EFFECTS OF PESTICIDES IN WATER

A Report to the States

U.S. ENVIRONMENTAL PROTECTION AGENCY

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FOREWORD

The Water Quality Improvement Act of 1970 amended the Federal Water Pollution Control Act by adding a new subsection 5(1). The Federal Water Pollution Control Act Amendments of 1972 modified the language of Subsection 5(1) and renumbered it as Subsection 104(1) of the Federal Water Pollution Control Act. Subsection 104(1) reads as follows:

> (1)(1) The Administrator shall, after consultation with appropriate local, State and Federal agencies, public and private organizations, and interested individuals, as soon as practicable but not later than January 1, 1973, develop and issue to the States for the purpose of carrying out this Act the latest scientific knowledge available in indicating the kind and extent of effects on health and welfare which may be expected from the presence of pesticides in the water in varying quantities. He shall revise and add to such information whenever necessary to reflect developing scientific knowledge.
>
> (2) The President shall, in consultation with appropriate local, State and Federal agencies, public and private organizations, and interested individuals, conduct studies and investigations of methods to control the release of pesticides into the environment which study shall include examination of the persistency of pesticides in the water environment and alternatives thereto. The President shall submit reports, from time to time, on such investigations to Congress together with his recommendations for any necessary legislation.

This document is issued to fulfill the requirement of paragraph 104(1)(1). A document entitled Pesticides in the Aquatic Environment has been prepared for submission to the Congress by the President to fulfill the requirement now contained in paragraph 104(1)(2). Any person interested in the problems associated with pesticides in the aquatic environment may wish to read both of these documents.

The scientific information contained in this document consists of current knowledge of the effects on health and welfare of the presence of pesticides in water. It must be emphasized, however, that many other factors must be considered in reaching decisions as to whether to undertake particular control measures. Some of the more important considerations are:

-- The nature of the environmental effect of the presence of pesticides in water (e.g., long or short term, temporary or permanent, localized or widespread, etc.).

-- The economic and social impact of the control measure, including both impact associated with restricting use of pesticides, and the impact of the environmental damage to be alleviated.

-- The practicality and enforceability of the control measure, including the availability of techniques and instrumentation for determining whether particular standards are being met.

-- The availability of other control measures for meeting the same objectives, and the relationship to, and consistency of the control measure with, policy and action under other programs. Especially to be kept in mind, in this regard, is the national program administered by the Environmental Protection Agency pursuant to the Federal Insecticide Fungicide and Rodenticide Act (FIFRA). Historically, this program has controlled the distribution and labeling of pesticides through a case by case registration process. The major extension and revision of the Environmental Protection Agency's authority in the pesticide field provided for in the recent amendments to FIFRA will vastly improve the means available to EPA for protecting the aquatic environment.

Thus, this document provides available information to the States for the purpose of carrying out the Federal Water Pollution Control Act, but it provides information on only one of several factors to be considered in determining whether to undertake a given control measure. It does not recommend the adoption of particular standards or other types of control measures.

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INTRODUCTION

Because water is used by man for many different purposes, pesticides in water may affect health and welfare in a variety of ways. For convenience, we can discuss the effects of pesticides according to the various uses of water, whether the water is withdrawn for use or is used where it is. Water for municipal, industrial, and agricultural uses is drawn from surface or subsurface sources; effects of pesticides on health, industrial processes, domestic animals and crops are of interest here.

Water in place is useful for recreation, aesthetic purposes, and propagation of fish and other aquatic life; the effects of pesticides on organisms living in, or dependent upon organisms living in, water are of concern. In addition to the obvious effects on fish or shellfish and the well-known transfer of certain pesticides to man or other mammals and birds through food chains, effects on other biological processes such as decomposition, energy transfer, mineral cycling, and photosynthesis are of interest.

The effects of pesticides in potable water and irrigation waters are not dealt with here because that subject is addressed specifically in setting tolerances for pesticides in potable water, fish, shellfish, meat, and poultry, and crops watered by irrigation water under authority provided by the Federal Food, Drugs and Cosmetic Act (see 408, 409, 68 Stat. 512; 21 USC 346). For this report it is sufficient to note that: (a) in regulating human intake of pesticides, all routes must be considered -- not just water. The amount taken in from drinking water is relatively small compared to other sources; (b) fish and other aquatic organisms are more influenced by pesticide levels in water than are other organisms, including man. (Aquatic organisms are continuously submersed in water and its associated contaminants, and thus are subjected to the contaminants through their gills and body surfaces as well as through their food.) Thus, levels of pesticides in water sufficiently low to protect fish and aquatic life are generally more than adequate to protect man. In the unusual event that drinking water supplies are drawn from waters that cannot support fish and aquatic life, special attention must be paid to assuring that drinking water standards for pesticides are met.

Pesticides are chemicals, natural and synthetic, used to control or destroy plant and animal life considered adverse to human society. Since the 1940's, a large number of new synthetic organic compounds have been developed for pesticide purposes. While there are approximately 33,000 registered formulations incorporating nearly 900 different chemicals, 25 substances account for 75 percent of U.S. production. Production and use of pesticides increased annually from 1957 through 1968; in 1969 and 1970 pesticide production declined.

The maximum pesticide levels found in 529 samples of surface water collected annually at approximately 100 stations during a five-year period are shown in Appendix Table 1. Coupling these figures with a 2-liter/day water consumption, the daily intake per person for each pesticide is computed. For comparison, the average daily intake of pesticides from food is shown, as is the acceptable daily intake as established by WHO-FAO expert committees.

The final column shows that intake from water would be only 1/6 that from food in the case of aldrin-dieldrin; 1/10 that from food in heptachlor-heptachlor epoxide; and 1/20 that of DDT+DDE+DDD.

Because average levels in water are far below these maximum figures, the actual contribution of water to pesticide intake is much less. Furthermore, drinking water treatment removes suspended matter (in which much pesticide residue is adsorbed) from the raw water and therefore reduces still further the actual amount reaching man.

Pesticides are used for a wide variety of purposes in a multitude of environmental situations. Often they are categorized according to their use or intended target (e.g., insecticide, herbicide, fungicide), but their release in the environment presents an inherent hazard to many non-target organisms. Some degree of contamination and risk is assumed with nearly all pesticide use. The risk to aquatic ecosystems is dependent upon the chemical and physical properties of the pesticide formulation; weather conditions, methods of application, and other factors influencing the amount reaching the system; and the nature of the receiving system.

The pesticides of greatest concern are those which are persistent for long periods and accumulate in living organisms and the environment; those which are highly toxic to man, fish and wildlife; and those which are used in large amounts over broad areas.

The majority of these compounds are either insecticides or herbicides which are used extensively in agriculture, in public health and for household or garden purposes. Generalization about such a diverse group of chemicals is subject to many contradictions, but some generalization is required to serve as a guide for managing pesticide residues in water. In any final consideration, however, each pesticidal formulation must be considered individually according to information on its behavior in the environment and its effects on man and other organisms. The benefits to be derived from its use also should be taken into account.

EFFECTS OF PESTICIDES IN AQUATIC SYSTEMS

The biota of aquatic systems is the result of complex evolutionary processes in the course of which organisms tolerating many different conditions have evolved. Thus, under natural conditions, the biota of a given body of water is made up of an aggregation of organisms adapted to, and in dynamic balance with, the environmental conditions.

As conditions change, organisms unable to tolerate the new conditions are eliminated, and new organisms suited to these new conditions replace them. With evolutionary rates of change, many of the earlier organisms evolve to tolerate the new conditions; with rapid changes, such as many of those caused by man, most new organisms arrive by immigration rather than evolution. Bacteria are an exception and often accommodate to new conditions by very rapid evolution. When the rate of change is very rapid, or the change very severe, relatively few organisms survive. Depending upon the nature of the area and accessability to replacements, immigration may not provide replacements immediately. When the change consists of the introduction of substances toxic to a wide variety of organisms, the biota may be diminished greatly, as to both numbers of species and number of individuals within species; if the toxic substance remains in the system (is "persistent" or is continuously replaced), the lowered populations and numbers of species may continue until the material is sufficiently diluted, sequestered, or detoxified to permit repopulation of the systems. If the area affected is large, return to the earlier condition may take a very long time, and some species may have been extirpated. If the toxic material degrades rapidly, depopulation will be temporary if the area affected is small.

Behavior of Pesticides in the Environment

Many pesticides have a very low water solubility, and often are rapidly sorbed on suspended or sedimented materials; those with high fat solubility often accumulate in plant and animal lipids. Soluble or dispersed fractions in the water rapidly diminish after initial contamination resulting in increased concentrations in the sediments (Yule and Tomlin, 1971). In streams, much of the residue is in continuous transport on suspended particulate material or in sediments (Zabik, 1969). The distribution within the stream flow is non-uniform because of unequal flow velocity and distribution of suspended materials within the stream bed (Feltz, 1971). Seasonal fluctuations in run-off and use patterns cause major changes in concentration during the year, but the continuous downstream transport tends to reduce levels in the upper reaches of streams while increases may be observed in the downstream areas and eventually in major receiving basins (lake, reservoir, estuary, and ocean). If applications in a watershed cease entirely, residues in the stream gradually and continuously decline (Sprague, et al., 1971), and a similar decline would be expected in the receiving basins but at a slower rate and a later time.

In lakes, sediments apparently act as a reservoir from which the pesticide is partitioned into the water phase according to the solubility of the compounds, the concentration in the sediment, the type of sediment, and the degree of absorption (Hamelink, et al., 1971). Many herbicides applied to aquatic systems to control aquatic plant growth pass from water to organic sediments where they may persist for long periods, although water concentrations remain low (Frank and Comes, 1967). Dissolved natural organic materials in the water may greatly enhance the amounts of some pesticides carried in water (Wershaw, et al., 1969). Some investigations indicate pesticides may be less available to the water in highly fertile systems where the higher organic content in the sediments has a greater capacity to bind pesticide residues. This may in part explain the difference in times required for different waters to "detoxify" as observed in lakes treated with toxaphene to eradicate undesirable fish species (Terriere, 1966).

Kinds of Effects

Pesticides may be harmful because they eliminate or reduce populations of desirable organisms directly, or because they indirectly alter conditions required by these organisms. Direct effects include mortality, birth defects, induction of tumors and genetic changes, altered behavior patterns, or physiological changes including alterations in reproduction; the effects may take place during any stage of the organism's life history. Indirect effects may include reduction of species used as food sources by other species; reduction in rates of photosynthesis, decomposition or mineralization, with attendant unsatisfactory conditions for certain species; and temporary increased BOD (biological oxygen demand) in a body of water resulting from decomposition following death of plankton or other organisms caused by a pesticide. Additionally, many species can accumulate pesticide residues directly from the water, or from sediments, and these residues may in turn be accumulated in organisms that feed on the lower forms of life. This latter phenomenon has resulted in pesticide residues entering human food supplies and in effects on other mammals and fish-eating birds.

Except in the case of man and domestic animals, effects on individuals are less important than effects on populations, communities of organisms, and whole ecosystems. Most organisms in the wild have short life spans, and the turnover rates of the populations are very high. Furthermore, because most species have high reproductive rates, most individuals in a population are biologically excess to the continued existence of the population and unless the fraction of the population killed is high, the level of the population will be only temporarily suppressed. Birth defects, tumors, and even genetic changes may be relatively unimportant to survival in wild populations with rapid turnover rates because individuals rendered unfit will be eliminated without detriment to the continuation of the population; i.e., mortality is transferred to the unfit. Where turnover rates are low and life spans relatively long as in osprey, eagle, brown pelican and certain other species, birth defects, genetic changes, and tumors may be significant.

