14

HATCHERY DISINFECTION AND DISPOSAL OF INFECTED STOCKS

J. G. HNATH
Michigan Department of Natural Resources
Fisheries Section
Mattawan, MI

O'Donnell (1944) wrote: "Within recent years, with the increase in production of legal trout at a comparatively high cost, the necessity of preventing and controlling fish diseases has assumed major importance. Our knowledge of the methods of preventing and eliminating disease has increased considerably but there is still much to be learned. Some diseases are controlled quite easily, while others, such as furunculosis, caused by Bacterium ***salmonicida*** ***(Aeromonas*** salmonicida) has failed to yield to experimental treatments. The only known method of absolute control of B. salmonicida involves complete elimination of all fish from a hatchery, through disinfection of the hatchery, the rebuilding of a new stock of disease-free fish, and the maintenance of disease-free conditions throughout future operations. Unfortunately, however, this method is practical only at those hatcheries having a controlled water supply, that is, originating in wells or springs that can be kept free of fish. The disinfection of hatcheries utilizing river water, or other public waters, would be inadvisable because of the constant danger of new infections from fish in these waters".

This introduction to a paper written nearly 40 years ago provides a critical reminder to us that while our "knowledge?" may be increasing, we are slow to put what we know into practice. Our most current information confirms what O'Donnell said in 1944, namely that the control of certain fish diseases can be achieved only through disinfection and eradication of contaminated stocks. The purpose of this paper is to provide guidelines for hatchery disinfection.

WHY Disinfect

Disinfection should be done whenever it becomes desirable to rid a facility of an infectious agent because of production problems that agent has caused, or because of the implications of rearing and shipping infected fish. The time to disinfect is whenever the facility can be taken out of production because effective disinfection will kill fish. Whenever a particularly serious disease problem occurs at a facility, it may be necesssary to destroy all stocks of fish in order to prevent further spread of the infectious agent — see "Disposal of Infected Stocks".

CONSTRAINTS ON DISINFECTION

Under some circumstances, disinfection is not practical. One such situation occurs when there are infected fish, which serve as reservoirs of infection, that cannot be removed from the hatchery water supply. In this case, it may be necessary to install special equipment and effectively treat all of the incoming water to remove the pathogens before a disinfection operation is practical. In other situations, it may be appropriate to drill wells or to seek alternative pathogen-free water sources to avoid contaminated water supplies entirely.

Disinfection may be impractical if economic consequences of the disease are less than the costs of disinfection, or where the probability of reinfection from nearby waters or fish farms is unavoidably high. On the other hand, when serious diseases are encountered a major disinfection operation may be called for. The situation that has occurred in Denmark (Jorgensen 1977) is a good example of how effective disease control can be achieved through disinfection and eradication. Such programs insure that a fish farm which undergoes disinfection is relatively sure that it will not be recontaminated by its neighbors. In Denmark, viral hemorrhagic septicemia (VHS) had spread to the majority of the 540 Danish trout farms by 1974. Through a rigorous disinfection program, approximately 380 of these farms had been registered as free of VHS by 1977 Uorgensen 1977).

DISPOSAL AND/OR UTILIZATION OF INFECTED STOCKS

In any situation where the disinfection of facilities is contemplated, ways should be explored for the maximum utilization of the fish stocks on hand in ways that do not aggravate the disease problem or contribute to its spread to non-enzootic areas. For a commercial operator, first consideration should be given to controlled marketing in ways which do not exacerbate the disease problem. Diseased live fish should obviously not be sold to another fish farmer who intends to raise them. However, market-sized fish may be sold commercially under certain circumstances (check with regulatory agencies on this aspect). For example, it has recently been demonstrated (Wolf and Markiw 1982) that hot smoking of fish infected with whirling disease will effectively destroy infectivity of the parasite. It may even be possible to utilize small fish in a pet food industry if the fish product would be pasteurized during processing State and federal hatcheries may be able to utilize infected stocks in a controlled stocking program in which infected fish could be planted in a known enzootic area where there would be little danger of spreading the disease to other fish or outside of the enzootic area.

