	0,165 mg/l TRO			6 log reduction	Estimated based on Chick-Watson parametre.	92	C T value: 10 mg*s/l
10^6 cfu/ml	ozone	1 min	0,370 mg/l TRO			”inactivated”	Sea water, sterile filtered.	92	Read off a graph. C T value: 22 mg*s/l

Pseudomonas flourescens

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^7/ml	ozone	4½ min	0,1 mg/l	7		app. 4 log reduction	Distilled water, continous ozonation.	16	Read off a graph. C T value: 27 mg*s/l
10^7/ml	ozone	2½ min	0,15 mg/l	7		app. 4 log reduction	Distilled water, continous ozonation.	16	Read off a graph. C T value: 22,5 mg*s/l
10^7/ml	ozone	2 min	0,2 mg/l	7		app. 4 log reduction	Distilled water, continous ozonation.	16	Read off a graph. C T value: 24 mg*s/l
10^7/ml	ozone	2½ min	0,15 mg/l	7		”inactivated”	Distilled water, continous ozonation.	16	Read off a graph. C T value: 22,5 mg*s/l
108/ml	ozone	1 min	1 mg/l	7		app. 3 log reduction	Distilled water, ozonation stopped when bacteria added.	16	No further reduction during the next 4 min. Read off a graph.

Conclusion: *P. flourescens* is sensitive to treatment with ozone. Based on these figures the dose needed for a 4 log reduction is 20-30 mg*s/l.

Renibacterium salmoninarum

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
unknown	ozone		0,1 mg/l residual			Not detectable	Test af laboratoriespildevand	10	R. salm is known to be part of the wastewater, but it has not been tested whether it was possible to re-isolate the bacteria before ozonation.

Vibrio anguillarum

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^6 cfu/ml	ozone	6 min	0,018 mg/l TRO			Stable	Sea water, sterile filtered.	92	Read off a graph. C T value: 6,5 mg*s/l
	ozone	1 min	0,029 mg/l TRO			6 log reduction	Estimated based on Chick-Watson parametre.	92	C T value: 1,8 mg*s/l
unknown	ozone		0,1 mg/l residual			Not detectable	Test af laboratoriespildevand	10	V. ang is known to be part of the wastewater, but it has not been tested whether it was possible to re-isolate the bacteria before ozonation.
3 x 10^8 CFU/ml	ozone	60 sec	0,15 mg/l		9-12	app. 5 log reduction	Sea water, salinity 32 ‰, autoclaved.	70	Read off a graph. C T value: 9 mg*s/l
3 x 10^8 CFU/ml	ozone	60 sec	0,15 mg/l		9-12	app. 6 log reduction	Brackish water, salinity 15 ‰, autoclaved.	70	Read off a graph. C T value: 9 mg*s/l
10^6 cfu/ml	ozone	1½ min	0,196 mg/l TRO			”inactivated”	Sea water, sterile filtered.	92	Read off a graph. C T value: 18 mg*s/l
3 x 10^8 CFU/ml	ozone	60 sec	0,20 mg/l		9-12	app. 5 log reduction	Lake water, autoclaved.	70	Read off a graph. C T value: 12 mg*s/l

Conclusion: *V. anguillarum* is sensitive to treatment with ozone. Based on these figures the dose needed for a 5-6 log reduction is 10-20 mg*s/l. The results indicate that there is a minimum TRO needed in order for the ozone to inactivate the microorganism. When *V. anguillarum* was treated with

0,018 mg/l TRO (6m5 mg*s/l) for 6 min the titer was stable, whereas treatment using 0,029 mg/l TRO (1,8 mg*s/l) for 1 min the bacteria was inactivated.

Vibrio salmoicida

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
3 x 10^6 CFU/ml	ozone	60 sec	0,20 mg/l		9-12	4 log reduction	Lake water, autoclaved.	70	C T value: 12 mg*s/l
3 x 10^6 CFU/ml	ozone	120 sec	0,15 mg/l		9-12	4 log reduction	Sea water, salinity 32 ‰, autoclaved.	70	C T value: 18 mg*s/l
3 x 10^6 CFU/ml	ozone	180 sec	0,15 mg/l		9-12	4 log reduction	Brackish water, salinity 15 ‰, autoclaved.	70	C T value: 27 mg*s/l

Conclusion: *V. salmonicida* is sensitive to treatment with ozone. Based on these figures the dose needed for a 4 log reduction is 10-30 mg*s/l.