Lethality

Concentrations of pesticides that are lethal to aquatic life have occurred in local areas where applications overlap streams or lakes, in streams receiving runoff from recently treated areas, and where misuse, spillage, or improper waste disposal have occurred. Applications of pesticides to water to control noxious plants, fish, or insects have also killed desirable species. Past experience with local fish mortalities from pesticide contamination has shown that some fish populations recover within a few months to a year after pesticide contamination is stopped (Elson, 1967). The recovery of aquatic invertebrates in areas that have been heavily contaminated may require a longer period with some species requiring several years to regain precontamination numbers (Cope, 1961; Ide, 1967). Recovery in Arctic areas also is very slow (Reed, 1966). Less desirable species of insects may be the first to repopulate the area (Hynes, 1961) and in some instances the species composition has been completely changed (Hopkins, 1966). Areas that are contaminated by pesticide application are subject to loss of fish populations and/or reduced food available for fish growth (Schoenthal, 1963; Kerswill, et al., 1967). Where residues are persistent in bottom sediments for long periods, benthic organisms may be damaged even though water concentrations remain low (Wilson and Bond, 1969).

Great differences in susceptibility exist among species and within species for different compounds. As an example, Pickering, et al. (1962) reported 96-hour LC-50 values of 5 to 610,000 ug/l (ppb) for various fish species exposed to organophosphate pesticides. In addition to species differences, the toxicity may be modified by differences in formulation, environmental conditions such as temperature and water hardness, animal size and age, previous exposure, and physiological condition. The effects of combinations of pesticides on aquatic organisms are not well understood. Macek (unpublished) reported that some combinations of various common pesticides were synergistic in their action on bluegill and rainbow trout, while others had only additive effects.

Most data on the effects of a given pesticide on aquatic life are limited to concentrations that are lethal in short-term tests and for only a few species. The relatively few chronic tests conducted with aquatic species indicate that effects usually occur at concentrations much lower than lethal concentration levels, and that continued exposure to relatively low concentrations may often result in detectable effects. Mount and Stephan (1967) found the 96-hour LC_{50} for fathead minnows to malathion was 9000 ug/l, but spinal deformities in adult fish occurred during a 10-month exposure to 580 ug/l. Eaton (1970) found that bluegills with a 96-hour LC_{50} of 108 ug/l suffered the same spinal deformities as the fathead minnows after chronic exposure to only 7.4 ug/l malathion.

Mount and Stephan (1967) have raised the possibility of estimating no detectable effect levels for species of fish for which such levels have not been experimentally determined through the use of "application factor" values. The "application factor" for a pesticide or other chemical is the ratio obtained by dividing laboratory determined maximum concentrations of the pesticide or other chemical that have no detectable chronic exposure effect in a species of fish by the 96-hour LC_{50} for that species. The hypothesis is that the ratio or "application factor" does not vary substantially for the same compound among species of fish, whereas both sensitivity of a fish species to different toxicants and sensitivity to the same toxicant by different species vary widely. The experimental data to support the hypothesis are as yet few, and for pesticides even fewer. Table 1 presents available data on application factors for pesticides and, in addition, presents data on other substances where more than a single species of fish has been tested.

Where data for more than a single species or a compound exist, the greatest disparity between the high and low application factor is a factor of 10 for $Chromium^{+6}$. Copper is next with a factor of 7. For all others, the difference is 3 or less. On the other hand, the application factors for different compounds for the same species differ as much as 1000-fold (fathead minnows in relation to diazinon at 0.0005 and lindane at 0.5).

Table 1. "Application Factors" Determined Experimentally.

Chemical	Fish Species	96- Hour LC_{50} (mg/l)	Application Factor c/
More than 1 species tested			
Malathion	Fathead Minnow	10.5	.02
	Bluegill	.08	.04
	Brook Trout	.2	.02
Lindane	Fathead Minnow	50	.5
	Brook Trout	26	.38
$Chromium^{+6}$	Fathead Minnow	33	.03
	Brook Trout	50	.01
	Rainbow Trout	69	.003
Copper	Fathead Minnow a/	.47	.03
	Fathead Minnow b/	.075	.14
	Bluegill	1.1	.02
	Brook Trout	.1	.09
Cadmium	Fathead Minnow	31	.001
	Bluegill	20	.0015
	Green Sunfish	20	.0025
Methyl Mercury	Fathead Minnow	.04	.006
	Brook Trout	.096	.003
Lead	Brook Trout	4.5	.013
	Rainbow Trout	.14 (18 day)	.043
Pesticides where only a single species has been tested			
Diazinon	Fathead Minnow	6	.0005
Captan	Fathead Minnow	.065	.10
2,4-D Butoxy-ethanol ester	Fathead Minnow	5.6	.05
Carbaryl	Fathead Minnow	9	.023
Methoxychlor	Fathead Minnow	.0075	.017

a/ Hardwater.

b/ Softwater.

c/ The "application factor" is the ratio obtained by dividing experimentally determined maximum concentrations of a pesticide that have no detectable effect during chronic exposures by the 96-hour LC_{50} for that species.

Thus, further investigation may provide additional support for estimating no detectable chronic effect levels when only acute toxicity data for the fish species of interest is available, but an application factor has been determined experimentally for some other fish species for the pesticide of interest.

Some reported acute toxicity values and sub-acute effects of pesticides for freshwater aquatic life are listed in Appendix Table 2 and for estuarine and marine life in Appendix Table 3.

Work done in this area for invertebrates has shown acute and chronic toxicity levels to be much closer together than those for fish. As a result of this phenomenon, the possibility of determining application factors for use in establishing no detectable effect levels for invertebrates is not promising.

Even when concentration levels which are acutely toxic and those which produce no detectable effect are both known, their use in the regulation of pesticides is complex. Maximum "acceptable" levels for particular bodies of water or portions thereof must reflect full consideration of both the benefits of pesticide use and the environmental costs of such use. The two levels discussed thus far may be considered as merely two points among the full range of dose and effect; the entire range may be of interest as regulatory decisions are made. Concentrations equal to or greater than the 96-hour LC_{50} may well be "acceptable" depending on the area affected, the time involved, the importance of pesticide use, water use classification, and other factors.

Persistence and Biological Accumulation

All organic pesticides are subject to metabolic and non-metabolic degradation in the environment. Different compounds vary tremendously in their rate of degradation and some form degradation products which may be both persistent and toxic. Many pesticides are readily degraded to non-toxic or elemental materials within a few days to a few weeks. These "non-persistent" compounds may be absorbed by aquatic organisms, and may affect the organism, but the residues do not necessarily accumulate or persist for long periods. Concentrations in the organism may be higher than ambient water levels, but sublethal amounts decline rapidly as water concentrations decrease. Examples of such dynamic exchange have been demonstrated with malathion (Bender, 1969), methoxychlor (Burdick, 1968), various herbicides (Mullison, 1970, and others). If degradation in water is sufficiently rapid that adverse physiological effects do not occur, these non-persistent compounds do not pose a long-term hazard to aquatic life. Degradation rates are often a function of environmental conditions, however, and great variation may be observed. The organophosphate insecticides, for example, are rapidly hydrolysed in alkaline waters and at higher temperatures, whereas at lower pH and temperature they may persist for several months (Gakstatter and Weiss, 1965). Repeated applications and slow degradation rates may maintain elevated environmental concentrations and hence bring about undesired changes in the biota, but there is no indication that these compounds can be accumulated through the food chain.

Effects of pesticides may be persistent or even cumulative, even though the pesticide may not be persistent or continuously present in the environment. Thus fish exposed to sublethal levels of malathion have shown depressed acetylcholinesterase levels which are slow to recover. Subsequent sublethal exposures have resulted in additional cholinesterase depression sufficient to result in death (Coppage and Duke, in press).

Some pesticides, primarily the organochlorine and metallic compounds, are extremely stable, degrading only slowly or forming persistent degradation products. Residues may be detectable for weeks, months or years. Aquatic organisms may accumulate these compounds directly from water and from contaminated food. Some fish and some other aquatic organisms accumulate organochlorine compounds from remarkably low levels. Thus it has been shown experimentally that shrimp and some fish can take up polychlorinated biphenyls (PCB's) from concentrations of less than 1/10 part per billion (ppb) in water, and accumulate them by factors of as much as 75,000. (Nimmo, et al., 1971; Stallings and Mayer, 1972). In other cases, it appears that uptake is by algae and invertebrates with residues in fish resulting from feeding on contaminated foods. Either process, or a combination of the processes ultimately results in residues in the higher feeding levels that may be many thousand times higher than ambient water levels.

Food chain accumulation does not stop at the water's edge. In fact, fish-eating birds often contain the highest residue levels of DDT and its breakdown products (DDE and DDD) in food chains studied. DDT (including its breakdown products) is the best understood of the persistent pesticides. It is widely distributed in freshwater and marine environments in North America and throughout the world. Its most abundant breakdown product is DDE.

The discovery and clear demonstration of DDE-induced thinning of shells of the eggs of wild birds constituted a major research breakthrough of the late 1960's. In 1967, Derek Ratcliffe reported a synchronous, rapid, and widespread decline in weight and thickness of shells of eggs laid by British peregrine falcons and sparrowhawks that occurred in the mid-forties (Ratcliffe, 1967). Eggshell thinning proved not to be confined to Great Britain, for in 1968 Hickey and Anderson reported eggshell thinning of 18-26 percent in regional populations of three species of raptorial birds that had declined markedly in the United States (Hickey and Anderson, 1968). The period of decline coincided with the same occurrence in Great Britain and persisted through succeeding years. Museum studies were extended to include more than 23,000 eggs of 25 species (Anderson and Hickey, 1970). Some degree of shell thinning was found among 22 species representing seven Orders of birds. Nine of the species sustained shell thinning of 20 or more percent. Other workers have subsequently extended the list.

These findings produced the hypothesis of DDT involvement. The hypothesis was tested experimentally. The first clearcut experimental demonstration that DDE caused thin eggshells was provided in studies of mallard ducks (Heath, et al., 1969). In subsequent controlled experiments, dietary dosages of approximately 3 ppm wet weight of DDE thinned the shells of eggs laid by kestrels (Wiemeyer and Porter, 1970), black ducks (Longcore, et al., 1971), and screech owls (McLane and Hall, 1972), extending the experimental demonstration to four species of three Orders of birds. Quail and chickens, seed-eating galliform birds, were, at the most, only slightly susceptible (Smith, et al., 1970; Stickel and Rhodes, 1970; Cecil et al., 1971, 1972).

The third stage of investigation was to return again to the field and study the relationships between thinning of shells and residues in the eggs. The brown pelican provided the ideal test because of contrasting residues and reproductive success in different localities. The California colony was essentially failing, the Carolina population declining, and the Florida colonies remaining reasonably stable. Measurements of shell thickness and residues of dieldrin, PCB's, mercury, lead, DDT, DDD, and DDE were subjected to computerized statistical tests, which implicated DDE as the shell thinner (Blus, 1970; Blus, et al., 1971, 1972).

