Chapter
11

Disinfection Policy & Procedures

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> *"Or if a person touches anything ceremonially unclean-whether the carcasses of unclean wild animals or of unclean livestock or of unclean creatures that move along the ground-even though he is unaware of it, he has become unclean and is guilty" Lev. 5:2*

Several factors should be included in an evaluation of a disinfectant. A prerequisite for a disinfectant is its effectiveness against the expected spectrum of pathogens (Table 11-1, 11-2, and 11-3). A general guideline for effective killing of pathogens by a disinfectant is a 5-log killing of bacteria and a 4-log killing of viruses. In addition to the activity of the disinfectant, its compatibility with devices should be reviewed in detail; this should include a review of data on devices that have been immersed for longer than recommended times. Instruments can be forgotten after immersion, and this mistake should not necessarily result in irreparable damage to the device. Other issues are toxicity, odor, compatibility with other compounds, and residual activity. Various and numerous organisms can cause diseases in fish. Viruses, bacteria, fungi, protozoan and many invertebrate animals are included in this list. No single disinfectant destroys them all. It is up to the applicant to decide what is the pathogen of most concern, and how it is to be reduced or eliminated.

The Maine Department of Inland Fisheries & Wildlife: Hatchery Division has over the years been very successful in preventing and controlling the occurrence of many fish diseases. One of the reasons for this is a very strict disinfection policy. To insure our success in the future we must not only maintain this policy, but also strive to update and enhance these procedures.

Safety Issues with Chemicals

Many of the stock solutions the department purchases to disinfect eggs and equipment are concentrated and can be very dangerous. Anyone who uses any of the chemicals discussed in this manual should read the product labels and Material Safety Data Sheet (MSDS) See Appendix XX. Always wear appropriate safety equipment and follow directions.

Efficacy & Characteristics of Commonly Used Disinfectants

See Table XX

Classification of Important Fish Pathogens

See Table XX

Transmission & Susceptibility Characteristics of Important Fish Pathogens

See Table XX

Description of Commonly Used Disinfectants

Formaldehyde:

Example: Paracide F, Argent Chemical Laboratories, Washington

Formaldehyde, HCHO, is manufactured by mixing methanol and air then passing the mixture through a heated tube containing either silver or a mixture of iron powder and molybdenum oxide. Formaldehyde is a colorless gas with a pungent and irritating odor; it is soluble in water in all proportions. Formaldehyde is sold in aqueous solution that contains about 37-37.5% of formaldehyde by weight and is know as formalin. The solution also contains 7% methyl alcohol, which is added to inhibit the reaction of formaldehyde molecules with each other to form an insoluble polymer, Bakelite. Formaldehyde causes coagulation of proteins, making it useful as a preservative of anatomical specimens and in embalming fluids. It is also useful as a disinfectant and as a reducing agent in the production of silvered mirrors (Nebergall et al 1980).

Paracide-F has been used since 1909 in the United States in the production of sport, commercial and experimental fishes. It is used as a therapeutants and prophylactic for the control of external parasites on salmon, trout, catfish, largemouth bass, and bluegill; and for the control of fungi on salmon, trout and esocid eggs. Its use in the health care setting, however, has sharply decreased for several reasons. **The irritating vapors and pungent odor produced by formaldehyde are apparent at very low levels (<1 ppm).** In addition, an allergy to formaldehyde can develop in some individuals. The strongest banning of formaldehyde for sterilization and disinfection processes was the actions of agencies of the US federal government, such as OSHA and the Health and Safety Executive of the United Kingdom. They indicated that the inhalation of formaldehyde vapors may pose a carcinogenic risk. OSHA limits an 8-h time-weighted average exposure to a concentration of 0.75 ppm in the workplace. **Other disinfectants, such as chlorines, glutaraldehydes, hydrogen peroxide and peracetic acid, may replace formaldehyde for the reprocessing of certain medical equipment**. (Murray et al., 1999.