Yersinia ruckeri

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^3 cells/ml	ozone	30 sec	0,01 mg/l residual	6,9	20	”inactivated”	Distilled water.. Samples tested after ½, 1, 2, 5, 10, 20 and 30 min.	98, 97	C T value: 0,3 mg*s/l
10^7/ml	ozone	5½ min	0,05 mg/l	7		app. 4 log reduction	Distilled water, continous ozonation.	16	Read off a graph. C T value: 16,5 mg*s/l
10^7/ml	ozone	4 min	0,1 mg/l	7		app. 4 log reduction	Distilled water, continous ozonation.	16	Read off a graph. C T value: 24 mg*s/l
10^7/ml	ozone	2½ min	0,15 mg/l	7		app. 4 log reduction	Distilled water, continous ozonation.	16	Read off a graph. C T value: 22,5 mg*s/l
3 x 10^9 CFU/ml	ozone	30 sec	0,15 mg/l		9-12	app. 6 log reduction	Sea water, salinity 32 ‰, autoclaved.	70	Read off a graph. C T value: 4,5 mg*s/l
3 x 10^9 CFU/ml	ozone	60 sec	0,15 mg/l		9-12	app. 7 log reduction	Brackish water, salinity 15 ‰, autoclaved.	70	Read off a graph. C T value: 9 mg*s/l
10^7/ml	ozone	1½ min	0,2 mg/l	7		app. 4 log reduction	Distilled water, continous ozonation.	16	Read off a graph. C T value: 18 mg*s/l
10^7/ml	ozone	1½ min	0,2 mg/l	7		”inactivated”	Distilled water, continous ozonation.	16	Read off a graph. C T value: 18 mg*s/l
3 x 10^9 CFU/ml	ozone	60 sec	0,20 mg/l		9-12	app. 7 log reduction	Lake water, autoclaved.	70	Read off a graph. C T value: 12 mg*s/l
10^8/ml	ozone	1 min	1 mg/l	7		app. 3½ log reduction	Distilled water, ozonation stopped when bacteria added.	16	No further reduction during the next 4 min. Read off a graph.
10^3 cells/ml	ozone	25 min	20 mg/h/l	8,2	20	”inactivated”	Hard lake water., 120 mg/l $CaCO_3$ Samples tested after ½,	98, 97	

							1, 2, 5, 10, 20 and 30 min.		
10^3 cells/ml	ozone	25 min	20 mg/h/l	6,9	20	”inactivated”	Soft lake water., 30 mg/l $CaCO_3$ Samples tested after ½, 1, 2, 5, 10, 20 and 30 min.	98, 97	
10^3 cells/ml	ozone	10 min	90 mg/h/l	8,2	20	”inactivated”	Hard lake water., 120 mg/l $CaCO_3$ Samples tested after ½, 1, 2, 5, 10, 20 and 30 min.	98, 97	
10^3 cells/ml	ozone	10 min	90 mg/h/l	6,9	20	”inactivated”	Soft lake water., 30 mg/l $CaCO_3$ Samples tested after ½, 1, 2, 5, 10, 20 and 30 min.	98, 97	

Conclusion: *Y. ruckeri* is sensitive to treatment with ozone. Based on these figures the dose needed for a ≥ 4 log reduction is 10-30 mg*s/l.

Other oxidising disinfectants

Virus

IPNV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
$10^{6,08\text{-}7,41}$ $TCID_{50}$/ml	pentakalium bis (peroxymonsulfate) bis (sulfat)	30 min	0,5 % (v/v)		4	> 4 log reduction	Tested at 0,1, 0,2 and 0,5%. Hard water, high organic load.	49	Contains > 10% available oxygen.
	peracetic acid (divosan forte)	39 days	0,5%		4	Survival	Mixing of virus and fish silage.	91	Type Sp. Titer reduction 2,75. Titer day 39 without Divosan Forte: 5,45, with DF 2,70
	peracetic acid (divosan forte)	16 days	5%		4	> 2,45 reduction	Mixing of virus and fish silage.	91	Type Sp. Titer reduction > 2,45. Titer day 16 without Divosan Forte: 5,45, with DF < 3.00
$10^{6,58\text{-}6,74}$ $TCID_{50}$/ml	peracetic acid/hydrogen peroxid	30 min	0,276% (v/v)		4	> 4 log reduction	Tested at 0,16, 0,276 and 1,6%. Hard water, high organic load.	49	
4 x 10^6 pfu/ml	VirkonS in fish silage treated with formic acid and	30 min	1/100 w/v	?	?	”inactivated”	Mixing of virus and fish silage.	90, 91	Startdosis: 4x10^6, slutdosis <400

	propionic acid								
$10^{5,00\text{-}6,23}$ $TCID_{50}$/ml	Hydrogenperoxid/acetic acid/peracetic acid	30 min	1,0%		4	> 4 log reduction	Sea water. Contact time 15 and 30 min. Koncentration: 0,5, 1,0, 1,5 and 2,0%. 1% BSA + 1% yeast extract.	18	IPNV isolat N1. Kick-Start2: H_20_2 20%, organic acids > 10%, peracetic acid 5%, surfactant, stabilizing and complex inducing agents.

ISAV

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
5,0 log10 ffu/ml	peracetic acid/H_2O_2/acetic acid	5 min	1:80		4	> 4,7 log reduction	Hard water, 342 ppm total hardness, no addition of serum.	89	Proxitane
5,0 log10 ffu/ml	peracetic acid/H_2O_2/acetic acid	5 min	1:80		4	> 4,7 log reduction	Hard water, 342 ppm total hardness, addition of serum.	89	Proxitane