The final option when direct utilization of the fish stocks is not applicable, requires destruction of the fish stocks through burial or incineration. Either method will eliminate the pathogens.

Burial is the least expensive, and the only practical method for large amounts of fish. For this method of disposal, a site should be selected that is remote from fish cultural areas and without drainage into natural waters. Local regulatory agencies often have special requirements which should be observed. A pit should be dug large enough to accommodate all the fish to be disposed of and provide for several feet of clean fill over the top. The fish should be buried in the pit over a layer of quicklime (Hoffman 1976) and each layer of fish should have another layer of quicklime spread over it. Since there are no apparent literature references to this type of disposal the relative amounts of quicklime to fish must be left to the judgement of the person supervising the disposal operation. In Michigan, it was found that a layer of clean uncontaminated soil 0.7 m deep over carcasses infected with whirling disease effectively prevented reinfection of fish at a disinfected hatchery.

COOKING

Thorough cooking followed by any utilization is satisfactory and acceptable (G. Hoffman, USFWS, Stuttgart, AR, Personal Communication).

INCINERATION

Since heat effectively destroys all fish pathogens, any incineration which reduces the carcasses to ash is adequate. It should be kept in mind, though, that fish carcasses contain much water, and an incinerator to be used for this purpose must be capable of handling the water content involved.

STEAM STERILIZATION

Pathogens in small amounts of fish could effectively be destroyed by steam sterilization under pressure (autoclaving) at 6.8 kg steam pressure at 121°C for 20 min.

PREPARATION FOR CHEMICAL DISINFECTION

Note: The following material has been adapted from U.S. Fish and Wildlife Service and Great Lakes Fishery Commission recommendations for the disinfection of fish cultural facilities.

SEQUENCE OF EVENTS

1. A preliminary planning conference should be convened at the hatchery for the purpose of relating planning to the actual physical facilities and situation.
2. Needed chemicals and materials should be obtained.
3. Cleaning and w-disinfection preparation at the hatchery should be done several weeks prior to the actual disinfection.

4. A final planning and preparedness conference should be held and attended by participants at the first meeting.
5. Final acquisition of chemicals, supplies, and equipment should be completed.
6. The hatchery disinfection should be carried out.
7. Success of the process must be reviewed and evaluated. Before starting actual disinfection of a hatchery, a number of preliminary steps are necessary. It is important that hatchery blueprints be carefully reviewed at this time to see that all unexposed piping (supply and drains) are included for disinfection at appropriate times. All raceways and troughs must be measured at full capacity and calculations made for the quantity of chlorine needed to produce a concentration of 200 ppm (available chlorine). Additional chlorine will be needed for preparation of the 1600 ppm spray solutions to be used on the interior of hatchery buildings and on walkways, etc. around raceways. A 200 ppm level of chlorine is produced by adding285 gm of dry HTH powder (70% active) to 1,000 I of water.

SAFETY PRECAUTIONS

Although chlorine applied as a dry chemical according to label specifications should not be harmful to the applicators, it can pose a human health hazard if misused. Always follow manufacturer's precautions as indicated on the label. A sample label from Olii HTH Chlorine Granular is given in Table 1.

If the chlorine treatment solution will enter fish-bearing waters upon leaving the hatchery, neutralization will be necessary to inactivate the chlorine. Commercial sodium thiosulfate (Hypo) is used as a neutralizer; 1.5 gm is required to neutralize each liter of 200 ppm chlorine solution with a safety factor of 4. The amount of thiosolfate needed should be calculated and ordered to be on hand with the supplies of chlorine and Hypo for the actual disinfection.

Table 1. Label Description from Olin HTH Chlorine Granular

AVAILABLE CHLORINE	65%
Active Ingredient: Calcium hypochlorite	65%
Inert Ingredients	35%

APPLICATION OF OLIN HTH DRY CHLORINATOR GRANULAR IN FISH HATCHERY FACILITIES AND FISH PONDS

1. Sanitizing Fish Tanks, Raceways, and Utensils

(a) Clean thoroughly with soap and water to remove scum and dirt. Then rinse with clean water.
(b) Apply Olii HTH Dry Chlorinator Granular to tank and raceways (filled with water) to provide 200 ppm available chlorine (1 ounce HTH Granular for every 25 gallons of water will orovide approximately 200 ppm).
(c) Allow one-hour of exposure to this con&ration of HTH solution and then thoroughly rinse with clean water. NOTE: For utensils such as nets. after

thoroughly cleaning, allow to remain in an HTH solution (200 ppm available chlorine) for one hour, and then thoroughly rinse with clean water.

