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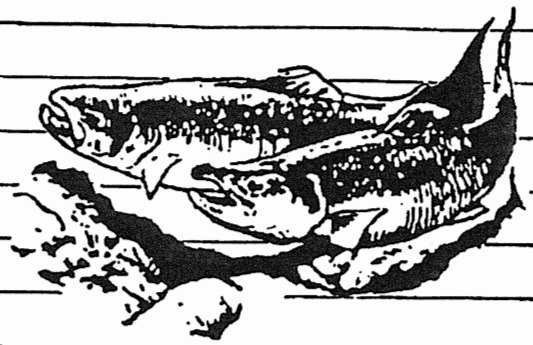

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Fire-fighting Chemicals Are Toxic to Rainbow Trout

Fire-fighting retardants and foams are toxic to young rainbow trout (*Oncorhynchus mykiss*) at concentrations likely to occur in aquatic habitats if the habitats are contaminated with the chemicals during fire-fighting.

In the United States, more than 24 million gallons of ammonia-based fire-fighting chemicals were applied in 1992, primarily by aircraft during fire-fighting. Although most ammonia-based fire-retardant chemicals are essentially fertilizer compounds and believed to have minimal toxicity, fish kills have been associated with accidental stream contamination from retardant drops. In recent years, a new group of fire-fighting chemicals called fire-suppressant foams have increasingly been used in fire-fighting. Foams, composed of mixtures of surfactants, are mostly applied by ground crews in the United States, but are extensively applied by aircraft in Canada.

Limited information is available concerning the acute toxicity of fire-fighting chemicals to fish. Most previous studies were conducted with only one life stage of fish and only one water quality. In addition, many past studies were conducted with formulations no longer in use today.

Toxicity Tests Were Conducted

Static acute toxicity tests were conducted with five early life stages (eyed egg, embryo–larval, swim-up, 60-day posthatch, and 90-day posthatch) of rainbow trout to determine the acute toxicities of three ammonia-based retardants (Fire-Trol LCG-R, Fire-Trol GTS-R, and Phos-Chek D-75-F) and two fire-suppressant foams (Phos-Chek WD-881 and Silv-Ex).

Tests were conducted in standard American Society of Testing and Materials soft (42 mg/L $CaCO_3$) and hard (163 mg/L $CaCO_3$) water qualities to determine if water-quality type influenced the toxicity of the fire-fighting chemicals to fish. Each life stage of rainbow trout was exposed for 4 days (96 h) to the five chemicals individually. Results of these toxicity

tests were used to calculate a standard measure of toxicity, the 96-h LC50, which is the concentration of a toxicant that kills 50% of the test organisms after 96-h exposure.

Fire-Suppressant Foams Most Toxic

The two foams tested, Phos-Chek WD-881 and Silv-Ex, were more toxic to all life stages tested than the three ammonia-based fire retardants. Phos-Chek WD-881 and Silv-Ex were at least 10 times more toxic than the two most toxic fire-retardants tested, Fire-Trol GTS-R and Phos-Chek D-75-F. The fire-suppressant foams were at least 67 times more toxic than the least toxic formulation tested, Fire-Trol LCG-R. The 96-h LC50's were rank ordered from the most toxic to the least toxic formulation as follows: Phos-Chek WD-881 (11–44 mg/L [ppm]) > Silv-Ex (11–78 mg/L) > Phos-Chek D-75-F (218–>3,600 mg/L) > Fire-Trol GTS-R (207–>6,000 mg/L) > Fire-Trol LCG-R (872–>10,000 mg/L); (ranges are the lowest and highest 96-h LC50 calculated for each formulation; Table).

Toxicity was significantly greater in hard water than in soft water for Fire-Trol LCG-R tested with 90-day posthatch fish, Fire-Trol GTS-R tested with three life stages, and Silv-Ex tested with four life stages. Water hardness had no significant effect on fish in other tests. Rainbow trout swim-up fry was generally the most sensitive life stage, whereas the eyed-egg was the most resistant life stage.