Nodavirus

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
$10^{6,375}$ $TCID_{50}$/ml	Virkon (peroxygen)	5 min	1:125 w/v		15	3,8 log reduction	Distilled water.. Tested after 5, 15 and 30 min.	30	Isolate: sea bass nodavirus
$10^{6,375}$ $TCID_{50}$/ml	Virkon (peroxygen)	30 min	1:125 w/v		15	3,3 log reduction	Distilled water.. Tested after 5, 15 and 30 min.	30	Isolate: sea bass nodavirus
$10^{6,375}$ $TCID_{50}$/ml	Virkon (peroxygen)	5 min	1:500 w/v		15	Stable	Distilled water.. Tested after 5, 15 and 30 min.	30	Isolate: sea bass nodavirus
$10^{6,375}$ $TCID_{50}$/ml	Virkon (peroxygen)	30 min	1:500 w/v		15	3,3 log reduction	Distilled water.. Tested after 5, 15 and 30 min.	30	Isolate: sea bass nodavirus
$10^{6,375}$ $TCID_{50}$/ml	Virkon (peroxygen)	5 min	1:125 w/v		15	2,8 log reduktoin	HBSS+calf serum. Tested after 5, 15 and 30 min.	30	Isolate: sea bass nodavirus
$10^{6,375}$ $TCID_{50}$/ml	Virkon (peroxygen)	30 min	1:125 w/v		15	2,8 log reduktoin	HBSS+calf serum. Tested after 5, 15 and 30 min.	30	Isolate: sea bass nodavirus
$10^{6,375}$ $TCID_{50}$/ml	Virkon (peroxygen)	30 min	1:500 w/v		15	Stable	HBSS+calf serum. Tested after 5, 15 and 30 min.	30	Isolate: sea bass nodavirus

Oncorhynchus masou virus

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	kaliumpermanganat	30 sec	32		0	”inactivated”		35	
	kaliumpermanganat	30 sec	16		15	”inactivated”		35	
	kaliumpermanganat	30 sec	16		25	”inactivated”		35	

Ranavirus

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
1 x 10^7 PFU/ml	VirkonS	1 min	1%		22	”inactivated”		14	Isolate from American bullfrog

Aeromonas salmonicida

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	pentakalium bis (peroxymonsulfate) bis (sulfat)	30 min	0,5 % (w/v)		4	> 5 log reduction	Tested at 0,01, 0,05, 0,1, 0,2, 0,5 and 1%. Hard water, high organic load.	49	Contains > 10% available oxygen.
	peracetic acid/hydrogen peroxid	30 min	0,1% (w/v)		4	> 5 log reduction	Tested at 0,05, 0,1, 0,2, 0,33 and 0,5%. Hard water, high organic load..	49	

Carnobacterium piscicola

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	pentakalium bis (peroxymonsulfate) bis (sulfat)	30 min	0,5 - 1% (w/v)		4	> 5 log reduction	Tested at 0,01, 0,05, 0,1, 0,2, 0,5 and 1%. Hard water, high organic load.	49	Contains > 10% available oxygen.
	peracetic acid/hydrogen peroxid	30 min	0,2 % (v/v)		4	> 5 log reduction	Tested at 0,05, 0,1, 0,2, 0,33 and 0,5%. Hard water, high organic load..	49	

Edwardsiella tarda

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^7 CFU/ml	H_2O_2	20 min	1600 ppm		20	> 5 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.
10^7 CFU/ml	H_2O_2	60 min	1600 ppm		20	> 5 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.

Lactococcus garviae

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	pentakalium bis (peroxymonsulfate) bis (sulfat)	30 min	0,5 - >1% (w/v)		4	> 5 log reduction	Tested at 0,01, 0,05, 0,1, 0,2, 0,5 and 1%. Hard water, high organic load.	49	Contains > 10% available oxygen.
	peracetic acid/hydrogen peroxid	30 min	0,2 - 0,3 % (v/v)		4	> 5 log reduction	Tested at 0,05, 0,1, 0,2, 0,33 and 0,5%. Hard water, high organic load..	49	

Streptococcus sp

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^7 CFU/ml	H_2O_2	20 min	3200 ppm		20	5 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.
10^7 CFU/ml	H_2O_2	60 min	1600 ppm		20	4 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.

Vibrio sp.

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
10^7 CFU/ml	H_2O_2	20 min	1600 ppm		20	4 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm). Growht at 20°C and counting already after 24 hours.	58	The actual concentration of disinfectant probably only half of stated in article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.
10^7 CFU/ml	H_2O_2	60 min	800 ppm		20	4 log reduction	Dilution 1:1 of bacteria and disinfectant (25, 50, 100, 200, 400, 800, 1600, 3200 ppm).	58	The actual concentration of disinfectant probably only half of stated in

							Growht at 20°C and counting already after 24 hours.		article table. Generally speaking the neccessary concentration for disinfection in this paper is much higher than published in other papers.

Yersinia ruckeri

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	pentakalium bis (peroxymonsulfate) bis (sulfat)	30 min	0,5 % (w/v)		4	> 5 log reduction	Tested at 0,01, 0,05, 0,1, 0,2, 0,5 and 1%. Hard water, high organic load.	49	Contains > 10% available oxygen.
	peracetic acid/hydrogen peroxid	30 min	0,2 % (v/v)		4	> 5 log reduction	Tested at 0,05, 0,1, 0,2, 0,33 and 0,5%. Hard water, high organic load..	49	

Parasites

Ichthybodo necator

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	Detarox (20% H_2O_2, 4-5% peracetic acid)					All dead	2 treatments of naturally infected trout.	45	

Ichthyophthirius multifiliis

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	H2O2	10 hours	50 µl/l		20	Stable	In vitro - trophonts	66	
	perotan	10 hours	50 µl/l		20	Stable	In vitro - trophonts	66	perotan: H_2O_2 + acetic acid
	perotan	10 hours	100 µl/l		20	Døde	In vitro - trophonts	66	perotan: H_2O_2 + acetic

									acid
	VirkonS	10 hours	50 µl/l		20	Stable	In vitro - trophonts	66	

Myxosoma cerebralis

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
	H_2O_2	10 min	8,5 %		room temp.	Survival	in vitro. Triactinomyxon spores	96	
	H_2O_2	10 min	10,2%		room temp.	All dead	in vitro. Triactinomyxon spores	96	
	$KMnO_4$	14 days	1%		22	Survival	In vitro - spores	42	