Residues

Samples of fish have often contained pesticide residues in concentrations that give rise to concern. The highest concentrations are often in those species most highly prized as food or game species inasmuch as these species are usually at the top of a relatively long food chain. Sales in interstate commerce of coho salmon and several other species from Lake Michigan and of canned Jack mackerel in California, were prohibited in 1967 on the basis of DDT residues in excess of the 5 ppm interim guideline for DDT and its metabolites set for fish by the U.S. Food and Drug Administration. Pesticide residues in fish or fish products may enter the human food chain less directly; for example, through fish oil and meal used in domestic animal feeds, which result in turn in residues in meat and other animal products.

Fish may survive relatively high residue concentrations in their body fats, but residues concentrated in the eggs of mature fish may be lethal to the developing fry. Burdick (1964) reported up to 100 percent loss of lake trout fry when residues of DDT-DDD in the eggs exceeded 4.75 mg/kg. (ppm). A similar mortality was reported in coho salmon fry from Lake Michigan when eggs contained significant quantities of DDT, dieldrin, and polychlorinated biphenyls (Johnson and Pecor, 1969; Johnson, unpublished). Johnson (1967) reported that adult fish which did not appear to be harmed by low concentrations of endrin in water, accumulated endrin levels in the eggs that were lethal to the developing fry.

Residues in fish may be directly harmful under stress conditions or at different temperature regimes. Brook trout fed DDT at 3.0 mg/kg. body weight per week for 26 weeks suffered 96.2 percent mortality during a later period of reduced feeding on clean food and declining water temperature; mortality of untreated control fish during the same period was 1.2 percent (Macek, 1968). Declining water temperature during the fall was believed to cause delayed mortality of salmon parr in streams contaminated with DDT (Elson, 1967).

Certain organochlorine pesticides (DDT, TDE, aldrin, dieldrin, endrin, chlordane, heptachlor, mirex, toxaphene, lindane, endosulfan and benzene hexachloride) are considered especially hazardous to aquatic life because of their accumulation in aquatic organisms. Some of these compounds, including some of their metabolites, are toxic to various aquatic species at concentrations of less than one ug/l, (See Appendix Tables 1 and 2). Their accumulation in aquatic systems presents a hazard, both real and potential, to animals in the higher part of the food chain, including man (Pimentel, 1971, Mrak, 1969; Kraybill, 1969; and Gillett, 1969).

On the basis of present knowledge, we cannot estimate with certainty levels of persistent pesticides in water that will not result in undesired effects. Water concentrations below the practical limits of detection have resulted in residues in fish sufficiently high to be unacceptable for human consumption, to prevent normal reproduction in some fish-eating bird species, and to affect reproduction and survival of aquatic life. In these circumstances, criteria may be based upon specific residue concentrations in the tissues of selected species. The ratio of residue concentrations in tissue to concentrations in the water can be determined experimentally. This accumulation factor might then be applied to acceptable tissue concentration levels to estimate acceptable water concentration levels.

Table 2 lists some "accumulation factors" determined experimentally. These accumulation factors represent direct uptake from water; they do not include food chain accumulations which often may be a factor of up to 8 to 10 from one feeding level to another (Buckley, 1969; Woodwell, et al., 1967). The combined accumulation factor of direct uptake from water and a single level of food chain accumulation could exceed 100,000 for DDT in certain fish and could be less than 500 for lindane in mussels. This is not to say that food chain accumulation and direct uptake from water are necessarily additive. The residue level existing at any time is a dynamic balance between intake and elimination, and the contribution to intake directly from water or from food will vary according to concentration in and assimilation rates from the two sources.

There are, of course, a number of difficulties in applying this system. The desirable levels in water will sometimes be below the practical limits of detection; accumulation factors will not be known with precision, especially where both direct uptake from the environment and food chain accumulation with several feeding levels are involved. Nonetheless, based on estimates of residue levels that will not adversely affect man or valuable organisms at the top of food chains, and estimates of accumulation factors (from both direct uptake and food chain transfers), corresponding levels in water can be computed.

Table 2 BIOLOGICAL ACCUMULATION OF PESTICIDE CHEMICALS

ORGANISM	CHEMICAL	EXPOSURE CONCENTRATION	CONCENTRATION FACTOR	TIME	SPECIAL DETAILS	REFERENCE
BACTERIA						
Pseudomonas spp.	Nonachlor	10 ppm	0.57	10 days	Mixed culture of four species	Bourquin, 1972
	Chlordane	10 ppm	0.83			
	Heptachlor	10 ppm	0.1			
CILIATES						
Tetrahymena pyriformis W	Mirex	0.9 ppb	193	1 week	Axenic cultures incubated at 26°C; concentration factor on dry weight basis	Cooley, et al., 1971
	Aroclor® 1248	10 ppb	40			Cooley and Keltner, 1971
	Aroclor® 1254	1 ppm	60			Cooley, et al., 1971
	Aroclor® 1260	1 ppm	79			Cooley and Keltner, 1971
MOLLUSCS						
Hooked mussel *Brachidontes recurvus*	DDT	1 ppb	24,000	1 week	Whole body residues (Meats)	Butler, 1966
Hard-shell clam *Mercenaria mercenaria*	DDT	0.1 ppb	1,260	5 days		Butler, 1971
		1 ppb	6,000	1 week		Butler, 1966
	Aldrin	0.5 ppb	380	5 days		Butler, 1971

ORGANISM	CHEMICAL	EXPOSURE CONCENTRATION	CONCENTRATION FACTOR	TIME	SPECIAL DETAILS	REFERENCE
MOLLUSCS (continued) M. mercenaria	Dieldrin	0.5 ppb	760	5 days	Whole body residues (Meats)	Butler, 1971
	Endrin	0.5 ppb	480	5 days	↓	Butler, 1971
	Heptachlor	0.5 ppb	220	5 days		Butler, 1971
	Lindane	5.0 ppb	12	5 days		Butler, 1971
	Methoxychlor	1.0 ppb	470	5 days		Butler, 1971
Soft-shell clam Mya arenaria	Aldrin	0.5 ppb	4,600	5 days		Butler, 1971
	DDT	0.1 ppb	8,800	5 days		Butler, 1971
	Dieldrin	0.5 ppb	1,740	5 days		Butler, 1971
	Endrin	0.5 ppb	1,240	5 days		Butler, 1971
	Heptachlor	0.5 ppb	2,600	5 days		Butler, 1971
	Lindane	5.0 ppb	40	5 days		Butler, 1971
	Methoxychlor	1.0 ppb	1,500	5 days		Butler, 1971
Pacific oyster Crassostrea gigas	DDT	1.0 ppb	20,000	7 days		Butler, 1966
European oyster Ostrea edulis	DDT	1.0 ppb	15,000	7 days		Butler, 1966
Crested oyster O. equestris	DDT	1.0 ppb	23,000	7 days		Butler, 1966

ORGANISM	CHEMICAL	EXPOSURE CONCENTRATION	CONCENTRATION FACTOR	TIME	SPECIAL DETAILS	REFERENCE
MOLLUSCS (continued)						
Eastern oyster <u>Crassostrea</u> <u>virginica</u>	DDT	10 ppb	15,000	7 to 15 days	Whole body residues (Meats)	Butler, 1967
		1 ppb	30,000		↓	Butler, 1967
		0.1 ppb	70,000		↓	Butler, 1967
		0.01 ppb	70,000		↓	Butler, 1967
		0.0001 ppb	0		↓	Butler, 1967
		0.01 ppb	50,000	8 weeks	↓	Parrish, 1972
		1 ppb	76,000	24 weeks	↓	Lowe, et al., 1970
	Aroclor® 1254	0.01 ppb	160,000	8 weeks	↓	Parrish, 1972
		1 ppb	101,000	30 weeks	↓	Parrish, et al., 1972
	Dieldrin	0.01 ppb	8,000	8 weeks	↓	Parrish, 1972
CRUSTACEAN						
Grass shrimp <u>Palaemonetes</u> <u>pugio</u>	Aroclor® 1254	0.62 ppb	2,069	1 week	Whole body residues (Meats)	Nimmo and Heitmuller, 1972
			11,920	2 weeks	↓	Nimmo and Heitmuller, 1972
			10,903	3 weeks	↓	Nimmo and Heitmuller, 1972
			17,425	4 weeks	↓	Nimmo and Heitmuller, 1972
			26,580	5 weeks	↓	Nimmo and Heitmuller, 1972

ORGANISM	CHEMICAL	EXPOSURE CONCENTRATION	CONCENTRATION FACTOR	TIME	SPECIAL DETAILS	REFERENCE
CRUSTACEAN (continued)						
P. pugio	Aroclor® 1254	0.09 ppb	3,611	1 week	Whole body residues	Nimmo and Heitmuller, 1972
			4,800	2 weeks		Nimmo and Heitmuller, 1972
			5,000	3 weeks		Nimmo and Heitmuller, 1972
			17,400	4 weeks		Nimmo and Heitmuller, 1972
			8,355	5 weeks		Nimmo and Heitmuller, 1972
		0.037 ppb	1,594	1 week		Nimmo and Heitmuller, 1972
			3,405	2 weeks		Nimmo and Heitmuller, 1972
			3,918	3 weeks		Nimmo and Heitmuller, 1972
			4,567	4 weeks		Nimmo and Heitmuller, 1972
			5,729	5 weeks		Nimmo and Heitmuller, 1972
Pink shrimp _Penaeus duorarum_	Mirex	0.1 ppb	2,600	3 weeks	Whole body residues	Lowe, et al., 1971
			24,000	3 weeks	Hepatopancrease	Lowe, et al., 1971
	DDT	0.14 ppb	1,500	3 weeks	Whole body residues	Nimmo, et al., 1970
	Aroclor® 1254	2.5 ppb	1,800	2 days	Whole body residues	Nimmo, et al., 1971
			2,760	4 days		Nimmo, et al., 1971
			6,800	6 days		Nimmo, et al., 1971
			7,600	9 days		Nimmo, et al., 1971

ORGANISM	CHEMICAL	EXPOSURE CONCENTRATION	CONCENTRATION FACTOR	TIME	SPECIAL DETAILS	REFERENCE
CRUSTACEAN (continued)						
P. duorarum	Aroclor® 1254	2.5 ppb	9,600	12 days	Whole body residues	Nimmo, et al., 1971
			15,600	15 days	↓	Nimmo, et al., 1971
			12,400	22 days	↓	Nimmo, et al., 1971
Mud crab (larvae) *Rhithropanopeus harrisii*	Mirex	0.1 ppb	1,000	7 weeks	Static culture bowl method with a change to fresh medium + chemical each day	Bookhout, et al., 1972
	Malathion	10 ppb	0 (larvae) 0 (adults)	4 weeks		Tyler, 1971
Blue crab (juveniles) *Callinectes sapidus*	Mirex	0.1 ppb	1,100 - 5,200	3 weeks	Whole body residues	Lowe
FISH						
Pinfish *Lagodon rhomboides*	DDT	0.1, 1.0 ppb	10,600 - 38,000	2 weeks	Whole body residues	Hansen and Wilson, 1970
	Aroclor® 1254	5 ppb	2,800 - 21,800	2 - 15 weeks	↓	Hansen, et al., 1971
Spot *Leiostomus xanthurus*	Aroclor® 1254	1 ppb	17,000 - 27,000	4 - 8 weeks	Whole body residues	Hansen, et al., 1971
		5 ppb	9,200 - 30,400	3 - 6 weeks	↓	Hansen, et al., 1971
Atlantic croaker *Micropogon undulatus*	DDT	0.1, 1.0 ppb	10,000 - 14,000	3 weeks	Whole body residues	Hansen and Wilson, 1970