2. Fish Pond

To control growth of algae and kill many bacteria in fish ponds. (NOTE: this also kills all remaining fish).

(a) Remove all fish from fish pond.

(b) Superchlorinate to establish a chlorine residual of 5-10 ppm (1 ounce per 500-100 gallons of water). Allow 5 minutes for the Olin HTH Dry Chlorinator to disperse and then test the chlorine residual with a pool test kit. Repeat this dosage as needed to maintain the 5-10 ppm residual for 12 to 24 hours. Afterwards allow the pond to stand until the chlorine residual drops to 0 (usually 1-2 days). Assure yourself that there is no chlorine residual in the pond before fish are allowed in the fish pond.

DANGER! FATAL OR HARMFUL IF SWALLOWED, MAY PRODUCE SEVERE CHEMCIAL BURNS. DO NOT ALLOW CONTACT WITH EYES, SKIN, MUCOUS MEMBRANES, OR CLOTHING. STRONG OXIDIZER, CONTACT WITH OTHER MATERIAL MAY CAUSE FIRE OR EXPLOSION.

Keep from contact with clothing and other combustible materials. Remove and wash contaminated clothing promptly. While HTH by itself is not a combustible material, it must not be mixed or contaminated with any foreign materials such as household products, Olin pool stablizer, soap products, paint products, garbage, solvents, acids, pool chemicals, vinegar, beverages, oils, pine oil, dirty rags, etc. Contamination or mixing with these types of chemicals and products may result in fire or explosion and the fire can be of great intensity. Prevent any burning material such as a lighted cirarette from falling into product. Drench fires with water. Flush spilled **product** by flushing with large amounts of water. Keep in a cool dry place in original container. Always replace lid. Wash empty container thoroughly with water and discard. Do not reuse empty container.

FIRST AID: External — flood skin or eyes with plenty of water for 15 minutes. If irritation to skin persists, get medical attention. For eyes-call a physician immediately. Internal — drink milk, gelatin solution, or egg whites. Follow with milk of magnesia or vegetable oil. Call physician immediately.

HTH is toxic to fish. Keep out of lakes, streams, or ponds. Do not contaminate water by cleaning of equipment, or disposal of waste. Apply **this** product only as specified on the label.

OLIN CORPORATION
120 Long Ridge Road
Stamford, Connecticut 06904

Each member of the disinfection team should be provided with complete rubber outfits, incuding boots, coat, hat, and gloves. The outer garments must be removed and left on the hatchery grounds at the end of each day's work if the crew does not remain until the disinfection has been completed, and should be thoroughly disinfected before removal.

The following equipment should be obtained by the hatchery manager for a disinfection operation:

1 high pressure spray unit (car washing sprayer)
2 100 ft. lengths of hose for sprayer
— pairs of rubber boots
pairs of wet weather gear (coats, hats, pants)
1 pickup truck
2 wire brushes
2 heavy brooms
2 pails, 12-16 quart
3 large sponges
— respirators (gas masks)
2 pairs of safety goggles
3 heavy duty extension cords
electric frypans
— all other equipment and supplies as needed

Prior to disinfection, all loose equipment should be throughly scrubbed with warm soapy water or 600 ppm Hyamine, if possible, and left near a raceway for later disinfection. Alternatively, such items may be reserved after cleaning for fumigation with paraformaldehyde gas. Such equipment includes buckets, pans, small troughs, tubs, screens, and seine nets. Hatching and rearing troughs should be scrubbed clean. Side walls of all raceways should be scrubbed and the bottoms raked. Particular attention should be given to removing any left-over fish food, pond scum, or other organic detritus.