Trichodina jadranica

Concentration pathogen	Disinfectant	Contact time	Concentration disinfectant	pH	Temp.	Result	Method	Reference	Comments
2,4	Detarox (20% H2O2, 4-5% peracetic acid)	24 hours	45 ppm		25	Survival (0,4)	In vivo, ål	75	Catergorization (category/number of parasites on ell): 0/0, 1/1-10, 2/11-100, 3/100-1000, 4/>1000
2,7	H2O2	4 hours	1000 ppm		25	Survival (2,3)	In vivo, ål	75	Catergorization (category/number of parasites on ell): 0/0, 1/1-10, 2/11-100, 3/100-1000, 4/>1000
2,0	kaliumpermanganat	24 hours	20 ppm		25	All dead	In vivo, ål	75	Catergorization (category/number of parasites on ell): 0/0, 1/1-10, 2/11-100, 3/100-1000, 4/>1000
2,6	VirkonPF	24 hours	20 ppm		25	All dead	In vivo, ål	75	Catergorization (category/number of parasites on ell): 0/0, 1/1-10, 2/11-100, 3/100-1000, 4/>1000

Reference List

1. Anon. (2009): Gyrodactylosis (*Gyrodactylus salaris*). *OIE Manual of Diagnostic Tests for Aquatic Animals* .

2. Anon. Disinfectants. Chlorine. http://www.lenntech.com/processes/disinfection/chemical/disinfectants-chlorine.htm. Assessed 17-03-2011.

3. Ahne W (1976): Untersuchungen über die Stabilität des karpfenpathogenen Virusstammes 10/3. *Fisch und Umwelt* **2**: 121-127.

4. Ahne W (1982): Vergleichende Untersuchung über die Stabilität von vier fischpathogenen Viren (VHSV, PFR, SVCV, IPNV). *Zentralblatt für Veterinarmedizin* **29**(6): 457-476.

5. Ahne W (1982): Untersuchungen zur Tenazität der Fischviren. *Fortschritte der Veterinärmedizin* **35**: 305-309.

6. Ahne W and Held C (1980): Untersuchungen über die viruzide Wirkung von Actomar K30* auf fischpathogene Viren. *Zeitschrift für alle Gebiete der Veterinärmedizin* **35**(5): 308-318.

7. Amend DF (1975): Detection and transmission of infectious haematopoietic necrosis virus in rainbow trout. *Journal of Wildlife Diseases* **11**(4): 471-478.

8. Amend DF and Pietsch JP (1972): Virucidal activity of two iodophors to salmonid viruses. *Journal of the Fisheries Research Board of Canada* **29**(1): 61-65.

9. Arimoto M, Sato J, Maruyama K, Mimura G, and Furusawa I (1996): Effect of chemical and physical treatments on the inactivation of striped jack nervous necrosis virus (SJNNV). *Aquaculture* **143**(1): 15-22.

10. Austin B (1983): Effectiveness of ozone for disinfection of laboratory effluent. *FEMS Microbiology Letters* **19**: 211-214.

11. Batts WN, Landolt ML, and Winton JR (1991): Inactivation of infectious hematopoietic necrosis virus by low levels of iodine. *Applied and Environmental Microbiology* **57**(5): 1379-1385.

12. Bootland LM, Dobos P, and Stevenson RMW (1991): The IPNV Carrier State and Demonstration of Vertical Transmission in Experimentally Infected Brook Trout. *Diseases of Aquatic Organisms* **10**(1): 13-21.

13. Brudeseth BE, Skall HF, and Evensen Ø (2008): Differences in virulence of marine and freshwater isolates of viral hemorrhagic septicemia virus in vivo correlate with in vitro ability to infect gill epithelial cells and macrophages of rainbow trout (*Oncorhynchus mykiss*). *Journal of Virology* **82**(21): 10359-10365.

14. Bryan LK, Baldwin CA, Gray MJ, and Miller DL (2009): Efficacy of select disinfectants at inactivating Ranavirus. *Diseases of Aquatic Organisms* **84**(2): 89-94.

15. Bullock G and Stuckey HM (1977): Ultraviolet treatment of water for destruction of five gram negative bacteria pathogenic to fishes. *Journal of the Fisheries Research Board of Canada* **34**(8): 1244-1249.

16. Colberg PJ and Lingg AJ (1978): Effect of ozonation on microbial fish pathogens, ammonia, nitrate, nitrite, and BOD in simulated reuse hatchery water. *Journal of the Fisheries Research Board of Canada* **35**(10): 1290-1296.

17. Desautels D and MacKelvie RM (1975): Practical aspects of survival and destruction of infectious pancreatic necrosis virus. *Journal of the Fisheries Research Board of Canada* **32**: 523-531.

18. Devold M and Nylund A (2002) Disinfecting effect of Kick-Start2/D50 against IPN virus in seawater and in standardized hard water. Protevs AS, Thormølensgate 55, 5008 Bergen, Norway.

19. Dixon PF, Joiner C, and Way K (2007) P-07: First occurrence of viral haemorrhagic septicaemia virus in rainbow trout in the United Kingdom: studies on the virulence of the virus for rainbow trout and brown trout. *13th international conference of the EAFP* **Abstract book**, 144.

