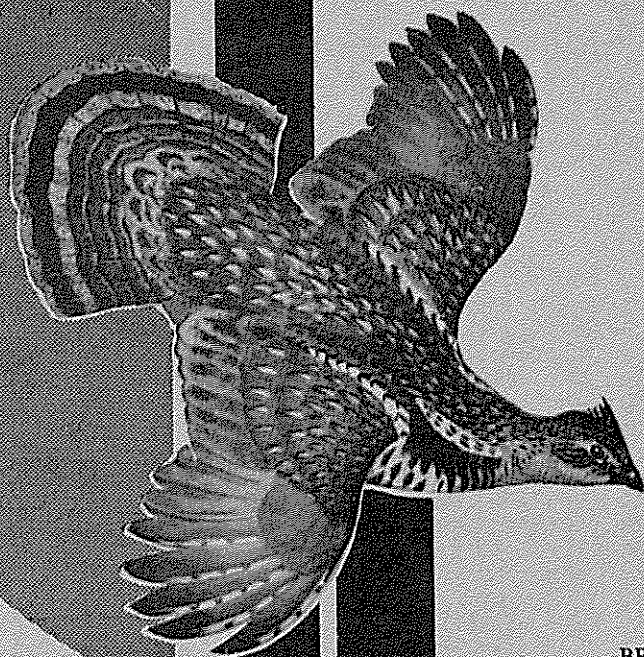


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ENVIRONMENTAL POLLUTION BY BENZENE HEXACHLORIDE  
USED FOR CONTROL OF AMBROSIA BEETLE

R. P. FINEGAN

WILDLIFE MANAGEMENT DIVISION



BRITISH COLUMBIA FISH AND WILDLIFE BRANCH

ENVIRONMENTAL CONTAMINATION BY BENZENE HEXACHLORIDE  
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R. P. FINEGAN  
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INTRODUCTION

Technical BHC, a mixture of alpha, beta and gamma isomers of benzene hexachloride, has been used fairly extensively for the control of ambrosia beetles in British Columbia. Ambrosia beetles of the genera Trypodendron, Gnathotricha, Platypus, and Xyleborinus, damage logs by boring, thus creating worm holes in lumber.

A typical treatment is to spray log booms with a solution of 1 lb. BHC per gallon non-emulsifiable carrier at a rate of 10 gallons per acre. The average boom occupies 1 acre and contains 250,000 board feet of timber.

Until 1967 approximately sixty 40 lb. drums of BHC were used by the forest industry annually. The main locations in which it was used were Cowichan Lake, Comox Lake, and some locations around the coast. In 1967 due to a tightening market which rejected wormy lumber, the use of BHC was greatly expanded and a large number of locations around the coast, plus Cowichan Lake, Comox Lake and Sproat Lake, were the sites of spraying operations.

As the result of representations by Federal Fisheries, Commercial Fisheries, the Fish and Wildlife Branch and the Health Branch, the programme was modified to reduce the hazard to wildlife and human health. Nevertheless, approximately 180 drums of BHC were used. It also became obvious that there was a need for an investigation to document any resulting environmental contamination.

At a spraying efficiency of 90% it would be expected that 1 lb. BHC per acre would be applied directly to the water surface. In theory, because BHC is insoluble, and because the carrier contains no emulsifier, no direct pollution of water should occur. In practice, a measurable pollution occurs. There is a large danger of the BHC laden scum being stranded on beaches and mud flats and in addition biological concentration of BHC occurs through food chains, so that dangerous quantities can appear in living organisms. The effect of the latter is to pose a problem in human health and in the welfare of economically or otherwise desirable species.

METHODS

To demonstrate that pollution exists, samples of water and living organisms were taken before and after the 1967 spraying operation which commenced on April 1st. Samples of oysters, fish and birds were placed in specimen jars and covered with absolute ethyl alcohol. This is a method of preservation for chlorinated hydrocarbon analysis favoured by Sargent (see Acknowledgements). Samples of water and gravel were placed in jars and approximately 30 mls of hexanol (petroleum ether) added to prevent adsorption onto glass. Caps of jars were lined with metal foil to avoid any possible contamination from cap liners. The results of analyses performed at the Pesticide Laboratory, Department of Agriculture, Vancouver, are given in the tables.

TABLE I - BENZENE HEXACHLORIDE RESIDUES FOUND IN THE EXTERNAL ENVIRONMENT

SUBSTANCE	LOCATION	DATE	BHC $\alpha$	BHC $\beta$	BHC $\gamma$	TOTAL BHC PPM.
I Water	Cowichan Lake (a) * At boom. (b) * 100 yds from booms. (c) * Water outlet.	April 1, /67 At time of spraying				7.7
						0.16
						0.00004- 24 hours
						0.00003- 48 hours
						0.00006- 96 hours
I Water	Cowichan Lake	April 27, /67	.0001	.00008	.0002	.00038
II Gravel	Near booms Beach, near booms	April 27, /67	.0001	.0002	.0001	.0004

\* Figures supplied by the Health Branch.