ORGANISM	CHEMICAL	EXPOSURE CONCENTRATION	CONCENTRATION FACTOR	TIME	SPECIAL DETAILS	REFERENCE
VASCULAR PLANTS						
Turtle grass *Thalassia testudinum*	Tordon 101 (39.6% 2,4-D; 14.3% Picolinic acid)	1 ppm	leaves 0 (2,4-D) 0 (Picolinic acid)	10 days	Plants exposed to chemical through rhizomes; concentration factor on wet weight basis	Walsh and Hollister, 1971
			rhizomes 0.05 (2,4-D) 0 (Picolinic acid)			
		5 ppm	leaves 0 (2,4-D) 0 (Picolinic acid)			
			rhizomes 0.12 (2,4-D) 0.02 (Picolinic acid)			
	Aroclor® 1254	5,820 ppb	0 leaves 0 rhizomes	10 days		Walsh and Hollister, 1971
	Mirex	0.1 ppb	0 leaves 0.36 rhizomes	10 days		Walsh and Hollister, 1971

ORGANISM	CHEMICAL	EXPOSURE CONCENTRATION	CONCENTRATION FACTOR	TIME	SPECIAL DETAILS	REFERENCE
VASCULAR PLANTS (continued)						
Red mangrove Rhizophora mangle	Tordon 101 (39.6% 2,4-D; 14.3% Picolinic acid)	14.4 ppb	roots 1.28 (2,4-D) 0.64 (Picolinic acid)	20 days	Seedlings treated when two pairs of leaves were present; concentration factor on wet weight basis	Walsh, et al., 1972
			hypocotyl 0.64 (2,4-D) 2.1 (Picolinic acid)		↓	
			stems 1.28 (2,4-D) 0.64 (Picolinic acid)		↓	
			1st leaves 1.28 (2,4-D) 0.63 (Picolinic acid)		↓	
			2nd leaves 9.0 (2,4-D) 4.2 (Picolinic acid)		↓	

ORGANISM	CHEMICAL	EXPOSURE CONCENTRATION	CONCENTRATION FACTOR	TIME	SPECIAL DETAILS	REFERENCE
VASCULAR PLANTS (continued)						
Red mangrove Rhizophora mangle	Tordon 101 (39.6% 2,4-D; 14.3% Picolinic acid)	14.4 ppb	roots 1.28 (2,4-D) 0.64 (Picolinic acid)	40 days	Seedlings treated when two pairs of leaves were present; concentration factor on wet weight basis	Walsh, et al., 1972
			hypocotyl 16.0 (2,4-D) 6.0 (Picolinic acid)		↓	
			stems 16.0 (2,4-D) 6.0 (Picolinic acid)		↓	
			1st leaves 20.0 (2,4-D) 6.0 (Picolinic acid)		↓	
			2nd leaves 24.3 (2,4-D) 6.0 (Picolinic acid)		↓	

ORGANISM	CHEMICAL	EXPOSURE CONCENTRATION	CONCENTRATION FACTOR	TIME	SPECIAL DETAILS	REFERENCE
VASCULAR PLANTS (continued)						
Red mangrove *Rhizophora mangle*	Tordon 101 (39.6% 2,4-D; 14.3% Picolinic acid)	144 ppb	roots 10.8 (2,4-D) 2.9 (Picolinic acid)	10 days	Seedlings treated when two pairs of leaves were present; concentration factor on wet weight basis	Walsh, et al., 1972
			hypocotyl 14.7 (2,4-D) 4.3 (Picolinic acid)		↓	
			stems 9.0 (2,4-D) 3.8 (Picolinic acid)		↓	
			1st leaves 5.5 (2,4-D) 2.1 (Picolinic acid)		↓	
			2nd leaves 7.7 (2,4-D) 3.6 (Picolinic acid)		↓	

ACKNOWLEDGEMENT

Appendix Tables 2 and 3 are based on data assembled by the National Academy of Sciences - National Academy of Engineering Committee on Water Quality Criteria.

ABBREVIATIONS USED

LC_{50} or LC-50	median lethal concentration: the concentration of toxicant in the environment which kills 50 percent of the organisms exposed to it. Usually duration of exposure is specified, e.g., 96-hour LC_{50}.
ppb	parts per billion
ppm	parts per million
mg/kg	milligrams per kilogram = parts per million
mg/l	milligrams per liter = parts per million
TLm	median tolerance limit: the concentration of a test material in experimental water at which just 50 percent of the test animals are able to survive for a specified period of exposure, e.g., 96 hours.
ug/g	Micrograms per gram - parts per million
ug/kg	micrograms per kilogram - parts per billion
ug/l	micrograms per liter - parts per billion

ABATE
Chemical name: 0,0,0',0'-tetramethyl 0,0'-thiodi-p-phenylene phosphorothioate
Other name: Biothion
Action: Insecticide

ALDRIN
Chemical name: 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-endo-exo-5,8-dimethanonaphthalene

AMETRYNE
Chemical name: 2-(ethylamino)-4-(isopropylamino)-6-(methylthio)-s-triazine
Other name: Gesapax
Action: Herbicide

AMIBEN
Chemical name: 3-amino-2,5-dichlorobenzoic acid
Other name: Chloramben
Action: Herbicide

ALTRAZINE
Chemical name: 2-chloro-4-ethylamino-6-isopropylamino-s-triazine
Other names: Aatrex, Fenamine, Fenatrol, Gesaprim, Primatol A
Action: Herbicide

AZINPHOS-METHYL
Chemical name: 0,0-dimethyl S-[4-oxo-1,2,3-benzotriazin-3(4H)-ylmethyl] phosphorodithioate
Other names: Carfene, DBD, Gusathion, Gusathion M, Gustathion, Guthion, Methyl Guthion
Action: Insecticide

BAYGON
See PROPOXUR

BAYTEX
See FENTHION

BENZOIC ACID
Action: Fungicide

BHC
See LINDANE

CARBARYL
Chemical name: 1-naphthyl methylcarbamate
Other name: Sevin
Action: Insecticide

CHLORAMBEN
See AMIBEN

CHLORDANE
Chemical name: 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methanoindene
Other names: Chlordan, Chlor Kil, Corodane, Kypchlor, Octachlor, Octa-Klor, Ortho-Klor, Synklor, Topiclor 20, Velsicol 1068
Action: Insecticide

CO-RAL
See COUMAPHOS

COUMAPHOS
Chemical name: 0,0-diethyl 0-[3-chloro-4-methyl-2-oxo-(2H)-benzopyran-7-yl] phosporothioate
Other names: Agridip, Asuntol, Co-Ral, Muscatox, Resistox
Action: Insecticide

2,4-D
Chemical name: 2,4-dichlorophenoxyacetic acid or its sodium salt or amine
Other names: Chloroxone, Crop Rider, Ded-Weed, Weed-Ag-Bar, Weedar 64, Weed-B-Gon, Weedone
Action: Herbicide

DALAPON
Chemical name: 2,2-dichloropropionic acid
Other names: Ded-Weed, Dowpon, Gramevin, Radapon, Unipon
Action: Herbicide

DDD
See TDE

DDT
Chemical name: dichloro diphenyl trichloroethane
Other names: Anofex, Chlorophenothane, Dedelo, Genitox, Gesapon, Gesarex, Gesarol, Gyron, Ixodex, Kopsol, Neocid, Pentachlorin, Rukseam, Zerdane
Action: Insecticide

DDVP
See DICHLORVOS

DELNAV
See DIOXATHION

DIAZINON
Chemical name: 0,0-diethyl 0-(2-isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate
Other names: Basudin, Dazzel, Diazajet, Diazide, Gardentox, Spectracide
Action: Insecticide

DICAPTHON
Chemical name: 0-(2-chloro-4-nitrophenyl) 0,0-dimethyl phosphorothioate
Other name: Di-Captan
Action: Insecticide

DICHLOBENIL
Chemical name: 2,6-dichlorobenzonitrile
Other names: Casoron, Du-Sprex, 2,6-DBN
Action: Herbicide

DICHLORVOS
Chemical name: 2,2-dichlorovinyl 0,0-dimethyl phosphate
Other names: DDVF, DDVP, Dedevap, Dichlorphos, Herkol, Mafu, Marvex, Nogos, No-Pest, Nuvan, Oko, Phosvit, Vapona
Action: Insecticide

DIELDRIN
Chemical name: 1,2,3,4,10,10-hexachloro-exo-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-exo-5,8-dimethanonaphthalene, and related compounds
Other names: HEOD, Octalox, Panoram D-31
Action: Insecticide

DIOXATHION
Chemical name: 2,3-p-dioxanedithiol S,S-bis-(0,0-diethyl phosphorodithioate)
Other names: Delnav, Navadel, Ruphos
Action: Insecticide

DIPTHEREX
See TRICHLORFON

DIQUAT
Chemical name: 1,1'-ethylene-2,2'-dipyridylium dibromide
Other names: Aquacide, Dextrone, FB/2, Reglone
Action: Herbicide

DISULFOTON
Chemical name: 0,0-diethyl S-2-(ethylthio)ethyl phosphorodithioate
Other names: Diethylethylthioethyl dithiophosphate, Di-syston, Dithiodemeton, Dithiosystox, Frumin Al, Frumin G, Solvirex, Thiodemeton
Action: Insecticide

DI-SYSTON
See DISULFOTON

DIURON
Chemical name: 3-(3,4-dichlorophenyl)-1,1-dimethylurea
Other names: DCMU, DMU, Karmex, Marmer
Action: Herbicide

DURSBAN
Chemical name: 0,0-diethyl 0-3,5,6-trichloro-2-pyridyl phosphorothioate
Action: Insecticide

ENDOSULFAN
Chemical name: 6,7,8,9,10,10-hexachloro-1,5,5a,-6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin 3-oxide
Other names: Chlorthiepin, Cyclodan, Insectophene, Kop-Thiodan, Malic, Malix, Thifor, Thimul, Thiodan
Action: Insecticide

ENDOTHALL
Chemical name: 7-oxabicyclo (2,2,1) heptane-2,3-dicarboxylic acid
Other names: Accelerate, Aquathol, Des-i-cate, Endothal, Hydrothol, Niagrathal, Tri-Endothal
Action: Herbicide

ENDRIN
Chemical name: 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-endo-5,8-dimethanonaphthalene
Other names: Hexadrin, Mendrin
Action: Insecticide

FENTHION

Chemical name: 0,0-dimethyl 0[4-(methylthio)-m-tolyl] phosphorothioate

Other names: Baytex, DMPT, Entex, Lebaycid, Mercaptophos, Quelatox, Queletox, Tiguvon

Action: Insecticide

FENURON

Chemical name: 3-phenyl-1,1-dimethylurea

Other names: Dybar, Fenidim, Fenulon, PDU

Action: Herbicide

GUTHION

See AZINPHOS-METHYL

HEPTACHLOR

Chemical name: 1,4,5,6,7,8,8-heptachloro-3a,4,7,-7a-tetrahydro-4,7-methanoindane

Other names: Drinox H-34, Heptamul

Action: Insecticide

LEAD ARSENATE

Other names: Gypsine, Soprabel

Action: Insecticide

LINDANE

Chemical name: gamma isomer of 1,2,3,4,5,6-hexachlorocyclohexane; also known as gamma benzene hexachloride

Other names: Gamaphex, Gamma BHC, Gammaline, Gammex, Gammexane, Isotox, Lindafor, Lindagam, Lintox, Novigam, Silvanol, Tri-6-Dust