20. Dixon PF, Smail DA, Algoet M, Hastings T, Bayley A, Byrne H, Dodge M, Garden A, Joiner C, Roberts E, and Thompson F (2003) Inactivation of fish pathogenic viruses and bacteria for waste disposal purposes: laboratory and field studies. *12th International Conference of the EAFP* [Abstract O-030], 35.

21. Dorson M and Torchy C (1981): The influence of fish age and water temperature on mortalities of rainbow trout, *Salmo gairdneri* Richardson, caused by a European strain of infectious pancreatic necrosis virus. *Journal of Fish Diseases* **4**(3): 213-221.

22. Eggset G and Sommer A-I (1990) SETAX - effect på fiskepatogene bakterier og virus. Uttesting av betingelser for dreping. **R 0404**, 1-11. FORUT (Forskningsstiftelsen ved universitetet i Tromsø).

23. Elliot DG and Amend DF (1978): Efficacy of certain disinfectants against infectious pancreatic necrosis virus. *Journal of Fish Biology* **12**(4): 277-286.

24. Eskildsen UE and Jørgensen PEV (1974): Jodophorer som desinfektionsmiddel i dambrugene. *Ferskvandsfiskeribladet* **72**(12): 1-3.

25. Evelyn TPT, Ketcheson JE, and Prosperi-Porta L (1984): Further evidence for the presence of *Renibacterium salmoninarum* in salmonid eggs and for the failure of povidone-iodine to reduce the intra-ovum infection rate in water-hardened eggs. *Journal of Fish Diseases* **7**(3): 173-182.

26. Evensen Ø, Meier W, Wahli T, Olesen NJ, Jørgensen PEV, and Håstein T (1994): Comparison of immunohistochemistry and virus cultivation for detection of viral haemorrhagic septicaemia virus in experimentally infected rainbow trout *Oncorhynchus mykiss*. *Diseases of Aquatic Organisms* **20**(2): 101-109.

27. Falk K, Namork E, Rimstad E, Mjaaland S, and Dannevig BH (1997): Characterization of infectious salmon anemia virus, an orthomyxo-like virus isolated from Atlantic salmon (Salmo salar L.). *The Journal of Virology* **71**(12): 9016-9023.

28. Fløgstad H, Torgersen Y, Schei I, and Røttereng PJ (1991) Desinfeksjon af blodvann fra fiskeslakterier. **STF60 A91096**, 101 pp. Trondheim, SINTEF.

29. Fregeneda-Grandes JM, Skall HF, and Olesen NJ (2009): Antibody response of rainbow trout with single or double infections involving viral haemorrhagic septicaemia virus and infectious haematopoietic necrosis virus. *Diseases of Aquatic Organisms* **83**(1): 23-29.

30. Frerichs GN, Tweedie A, Starkey WG, and Richards RH (2000): Temperature, pH and electrolyte sensitivity, and heat, UV and disinfectant inactivation of sea bass (Dicentrarchus labrax) neuropathy nodavirus. *Aquaculture* **185**(1-2): 13-24.

31. Goldes SA and MEAD SL (1995): Efficacy of Iodophor Disinfection against Egg Surface-Associated Infectious Hematopoietic Necrosis Virus. *The Progressive Fish-Culturist* **57**(1): 26-29.

32. Gosting LH and Gould RW (1981): Thermal inactivation of infectious hematopoietic necrosis and infectious pancreatic necrosis viruses. *Applied and Environmental Microbiology* **41**(4): 1081-1082.

33. Graham DA, Staples C, Wilson CJ, Jewhurst H, Cherry K, Gordon A, and Rowley HM (2007): Biophysical properties of salmonid alphaviruses: influence of temperature and pH on virus survival. *Journal of Fish Diseases* **30**(9): 533-543.

34. Gratzek JB, Gilbert JP, Lohr AL, Shotts Jr EB, and Brown J (1983): Ultraviolet light control of *Ichthyophthirius multifiliis* Fouquet in a closed fish culture recirculation system. *Journal of Fish Diseases* **6**(2): 145-153.

35. Hatori S, Motonishi A, Nishizawa T, and Yoshimizu M (2003): Virucidal effect of disinfectants against *Oncorhynchus masou* virus (OMV). *Fish Pathology - Gyobyo Kenkyu* **38**(4): 185-187.

36. Hedrick RP, Petri B, McDowell TS, Mukkatira K, and Sealey LJ (2007): Evaluation of a range of doses of ultraviolet irradiation to inactivate waterborne actinospore stages of *Myxobolus cerebralis*. *Diseases of Aquatic Organisms* **74**(2): 113-118.

37. Hedrick RP, McDowell TS, Mukkatira K, MacConnell E, and Petri B (2008): Effects of freezing, drying, ultraviolet irradiation, chlorine, and quaternary ammonium treatments on the infectivity of myxospores of *Myxobolus cerebralis* for *Tubifex tubifex*. *Journal of Aquatic Animal Health* **20**(2): 116-125.

38. Hershberger PK, Kocan RM, Elder NE, Meyers TR, and Winton JR (1999): Epizootiology of viral hemorrhagic septicemia virus in Pacific herring from the spawn-on-kelp fishery in Prince William Sound, Alaska, USA. *Diseases of Aquatic Organisms* **37**(1): 23-31.

39. Hirvelä-Koski V (2004): Renibacterium salmoninarum: effect of hypochlorite treatment, and survival in water. *Diseases of Aquatic Organisms* **59**(1): 27-33.