Chlorine and Chlorine-Releasing Compounds:

Example: Chlorox ® The Chlorox Company, California

Among the large number of chlorine compounds commercially available, hypochlorites are the most widely used disinfectants. Hypochlorite has been used for more than a century and remains an important disinfectant. Aqueous solutions of sodium hypochlorite are usually called household bleach. **Bleach commonly contains 5.25% sodium hypochlorite or 52,500 ppm available chlorine; a 1:10 dilution of bleach provides about 5,000-ppm available chlorine.** Alternative chlorine-releasing compounds frequently used in health care facilities include chloramineT, sodium dichloroisocyanurate tablets, and demand –release chlorine dioxide. Demand-release chlorine dioxide is an extremely reactive compound, and consequently, is prepared at the point of use. It is largely used in the chlorination of potable water, swimming pools, and wastewater. Due to its hazardous nature, chlorine gas is rarely used as a disinfectant. In aqueous solution, all chlorine compounds release hypochlorous acid, which is considered the active compound. **The mechanism of microbiocidal action of hypochlorous acid has not been full elucidated. Inhibition of some key enzymatic reactions within the cell and denaturation of proteins play major roles in killing.** Lowering of the pH or an increase in the temperature or concentration increases its antimicrobial efficacy. Chlorine compounds have broad antimicrobial spectra that include bacterial spores and M. tuberculosis at higher concentrations. Therefore, hypochlorite can be used as a high-level disinfectant for semi-critical items. Hypochlorite is fast acting, non-staining, nonflammable, and inexpensive. However, its use is limited by its corrosive effects, inactivation by organic matter, and relative instability. Although exposure to sodium hypochlorite through direct contact may result in tissue injury, the incidence of injury due to hypochlorite use in health care facilities is extremely low. Inhalation of chlorine gas may cause irritation of the respiratory tract, resulting in cough, dyspnea, and pulmonary edema or chemical pneumonitis.

Available chlorine **concentrations of 100 ppm for contact time of 10 minutes very effectively inactivate vegetative bacteria and viruses**. In general, endospore-forming bacteria, mycobacteria, fungi, and protozoa are less susceptible, and a higher concentration of chlorine (1,000 ppm) is required to completely destroy these germs. ChloramineT and sodium dichloroisocyanurate seem to have less sporicidal action than sodium hypochlorite. Hypochlorites and other chlorine compounds are substantially inactivated in the presence of blood or other organic matter. Consequently, items used for patient care and environmental surfaces must be cleaned before the disinfectant is used. The presence of a biofilm (e.g., in the pipes of a water distribution system), significantly reduces the efficacies of chlorines as well. The free available chlorine levels in solutions of opened containers can decay to 40 to 50 % of the original concentration within 1 month. **The United States Center for Disease Control (CDC) recommends use of a 1:100 dilution (500 ppm) to decontaminate environmental spills of blood and certain other body fluids. (Murray et al. 1999)**

Chlorine is an ever-present toxic concern with aquaculture. Levels of 0.1 ppm that are common in city drinking water supplies are fatal to many fish species. Fish exposed to chlorine lose color and develop nonspecific signs of respiratory difficulty because of damage to their gill epithelium. The pattern of mortalities differs with the level of exposure. At post mortem examination, nonspecific branchial epithelial hyperplasia is commonly the only finding. Occasionally fish affected by chlorine exhibit sunken eyes. There is no suitable treatment for chronic damage due to chlorine exposure. The obvious course is to eliminate further exposure. Immediate application of sodium thiosulfate to the tank will reduce chlorine to chloride extremely rapidly and is the best remedial action when there is an accidental exposure.

The US Environmental Protection Agency (EPA) recommends that effluents into natural waters have no more than 0.03 mg/L (30 ppb) of residual chlorine when released.