Action: Insecticide

MALATHION

Chemical name: 0,0-dimethyl S-(1,2-dicarbethoxyethyl) dithiophosphate

Other names: Carbofos, Carbophos, Cythion, Emmatos, Karbofos, Kop-Thion, Kypfos, Malamar, Malaspray, Malathon, Mercaptothion, Zithiol

Action: Insecticide

MCPA

Chemical name: 4-chloro-2-methylphenoxyacetic acid

Other names: Agroxone, Chiptox, Hormotuho, Kilsem, MCP, Mephanac, Metaxon, Methoxone, Rhomene, Rhonox

Action: Herbicide

MERCURY

Action: Fungicide

METHOXYCHLOR

Chemical name: 1,1,1-trichloro-2,2-bis(p-methoxyphenyl)ethane

Other names: Dianisyltrichloroethane, Dimethoxy-DT, DMDT, Marlate, Methoxy DDT

Action: Insecticide

METHYL PARATHION

Chemical name: 0,0-dimethyl 0-p-nitrophenyl phosphorothioate

MEVINPHOS
Chemical name: 2-methoxycarbonyl-1-methyl-vinyl dimethyl-phosphate
Other names: Phosdrin, Phosfene
Action: Insecticide

MIREX
Chemical name: dodecachlorooctahydro-1,3,3-metheno-2H-cyclobuta(cd)pentalene
Other name: Dechlorane
Action: Insecticide

MONURON
Chemical name: 3-(p-chlorophenyl)-1,1-dimethylurea
Other names: Chlorfenidim, Telvar
Action: Herbicide

NEBURON
Chemical name: 1-n-butyl-3-(3,4-dichlorophenyl)-1-methylurea
Other names: Kloben, Neburea
Action: Herbicide

PARAQUAT
Chemical name: 1,1'-dimethyl-4,4'-bipyridynium ion
Other names: Gramoxone, Weedol
Action: Herbicide

PARATHION
Chemical name: 0,0-diethyl 0-p-nitrophenyl phosphorothioate
Other names: AAT, Alkron, Alleron, Aphamite, Corothion, DNTP, Ethyl Parathion, Etilon, Folidol, Niran, Nitrostigmine, Orthophos, Panthion, Paramar, Paraphos, Parathene, Parawet, Phoskil, Rhodiatox, SNP, Soprathion, Stathion, Thiophos
Action: Insecticide

PHORATE
Chemical name: 0,0-diethyl S-(ethylthio)-methyl phosphorodithioate
Other names: Thimet, Timet
Action: Insecticide

PHOSDRIN
See MEVINPHOS

PICLORAM
Chemical name: 4-amino-3,5,6-trichloropicolinic acid
Other names: Borolin, Tordon
Action: Herbicide

POLYCHLORINATED BIPHENYLS
Chemical name: mixture of chlorinated terphenyls
Other names: Chlorinated biphenyls, PCB's, Aroclors
Action: Insecticide

PROMETONE
Chemical name: 2-methoxy-4,6-bis(isopropylamino)-s-triazine
Other names: Gesafram, Pramitol, Prometon
Action: Herbicide

PROPOXUR
Chemical name: o-isopropoxyphenyl methylcarbamate
Other names: Arprocarb, Baygon, Blattanex, Suncide, Unden
Action: Insecticide

SEVIN
See CARBARYL

SILVEX
Chemical name: 2-(2,4,5-trichlorophenoxy)propionic acid
Other names: Esteron, Fenoprop, Garlon, Kuron, Kurosal, 2,4,5-TP
Action: Herbicide

SIMAZINE
Chemical name: 2-chloro-4,6-bis (ethylamino)-s-triazine
Other names: Gesatop, Princep
Action: Herbicide

2,4,5-T
Chemical name: 2,4,5-trichlorophenoxyacetic acid
Other names: Ded-Weed Brush Killer, Esteron 245 Concentrate, Fence Rider, Inverton 245, Line Rider, Reddon
Action: Herbicide

TDE
Chemical name: 2,2-bis(p-chlorophenyl)-1,1-dichloroethane
Other names: DDD, Rhothane
Action: Insecticide

TEPP
Chemical name: tetraethyl pyrophosphate and other ethyl phosphates
Other names: Bladan, HETP, Kilmite 40, TEP, Tetron, Vapotone
Action: Insecticide

THIODAN
See ENDOSULFAN

TORDON
See PICLORAM

TOXAPHENE
Chemical name: mixture of various chlorinated camphenes
Other names: Alltox, Chlorinated camphene, Octachlorocamphene, Phenacide, Phenatox, Polychlorocamphene, Strobane-T, Toxakil
Action: Insecticide

TRICHLORFON
Chemical name: dimethyl (2,2,2-trichloro-1-hydroxyethyl) phosphonate
Other names: Anthon, Chlorofos, Dipterex, Dylox, Neguvon, Trichlorphon, Tugon
Action: Insecticide

TRIFLURALIN
Chemical name: a,a,a-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine
Other names: Elancolan, Treflan
Action: Herbicide

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Appendix Table 1. PESTICIDE INTAKE FROM FOOD AND WATER

	(1) Maximum concentration in water samples from 5-year survey b/ ugm/l (ppb)	(2) Computed daily intake (Column 1 x 2 liters per person per day) Mg	(3) 6-year average daily intake from food by 70 kg person c/ Mg	(4) WHO-FAO acceptable daily intake d/ 70 kg person Mg	(5) Fraction: intake from water (Column 2) / intake from food (Column 3)
Aldrin	0.085	0.0002			
Dieldrin	0.407	0.0008			
Total	0.492	0.0010	0.006	0.007	1/6
Chlordane	0.169	0.0003			
DDT	0.316	0.0006			
DDE	0.050	0.0001			
DDD	0.840	0.0018			
Total	1.206	0.0025	0.049	0.35	1/20
Endrin	0.133	0.0003	0.0004		3/4
Heptachlor	0.048	0.0001			
Heptachlor Epoxide	0.067	0.0001			
Total	0.115	0.0002	0.002	0.035	1/10
Lindane (BHC)	0.112	0.0002	0.002	0.875	1/10
Total organophosphates a/	0.380	0.0008	0.013	0.35	1/16
Total chlorinated pesticides		0.0045	0.077		1/17

a/ Columns 1 and 2 are organophosphates plus carbamates. Columns 3 and 4 are organophosphates only. Column 5 therefore overestimates contribution from water of organophosphates. Column 4 is the value of the most toxic organophosphate (Parathion).

b/ Data from Lichtenberg, et al. (1970).

c/ Data from Duggan and Corneliussen (1972).

d/ Acceptable daily intake set by WHO-FAO expert committees, as presented by Duggan and Corneliussen (1972).

APPENDIX TABLE 2. TOXICITY DATA ON PESTICIDES FOR FRESHWATER ORGANISMS

ORGANOCHLORINE INSECTICIDES

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50 ug/liter	hours	SUB-ACUTE EFFECTS ug/liter	REFERENCE
ALDRIN	CRUSTACEANS				
	Gammarus lacustris	9800	96		Sanders, 1969
	Gammarus fasciatus	4300	96		Sanders, in press
	Palaemonetes kadiakensis	50	96		Sanders, in press
	Asellus brevicaudus	8	96		Sanders, in press
	Daphnia pulex	28	48		Sanders and Cope, 1966
	Simocephalus serrulatus	23	48		Sanders and Cope, 1966
	INSECTS				
	Pteronarcys californica	1.3	96		Sanders and Cope, 1968
	Pteronarcys californica	180	96	2.5 ug/liter (30-day LC-50)	Jensen and Gaufin, 1966
	Acroneuria pacifica	200	96	2.2 ug/liter (30-day LC-50)	Jensen and Gaufin, 1966
	FISHES				
	Pimephales promelas	28	96		Henderson, et al., 1959
	Lepomis macrochirus	13	96		Henderson, et al., 1959
	Salmo gairdneri	17.7	96		Katz, 1961
	Oncorhynchus kisutch	45.9	96		Katz, 1961
	Oncorhynchus tschawytscha	7.5	96		Katz, 1961
DDT	CRUSTACEANS				
	Gammarus lacustris	1.0	96		Sanders, 1969
	Gammarus fasciatus	0.8	96		Sanders, in press
	Palaemonetes kadiakensis	2.3	96		Sanders, in press
	Orconectes nais	0.24	96		Sanders, in press
	Asellus brevicaudus	4.0	96		Sanders, in press
	Simocephalus serrulatus	2.5	48		Sanders and Cope, 1966
	Daphnia pulex	0.36	48		Sanders and Cope, 1966
	INSECTS				
	Pteronarcys californica	7.0	96		Sanders and Cope, 1968
	Pteronarcella badia	1.9	96		Sanders and Cope, 1968
	Claassenia sabulosa	3.5	96		Sanders and Cope, 1968

APPENDIX TABLE 2 (continued)

ORGANOCHLORINE INSECTICIDES

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50		SUB-ACUTE EFFECTS	REFERENCE
		ug/liter	hours	ug/liter	
DDT	FISHES				
	Pimephales promelas	19	96		Macek and McAllister, 1970
	Lepomis macrochirus	8	96		Macek and McAllister, 1970
	Lepomis microlophus	5	96		Macek and McAllister, 1970
	Micropterus salmoides	2	96		Macek and McAllister, 1970
	Salmo gairdneri	7	96		Macek and McAllister, 1970
	Salmo gairdneri			0.26 ug/l (15-day LC-50)	FPRL Annual Report
	Salmo trutta	2	96		Macek and McAllister, 1970
	Oncorhynchus kisutch	4	96		Macek and McAllister, 1970
	Perca flavescens	9	96		Macek and McAllister, 1970
	Ictalurus punctatus	16	96		Macek and McAllister, 1970
	Ictalurus melas	5	96		Macek and McAllister, 1970
TDE (DDD) RHOTHANE®	CRUSTACEANS				
	Gammarus lacustris	0.64	96		Sanders, 1969
	Gammarus fasciatus	0.86	96		Sanders, in press
	Palaemonetes kadiakensis	0.68	96		Sanders, in press
	Asellus breviacaudus	10.0	96		Sanders, in press
	Simocephalus serrulatus	4.5	48		Sanders and Cope, 1966
	Daphnia pulex	3.2	48		Sanders and Cope, 1966
	INSECT				
	Pteronarcys californica	380	96		Sanders and Cope, 1968
DIELDRIN	CRUSTACEANS				
	Gammarus lacustris	460	96		Sanders, 1969
	Gammarus fasciatus	600	96		Sanders, in press
	Palaemonetes kadiakensis	20	96		Sanders, in press
	Orconectes nais	740	96		Sanders, in press
	Asellus brevicaudus	5	96		Sanders, in press
	Simocephalus serrulatus	190	48		Sanders and Cope, 1966
	Daphnia pulex	250	48		Sanders and Cope, 1966

APPENDIX TABLE 2 (continued)