Any building to be fumigated with formaldehyde gas should be measured and the entire volume of space therein calculated. Paraformaldehyde powder should than be ordered at the rate of 10.0 gm per cubic meter of space.

After disposing of all fish, hatchery personnel should clean, drain, and dry all rearing facilities. During the cleaning process, the person in charge should tour the entire hatchery facility to plan and schedule disinfection work to make sure that all facilities are in the proper state of preparation for effective disinfection.

During the cleaning process, all fish rearing facilities should be scrubbed clean of algae, dirt, and organic wastes. Concrete tanks, incubators, troughs, raceways, water supply headboxes and tailraces should be thoroughly cleaned. Earthen ponds must be drained and the entire area cleaned of olant growth and debris.

When cleaning operations have been completed, all equipment and facilities should be readied for disinfection. All interior surfaces of hatchery buildings should be saturated with an effective disinfectant solution. A solution of 1600

ppm chlorine or 200 ppm of Roccal, Hyamine or other suitable disinfectants should be applied with a power sprayer. A backpack spray pump can be used for small areas. Sufficient solution should be applied so that it will penetrate every crevice and destroy infectious organisms. All concrete, metal, plastic, fiberglass, or wooden rearing facilities and all fish cultural equipment including nets, screens, and distribution equipment should receive similar disinfection.

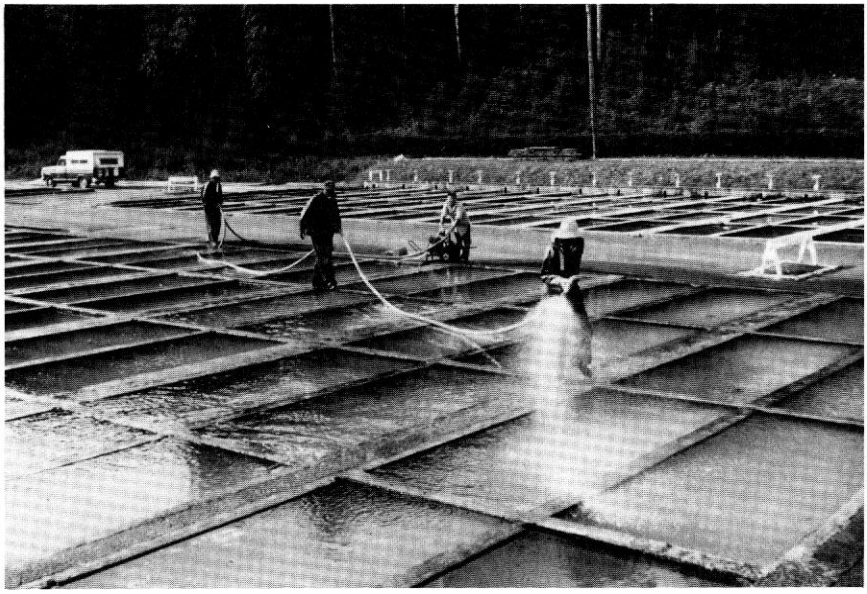
When dealing with whirling disease, drained (but wet) earthen ponds should be disinfected by applying slaked lime at a rate of about one ton of lime per acre of wet pond bottom. As earthen ponds are the most dangerous source of whirling disease spores, special attention must be given to these rearing units. Several treatments may be required to thoroughly disinfect earthen ponds because most chemicals are not effective in mud.

Drying and plowing of the pond bottom is advisable between successive treatments. On successive applications, the lime should be worked into the earth of the pond bottom, to a depth of 25 cm (10 in). If the earth is dry, the pond should be soaked with water to activate the lime and gradually drained after about 2 d, then allowed to dry in the sun for at least 30 d.