Hydrogen Peroxide

Example: Chute Chemical Company H_2O_2. Bangor, ME

Hydrogen peroxide is a strong oxidizer that is used for high-level disinfection and sterilization. It produces destructive hydroxyl free radicals that can attack membrane lipids, DNA, and other essential cell components. Although the catalase produced by anaerobic and some aerobic bacteria may protect cells from hydrogen peroxide, this defense is overwhelmed by the concentrations used for disinfection. Generally, a 2% hydrogen peroxide solution is rapidly bactericidal. It is less rapid in its action against organisms with high cellular catalase activity (e.g., *S. aureus*) and especially bacterial spores. ***Bacillus subtilis*** **spores were killed by concentrations of 17.7 and 35.4% in**

9.4 and 2.3 minutes, respectively. 10% hydrogen peroxide was the most active chemical disinfectant against *B. Subtilis* spores among seven liquid agents tested. Killing of spores is greatly enhanced by increased concentration or temperature. Hydrogen peroxide also acts synergistically with some chemical agents such as peracetic acid. **Hydrogen peroxide has low levels of toxicity to humans and the environment. It is neither carcinogenic nor mutagenic. Concentrated solutions may irritate the eyes, skin and mucous membranes**. Hydrogen peroxide can be easily destroyed by heat or the enzyme catalase and peroxidase to give the innocuous products oxygen and water. **Therefore, it is environmentally safe** (Murray et al. 1999). When used as an oxidizing agent, it has an advantage over other oxidizing agents, because the only by-product of the oxidizing reaction is water.

$$Oxidizing -$$

$$H_2SO_3 + H_2O_2 \rightarrow H_2SO_4 + H_2O$$

$$\mathrm{Re}\,ducing -$$

$$Ag_2O + H_2O_2 \rightarrow 2Ag + H_2O + O_2$$

Pure hydrogen peroxide is colorless, syrupy liquid with a sharp odor and an astringent taste. It has a density of 1.438 g/cm^3 at 20°C, boils at 62.8°C at 21 torr, and freezes at 1.70°C. Three per cent (3%) solution of hydrogen peroxide is used in homes as a mild antiseptic, a deodorizer, and a germicide; a somewhat more concentrated solution is a bleach for hair. A 30% solution of hydrogen peroxide is commonly used in the laboratory as an oxidizing agent. In commerce, the principal consumption of hydrogen peroxide is as an oxidizing agent, particularly as a bleaching agent. It is often used to bleach substances of animal origin such as wool and hair. At present, most cotton cloth is bleached with hydrogen peroxide because of the innocuous character of the decomposition products and the permanency of the whiteness produced by the peroxide bleaching. 90% hydrogen peroxide is used as a rocket fuel (Nebergall et al 1980).

Quaternary Ammonium Compounds

Example: ROCCAL-D® Upjohn, Michigan

TBQ®, MERCK, St. Louis, Missouri

Benzalkonium Chloride 50%, Argent Chemical Laboratories, Washington

Wide varieties of quaternary ammonium compounds (quats) exhibiting antimicrobial activity have been introduced in the past decade. Some of the compounds used in health care settings are benzalkonium chloride, alkyl-dimethyl-benzyl-ammonium chloride, and di-decyl-dimethyl-ammonium chloride. Quats are cationic surface-active detergents. The biocidal action appears to result from the disruption of the cell membrane, inactivation of enzymes, and denaturation of the cell proteins. **Quat are**

non-staining, odorless, non-corrosive, and relatively nontoxic. However, they have limited antimicrobial spectrum. Products sold as hospital disinfectants are not sporicidal and are generally not tuberculocidal or virucidal against hydrophilic viruses. Scientific investigations by the AOAC use-dilution method have failed to reproduce the bactericidal and tuberculocidal claims made by manufacturers of quats. Manufacturer's label claims and results from in-house evaluations not verified by an independent laboratory should be considered questionable. The overestimation of the germicidal activity may be related to incomplete inactivation of the compounds tested. In this case, the bacteriostatic activity rather than the bactericidal activity is measures. Several outbreaks of infections associated with in-use contamination of quat solutions have been reported. In those solutions, gram-negative bacteria such as Pseudomonas species and *S. marcescens* were found to survive or grow. **Organic matter, anionic detergents (soaps), and materials such as cotton and gauze pads can reduce the microbiocidal activity of quats**. Quaternary ammonium germicidal detergent solutions are excellent cleaning agents. Therefore, they are preferred agents for the cleaning of floors. Based on their limited antimicrobial spectra, their use in hospitals (and fish hatcheries?) should be restricted to ordinary environmental sanitation of non-critical surfaces such as floors, furniture and walls (Murray et al., 1999).