ORGANOCHLORINE INSECTICIDES

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50 ug/liter	ACUTE TOXICITY LC-50 hours	SUB-ACUTE EFFECTS ug/liter	REFERENCE
DIELDRIN	INSECTS				
	Pteronarcys californica	0.5	96		Sanders and Cope, 1968
	Pteronarcys californica	39	96	2.0 (30-day LC-50)	Jensen and Gaufin, 1966
	Acroneuria pacifica	24	96	0.2 (30-day LC-50)	Jensen and Gaufin, 1966
	Pteronarcella badia	0.5	96		Sanders and Cope, 1968
	Claassenia sabulosa	0.58	96		Sanders and Cope, 1968
	FISHES				
	Pimephales promelas	16	96		Henderson, et al., 1959
	Lepomis macrochirus	8	96		Henderson, et al., 1959
	Salmo gairdneri	10	96		Katz, 1961
	Oncorhynchus kisutch	11	96		Katz, 1961
	Oncorhynchus tschawytscha	6	96		Katz, 1961
	Poecillia latipipna			3.0 (19-week LC-50)	Lane and Livingston, 1970
	Poecillia latipipna			0.75 (reduced growth & reproduction - 34-week)	Lane and Livingston, 1970
	Lepomis gibbosus	6.7	96	1.7 (affected swimming ability and oxygen consumption - 100-day)	Cairns and Scheir, 1964
	Ictaluras punctatus	4.5	96		FPRL
CHLORDANE	CRUSTACEANS				
	Gammarus lacustris	26	96		Sanders, 1969
	Gammarus fasciatus	40	96		Sanders, in press
	Palaemonetes kadiakensis	4.0	96	2.5 (120-hour LC-50)	Sanders, in press
	Simocephalus serrulatus	20	48		Sanders and Cope, 1966
	Daphnia pulex	29	48		Sanders and Cope, 1966
	INSECT				
	Pteronarcys californica	15	96		Sanders and Cope, 1968

APPENDIX TABLE 2 (continued)

ORGANOCHLORINE INSECTICIDES

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50 ug/liter	hours	SUB-ACUTE EFFECTS ug/liter	REFERENCE
CHLORDANE	FISHES				
	Pimephales promelas	52	96		Henderson, et al., 1959
	Lepomis macrochirus	22	96		Henderson, et al., 1959
	Salmo gairdneri	44	96		Katz, 1961
	Oncorhynchus kisutch	56	96		Katz, 1961
	Oncorhynchus tschawytscha	57	96		Katz, 1961
ENDOSULFAN	CRUSTACEANS				
THIODAN	*Gammarus fasciatus*	6.0	96		Sanders, 1969
	Daphnia magna	52.9	96		Schoettger, 1970
	INSECTS				
	Pteronarcys californica	2.3	96		Sanders and Cope, 1968
	Ischnura sp.	71.8	96		Schoettger, 1970
	FISHES				
	Salmo gairdneri	0.3	96		Schoettger, 1970
	Catastomus commersoni	3.0	96		Schoettger, 1970
ENDRIN	CRUSTACEANS				
	Gammarus lacustris	3.0	96		Sanders, 1969
	Gammarus fasciatus	0.9	120		Sanders, in press
	Palaemonetes kadiakensis	0.4	120		Sanders, in press
	Orconectes nais	3.2	96		Sanders, in press
	Asellus brevicaudus	1.5	96		Sanders, in press
	Simocephalus serrulatus	26	48		Sanders and Cope, 1966
	Daphnia pulex	20	48		Sanders and Cope, 1966
	INSECTS				
	Pteronarcys californica	0.25	96		Sanders and Cope, 1968
	Pteronarcys californica	2.4	96	1.2 (30-day LC-50)	Jensen and Gaufin, 1966
	Acroneuria pacifica	0.32	96	0.03 (30-day LC-50)	Jensen and Gaufin, 1966

APPENDIX TABLE 2 (continued)

ORGANOCHLORINE INSECTICIDES

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50		SUB-ACUTE EFFECTS	REFERENCE
		ug/liter	hours	ug/liter	
ENDRIN	INSECTS				
	Pteronarcella badia	0.54	96		Sanders and Cope, 1968
	Claassenia sabulosa	0.76	96		Sanders and Cope, 1968
	FISHES				
	Pimephales promelas	0.5	96		Henderson, et al., 1959
	Lepomis macrochirus	0.6	96		Henderson, et al., 1959
	Salmo gairdneri	0.6	96		Katz, 1961
	Oncorhynchus kisutch	0.5	96		Katz, 1961
	Oncorhynchus tschawytscha	1.2	96		Katz, 1961
HEPTACHLOR	CRUSTACEANS				
	Gammarus lacustris	29	96		Sanders, 1969
	Gammarus fasciatus	40	96		Sanders, in press
	Palaemonetes kadiakensis	1.8	96		Sanders, in press
	Orconectes nais	7.8	96		Sanders, in press
	Simocephalus serrulatus	47	48		Sanders and Cope, 1966
	Daphnia pulex	42	48		Sanders and Cope, 1966
	INSECTS				
	Pteronarcys californica	1.1	96		Sanders and Cope, 1968
	Pteronarcella badia	0.9	96		Sanders and Cope, 1968
	Claassenia sabulosa	2.8	96		Sanders and Cope, 1968
	FISHES				
	Pimephales promelas	56	96		Henderson, et al., 1959
	Lepomis macrochirus	19	96		Henderson, et al., 1959
	Lepomis microlophus	17	96		Bridges, 1961
	Salmo gairdneri	19	96		Katz, 1961
	Oncorhynchus kisutch	59	96		Katz, 1961
	Oncorhynchus tschawytscha	17	96		Katz, 1961

APPENDIX TABLE 2 (continued)

ORGANOCHLORINE INSECTICIDES

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50 ug/liter	ACUTE TOXICITY LC-50 hours	SUB-ACUTE EFFECTS ug/liter	REFERENCE
LINDANE	CRUSTACEANS				
	Gammarus lacustris	48	96		Sanders, 1969
	Gammarus fasciatus	10	96		Sanders, in press
	Asellus brevicaudus	10	96		Sanders, in press
	Simocephalus serrulatus	520	48		Sanders and Cope, 1966
	Daphnia pulex	460	48		Sanders and Cope, 1966
	INSECT				
	Pteronarcys californica	4.5	96		Sanders and Cope, 1968
	FISHES				
	Pimephales promelas	87	96		Macek and McAllister, 1970
	Lepomis macrochirus	68	96		Macek and McAllister, 1970
	Lepomis microlophus	83	96		Macek and McAllister, 1970
	Micropterus salmoides	32	96		Macek and McAllister, 1970
	Salmo gairdneri	27	96		Macek and McAllister, 1970
	Salmo trutta	2	96		Macek and McAllister, 1970
	Oncorhynchus kisutch	41	96		Macek and McAllister, 1970
	Perca flavescens	68	96		Macek and McAllister, 1970
	Ictalurus punctatus	44	96		Macek and McAllister, 1970
	Ictalurus melas	64	96		Macek and McAllister, 1970
METHOXYCHLOR	CRUSTACEANS				
	Gammarus lacustris	0.8	96		Sanders, 1969
	Gammarus fasciatus	1.9	96		Sanders, in press
	Palaemonetes kadiakensis	1.0	96		Sanders, in press
	Orconectes nais	0.5	96		Sanders, in press
	Asellus brevicaudus	3.2	96		Sanders, in press
	Simocephalus serrulatus	5	48		Sanders and Cope, 1966
	Daphnia pulex	0.78	48		Sanders and Cope, 1966

APPENDIX TABLE 2 (continued)

ORGANOCHLORINE INSECTICIDES

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50		SUB-ACUTE EFFECTS	REFERENCE
		ug/liter	hours	ug/liter	
METHOXYCHLOR	INSECTS				
	Pteronarcys californica	1.4	96		Sanders and Cope, 1968
	Taeniopteryx nivalis	0.98	96		Merna (Univ. of Mich.)
	Stenonema spp.	0.63	96		Merna (Univ. of Mich.)
	FISHES				
	Pimephales promelas	7.5	96	0.125 (reduced egg hatchability)	Merna (Univ. of Mich.)
	Lepomis macrochirus	62.0	96		Henderson, et al., 1959
	Salmo gairdneri	62.0	96		Katz, 1961
	Oncorhynchus kisutch	66.2	96		Katz, 1961
	Oncorhynchus tschawytscha	27.9	96		Katz, 1961
	Perca flavescens	20.0	96	0.6 (reduced growth - 8-month)	Merna (Univ. of Mich.)
TOXAPHENE	CRUSTACEANS				
	Gammarus lacustris	26	96		Sanders, 1969
	Gammarus fasciatus	6	96		Sanders, in press
	Palaemonetes kadiakensis	28	96		Sanders, in press
	Simocephalus serrulatus	10	48		Sanders and Cope, 1966
	Daphnia pulex	15	48		Sanders and Cope, 1966
	INSECTS				
	Pteronarcys californica	2.3	96		Sanders and Cope, 1968
	Pteronarcella badia	3.0	96		Sanders and Cope, 1968
	Claassenia sabulosa	1.3	96		Sanders and Cope, 1968
	FISHES				
	Pimephales promelas	14	96		Macek and McAllister, 1970
	Lepomis macrochirus	18	96		Macek and McAllister, 1970
	Lepomis microlophus	13	96		Macek and McAllister, 1970
	Micropterus salmoides	2	96		Macek and McAllister, 1970

APPENDIX TABLE 2 (continued)

ORGANOCHLORINE INSECTICIDES

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50		SUB-ACUTE EFFECTS	REFERENCE
		ug/liter	hours	ug/liter	
TOXAPHENE	FISHES				
	Salmo gairdneri	11	96		Macek and McAllister, 1970
	Salmo trutta	3	96		Macek and McAllister, 1970
	Oncorhnychus kisutch	8	96		Macek and McAllister, 1970
	Perca flavescens	12	96		Macek and McAllister, 1970
	Ictalurus punctatus	13	96		Macek and McAllister, 1970
	Ictalurus melas	5	96		Macek and McAllister, 1970

APPENDIX TABLE 2 (continued)

ORGANOPHOSPHORUS INSECTICIDES

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50		SUB-ACUTE EFFECTS	NO EFFECT	REFERENCE
		ug/liter	hours	ug/liter	ug/liter	
ABATE ®	CRUSTACEAN					
	Gammarus lacustris	82	96			Sanders, 1969
	INSECT					
	Pteronarcys californica	10	96			Sanders and Cope, 1968
	FISH					
	Salmo gairdneri	158	96			FPRL
AZINPHOSMETHYL GUTHION ®	CRUSTACEANS					
	Gammarus lacustris	0.15	96			Sanders, 1969
	Gammarus fasciatus	0.10	96			Sanders, in press
	Gammarus pseudolimneaus				0.10 (30-day)	Bell, unpublished
	Palaemonetes kadiakensis	1.2	120	0.16 (20-day LC-50)		Sanders, in press
	Asellus brevicaudus	21.0	96			Sanders, in press
	INSECTS					
	Pteronarcys dorsata	12.1	96	4.9 (30-day LC-50)		Bell, unpublished
	Pteronarcys californica	1.5	96			Sanders and Cope, 1968
	Acroneuria lycorias			1.5 (30-day LC-50)	1.36 (30-day)	Bell, unpublished
	Ophiogomphus rupinsulensis	12.0	96	2.2 (30-day LC-50)	1.73 (30-day)	Bell, unpublished
	Hydropsyche bettoni			7.4 (30-day LC-50)	4.94 (30-day)	Bell, unpublished
	Ephemerella subvaria			4.5 (30-day LC-50)	2.50 (30-day)	Bell, unpublished
	FISHES					
	Pimephales promelas	93	96			Henderson, 1959
	Lepomis macrochirus	5.2	96			Henderson, 1959
	Lepomis microlophus	52	96			Macek and McAllister, 1970
	Micropterus salmoides	5	96			Macek and McAllister, 1970
	Salmo gairdneri	14	96			Macek and McAllister, 1970
	Salmo trutta	17	96			Macek and McAllister, 1970
	Oncorhynchus kisutch	17	96			Macek and McAllister, 1970