CHEMICAL DISINFECTION PROCEDURES

It is desirable that the actual disinfection be carried out in such a manner that the full strength of chlorine (200 ppm) will be maintained for at least 1 h and that a concentration of 100 ppm or more be maintained for several hours. Chlorine dissipates rapidly and is inactivated by organic matter. Most hatcheries are so large that complete disinfection cannot be completed in one day. As a consequence, treatment must be carried out in areas or blocks starting at the upper end of the hatchery. Before adding chlorine, all ponds, raceways, and troughs must be drained completely. Additional splash-boards should be provided if needed to cause the water level to rise to the top of each section. Rearing troughs should be plugged so that they will over-flow. After the initial draining, the splash-boards should be installed and the water allowed to rise until the particular unit is half full. Half the calculated amount of the concentrated chlorine to be added is then emptied into the raceway, and stirred thoroughly. When the water has risen to within 5 cm (2 in) of the top, the remaining chlorine should be added and again stirred. The same general procedure is continued for each raceway unit until the entire raceway system, including all pipe lines, has been completely filled with chlorinated water.

If the hatchery must be disinfectedin sections, the work should be carefully planned and timed so that all sections will contain the maximum chlorine level at the same time. This is necessary to insure that no contaminated waters flow through part of the system after it has already been disinfected, and to prevent dilution of the chlorine solution. When planning a hatchery disinfection, due consideration must be given to the sequence of events to ensure complete removal of resident fish and thorough disinfection of drain pipes, since these are frequently the source of continuing hatchery problems. The sequence of chemical addition and neutralization can be critical to an effective disinfection. While the maximum concentration of chlorine is being maintained in the raceway system all loose equipment such as pails, tubs, trays, boards, and other material may be placed in raceways for disinfection. Since chlorine is very corrosive,



Spraying ponds with chlorine during total hatchery disinfection (Ontario Min. of Nat. Res.)

certain metal tools and equipment should be disinfected in Hyamine or Roccal to prevent damage. Care must also be taken to see that wooden equipment is kept submerged. Throughout the course of disinfection, checks should be made on the approximate chlorine content of the water using orthotolidine reagent, or preferably by iodometric titration. If any section shows less than 100 ppm Cl, before 1 h has elapsed, additional chlorine should be applied.

FORMALDEHYDE FUMIGATION PROCEDURES

Buildings or rooms which can be sealed and made air-tight are most easily and effectively disinfected of all known disease organism& by fumigation with formaldehyde gas. Clothing, laboratory equipment, electronic gear, or other articles which may be harmed by various wet disinfectant solutions can be safely disinfected using tbis gas.

The most important consideration in preparation for this type of disinfection is that gases have poor penetrating powers so all surfaces must be clean of debris. Also, all equipment and materials to be disinfected must be mounted or hung in such a way as to allow free air circulation in and around them, because only **direct** contact with the gas will effect disinfection.

Formaldehyde gas is the active disinfecting agent. It can be produced by heating parafonnaldehyde powder in an electric frypan set on the highest temperature. The recommended application is 10 gm of paraformaldehyde per cubic meter of space.

Although there is ordinarily no danger of fire by this method, formaldehyde gas is highly flammable as it is generated and care shoud be taken to ensure that no open flame or sources of sparking are present in the area.

In as much as formaldehyde gas begins to escape soon after heating begins (it may take several hours -up to 8 h to sublime all the powder in the frypan), a long extension cord should be used to connect the pan to a source of power outside of the building or room being disinfected. It is mandatory that the room be prepared and everything be in readiness prior to commencing. All windows and doors should have been taped, all holes, vents, louvers, etc. covered to prevent escape of the gas. It is helpful to have one or more windows and a door adjusted so that they can be opened from the outside and a couple of fans set so they may be turned on from outside, in order to flush the interior with fresh air after disinfection has been completed. The room should be disinfected for a minimum of 8 h after all of the gas has been generated; then allowed to air wash for 24-48 h before entry. The room is safe to work in when individuals can work for an hour or more without eye and nose irritation.

Formaldehyde gas is most effective in moist air at 18°C. When necessary, rooms should be heated to at least 18°C prior to and during fumigation.

Although formaldehyde gas is toxic, it provides its own warning signal as it is extremely irritating to the eyes and mucous membranes and one can not tolerate enough exposure to be harmful. After a treated building has been sufficiently air washed to permit one to work inside without irritation, it is safe. The State of New York no longer uses formaldehyde gas because of reported effects and hazards associated with chronic exposure to this chemical.