Potential for Environmental Effects

Environmentally toxic concentrations of fire-fighting chemicals may result from incidental contamination of aquatic ecosystems. Fire-Trol GTS-R is prepared for field application by mixing 1.66 pounds of powder with 1 gallon of water to produce 1.10 gallons of mixed slurry. This mixture is equivalent to about 200,000 mg/L. The 96-h LC50 of this compound in hard water to the swim-up life stage was 207 mg/L. Thus, an accidental drop of Fire-Trol GTS-R in an aquatic environment would require a dilution of more than 960-fold (i.e., 200,000/207 = 961) to dilute it to a concentration equivalent to the 96-h LC50—a concentration that could cause a substantial number of deaths. Similarly, a field mixture of Fire-Trol LCG-R would have to be diluted at least 310-fold to reach a concentration equal to the 96-h LC50; for Phos-Chek D-75-F the dilution would have to be 660-fold.

A safety factor may be applied to toxicity data to estimate a safe concentration for aquatic organisms. A safety factor for acute toxicity data is usually 100. Applying a safety factor of 100 to the above toxicity information would require a 96,000-fold dilution for GTS-R, 31,000 for LCG-R, and 66,000 for D-75-F to approach a safe concentration.

Foam chemicals are applied at about 1% foam, which is equivalent to 10,000 mg/L. The 96-h LC50 of Silv-Ex to swim-up rainbow trout in soft water is 20 mg/L, and is equivalent to a 0.002% foam solution. This acute toxicity value is 500 times less than the 1% foam field application rate. Consequently, if a 1% foam solution came in contact with an aquatic environment it would have to be diluted 500-fold to reach the 96-h LC50 concentration. Applying a safety factor of 100 to the above toxicity information would require a 50,000 dilution of the 1% foam field application solution to approach a safe concentration.

The life stages present during contamination may affect the overall significance, with certain life stages being more sensitive to the formulations than others. From our data, contamination occurring after the salmonid spawning period would probably produce fewer deaths in the egg life stage than would contamination during the swim-up phase of a salmonid's development. Control managers should be cautious of their use of fire retardants or foams near streams with salmonid populations, especially streams with low flows that would not be capable of diluting fire retardant chemicals to safe concentrations.

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Table. Acute toxicity (96-h LC50; mg/L) of five fire-fighting chemical formulations to rainbow trout exposed in American Society of Testing and Materials soft and hard water at five life stages.

Chemical[a]	Water type	Egg	Embryo–larval	Swim-up	60 day	90 day
FT LCG-R	Soft	>10,000[b]	3600[c]	910[d]	1080[d,e]	1413[e*]
	Hard	>10,000[b]	2642[c]	872[d]	1413[e]	1006[d*]
FT GTS-R	Soft	>3600[b]	718[c]	363[d*]	390[d*]	363[d*]
	Hard	>6000[b]	606[c]	207[d*]	234[d*]	234[d*]
PC D-75-F	Soft	>1700[b]	266[c]	279[c]	234[c]	218[c]
	Hard	>3600[b]	235[c]	218[c]	218[c]	218[c]
PC WD-881	Soft	44[b]	13[c]	13[c]	15[c]	20[d]
	Hard	22[b]	10[c]	11[c]	13[c]	13[c]
Silv-Ex	Soft	>78[b]	15[c*]	20[cd*]	22[d*]	22[d*]
	Hard	47[b]	11[c*]	13[c*]	14[c*]	15[c*]

[a]Chemicals

FT LCG-R: Fire-Trol LCG-R
FT GTS-R: Fire-Trol GTS-R
PC D-75-F: Phos-Chek D-75-F
PC WD-881: Phos-Chek WD-881

[b,c,d,e]Letters in common denote no significant difference ($P < 0.05$) among life stages within a test formulation and water quality.

*Asterisks denote a significant difference ($P < 0.05$) between soft and hard water for a test formulation.