APPENDIX TABLE 2 (continued)

ORGANOPHOSPHORUS INSECTICIDES

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50		SUB-ACUTE EFFECTS	NO EFFECT	REFERENCE
		ug/liter	hours	ug/liter	ug/liter	
AZINPHOSMETHYL GUTHION ®	FISHES					
	Perca flavescens	13	96			Macek and McAllister, 1970
	Ictalurus punctatus	3290	96			Macek and McAllister, 1970
	Ictalurus melas	3500	96			Macek and McAllister, 1970
AZINPHOSETHYL ETHYL GUTHION ®	CRUSTACEANS					
	Simocephalus serrulatus	4	48			Sanders and Cope, 1966
	Daphnia pulex	3.2	48			Sanders and Cope, 1966
	FISH					
	Salmo gairdneri	19	96			FPRL
CARBOPHENOTHION TRITHION ®	CRUSTACEANS					
	Gammarus lacustris	5.2	96			Sanders, 1969
	Palaemonetes kadiakensis	1.2	96			Sanders, in press
	Asellus brevicaudus	1100	96			Sanders, in press
CHLOROTHION	CRUSTACEAN					
	Daphnia magna	4.5	48			"Water Quality Criteria", 1968
	FISHES					
	Pimephales promelas	2700	96			Pickering, et al., 1962
	Lepomis macrochirus	700	96			Pickering, et al., 1962
CIODRIN ®	CRUSTACEANS					
	Gammarus lacustris	15	96			Sanders, 1969
	Gammarus fasciatus	11	96			Sanders, in press
	FISHES					
	Lepomis macrochirus	250	96			FPRL
	Micropterus salmoides	1100	96			FPRL

APPENDIX TABLE 2 (continued)

ORGANOPHOSPHORUS INSECTICIDES

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50 ug/liter	hours	SUB-ACUTE EFFECTS ug/liter	NO EFFECT ug/liter	REFERENCE
CIODRIN ®	FISHES					
	Salmo gairdneri	55	96			FPRL
	Ictalurus punctatus	2500	96			FPRL
COUMAPHOS CO-RAL ®	CRUSTACEANS					
	Gammarus lacustris	0.07	96			Sanders, 1969
	Gammarus fasciatus	0.15	96			Sanders, in press
	Daphnia magna	1.0	48			"Water Quality Criteria", 1968
	INSECTS					
	Hydropsyche sp.	5	24			Carlson, 1966
	Hexagenia sp.	430	24			Carlson, 1966
	FISHES					
	Pimephales promelas	18000	96			Katz, 1961
	Lepomis macrochirus	180	96			Henderson, 1959
	Salmo gairdneri	1500	96			Katz, 1961
	Oncorhynchus kisutch	15000	96			Katz, 1961
DEMETON SYSTOX ®	CRUSTACEAN					
	Gammarus fasciatus	27	96			Sanders, in press
	FISHES					
	Pimephales promelas	3200	96			Pickering, et al., 1962
	Lepomis macrochirus	100	96			Pickering, et al., 1962
DIAZINON	CRUSTACEANS					
	Gammarus pseudolimneaus			0.27 (30-day LC-50)	0.20 (30-day)	Bell, (NWQL - unpublished)
	Gammarus lacustris	200	96			Sanders, 1969
	Simocephalus serrulatus	1.4	48			Sanders and Cope, 1966
	Daphnia pulex	0.90	48			Sanders and Cope, 1966
	Daphnia magna				0.26 (21-day)	Biesinger, (NWQL - unpub.)

APPENDIX TABLE 2 (continued)

ORGANOPHOSPHORUS INSECTICIDES

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50 ug/liter	hours	SUB-ACUTE EFFECTS ug/liter	NO EFFECT ug/liter	REFERENCE
DIAZINON	INSECTS					
	Pteronarcys californica	25	96			Sanders and Cope, 1968
	Pteronarcys dorsata			4.6 (30-day LC-50)	3.29 (30-day)	Bell, (NWQL - unpublished)
	Acroneuria lycorias	1.7	96	1.25 (30-day LC-50)	0.83 (30-day)	Bell, (NWQL - unpublished)
	Ophiogomphus rupinsulensis			2.2 (30-day LC-50)	1.29 (30-day)	Bell, (NWQL - unpublished)
	Hydropsyche pettoni			3.54 (30-day LC-50)	1.79 (30-day)	Bell, (NWQL - unpublished)
	Ephemerella subvaria			1.05 (30-day LC-50)	0.42 (30-day)	Bell, (NWQL - unpublished)
DICHLOROVOS DDVP VAPONA ®	CRUSTACEANS					
	Gammarus lacustris	0.50	96			Sanders, 1969
	Gammarus fasciatus	0.40	96			Sanders, in press
	Simocephalus serrulatus	0.26	48			Sanders and Cope, 1966
	Daphnia pulex	0.07	48			Sanders and Cope, 1966
	INSECT					
	Pteronarcys californica	0.10	96			Sanders and Cope, 1968
	FISH					
	Lepomis macrochirus	869	96			FPRL
DIOXATHION DELNAV ®	CRUSTACEANS					
	Gammarus lacustris	270	96			Sanders, 1969
	Gammarus fasciatus	8.6	96			Sanders, in press
	FISHES					
	Pimephales promelas	9300	96			Pickering, et al., 1962
	Lepomis macrochirus	34	96			Pickering, et al., 1962
	Lepomis cyanellus	61	96			Pickering, et al., 1962
	Micropterus salmoides	36	96			Pickering, et al., 1962
DISULFOTON DI-SYSTON ®	CRUSTACEANS					
	Gammarus lacustris	52	96			Sanders, 1969
	Gammarus fasciatus	21	96			Sanders, in press
	Palaemonetes kadiakensis	38	96			Sanders, in press

APPENDIX TABLE 2 (continued)

ORGANOPHOSPHORUS INSECTICIDES

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50 ug/liter	hours	SUB-ACUTE EFFECTS ug/liter	NO EFFECT ug/liter	REFERENCE
DISULFOTON	INSECTS					
DI-SYSTON ®	Pteronarcys californica	5	96			Sanders and Cope, 1968
	Pteronarcys californica	21.4	96	1.7 (30-day LC-50)		Jensen and Gaufin, 1964
	Acroneuria pacifica	8.4	96	1.2 (30-day LC-50)		Jensen and Gaufin, 1964
	FISHES					
	Pimephales promelas	63	96			Pickering, et al., 1962
	Lepomis macrochirus	3700	96			Pickering, et al., 1962
DURSBAN ®	CRUSTACEANS					
	Gammarus lacustris	0.11	96			Sanders, 1969
	Gammarus fasciatus	0.32	96			Sanders, in press
	INSECTS					
	Pteronarcys californica	10	96			Sanders and Cope, 1968
	Pteronarcella badia	0.38	96			Sanders and Cope, 1968
	Claassenia sabulosa	0.57	96			Sanders and Cope, 1968
	FISHES					
	Lepomis macrochirus	2.6	96			FPRL
	Salmo gairdneri	11	96			FPRL
ETHION	CRUSTACEANS					
NIALATE ®	Gammarus lacustris	1.8	96			Sanders, 1969
	Gammarus fasciatus	9.4	96			Sanders, in press
	Palaemonetes kadiakensis	5.7	96			Sanders, in press
	INSECT					
	Pteronarcys californica	2.8	96			Sanders and Cope, 1968
	FISHES					
	Lepomis macrochirus	220	96			FPRL
	Micropterus salmoides	150	96			FPRL
	Salmo gairdneri	560	96			FPRL
	Salmo clarkii	720	96			FPRL
	Ictalurus punctatus	7500	96			FPRL

APPENDIX TABLE 2 (continued)

ORGANOPHOSPHORUS INSECTICIDES

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50		SUB-ACUTE EFFECTS	NO EFFECT	REFERENCE
		ug/liter	hours	ug/liter	ug/liter	
EPN	CRUSTACEANS					
	Gammarus lacustris	15	96			Sanders, 1969
	Gammarus fasciatus	7	96			Sanders, in press
	Palaemonetes kadiakensis	0.56	96			Sanders, in press
	FISHES					
	Pimephales promelas	110	96			Solon and Nair, 1970
	Lepomis macrochirus	100	96			Pickering, et al., 1962
FENTHION BAYTEX®	CRUSTACEANS					
	Gammarus lacustris	8.4	96			Sanders, 1969
	Gammarus fasciatus	110	96			Sanders, in press
	Palaemonetes kadiakensis	5	120	1.5 (20-day LC-50)		Sanders, in press
	Orconectes nais	50	96			Sanders, in press
	Asellus brevicaudus	1800	96			Sanders, in press
	Simocephalus serrulatus	0.62	48			Sanders and Cope, 1966
	Daphnia pulex	0.80	48			Sanders and Cope, 1966
	INSECT					
	Pteronarcys californica	4.5	96			Sanders and Cope, 1968
	FISHES					
	Pimephales promelas	2440	96			Macek and McAllister, 1970
	Lepomis macrochirus	1380	96			Macek and McAllister, 1970
	Lepomis microlophus	1880	96			Macek and McAllister, 1970
	Micropterus salmoides	1540	96			Macek and McAllister, 1970
	Salmo gairdneri	930	96			Macek and McAllister, 1970
	Salmo trutta	1330	96			Macek and McAllister, 1970
	Oncorhynchus kisutch	1320	96			Macek and McAllister, 1970
	Perca flavescens	1650	96			Macek and McAllister, 1970
	Ictalurus punctatus	1680	96			Macek and McAllister, 1970
	Ictalurus melas	1620	96			Macek and McAllister, 1970

APPENDIX TABLE 2 (continued)

ORGANOPHOSPHORUS INSECTICIDES

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50 ug/liter	hours	SUB-ACUTE EFFECTS ug/liter	NO EFFECT ug/liter	REFERENCE
MALATHION	CRUSTACEANS					
	Gammarus pseudolimneaus			0.023 (30-day LC-50)	0.008 (30-day)	Bell, (NWQL - unpublished)
	Gammarus lacustris	1.0	96			Sanders, 1969
	Gammarus fasciatus	0.76	96	0.5 (120-hour LC-50)		Sanders, in press
	Palaemonetes kadiakensis	12	96	9.0 (120-hour LC-50)		Sanders, in press
	Orconectes nais	180	96			Sanders, in press
	Asellus brevicaudus	3000	96			Sanders, in press
	Simocephalus serrulatus	3.5	48			Sanders and Cope, 1966
	Daphnia pulex	1.8	48			Sanders and Cope, 1966
	Daphnia magna				0.6 (21-day)	Biesinger, (NWQL - unpub.)
	INSECTS					
	Pteronarcys californica	10	96			Sanders and Cope, 1968
	Pteronarcys dorsata			11.1 (30-day LC-50)	9.4 (30-day)	Bell, (NWQL - unpublished)
	Acroneuria lycorias	1.0		0.3 (30-day LC-50)	0.17 (30-day)	Bell, (NWQL - unpublished)
	Pteronarcella badia	1.1	96			Sanders and Cope, 1968
	Claassenia sabulosa	2.8	96			Sanders and Cope, 1968
	Boyeria vinosa			2.3 (30-day LC-50)	1.65 (30-day)	Bell, (NWQL - unpublished)
	Ophiogomphus rupinsulensis			0.52 (30-day LC-50)	0.28 (30-day)	Bell, (NWQL - unpublished)
	Hydropsyche bettoni			0.34 (30-day LC-50)	0.24 (30-day)	Bell, (NWQL - unpublished)
	FISHES					
	Pimephales promelas	9000	96	580 (spinal deformity, 10-month)	200 (10-month exposure)	Mount and Stephan, 1967
	Lepomis macrochirus	110	96	7.4 (spinal deformity, several months)	3.6 (11-month)	Eaton, 1971
	Lepomis cyanellus	120	96			Pickering, et al., 1962
	Lepomis microlophus	170	96			Macek and McAllister, 1970
	Micropterus salmoides	285	96			Macek and McAllister, 1970
	Salmo gairdneri	170	96			Macek and McAllister, 1970
	Salmo trutta	200	96			Macek and McAllister, 1970
	Oncorhynchus kisutch	101	96			Macek and McAllister, 1970
	Perca flavescens	263	96			Macek and McAllister, 1970
	Ictalurus punctatus	8970	96			Macek and McAllister, 1970
	Ictalurus melas	12900	96			Macek and McAllister, 1970