DISINFECTION OF EARTHEN PONDS

Earthen ponds are considerably more difficult to disinfect than hard surface ponds or raceways. This is because organic material in the pond mud readily inactivates chlorine and can severely limit its effectiveness. The choice of disinfectant to be used will depend upon the specific disease agents to be

For bacteria, viruses, and non-specific protozoa, Finlay (1978) recommended a solution of 1% sodium and 0.1% Teepol (a detergent). The presence of the detergent enhances penetration of the disinfectant through soil and the combination is not affected by organic matter. The effectiveness of this disinfectant is dependent upon the maintenance of a high pH (11 or above); this can be easily checked with pH comparator paper.

Earthen ponds should preferably be treated in the summer when the surface is dry. The sodium hydroxide solution (with Teepol) must be applied at the rate of 1/2 gallon/m2 and left to react for several days before refilling the pond. Although the solution has low toxicity to fish, fresh water should be used to flush the pond for several days before fish are introduced.

When applying the disinfectant with a sprayer, protective clothing and a complete face mask should be worn to prevent inhalation and/or contact with the skin or clothing since the substance is very caustic.

Fiilay (1978) suggested that the effluents from ponds treated in this way present ‘: ..no danger to wildlife in rivers receiving them.” Even so, it is best to check with local authorities before commencing such a treatment if it may result in toxic materials being released through the effluent into receiving waters.

If earthen ponds are infected with whirling disease, (Myxoscma *cerebralis),* Hoffman (1976) recommends the replacement of the earthen ponds with con-

Crete raceways because of the great difficulty in effectively disinfecting mud to any great depth. If an attempt at disinfection of an earthen pond is to be made, Hoftinan cautions that the disinfection procedures may have to be repeated several times to ensure total eradication of the parasite. Under such circumstances, he recommends that the ponds first be drained and thoroughly cleaned. The quicklime at 380 g/m2 or calcium cyanamide at 500 g/m2 should be spread evenly over the drained, wet pond bottoms and dikes. This procedure should be repeated several weeks or months later. It is then desirable to put a small number of "test" fish (rainbow trout fry or fingerlings less than 7 cm and less than 8 months of age) in the pond for 2-4 months to see if they contact the infection before restocking the pond with large numbers of valuable fish.

MAINTENANCE OF HATCHERIES

After a hatchery has been completely disinfected and placed on a disease-free water supply, the prevention of recontamination is of utmost importance. The movement of any live fish into a disinfected hatchery should be absolutely forbidden, and production should be started only with disinfected eggs from certified disease-free stocks. All fish eggs should be disinfected with a solution of iodophor. It is important to protect the hatchery from contamination via the water, packing material, or cases of shipped eggs, and from the hands of carriers of eggs as well as the shipping truck.

All equipment coming into the hatchery should be thoroughly disinfected before coming into contact with clean hatchery equipment or water. All equipment at the hatchery and all employees hands should be cleaned and disinfected at frequent intervals. The liberal use of warm water and soap is recommended. All trucks and equipment coming into the hatchery to transport fish should be disinfected before entering the hatchery property. See guideliies on Transport Unit Disinfection.

The spread of disease can be prevented only by complete adherence to rigid standards of cleanliness similar to those used in operating rooms at hospitals. A KEEP IT CLEAN attitude must be instilled in all employees, with the realization that even a minor slip in procedure may undo all previous efforts to eliminate disease.

TRANSPORT UNIT DISINFECTION USING CHLORINE

It is good sanitary practice to disinfect transport units and associated equipment after hauling fish from one station and before entering another hatchery. To inadvertently introduce a disease to a station where it is absent may have serious consequences. Here are some suggested procedures for fish transport unit disinfection:

1. All equipment utilized in handling fish at one station should not be allowed to enter any other fish rearing station until it has been sanitized. Equipment involved includes all vehicles, scap nets, seines, fish pumps, waders, raingear, boots, or anything else which might come in contact with fish or fish cultural waters.