Phenolics

Example: Nolvasan® S, Fort Dodge Laboratories, Inc. Iowa.

Clove Oil (Eugenol), Sigma Chemical Company, Missouri

Listerine® mouth wash.,

Since the pioneering use of phenol (carbolic acid) as an antiseptic by Lister, a large number of phenol derivatives or phenolics have been developed and marketed. **Today, phenolics make up one of the major classes of disinfectants used in hospitals.** Phenolic derivatives originate when a functional group (e.g., alkyl, benzyl, phenyl, amyl, or chloro) replaces one of the hydrogen atoms on the aromatic ring. The three phenolics most commonly found, as constituents of disinfectants are o-phenylphenol, o-benzyl-p-chloro-phenol, and p-tert-amylphenol. **The addition of detergents to the basic formulation results in the products with excellent detergent properties that clean, dissolve proteins, and disinfect in one step**. Phenolic at higher concentrations act as a gross protoplasmic poison, penetrating and disrupting the bacterial cell wall and precipitating the cell proteins. Lower concentrations of these compounds inactivate cellular enzyme systems and cause leakage of essential metabolites from the cell. Phenol compounds at concentrations of 2 to 5% are generally considered bactericidal, tuberculocidal, fungicidal, and virucidal against lipophilic viruses. A phenol-based preparation (14.7% phenol diluted 1:256 in tap water) produced a reduction in rotovirus similar to that achieved with a bleach dilution (800 ppm available chlorine). In a further experiment, both the phenolic and the bleach were able to interrupt the transfer of virus from disks to finger pads.

Phenolic compounds are tolerant of anionic and organic matter. They are assimilated by porous materials and leave residual films. The residual films may cause irritation to the skin and tissues. Depigmentation of the skin caused by preparations containing p-tert-butylphenol and p-tert-amyl-phenol has been reported. Their use in nurseries should be prohibited since hyperbilirubinemia has occurred in phenol-exposed infants.

Phenols are not commonly used in aquaculture. Phenols have been introduced into aquaria through the unwise selection of creosoted driftwood or the use of pheno-based household disinfectants to clean tanks, substrates, or decorations. Phenols are very toxic to tropical fish. They cause severe corrosive damage to gills, skin, and intestinal mucosa. They are also hepatotoxic. Affected fish show restlessness, aimless swimming, and increased respiratory rates. Increased swimming, followed shortly by spastic staggering and death, will be seen with exposures to concentrations as low as 5 ppm. Recovery is possible only if the problem is noticed very shortly after exposure. Treatment is based on removal of further exposure (Stoskopf 1993).

Chlorhexidine gluconate, a cationic bisbiguanide, has been widely recognized as an effective and safe antiseptic for more than 30 years. Its most common formulation is a 4% aqueous solution in a detergent base. The antimicrobial spectrum includes vegetative bacteria, fungi, and viruses. Bactericidal concentrations cause destruction of the bacterial cell membrane, leading to leakage of cellular constituents and coagulation of cell contents. Chlorhexidine has been demonstrated to be bacterial against both gram positive and gram-negative bacteria. In addition to its rapid bactericidal action, chlorhexidine gluconate provides a persistent antimicrobial action that prevents the regrowth of microorganisms. This effect is desirable when a sustained reduction in microbial flora reduces infection risk. Chlorhexidine has little activity against bacterial and fungal spores except at high temperature. Mycobacteria are inhibited but are not killed by aqueous solutions. It is effective against lipophilic viruses. The antimicrobial activity of chlorhexidine is little affected by blood and other organic material, contrast to povidone-iodine. However, inorganic anions and organic anions such as soaps are incompatible with chlorhexidine. Its activity is also reduced at an extreme acidic or alkaline pH and in the presence of anionic and nonionic based moisturizers (fats?) and detergents.

