(TDR03B) DATA EVALUATION RECORD PAGE 1 OF

CASE GS0315 LINDANE PM PM# 04/05/84

CHEM 009001 Lindane (gamma isomer of benzene hexac

BRANCH EEB DISC 40 TOPIC 05054543

FORMULATION 00 - ACTIVE INGREDIENT

FICHE/MASTER ID 00105346 CONTENT CAT 01

Henderson, C.; Pickering, Q.; Tarzwell, C. (1959) Relative toxicity of ten chlorinated hydrocarbon insecticides to four species of fish. Trans. Am. Fish Soc. 88(1):23-32. (Also In unpublished submission received Nov 1, 1970 under unknown admin. no.; submitted by Hercules, Inc., Agricultural Chemicals, Wilmington, DE; CDL:005106-S)

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OTHER SUBJECT DESCRIPTORS
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SEC: EEB -35-05259943

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TITLE: Section Head
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SIGNATURE: Henry T. Craven DATE: 6/6/85

DATA EVALUATION RECORD

1. Chemical: Lindane and Other Chlorinated Hydrocarbons

2. Test Material: Technical. Percents active ingredient of each pesticide are given in the report under "dose."

3. Study Action Type: Freshwater Fish Acute Toxicity Test.

Fathead minnow (Pimephales promelas)
Bluegill (Lepomis macrochirus)
Goldfish (Carassius auratus)
Guppy(Lebistes reticulatus)

4. Study Identification: Henderson, C.; Pickering, Q.; Tarzwell, C. (1959) Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish. Trans. Am. Fish Soc. 88(1): 23-32. MRID: 00105346.

5. Reviewed By: Ann Stavola
Aquatic Biologist
HED/EEB

Signature: Ann Stavola
Date: June 5, 1985

6. Approved By: Harry Craven
Supervisory Biologist
HED/EEB

Signature: H. T. Craven
Date: 6/6/85

7. Conclusions:

The study is not scientifically sound and does not meet our guidelines requirement for a freshwater fish acute toxicity test.

8. Recommendations:

Some of the test solutions were aerated; however, there is no indication as to which solutions were aerated.

9. Background:

This study was submitted through the data-call-in process for the Lindane Standard.

10. Materials and Methods:

A. Test Animals: Fathead minnows (Pimephales promelas), bluegills (Lepomis macrochirus), goldfish (Carassius auratus), guppy (Lebistes reticulatus). The minnows and bluegills were wild native species raised in outdoor ponds at the State Fish Hatchery, Newtown, OH. The goldfish were obtained in uniform lots from a commercial fish farm, and the guppies were raised in the lab.

	Weights	Lengths
Minnows, bluegills, goldfish	1 - 2 g	1 1/2 - 1 1/2 in
Guppies	0.1 - 0.2 g	3/4 - 1 in

B. Dose: The following chlorinated hydrocarbons were studied: Aldrin, 88.4 percent; dieldrin, 90 percent; endrin, 91 percent; endrin EC, 19.5 percent; endrin WP, 75 percent; chlordane, 100 percent; chlordane EC, 75 percent; heptachlor, 72 percent; toxaphene, 67 to 69 percent; DDT, 76 percent; DDT, 100 percent; lindane, 100 percent; BHC, 15.5 percent gamma. The pesticides were prepared in acetone or water, either soft water or hard water.

C. Study Design: The tests were conducted at 25 °C. When D.O. decreased in a few test solutions 0_2 was added to maintain levels of 4 parts per million. For all species but guppies, there were five fish per 10-liter duplicate samples. For the guppies there were five fish in 2-liters of duplicate samples.

D. Statistical Analysis: TLM's were calculated by straight-line graphical interpolation from points representing percent survival of fish and log concentrations of insecticide formulations which bracketed the 50 percent point.

12. Results/Discussion:

The attached tables give the TLM values for the chlorinated hydrocarbons. Similar physiological reactions were observed in fish exposed to all the compounds but BHC. There was a period of excitability followed by alternating periods of muscular spasms and quiescence, the loss of equilibrium and death.

Endrin was the most toxic insecticide, and BHC was the least toxic. Bluegills were generally more sensitive than the other species. There were no significant differences in mortality for fathead minnows in soft water versus hard water.

13. Study Authors Conclusions/QA Measures

Lindane - 96 hr TLM values

Water Quality	Species	TLM (ppb)
Hard	Fatheads	56
Soft	Fatheads	62
Soft	Bluegills	77
Soft	Goldfish	152
Soft	Guppies	138

No QA Statement.