40. Hoffman GL (1974): Disinfection of Contaminated Water by Ultraviolet Irradiation, with Emphasis on Whirling Disease (Myxosoma cerebralis) and Its Effect on Fish. *Transactions of the American Fisheries Society* **103**: 541-550.

41. Hoffman GL (1975): Whirling disease (Myxosoma cerebralis): control with ultraviolet irradiation and effect on fish. *Journal of Wildlife Diseases* **11**(4): 505-507.

42. Hoffman GL, Sr. and Hoffman GL, Jr. (1972): Studies on the control of whirling disease (*Myxosoma cerebralis*).: I. The effects of chemicals on spores in vitro, and of calcium oxide as a disinfectant in simulated ponds. *Journal of Wildlife Diseases* **8**(1): 49-53.

43. Hoffman GL and Markiw ME (1977): Control of whirling disease (*Myxosoma cerebralis*): use of methylene blue staining as a possible indicator of effect of heat on spores. *Journal of Fish Biology* **10**(2): 181-183.

44. Hoffman GL and O'Grodnick JJ (1977): Control of whirling disease (*Myxosoma cerebralis*): effects of drying, and disinfection with hydrated lime or chlorine. *Journal of Fish Biology* **10**(2): 175-179.

45. Holten K, Skjelstad B, Aunsmo A, and Skjelstad HR (2003): Effect of Detarox(R)AP against infection with Ichthyobodo necator. *Norsk Veterinærtidsskrift* **115**(11): 719-723.

46. Huber P, Petri B, Allen S, and Lumsden JS (2010): Viral haemorrhagic septicaemia virus IVb inactivation by ultraviolet light, and storage viability at 4 and -20 °C. *Journal of Fish Diseases* **33**(4): 377-380.

47. Husby A (2003) Hygieniserende effekt av Gellyfeed-prosessen. **4502/107**, 15 pp. Trondheim, Stiftelsen Rubin.

48. Jacobsen P, Liltved H, and Efraimsen H (1989): Disinfection of effluent from fish slaughteries. *Aquacultural Engineering* **8**(3): 209-216.

49. Jeffreys DW, Joiner CL, Bagwell NJ, Reese RA, Husby A, and Dixon PF (2009): Development of bactericidal and virucidal testing standards for aquaculture disinfectants. *Aquaculture* **286**(3-4): 190-197.

50. Jørgensen PEV and Olesen NJ: Indflydelse af vandtemperatur og smitteintensitet på sygdommens forløb, in Jørgensen PEV and Olesen NJ (Eds): *Bekæmpelse af egtvedsyge (VHS) hos regnbueørreder*, Fællesudvalget for det danske ørrederhverv, 1983, pp 16-21.
Ref Type: Book Chapter

51. Jørgensen PEV: Untersuchungen über das Egtved-virus: Seine Stabilität und Identifizierung, in Liebmann H (Ed): *Die hämorrhagische Virusseptikämie (HVS) der Forellen*. München und Wien, 1970, pp 60-71.
Ref Type: Book Chapter

52. Jørgensen PEV (1973): Inactivation of IPN and Egtved virus. *Rivista Italiana di Piscicoltura e Ittiopatologia* **4**(VIII): 107-108.

53. Jorquera MA, Valencia G, Eguchi M, Katayose M, and Riquelme C (2002): Disinfection of seawater for hatchery aquaculture systems using electrolytic water treatment. *Aquaculture* **207**(3-4): 213-224.

54. Kasai H, Ishikawa A, Hori Y, Watanabe K, and Yoshimizu M (2000): Disinfectant effects of electrolyzed salt water on fish pathogenic bacteria and viruses. *Nippon Suisan Gakkaishi* **66**(6): 1020-1025.

55. Kasai H, Muto Y, and Yoshimizu M (2005): Virucidal effets of ultraviolet, heat treatment and disinfectants against koi herpesvirus (KHV). *Fish Pathology - Gyobyo Kenkyu* **40**(3): 137-138.

56. Kasai H, Watanabe K, and Yoshimizu M (2001): Bactericidal effect of continuous flow electrolyzer on hatchery waste-seawater. *Nippon Suisan Gakkaishi* **67**(2): 222-225.

57. Kasai H, Watanabe K, and Yoshimizu M (2001): Disinfectant effects of hypochlorite produced by batch electrolytic system on fish pathogenic bacteria and virus. *Suisan Zoshoku* **49**(2): 237-241.

58. Kim S-R, Park K-H, Kim D, Jung S-J, Kang S-Y, and Oh M-J (2008): Antimicrobial effects of chemical disinfectants on fish pathogenic bacteria. *Food Science and Biotechnology* **17**(5): 971-975.

59. Kimura T, Yoshimizu M, Tajima K, and Ezura Y (1980): Disinfection of hatchery water supply by ultraviolet (U. V.) irradiation - II. U.V. susceptibility of some fish pathogenic fungi. *Fish Pathology - Gyobyo Kenkyu* **14**(3): 133-137.

60. Kimura T, Yoshimizu M, Tajima K, Ezura Y, and Sakai M (1976): Disinfection of hatchery water supply by UV irradiation part I. Susceptibility of some fish pathogenic bacterium and microorganisms inhabiting pond waters. *Nippon Suisan Gakkaishi* **42**(2): 207-211.

61. Kiryu I, Sakai T, Kurita J, and Iida T (2007): Virucidal effect of disinfectants on spring viremia of carp virus. *Fish Pathology - Gyobyo Kenkyu* **42**(2): 111-113.