TABLE II- BENZENE HEXACHLORIDE RESIDUES IN MOLLUSCS

SPECIES	LOCATION	DATE	NO. OF SPECIMENS IN SAMPLE	ALPHA BHC	BETA BHC	GAMMA BHC	TOTAL BHC PPM	REMARKS
Whole Oysters	Cowichan Estuary (1) Upper Littoral Rocks (2) Middle Littoral (3) Middle Littoral (High point in oyster bed)	Mar. 16, /67 Specimens taken prior to 1967 spraying	4			.008	.008	Oysters in poor condition High point on bed has greatest exposure to fresh water Poor condition
			4			.009	.009	
			4			.027	.027	
Whole Oysters Adductor muscle Mantle, palps, Gills. Digestive gland (plus other)	Cowichan Estuary	May 10, /67 Taken following 1967 spray	6		.0	.001	.001	Good condition
			3		.0	.009	.009	
			3		.006	.005	.013	
					.008	.014	.014	
Whole Oysters Adductor muscle Palps, gills, mantle. Digestive gland	Gabriola Island	May 10, /67 One mile from sprayed area	3			Trace	Trace	Good condition
			3			0	0	
			3			0	0	
			3			0	0	
Whole Oysters	Puntledge Estuary (drains Comox Lake) (1) Lower Littoral (2) Middle Littoral	Mar. 30, /67 Specimens taken prior to 1967 spraying	2			.005	.005	Poor condition
			4			.025	.025	
	Seal Island	Mar. 30, /67 (Control- no spraying)				0	0	Excellent condition

TABLE III - BENZENE HEXACHLORIDE RESIDUES IN FISH

SPECIES	LOCATION	DATE	NO. OF SPECIMENS IN SAMPLE	ALPHA BHC	BETA BHC	GAMMA BHC	TOTAL BHC PPM	REMARKS	
Kokanee (whole fish)	Cowichan Lake: I Near spraying site, 4 miles from outlet	Apr. 28, /67 4 weeks after 1967 spray operation	5	.078	.087	.162	.327	Plankton feeders.	
	II Midway to outlet		.215	.226	.282	.723			
	III Lake outlet		.212	.155	.250	.517			
Cutthroat Trout Liver	Location I		4	.005	.005	.006	.011	mean value .011	
	Location II		1	.002	.002	.002	.004		
	Location III		6	.001	.016	.016	.017		
	Location I		4	.040	.040	.040	.080		mean value .069
	Location II		1	.005	.005	.047	.052		
	Location III		6	.042	.042	.034	.076		
Dolly Varden Liver Muscle	Location I & II		2	Trace	Trace	.089	.089+		
	Location I & II		2	.009	.022	.031	.031		
Rainbow Trout Liver Muscles	Location I		5	0	0	0	0		
	Location I		5	Trace	Trace	Trace	Trace		
	Location III		1	0	0	0	0		
Brown Trout-Liver Muscle	Location III		1	Trace	.065	.098	.163		
	Location III		1	Trace	.065	.098	.163		

TABLE IV - BENZENE HEXACHLORIDE RESIDUES IN BIRDS

SPECIES	LOCATION	DATE	NO. OF SPECIMENS IN SAMPLE	ALPHA BHC	BETA BHC	GAMMA BHC	TOTAL BHC PPM	REMARKS	
Peregrine Falcon Egg**	Queen Charlotte Is. (Frederick Island)	1966	1			.045	.045	Canadian Wildlife Service Analysis	
	Victoria (captive bird)	1966	1			.08	.08		Donald Hunter* Analysis
Ancient Murrelet Head Head Liver Head Liver Liver	Queen Charlotte Is.	June 3-12 1967						Collected by D. Blood	
			1	.003	Trace	Trace	.003+		
			1	.025	Trace	Trace	.025+		
			2	0	0	0	0		
		Athlow Bay		4	.008	Trace	Trace		.008
		Athlow Bay		4	0	0	0		0
		Skedans Island		4	0	0	0		0
Pigeon Guillemot Liver Egg Egg	Torrrens Island		6	.004	0	0	.004	Frozen specimen	
	Torrrens Island		2	0	0	.003	.003		
	Torrrens Island		3	0	0	0	0		
Rhinoceros Auklet Liver			1	0	0	0	0		