Alcohols

Example: Isopropyl Rubbing Alcohol USP 70%, Hannaford, Scarborough, ME

Ethyl Alcohol 95%, Denatured, EM Science, Gibbstown, NJ

For centuries, the alcohols have been appreciated for their antimicrobial properties. For infection control purposes, ethyl alcohol (ethanol) and isopropyl alcohol (isopropanol) are the alcoholic solutions most often used. Their antimicrobial efficacies are enhanced in the presence of water, with optimal concentrations being from 60 to 90%, by volume. The exact mechanism by which alcohols destroy microorganisms is not fully understood. The most plausible explanation of the antimicrobial action is coagulation (denaturation) of proteins, inactivation of enzymatic proteins, leading to the loss of specific cellular functions. Ethyl and isopropyl alcohols at appropriate concentrations have broad spectra of antimicrobial activity that includes vegetative bacteria, fungi, and viruses. However, they generally do not destroy bacterial spores. Alcohols possess many qualities that make them suitable both for antisepsis of skin and for disinfection of equipment. They are fast acting, hardly toxic with topical application, non-staining, and nonallergenic and readily evaporate. The rapid evaporation is advantageous for most disinfection and antisepsis procedures. The uptake of alcohol by intact skin and the lungs when alcohol is used on the skin surface is so small that health concerns are not justified. Alcohols have better wetting properties than water due to their low surface tensions. This represents an important feature for skin antisepsis, along with their cleansing and degreasing action. Repeated application of alcoholic antiseptics, however, may cause drying and irritation of the skin. Alcohols are also excellent for intermediate-level and low level disinfection of small and clean surfaces of objects, equipment and environment (e.g., rubber stoppers of medication vials, stethoscopes, and medication preparation areas. After prolonged and repeated use, alcohols may damage rubber and certain plastic items as well as the shellac mountings of lensed instruments. Since alcohols are flammable, one should consider the flame point.

Iodophors

Example: Argentyne**,** Argent Chemical Laboratories, Washington

Betadine, J.A. Webster, Inc. Sterling, MA

The previously used aqueous iodine and tincture have largely been replaced by the iodophors. The risk of side effects from the use of these compounds, such as staining irritation of tissue, and resorption is lower than that from the aqueous iodine. Iodophors are chemical complexes with iodine bound to a carrier such as polyvinylpyrrolidone (povidone, PVP) or ethoxylated nonionic detergents (poloxamers). These complexes gradually release small amounts of free microbicidal iodine. The most commonly used iodophor is povidone-iodine. Its preparations generally contain 1 to 10% povidone-iodine, which is equivalent to 0.1 to 1.0 % available iodine. The active species appears to be molecular iodine (I_2). A paradoxical effect of dilution on the activity of povidone-iodine has been observed. As the degree of dilution increases, bactericidal activity increases u0 to a maximum then falls. Commercial povidone-iodine solution at dilutions of 1:2 to 1:100 killed bacteria more quickly than stock solutions. Thus, iodophors must be used at he dilution stated by the manufacturer. The exact mechanism by which iodine destroys microorganisms is not known. It has been postulated that iodine reacts with amino acids and fatty acids of microorganisms, resulting in the destruction of cell structures and enzymes.