62. Kocan R, Bradley M, Elder N, Meyers TR, Batts WN, and Winton JR (1997): North American strain of viral hemorrhagic septicemia virus is highly pathogenic for laboratory-reared pacific herring. *Journal of Aquatic Animal Health* **9**(4): 279-290.

63. Kocan RM, Hershberger PK, Elder NE, and Winton JR (2001): Epidemiology of viral hemorrhagic septicemia among juvenile pacific herring and Pacific sand lances in Puget Sound, Washington. *Journal of Aquatic Animal Health* **13**(2): 77-85.

64. Kölbl O (1975): Neue Erkenntnisse über dei Bauchwassersucht bei Karpfen. *Österreichs Fischerei* **5/6**: 69-72.

65. Kurita J, Iida Y, Nakajima K, and Inouye K (2002): Virucidal effects of various disinfectants on viral hemorrhagic septicemia virus (VHSV) isolated from Japanese flounder. *Fish Pathology - Gyobyo Kenkyu* **37**(4): 175-181.

66. Lahnsteiner F and Weismann T (2007): Treatment of Ichthyophthiriasis in Rainbow Trout and Common Carp with Common and Alternative Therapeutics. *Journal of Aquatic Animal Health* **19**(3): 186-194.

67. Langdon JS (1989): Experimental transmission and pathogenicity of epizootic haematopoietic necrosis virus (EHNV) in redfin perch, Perca fluviatilis L., and 11 other teleosts. *Journal of Fish Diseases* **12**(4): 295-310.

68. Liltved H (2000) Disinfection of water in aquaculture: factores influencing the physical and chemical inactivation of microorganisms. The Norwegian College of Fishery Scinece, University of Tromsø, Norway.

69. Liltved H and Cripps SJ (1999): Removal of particle-associated bacteria by prefiltration and ultraviolet irradiation. *Aquaculture Research* **30**(6): 445-450.

70. Liltved H, Hektoen H, and Efraimsen H (1995): Inactivation of bacterial and viral fish pathogens by ozonation or UV irradiation in water of different salinity. *Aquacultural Engineering* **14**(2): 107-122.

71. Liltved H and Landfald B (1995): Use of alternative disinfectants, individually and in combination, in aquacultural wastewater treatment. *Aquaculture Research* **26**(8): 567-576.

72. Liltved H and Landfald B (1996): Influence of liquid holding recovery and photoreactivation on survival of ultraviolet-irradiated fish pathogenic bacteria. *Water Research* **30**(5): 1109-1114.

73. Liltved H, Vogelsang C, Modahl I, and Dannevig BH (2006): High resistance of fish pathogenic viruses to UV irradiation and ozonated seawater. *Aquacultural Engineering* **34**(2): 72-82.

74. MacKelvie RM and Desautels D (1975): Fish viruses - suvival and inactivation of infectious pancreatic necrosis virus. *Journal of the Fisheries Research Board of Canada* **32**(8): 1267-1273.

75. Madsen HCK, Buchmann K, and Mellergaard S (2000): Treatment of trichodiniasis in eel (*Anguilla anguilla*) reared in recirculation systems in Denmark: alternatives to formaldehyde. *Aquaculture* **186**(3-4): 221-231.

76. Maisse G, Dorson M, and Torchy C (1980): Inactivation de deux virus pathogénes pour les salmonides (virus de la nécrose Pancréatique infectieuse et de la septicémie hémorragique virale) par les rayons ultraviolets. *Bulletin Français de Pisciculture* **278**(3): 34-40.

77. Mulcahy D, Jenes CK, and Pascho R (1984): Appearance and quantification of infectious hematopoietic necrosis virus in female sockeye salmon (*Oncorhynchus nerka*) during their spawning migration. *Archives of Virology* **80**(2-3): 171-181.

78. Mulcahy D, Pascho RJ, and Jenes CK (1983): Detection of infectious haematopoietic necrosis virus in river water and demonstration of waterborne transmission. *Journal of Fish Diseases* **6**(4): 321-330.

79. Nelson RT, McLoughlin MF, Rowley HM, Platten MA, and McCormick JI (1995): Isolation of a toga-like virus from farmed Atlantic salmon Salmo salar with pancreas disease. *Diseases of Aquatic Organisms* **22**(1): 25-32.

80. Olstad K, Cable J, Robertsen G, and Bakke TA (2006): Unpredicted transmission strategy of *Gyrodactylus salaris* (Monogenea: Gyrodactylidae): survival ind infectivity of parasites on dead hosts. *Parasitology* **133**: 33-41.

81. Øye AK and Rimstad E (2001): Inactivation of infectious salmon anaemia virus, viral haemorrhagic septicaemia virus and infectious pancreatic necrosis virus in water using UVC irradiation. *Diseases of Aquatic Organisms* **48**(1): 1-5.

82. Pascho RJ, Landolt ML, and Ongerth JE (1995): Inactivation of Renibacterium salmoninarum by free chlorine. *Aquaculture* **131**(3-4): 165-175.

83. Pietsch JP, Amend DF, and Miller CM (1977): Survival of infectious haematopoietic necrosis virus held under various environmental conditions. *Journal of the Fisheries Research Board of Canada* **34**(9): 1360-1364.

84. Ross AJ and Smith CA (1972): Effect of two iodophors on bacterial and fungal fish pathogens. *Journal of the Fisheries Research Board of Canada* **29**(9): 1359-1361.