\* Raptor Research Foundation, South Dakota

\*\* Eggs submitted for Analysis by F. Beebe, B. C. Provincial Museum

## Discussion

Pollution of waters in British Columbia has occurred through the use of Technical Benzene Hexachloride and Lindane, probably that used for the control of Ambrosia Beetle. Concentrations found in water are very low, but are capable of being increased in living organisms to levels much higher than those occurring externally. The figures given here indicate an ability of oysters to accumulate BHC to a concentration 270 times that of an external concentration which can be maximally set at .0001 ppm. The kokanee can accumulate residues to approximately 2000 times the external concentration. Despite this no levels have been discovered which exceed the legal tolerances set for foodstuffs (Hogfat - 4 ppm, other meats - 7 ppm, fruit & vegetables - 10 ppm). However, in view of the selective distribution of BHC within animal tissues, in fish at least concentrating preferentially in the muscle, it seems not unlikely that for some species levels could exceed 4 ppm in the edible portions.

The rate of decay of gamma BHC in seawater has been estimated at 50% in 2 days (i.e. the half-life = 2 days) (1), and in freshwater 7 days (i.e. the half-life = 7 days). This is not in keeping with the results obtained here. Presumably the observations of Werner and Waldichuk did not take into account the BHC removed from circulation by the living components of the ecosystem. It is clear that BHC residues persist both in seawater and freshwater for very considerable periods, not in aqueous solution but contained within the bodies of aquatic plants and animals. On the Queen Charlotte Islands BHC has not been used for a number of years, yet three independent laboratories have each discovered residues in birds or their eggs taken from that area (see Table IV).

It would seem that in Cowichan Lake there is a year-round base level of approximately .0001 ppm gamma BHC, with local increases in the vicinity of treated booms at the time of spraying. This is the result of deposition of approximately 20,000 pounds of Technical BHC in the lake over the past 15 years. In a 50,000 acre lake with a mean depth of 50 feet a deposition of this size would result in a concentration of .003 ppm. if there was no degradation or carry-off with the water flow. Allowing for degradation and loss a residual concentration of .0001 in Cowichan Lake is what might reasonably be expected.

Some danger to wildlife and possibly to human health may result from this pollution. Velson and Alderdice (2) have described the toxicity of BHC to salmon. Thus 1 ppm will kill 50% of young coho salmon in 10 hours.

In view of the presence of concentrations greater than this in areas adjacent to sprayed log booms (see Table I) it is obvious that precautions should be taken to avoid spraying logs where young fish are present. Mortality of fish has been observed at spray sites, but it would appear that dilution rates are sufficiently rapid to prevent fish losses from acute toxicity at depths below 6 inches (4). Oysters and other molluscs may be affected in more than one way: by reduction in phytoplankton and other food organisms (3); by their reaction in closing their shells and ceasing to feed or grow in the presence of pesticides (5); or by the toxic effects of BHC in their tissues. The poor condition of oysters from BHC contaminated areas may stem from these causes but the presence of more general pollutions in the same areas makes it impossible to draw any definite conclusions. Birds and mammals may suffer the effects of acute and chronic toxicity, and the effects of disruption of food chains upon which they depend.

In considering human health it should be borne in mind that the principal isomers of BHC differ in their toxic effects. The beta and gamma isomers are the most toxic. The toxicity of gamma BHC (Lindane) is approximately equal to that of DDT (acute oral LD 50's; DDT - 113; BHC - 87.5 mgm/kgm in Rats) but greater accumulation and storage of beta BHC makes this isomer comparatively more dangerous. Benzene hexachloride, under appropriate circumstances, causes damage to liver, kidney and central nervous system. It has been implicated as a cause of some leukemias, and possesses the biological property of inducing chromosomal damage (polyploidy) in plant cells (6). The dangers of BHC to human health are well documented in the Reports from the Committee on Pesticides of the Council on Pharmacy and Chemistry. (7)

Whether or not the levels of BHC found in British Columbia waters constitute a hazard is a matter for debate - certainly they are a cause for concern. It should be kept in mind that the forest industry is aware of the problem and is making every attempt to find alternative ways to protect logs against Ambrosia Beetles. In response to expressions of concern voiced by the Health Branch, Commercial Fisheries, Federal Fisheries and the Fish and Wildlife Branch the forest industry modified their 1967 spraying program to minimize any possible hazards. It can be anticipated that they will voluntarily restrict their use of this chemical to avoid jeopardy to human health or other values upon which human well-being depends.

The figures presented here should be regarded only as a pilot study carried out to enable the Fish and Wildlife Branch to exercise informed judgement in approving the industrial or other use of benzene hexachloride in situations where the quality of wildlife habitat, of wildlife itself, or the edibility of game meat or fish, might be affected.



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