Depending on the concentration of free iodine and other factors, iodophors exhibit a broad range of microbicidal activity. Commercial preparations have been shown to be bactericidal, mycobactericidal, fungicidal, and virucidal but not sporicidal at their dilution recommended for use. Prolonged contact times are required to inactivate certain fungi and bacterial spores. Unlike iodine, iodophors are relatively free of toxic effects, do not cause irritability, and do not corrode metal surfaces. They have little if any residual effect. The antimicrobial efficacy of iodophors is reduced in the presence of organic material such as blood.

Choosing an Effective Disinfectant

A hypothetical disinfectant SUPERCLEAN 100 is marketed as able to kill 99.0% of bacteria and viruses. It's available in a shiny bottle, and is advertised on television. Chlorox bleach is plain, smells bad, but is able to provide a 5-log reduction in bacteria and viruses. Suppose you have 10 million bacteria per square centimeter (cm2) on your hatchery equipment and it takes 20 minutes for the bacteria to reproduce by binary fission (doubling every 20 minutes). **How long after using either SUPERCLEAN 100 or bleach, will the bacteria numbers be back to 10 million/cm2 on your tools?**

Product	Super Clean 100	Chlorox bleach
Initial bacterial count	10,000,000	10,000,000
Kills	99.0%	5 log reduction
Remaining bacteria	100,000	100
Reproducing bacteria which double every 20 minutes		
20 min	200,000	200
40 min	400,000	400
60 min	800,000	800
80 min	1,600,000	1,600
100 min	3,200,000	3,200
120 min	6,400,000	6,400
140 min	>10 Million	12,800
160 min		25,600
180 min		51,200
200 min		102,400
220 min		204,800
240 min		409,600
280 min		819,200
300 min		1,638,400
320 min		3,276,800
340 min		6,553,600
360 min		>!0 Milliion
ANSWER	2 HOURS	6 HOURS

Since hatched fish cannot be disinfected Egg Disinfection Procedure

Since hatched fish cannot be disinfected, the procedure must start with the egg.

1. Let the eggs water harden for at least 1 hour. The iodine stock must be diluted 20 ml activated iodine to 1 gallon (3.78 liters) clean water.. The use of water

that is high in organic material will cause the loss of active iodine. Because of this it may be necessary to bring water to the sight and maintain the same temperature as the water in the lake. An iodophor with a concentration of 1.6% active iodine should be prepared. Using 23.7 ml of Argentyne™ per gallon of water does this. The solution must be buffered to between pH 6.5 and 7.5. Argentyne™ comes buffered to 7.0 but the water used must be checked. The eggs are then immersed in the solution for 15 minutes, the solution should be used at four part disinfectant to one part eggs. This works out to about 2,000 eggs per liter. Afterwards rinse the eggs in uncontaminated water (water brought from the hatchery). Pack the eggs in jars that have been disinfected and rinsed with hatchery water. This same procedure should again be used at the receiving hatchery and all equipment used at the egg takes sight disinfected according to the following procedure.

Equipment Disinfection Procedure

There are two equipment disinfection chemicals that may be used to disinfect equipment. A solution of 200 parts per million will be effective in 20 to 60 minutes. This is the cheapest method of disinfection. Chlorine, like iodine solutions, is less effective when organic substances are found in the water. It can also be diluted by contact with air. Chlorine may be obtained as sodium hypochlorite in either liquid or powder (HTH) form. HTH is the more stable of the two. The amount of chlorine added to water depends on the percentage of available chlorine in the product used. HTH powder can be purchased wither 15, 50, or 65% available chlorine. To achieve a 200 parts per million solution follow the directions below:

200 Parts Per Million Solution (1: XX Dilution)
20 ounces of 15% HTH (available chlorine), powder to 10.5 gallons of water
1 ounce of 50% HTH (available chlorine), powder to 18 gallons of water
1 ounce of 65% HTH (available chlorine), powder to 23.25 gallons of water

Spray Disinfection Procedure

The second method of equipment disinfection is to use a commercial solution such as TBQ™ (dimethyl benzyl ammonium chloride, 8% active ingredients. TBQ™ is a detergent based fungicide, germicide, and virucide concentrate when used at 1:64 dilution for 10 minutes at 20°C. The most economical way of applying TBQ™ is with a garden sprayer. Any equipment or stocking truck going between stations should be disinfected before arriving at the next station. A good rinse is all that is needed to neutralize TBQ™. All equipment that has been off the hatchery premises whether to another hatchery or body of water should also be disinfected before returning to any other hatchery. Any new equipment brought into the hatchery should also be disinfected before use.