85. Sako H, Ishida N, Maeno Y, and Sorimachi M (1988): Bactericidal activities of five disinfectants on *Aeromonas salmonicida*, *Vibrio anguillarum* and *V. ordalii*. *Fish Pathology - Gyobyo Kenkyu* **23**(4): 219-229.

86. Sako H and Sorimachi M (1985): Susceptibility of fish pathogenic viruses, bacteria and fungus to ultraviolet irradiation and the disinfectant effect of UV-ozone water sterilizer on the pathogens in water. *Bulletin of the National Research Institute for Aquaculture* **8**: 51-58.

87. Sharrer MJ and Summerfelt ST (2007): Ozonation followed by ultraviolet irradiation provides effective bacteria inactivation in a freshwater recirculating system. *Aquacultural Engineering* **37**(2): 180-191.

88. Sharrer MJ, Summerfelt ST, Bullock GL, Gleason LE, and Taeuber J (2005): Inactivation of bacteria using ultraviolet irradiation in a recirculating salmonid culture system. *Aquacultural Engineering* **33**(2): 135-149.

89. Smail DA, Grant R, Simpson D, Bain N, and Hastings TS (2004): Disinfectants against cultured Infectious Salmon Anaemia (ISA) virus: the virucidal effect of three iodophors, chloramine T, chlorine dioxide and peracetic acid/hydrogen peroxide/acetic acid mixture. *Aquaculture* **240**(1-4): 29-38.

90. Smail DA, Huntly PJ, and Munro ALS (1990) Fate of four fish pathogens after exposure to an ensiling mixture containing fish farm mortalities. **CM 1990/F:50 Mariculture Committee**. International Council for the Exploration of the Sea.

91. Smail DA, Huntly PJ, and Munro ALS (1993): Fate of four fish pathogens after exposure to fish silage containing fish farm mortalities and conditions for the inactivation of infectious pancreatic necrosis virus. *Aquaculture* **113**(3): 173-181.

92. Sugita H, Asai T, Hayashi K, Mitsuya T, Amanuma K, Maruyama C, and Deguchi Y (1992): Application of ozone disinfection to remove *Enterococcus seriolicida*, *Pasteurella piscicida*, and *Vibrio anguillarum* from seawater. *Applied and Environmental Microbiology* **58**(12): 4072-4075.

93. Tabandeh MR and Akhlaghi M (2007): Efficacy of conventional disinfectants on isolated Streptococcus iniae from diseased rainbow trout in laboratory and culture tank conditions. *Iranian Scientific Fisheries Journal* **16**(3): 29-38.

94. Torgersen Y (1998) Annex 5 Physical and chemical inactivation o fthe infectious salmon anaemia (ISA) virus. Håstein, T. Workshop on ISA. *Workshop on ISA.New Brunswick, St Andrews* , 44-53.

95. Tuttle-Lau MT, Phillips KA, and Gaikowski MP (2010) Evaluation of the efficacy of iodophor disinfection of walleye and northern pike eggs to eliminate viral hemorrhagic septicemia virus. *U.S.Geological Survey Fact Sheet* **2009-3107**, 1-4.

96. Wagner EJ, Smith M, Arndt R, and Roberts DW (2003): Physical and chemical effects on viability of the *Myxobolus cerebralis* triactinomyxon. *Diseases of Aquatic Organisms* **53**(2): 133-142.

97. Wedemeyer GA and Nelson NC (1977): Survival of two bacterial fish pathogens (*Aeromonas salmonicida* and the enteric redmouth bacterium) in ozonated, chlorinated, and untreated waters. *Journal of the Fisheries Research Board of Canada* **34**: 429-432.

98. Wedemeyer GA, Nelson NC, and Yasutake WT (1979): Potentials and limits for the use of ozone as a fish disease control agent. *Science and Engineering* **1**: 295-318.

99. Wedemeyer GA, Nelson NC, and Smith CA (1978): Survival of the salmonid viruses infectious haematopoietic necrosis (IHNV) and infectious pancreatic necrosis (IPNV) in ozonated, chlorinated, and untreated waters. *Journal of the Fisheries Research Board of Canada* **35**(6): 875-879.

100. Whipple MJ and Rohovec JS (1994): The effect of heat and low pH on selected viral and bacterial fish pathogens. *Aquaculture* **123**(3-4): 179-189.

101. Wolf K: Infectious pancreatic necrosis*, Fish viruses and fish viral diseases*, 1 ed. United States of America, Comstock Publishing Associates, 1988, pp 115-157.
Ref Type: Book Chapter

102. Yoshimizu M, Yoshinaka T, Hatori S, and Kasai H (2005): Survivability of fish pathogenic viruses in environmental water, and inactivation of fish disease. *Bulletin of Fisheries Research Agency* **Suppl. 2**: 47-54.

103. Yoshimizu M, Takizawa H, and Kimura T (1986): U.V. susceptibility of some fish pathogenic viruses. *Fish Pathology - Gyobyo Kenkyu* **21**(1): 47-52.

104. Yoshimizu M, Takizawa H, Sami M *et al.*: Disinfectant effects of ultraviolet erradiation on fish pathogens in hatchery water supply*,* in Hirano R and Hanyo H (Eds): *The Second Asian Fisheries Forum*. Manila, Philippines, Asian Fisheries Society, 1990, pp 643-646.
Ref Type: Book Chapter