14. Reviewer's Evaluation:

A. Test Procedures:

The test procedures are generally acceptable except for one major point: some of the test solutions were aerated when D.O. levels fell too low. There is no indication as to which pesticides were aerated. Aeration is only acceptable if the concentrations are monitored. This was not done in this study. Also, goldfish and guppies are not approved species.

B. Statistical Analysis:

Without the raw mortality data the reported results cannot be verified.

C. Discussion/Results:

Because of the uncertainty as to which pesticides were aerated during testing none of the reported results are reliable.

D. Conclusions:

1. Category: Invalid

2. Rationale: Aeration of some of the test solutions without monitoring the concentrations. The authors do not indicate which pesticides were aerated. Also, lack of raw mortality data and D.O. and ph levels during the tests.

3. Repairability: If we knew which pesticides were not aerated, the results of the tests on fatheads and bluegills for those pesticides could be upgraded provided we also had the raw mortality data and data on D.O. and PH.

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Physical and chemical determinations (dissolved oxygen, pH, alkalinity, acidity, and hardness) were made on each test concentration initially and after fish mortality or at the completion of the test. This was done primarily to detect low dissolved oxygen levels so they could be controlled if necessary and to determine other conditions which might affect toxicity.

Fish reactions were observed over a 96-hour period. From the mortality in different concentrations, 24-, 48-, and 96-hour TL_m (median tolerance limit) values were obtained. The median tolerance limit is the concentration of a chemical in dilution water which causes 50 percent mortality of the test fish. These values were obtained by straight-line graphical interpolation from points representing percent survival of fish and log concentrations of insecticide formulations which bracketed the 50 percent point (Doudoroff *et al.*, 1951).

BIOASSAY RESULTS

A summary of bioassay results for the chlorinated hydrocarbon compounds and formulations is given in Table 1. Twenty-four, 48- and 96-hour TL_m values are shown for the different species of fish and different dilution waters. All values are reported as parts per million by weight (milligrams/liter) of the compound or formulation as described in the previous section (Chlorinated Hydrocarbon Insecticides).

In practically all of these bioassays fish mortality definitely increased between the 24- and 96-hour periods. In a few experiments which were allowed to remain for periods of ten days additional fish mortality occurred. Further experiments in which fathead minnows were exposed for twenty days to continuously renewed solutions of DDT showed that toxicity was approximately twice (TL_m value half) that obtained in 96-hour static experiments. These

compounds appar... chronic effect on ...

During the cour... and chemical chara... (dissolved oxyge... ness) were not gr... the dilution wate... was decreased in ... uted to the aceto... was added to ma... p.p.m.

Physiological re... somewhat similar ... tested except BHC ... of the compounds ... trations, was mu... served with many ... high concentration... of effect occurred ... posure while in l...

TABLE 1.—(Cont...

Formula...

Heptachlor, technical
72 percent active in aceto...

Toxaphene, reference sta...
100 percent active in ace...

DDT, technical
76 percent p,p'-isomer in ...

DDT, screened
100 percent p,p'-isomer in ...

Methoxychlor, recrystall...
100 percent active in ace...

Lindane, recrystalized
100 percent active in ace...

BHC, technical
13.5 percent gamma isom...

TABLE 1.—*TL_m (median tolerance limit) values for chlorinated hydrocarbon insecticide formulations.*

Formulation	Dilution water	Kind of fish	TL_m p.p.m. (milligrams/liter) 24 hour	48 hour	96 hour
Aldrin, technical 88.4 percent active in acetone	Soft	Fatheads	.047	.040	.037
	Hard	Fatheads	.041	.032	.032
	Soft	Bluegills	.018	.018	.015
	Soft	Goldfish	.026	.032	.032
	Soft	Guppies	.089	.050	.037
Dieldrin, technical 90 percent active in acetone	Soft	Fatheads	.040	.018	.018
	Hard	Fatheads	.018	.018	.018
	Soft	Bluegills	.014	.0093	.0068
	Soft	Goldfish	.048	.041	.041
	Soft	Guppies	.062	.032	.025
E. drin, technical 91 percent active in acetone	Soft	Fatheads	.0018	.0013	.0013
	Hard	Fatheads	.0016	.0015	.0014
	Soft	Bluegills	.00075	.00075	.00066
	Soft	Goldfish	.0050	.0023	.0021
	Soft	Guppies	.0034	.0028	.0016
Endrin, emulsible concentrate 19.5 percent active in water	Soft	Fatheads	.0048	.0032	.0029
	Hard	Fatheads	.0068	.0047	.0038
	Soft	Bluegills	.0042	.0042	.0037
Endrin, wettable powder 75 percent active in water	Soft	Fatheads	.0039	.0029	.0026
	Hard	Fatheads	.0041	.0035	.0032
Chlordane, reference standard 100 percent active in acetone	Soft	Fatheads	.069	.069	.052
	Hard	Fatheads	.098	.069	.069
	Soft	Bluegills	.036	.032	.022
	Soft	Goldfish	.166	.087	.062
	Soft	Guppies	.56	.19	.19
Chlordane, emulsible concentrate 75 percent active in water	Soft	Fatheads	.19	.17	.17
	Hard	Fatheads	.26	.18	.18

(Continued on following page)

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compounds apparently have a cumulative or chronic effect on fish.