2. All personnel directly involved in fish planting operations should wear outer protective garments when handling fish or fish cultural water. At the end of fish planting operations at a station, these protective garments should be disinfected.
3. Transport equipment disinfection must be thorough, complete, and rigidly enforced to be effective. A suitable site must be chosen where facilities are available, and where the chlorine treatment solution may be safely dumped.
   (a) Vehicles should be disinfected with a solution of 10.20 ppm Cl, sprayed over the exterior surfaces and circulated through the fish transport tanks for a minimum of 30 min. The 20 ppm Cl, solution can be prepared by adding 3.5 g of dry HTH powder (70% active) to 100 I of water. A solution of 2.2 I of household bleach (5.25% sodium hypochlorite) per 5680 1 of water will also give a 20 ppm Cl, solution.

   After disinfection the solution should be dumped in a *safe* site away from direct drainage into natural waters and where there will be no harmful effects of Cl,. If necessary, the chlorine solution can be neutralized with sodium thiosulfate before release. The chassis and all underparts of vehicles should be thoroughly cleaned and sprayed with the chlorine solution, and rinsed.

   All surfaces which come into contact with Cl, must be thoroughly rinsed immediately after disinfection with copious amounts of fresh water because chlorine is corrosive. The fish holding tanks and recirculation equipment should be rinsed with fresh water containing enough sodium thiosulfate to effectively neutralize any remaining Cl,. Normally 50 g of thiosulfate should neutralize any Cl, in 100 I of rinse water, within a ten minute period of recirculation. The effectiveness of neutralization should be checked by using orthotolidine test solution after this ten minute period.

   Orthotolidiie can be used to test for residual chlorine by taking identical samples of water to be tested in clean glass containers (approximately 125 ml of water each) and adding a dropperful of the test solution to one of the samples. Keep both samples in the shade and examine after 5 min. Any formation of yellow color in the solution to which orthotolidine has been added will indicate residual Cl,, and means that the neutralization was not complete. If this occurs add additional thiosulfate to the transport unit and repeat the othotolidine test until no color develops.

   Only after complete Cl, neutralization has occurred should the tanks be emptied. They should be refilled with enough fresh water to rinse out the remaining thiosulfate solution and then dumped. Tbiosulfate is not toxic to fish in the low levels used.

   (b) Interior surfaces of vehicles should not be disinfected with Cl, because of its strong oxidative and corrosive nature. If these areas require disinfection, use a 600 ppm solution of Hyamine or Roccal. Such solutions can be prepared by adding approximately 1.5 ml of the 50% stock solution per liter of water.

   (c) All other equipment, as defined in statement (1), shall be immersed, sprayed, scrubbed, or otherwise covered with a solution of 20 ppm Cl,. Porous or otherwise "difficult to clean" items should be soaked for a minimum of 30 min before rinsing. Other items, such as waders, and

raingear may be thoroughly scrubbed with the disinfectant and then rinsed well with fresh water. Some caution is needed as the disinfectant is somewhat caustic. Natural fabrics such as wool and cotton can be severely damaged by Cl, and should be disinfected with a solution of Hyamine or Roccal at 600 ppm and soaked for 30 min.

4. The State of New York does not use chlorine for transport unit disinfection because of the corrosive nature of chlorine and its adverse effects on aerators and pumps. They have switched to Roccal at 800 — 1000 ppm. According to technical information provided by the Hilton-Davis Chemical Company, these levels should provide adequate disinfection J. Schachte, NYDEC, Rome, NY, personel commmunication).

OTHER DISINFECTANTS AND APPLICATIONS

An excellent summary of other disinfectants was prepared by J. Finlay (1978). The reader is referred to that paper for more specific information. Table 2 provided is mostly taken from that reference. In addition to those mentioned in Table 2, the following disinfectants have been used:

1. Roccal (50% active) or Hyamine 3500 (50% active) (quaternary ammonia compounds) — 70 ml/l for dipping nets, brushes, boots, and seines, or same concentration for 30 min for fish transport unit disinfection.
2. 1,000 ppm of quaternary ammonium compounds spray for disinfecting hard surfaced rearing units 0. Schachte, NYDEC, Rome, NY, personal communication).
3. 2% formalin (200 g commercial formalin/10 1 water) may be used as a spray to disinfect nearly all apparatus used for fish culture (FAO 1977).
4. Iodophors — 50 to 100 ppm free iodine may be used as a spray on previously cleaned and dried equipment and machines (FAO 1977).
5. Sodium hydroxide (NaOH) — a 0.2% solution is recommended for cleaning hatchery equipment, rearing units, transport equipment, and buildings prior to disinfection with any of the above (FAO 1977).
6. Steam cleaning method of disinfecting ponds recommended in New Zealand (Hewitt 1972) is cleaning with live steam at temperatures of II5 — 130" C. Since normal steam cleaning equipment is set to operate at 104" C, it will be necessary to be sure that the required temperatures are produced in order to assure disinfection. It is also important that the steaming process proceed slowly enough that all surfaces to be disinfected also reach the higher temperature range. Some advantages of steam over chlorine are that no toxic chemical is used and therefore there need be no concern over leakage of toxic materials through the effluent into receiving waters and streams, and it is not corrosive to metal.

Table 2. Other Disinfectants and Their Application

Disinfectant	Working Strength	Application*	Effective against
Chlorine	1-2%	concrete Fiberglass Butyl-lined ponds Nets, etc. Footbaths	Bacteria Fungi Viruses (Whiling Disease (G.L. Hoffman, J.J. OGrodnick)
Sodium Hydroxide	1% with 0.1% Teepol 1/2 gallon/m2	Earthen ponds concrete Fiberglass Butyl-lined ponds Nets, etc. Footbaths	Bacteria Viruses Protozoa
Iodophors	250 ppm	Concrete Fiberglass Butyl-lined ponds Nets, etc. Angling Equipment Clothing, bands	Bacteria Viruses
	100 ppm	Ova	
Quaternary ammonium compounds (Hyamine, Roccal, etc.)	As manufacturers' instructions	Nets Clothing, hands	Bacteria
Calcium Oxide	As powder 380 g/m2	Earthen ponds Fiberglass concrete Butyl-lied ponds	Protozoa (Whirling Disease)

* All surfaces should be scrubbed clean before the disinfectant is applied and, if necessary, the disinfectant should be scrubbed into the surface.

REFERENCES

Anonymous 1977. Control of the spread of major communicable fish diseases. FAO Fish. Rep. No. 192. United Nations, Rome. 22p.

Anonymous 1982. Fish disease control policy. Appendix I: Approved disinfection methods. Wash. Dep. Fish. Game, Olympia, WA. Unpublished draft.

Clay, SD. 1978. Realistic control of fish diseases through hatchery sanitation and water conditioning. Salmonid. Vol. l(5): 10-11.

Davis, H.S. 1938. The use of chlorine for disinfecting fish ponds. Prog. Fish-Cult. 42: 24-29.

q J. 1978. Disinfectants in fish farming. G. B. Ministry Agric. Fish. Food, Fishery Notes, No. 59. Lowestoft, England. 7 p.

Hagen, W. Jr. 1940. Sterilizing hatchery water supplies. Prog. Fish- Cult. 48: 19.74.

Hewitt, G.C. 1972. Hygiene in New Zealand trout hatcheries. N.Z. Mar. Dep. Fish. Tech. Rep. No. 86, 12 p.

Hoffman, G.L. 1976. Whirling disease of trout. U.S. Fish Wildl. Serv. Fish Dis. Leafl. 47. Washington, DC. 10 p.

Hoffman, G. L., and J.J. O'Grodnick. 1977. Control of whirling disease Mwosoma cerebr&: effects of drying, and disinfection with hydrated lime or chlorine. J. Fish. Biol. 10: 175-179.

O'Donnell, D.J. 1944. The disinfection and maintenance of trout hatcheries for the control of disease, with special reference to furunculosis. Trans. Am. Fish. Sot. 74: 26-34.

Vestergard-Jorgensen, P.E. 1977. Surveillance and eradication of diseases from hatcheries, p. 72-73. In Proc. Int. Sympos. Dis. of Cult. Salm., Tavolek, Inc., Seattle, WA.

Wolf, K., and M. E. Mxkiw. 1982. Myxosoma cerebralis: Inactivation of spores by hot smoking of infected trout. Can. J. Fish. Aquat. Sci. 39: 926-928.