Dead Fish Disposal Procedure

One more disinfection procedure is worth mentioning. **Dead, diseased, or even suspicious morts that occur should not be flushed down effluent systems**. These fish should be buried deep and limed, incinerated, or taken to a proper landfill.

Foot Baths

A footbath is to be placed at the doorway entry of each hatchery in a location easily accessible, it should be large enough to stand in with both feet. The footbath should contain between ½ to 1½ inch deep solution of either chlorinated (100-200 ppm) or active iodine (30-50 ppm). This disinfection solution should be renewed at least weekly. Everyone entering and leaving the hatchery should step into the footbath each time through the doorway.

Note: A footbath disinfectant that begins the week at 100 ppm will not work properly after the disinfectant concentration decreases with evaporation, dirt, and utilization.

Hatchery Visitors

Hatcheries are to be open and accessible to the public. This does not mean that individuals have unrestricted, unsupervised use of the facility. Visitor should be greeted and treated appropriately. Biosecurity concerns associated with visitors can be reduced by asking them to:

1. Keep hand out of water.
2. Step into footbath before entering the hatchery.
3. Other (specify).

Hatchery Tools

Biosecurity of each lot of fish is very important to the Maine Hatchery Division. Our practice of moving fish amongst hatcheries exposes us to potentially catastrophic pathogen introduction. Each tank, trough series, or raceway series should have a separate set of hatchery tools. Tools should not be used between different tanks, troughs or raceways. Tools should be cleaned, disinfected and stored away properly after each use. Tools for each specific tank, trough or raceway should be color coordinated in a simple and easily identifiable manner.

Cleanliness

Keep equipment clean. Dirt, feces, and mud can all harbor pathogens and prevent effective disinfection of equipment.

Stocking Trucks

Empty truck, clean, disinfect, and rinse tanks with clean water. Fill stocking trucks with clean well water tempered to within 5 °C of the raceway water rather than raceway water wherever possible.

Suggested Readings:

Murray, P.R., E.J. Barron, M. A. Pfaller, F. C. Tenorver & R.H. Yolken. 1999. Manual of Clinical Microbiology. 7th Edition. American Society for Microbiology. ASM Press, Washington DC ISBN 1-55581-126-4

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Rossmoore, H.W., And M. Sondosi. 1988. Applications and mode of action of formaldehyde condensate biocides. Adv. Appl. Microbiol. 33: 223-277.

Stoskopf, M. 1993. Fish Medicine. Saunders Publishing, Philadelphia.

Ten Quiz Questions for Chapter 11-Disinfection Policy

1. What is the general guideline for effective killing of pathogens by a disinfectant?

2. Material Safety Data sheets have eight sections.

    a. In which section would you find out if a substance could cause damage to your eyes?

    b. In which section would you find the appropriate safety equipment suggested for a substance?

3. Give several examples of how to minimize the human health hazard of using formalin in a hatchery to disinfect green salmonid eggs?

4. TBQ® is what type of germicide? Which types of pathogens is it most effective at killing?

5. How often should a footbath's solution be replaced?

6. Describe the egg disinfection procedure using an iodophor.

7. Describe the truck disinfection procedure for moving fish from one hatchery to another.

8. Describe the truck disinfection procedure for stocking fish from a hatchery to a lake's boat ramp.

9. Describe how hydrogen peroxide works to kill germs and what are the products of its chemical breakdown.

10. What type of disinfectant would be most effective against IPNV, BKD and *Aeromonads*?