During the course of the bioassays, physical and chemical characteristics of the test solutions (dissolved oxygen, pH, alkalinity and hardness) were not greatly changed from those of the dilution water. While dissolved oxygen was decreased in a few test solutions (attributed to the acetone solvent), sufficient oxygen was added to maintain levels of at least 4 p.p.m.

Physiological reactions of the test fish were somewhat similar for all of the compounds tested except BHC. The reaction time to most of the compounds, even in the highest concentrations, was much slower than has been observed with many other toxic compounds. In high concentrations the first visible evidence of effect occurred after 30 to 60 minutes exposure while in lower concentrations a much longer time was required. Generally, a brief period of high excitability, during which the fish swam rapidly on the surface around the edges of the test aquaria, was followed by alternate periods of muscular spasms resulting in short jerky movements and then by short quiescent periods accompanied by partial loss of balance. This was followed by complete loss of equilibrium with the fish swimming on their backs in short jerky movements on the water surface is a circular pattern around the edges of the test jar. Death followed after varying periods, sometimes as long as 24 hours or more. A swelling in the abdominal region, especially pronounced in fathead minnows, was observed. The fish also appeared somewhat lighter in color than the controls. Fish exposed to BHC did not react characteristically but slowly sunk to the bottom of the aquaria and gradually expired.

TABLE 1.—(Cont'd).—*TL$_m$ (median tolerance limit) values for chorinated hydrocarbon insecticide formulations*

Formulation	Dilution water	Kind of fish	TL$_m$ p.p.m. (milligrams/liter) 24 hour	48 hour	96 hour
Heptachlor, technical 72 percent active in acetone	Soft	Fatheads	.134	.13	.13
	Hard	Fatheads	.084	.080	.078
	Soft	Bluegills	.042	.032	.026
	Soft	Goldfish	.72	.385	.320
	Soft	Guppies	.225	.148	.148
Toxaphene, reference standard 100 percent active in acetone	Soft	Fatheads	.013	.0075	.0075
	Hard	Fatheads	.016	.0075	.0051
	Soft	Bluegills	.0075	.0038	.0035
	Soft	Goldfish	.0082	.0068	.0056
	Soft	Guppies	.042	.024	.020
DDT, technical 70 percent *p,p'*isomer in acetone	Soft	Fatheads	.056	.045	.042
	Hard	Fatheads	.078	.068	.045
	Soft	Bluegills	.026	.021	.021
	Soft	Goldfish	.180	.047	.036
	Soft	Guppies	.135	.072	.056
DDT, screened 100 percent *p,p'*isomer in acetone	Soft	Fatheads	.032	.026	.026
	Hard	Fatheads	.029	.027	.026
Methoxychlor, recrystalized 100 percent active in acetone	Soft	Fatheads	.066	.064	.064
	Hard	Fatheads	.040	.038	.035
	Soft	Bluegills	.066	.062	.062
	Soft	Goldfish	.120	.086	.056
	Soft	Guppies	.24	.125	.120
Lindane, recrystalized 100 percent active in acetone	Soft	Fatheads	.072	.070	.062
	Hard	Fatheads	.070	.056	.054
	Soft	Bluegills	.120	.077	.077
	Soft	Goldfish	.23	.23	.152
	Soft	Guppies	.20	.145	.138
BHC, technical 15.5 percent gamma isomer in acetone	Soft	Fatheads	22	16	15
	Hard	Fatheads	15	13	13
	Soft	Bluegills	10	7.8	5.1
	Soft	Goldfish	26	21	15
	Soft	Guppies	18	18	14

TOXICITY TO DIFFERENT SPECIES OF FISH

The direct comparative 96-hour TL$_m$ values for the ten chlorinated hydrocarbon compounds to four species of fish are shown in Table 2. All values are reported in parts per billion (micrograms/liter) of the pure compounds computed from the percentage of compound in the technical grade or reference standard material. All of the values are based on bioassays conducted under carefully standardized conditions using soft water as the diluent and at a temperature of 25°C. Many are averages of two or more replicate experiments.

Endrin was by far the most toxic of the insecticides to all species of fish. In fact, it is the most toxic chemical that has been tested in this laboratory. The very closely related compounds, aldrin and dieldrin, were considerably less toxic, showing that a slight change in chemical structure can greatly change the degree of toxicity. Toxaphene was the second most toxic insecticide, followed by dieldrin, aldrin, and then DDT. Heptachlor, chlordane, methoxychlor, and lindane were only slightly less toxic than DDT. All of the compounds tested, except BHC, would be considered highly toxic to fish and were toxic to native species in concentrations of less than 100 p.p.b. (0.1 p.p.m.).

In numerous replicate experiments with BHC, the data were highly variable. The concentrations needed to produce any fish mortality far exceeded the solubility of this compound in water. It was observed during the bioassays that when acetone solutions of BHC were added to water, much of the material precipitated and settled to the bottom of the test containers. The values for BHC given in Table 2 are based on the *gamma* isomer content (15.5 percent) and these values should be roughly comparable to those for lindane, the pure *gamma* isomer. However, these values are widely different, with the *gamma* isomer in BHC much less toxic than the pure *gamma* isomer. Apparently the other isomers in BHC either reduce the solubility of the *gamma* isomer or have a very strong antagonistic effect. Additional experiments lend credence to this theory. A concentration of 0.1 p.p.m. of lindane alone caused 100 percent mortality of fathead minnows in 24 hours. When 3.2 p.p.m. of technical BHC and 0.1 p.p.m. of lindane were added to the same test tank, no fish mortality occurred in 96 hours. A concentration of 3.2 p.p.m. of technical BHC alone produced no fish mortality. BHC was by far the least toxic to fish of the compounds tested.

TABLE 2.—*Comparative toxicity of chlorinated hydrocarbon insecticides to different species of fish*[1]

Insecticide	96 hour TL$_m$ (median tolerance limit) p.p.b. (micrograms/liter) active agent			
	Fathead	Bluegills	Goldfish	Guppies
Aldrin	33	13	28	33
Dieldrin	16	7.9	37	22
Endrin	1.0	0.60	1.9	1.5
Chlordane	52	22	82	100
Heptachlor	94	19	230	107
Toxaphene	7.5	3.5	5.6	20
DDT	32	16	27	43
Methoxychlor	64	62	56	120
Lindane	62	77	152	138
BHC	2300	790	2300	2170

[1] Under standardized conditions — soft water as diluent. Temperature 25° C.

It is difficult to make generalizations concerning the toxicity of a group of compounds, regardless of how closely they are related. Each compound has its individual characteristics and may or may not have identical physiological effects on an organism. Thus the relative toxicity to different species may not be the same, even for very closely related compounds. This fact is borne out by a careful examination of the values given in Table 2.

Bluegills are generally more sensitive to the chlorinated hydrocarbon insecticides than the other species. Compared with fathead minnows, their sensitivity is approximately equal to two of the compounds, is two or three times greater to most, and is about five times greater to one compound. Fathead minnows in turn are more sensitive to most of the compounds than goldfish and guppies. While there is no definite relationship between the sensitivity of goldfish and guppies, goldfish may be considered slightly more sensitive to the whole group of compounds. Even such closely related compounds as dieldrin and endrin, chlordane and heptachlor, and DDT and methoxychlor do not necessarily give similar toxicity relationships.

In studies of the susceptibility of trout and warm water fishes to DDT, Surber and Hoffman (1949) state that "fingerling bluegills, smallmouth black bass, and black crappies were found more sensitive to DDT than largemouth bass, golden shiners and trout." On the basis of the summarized literature on the toxicity of chlorinated hydrocarbon insecticides to fish (Rudd and Gennely, 1956), bluegills apparently are among the most sensitive warm-water species. The salmon are appar... less sensitive than ... species of fish ha... less sensitive than ...

TOXICITY IN DIFF...

The toxicity of ... known to be gre... water characteristics ... hardness, and pow... erature, turbidity, ... assays were conduc... different in pH, ... similar in other ... If these qualities ... toxicity of the chl... ticides. The soft ... scribed in the sec... encompass the ran... tics of most natura...

The comparative ... insecticides for fa... hard waters are sh... are reported as par... liter) of active ag... centage values show... toxicity values in ... in close agreement ... experimental error ... bioassays. Two of ... chlordane, appear ... soft water, while ... methoxychlor are ... toxic in hard wate... suits, it may be co... and hardness (with ... no major effect on ... ed hydrocarbon in...

TABLE 3.—*Comparati... carbon insecticides ... dilution waters*

Insecticide	Per... ac... ag...
Aldrin	
Dieldrin	
Endrin	
Chlordane	
Heptachlor	
Toxaphene	
DDT	
Methoxychlor	
Lindane	
BHC	