APPENDIX TABLE 2 (continued)

ORGANOPHOSPHORUS INSECTICIDES

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50 ug/liter	hours	SUB-ACUTE EFFECTS ug/liter	NO EFFECT ug/liter	REFERENCE
METHYL PARATHION BAYER E601	FISHES					
	Pimephales promelas	8900	96			Macek and McAllister, 1970
	Lepomis macrochirus	5720	96			Macek and McAllister, 1970
	Lepomis microlophus	5170	96			Macek and McAllister, 1970
	Micropterus salmoides	5220	96			Macek and McAllister, 1970
	Salmo gairdneri	2750	96			Macek and McAllister, 1970
	Salmo trutta	4740	96			Macek and McAllister, 1970
	Oncorhynchus kisutch	5300	96			Macek and McAllister, 1970
	Perca flavescens	3060	96			Macek and McAllister, 1970
	Italurus punctatus	5710	96			Macek and McAllister, 1970
	Italurus melas	6640	96			Macek and McAllister, 1970
MEVINPHOS. PHOSDRIN ®	CRUSTACEANS					
	Gammarus lacustris	130	96			Sanders, 1969
	Gammarus fasciatus	2.8	96			Sanders, in press
	Palaemonetes kadiakensis	12	96			Sanders, in press
	Asellus brevicaudus	56	96			Sanders, in press
	Simocephalus serrulatus	0.43	48			Sanders and Cope, 1966
	Daphnia pulex	0.16	48			Sanders and Cope, 1966
	INSECT					
	Pteronarcys californica	5.0	96			Sanders and Cope, 1968
	FISHES					
	Lepomis macrochirus	70	96			FPRL
	Micropterus salmoides	110	96			FPRL
NALED DIBROM ®	CRUSTACEANS					
	Gammarus lacustris	110	96			Sanders, 1969
	Gammarus fasciatus	14	96			Sanders, in press
	Palaemonetes kadiakensis	90	96			Sanders, in press
	Orconectes nais	1800	96			Sanders, in press
	Asellus brevicaudus	230	96			Sanders, in press
	Simocephalus serrulatus	1.1	48			Sanders and Cope, 1966
	Daphnia pulex	0.35	48			Sanders and Cope, 1966

APPENDIX TABLE 2 (continued)

ORGANOPHOSPHORUS INSECTICIDES

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50		SUB-ACUTE EFFECTS	NO EFFECT	REFERENCE
		ug/liter	hours	ug/liter	ug/liter	
NALED DIBROM ®	INSECT					
	Pteronarcys californica	8.0	96			Sanders and Cope, 1968
	FISHES					
	Lepomis macrochirus	180	96			FPRL
	Salmo gairdneri	132	96			FPRL
OXYDEMETON METHYL META-SYSTOX ®	CRUSTACEANS					
	Gammarus lacustris	190	96			Sanders, 1969
	Gammarus fasciatus	1000	96			Sanders, in press
	INSECT					
	Pteronarcys californica	35	96			Sanders and Cope, 1968
	FISHES					
	Lepomis macrochirus	14000	96			FPRL
	Salmo gairdneri	4000	96			FPRL
PARATHION	CRUSTACEANS					
	Gammarus lacustris	3.5	96			Sanders, 1969
	Gammarus fasciatus	2.1	96	1.6 (120-hour LC-50)		Sanders, in press
	Palaemonetes kadiakensis	1.5	96			Sanders, in press
	Simocephalus serrulatus	0.37	48			Sanders and Cope, 1966
	Daphnia pulex	0.60	48			Sanders and Cope, 1966
	Orconectes nais	0.04	96			Sanders, in press
	Asellus brevicaudus	600	96			Sanders, in press
	INSECTS					
	Pteronarcys californica	3.6	96	2.2 (30-day LC-50)		Jensen and Gaufin, 1964
	Pteronarcys dorsata	3.0	96	0.90 (30-day LC-50)		Bell, (NWQL - unpublished)
	Pteronarcella badia	4.2	96			Sanders and Cope, 1968
	Claassenia sabulosa	1.5	96			Sanders and Cope, 1968
	Acroneuria pacifica	3.0	96	0.44 (30-day LC-50)		Jensen and Gaufin, 1964
	Acroneuria lycorias			0.013 (30-day LC-50)		Bell, (NWQL - unpublished)

APPENDIX TABLE 2 (continued)

ORGANOPHOSPHORUS INSECTICIDES

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50 ug/liter	ACUTE TOXICITY LC-50 hours	SUB-ACUTE EFFECTS ug/liter	NO EFFECT ug/liter	REFERENCE
PARATHION	INSECTS					
	Ephemerella subvaria	0.16	96	0.056 (30-day LC-50)		Bell,(NWQL - unpublished)
	Ophiogomphus rupinsulensis	3.25	96	0.22 (30-day LC-50)		Bell,(NWQL - unpublished)
	Hydropsyche bettoni			0.45 (30-day LC-50)		Bell,(NWQL - unpublished)
	FISHES					
	Pimephales promelas	1410	96			Solon and Nair, 1970
	Lepomis macrochirus	65	96			Pickering, et al., 1962
	Lepomis cyanellus	425	96			Pickering, et al., 1962
	Micropterus salmoides	190	96			Pickering, et al., 1962
PHORATE THIMET ®	CRUSTACEANS					
	Gammarus lacustris	9	96			Sanders, 1969
	Gammarus fasciatus	0.60	96			Sanders, in press
	Orconectes nais	50	96			Sanders, in press
PHOSPHAMIDON	CRUSTACEANS					
	Gammarus lacustris	2.8	96			Sanders, 1969
	Gammarus fasciatus	16	96			Sanders, in press
	Orconectes nais	7500	96			Sanders, in press
	Simocephalus serrulatus	6.6	48			Sanders and Cope, 1966
	Daphnia pulex	8.8	48			Sanders and Cope, 1966
	INSECT					
	Pteronarcys californica	150	96			Sanders and Cope, 1968
	FISHES					
	Pimephales promelas	100000	96			FPRL
	Lepomis macrochirus	4500	96			FPRL
	Ictalurus punctatus	70000	96			FPRL
RONNEL	FISH					
	Pimephales promelas	305	96			Solon and Nair, 1970

APPENDIX TABLE 2 (continued)

ORGANOPHOSPHORUS INSECTICIDES

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50		SUB-ACUTE EFFECTS	NO EFFECT	REFERENCE
		ug/liter	hours	ug/liter	ug/liter	
TEPP	CRUSTACEANS					
	Gammarus lacustris	39	96			Sanders, 1969
	Gammarus fasciatus	210	96			Sanders, in press
	FISHES					
	Pimephales promelas	840	96			Pickering, et al., 1962
	Lepomis macrochirus	520	96			Pickering, et al., 1962
TRICHLOROPHON DIPTEREX DYLOX	CRUSTACEANS					
	Gammarus lacustris	40	96			Sanders, 1969
	Simocephalus serrulatus	0.32	48			Sanders and Cope, 1966
	Daphnia pulex	0.18	48			Sanders and Cope, 1966
	INSECTS					
	Pteronarcys californica	69	96	9.8 (30-day LC-50)		Jensen and Gaufin, 1966
	Pteronarcys californica	35	96			Sanders and Cope, 1968
	Acroneuria pacifica	16.5	96	8.7 (30-day LC-50)		Jensen and Gaufin, 1966
	Pteronarcella badia	11	96			Sanders and Cope, 1968
	Claassenia sabulosa	22	96			Sanders and Cope, 1968
	FISHES					
	Pimephales promelas	109000	96			Pickering, et al., 1962
	Lepomis macrochirus	3800	96			Pickering, et al., 1962

APPENDIX TABLE 2 (continued)

CARBAMATE

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50 ug/liter	hours	SUB-ACUTE EFFECTS ug/liter	NO EFFECT ug/liter	Time	REFERENCE
CARBARYL	CRUSTACEANS						
SEVIN ®	Gammarus lacustris	16	96				Sanders and Cope, 1969
	Gammarus fasciatus	26	96				Sanders, in press
	Palaemonetes kadiakensis	5.6	96				Sanders, in press
	Orconectes nais	8.6	96				Sanders, in press
	Asellus brevicaudus	240	96				Sanders, in press
	Simocephalus serrulatus	7.6	48				Sanders and Cope, 1966
	Daphnia pulex	6.4	48				Sanders and Cope, 1966
	Daphnia magna				5.0	(63-day)	Biesigner, (NWQL - unpub.)
	INSECTS						
	Pteronarcys californica	4.8	96				Sanders and Cope, 1968
	Pteronarcys dorsata			23.0 (30-day LC-50)	11.5	(30-day)	Bell, (NWQL - unpublished)
	Pteronarcella badia	1.7	96				Sanders and Cope, 1968
	Claassenia sabulosa	5.6	96				Sanders and Cope, 1968
	Acroneuria lycorias			2.2 (30-day LC-50)	1.3	(30-day)	Bell, (NWQL - unpublished)
	Hydropysche bettoni			2.7 (30-day LC-50)	1.8	(30-day)	Bell, (NWQL - unpublished)
	FISHES						
	Pimephales promelas	9000	96	680 (deline survival and reproduction, 6-month)	210	(6-mo.)	Carlson, (NWQL - unpublished)
	Lepomis macrochirus	6760	96				Macek and McAllister, 1970
	Lepomis microlophus	11200	96				Macek and McAllister, 1970
	Micropterus salmoides	6400	96				Macek and McAllister, 1970
	Salmo gairdneri	4340	96				Macek and McAllister, 1970
	Salmo trutta	1950	96				Macek and McAllister, 1970
	Oncorhynchus kisutch	764	96				Macek and McAllister, 1970
	Perca flavescens	745	96				Macek and McAllister, 1970
	Ictalurus punctatus	15800	96				Macek and McAllister, 1970
	Ictalurus melas	20000	96				Macek and McAllister, 1970
BAYGON	CRUSTACEANS						
	Gammarus lacustris	34	96				Sanders, 1969
	Gammarus fasciatus	50	96				Sanders, in press
	INSECT						
	Pteronarcys californica	13	96				Sanders and Cope, 1968

APPENDIX TABLE 2 (continued)

CARBAMATE

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50 ug/liter	hours	SUB-ACUTE EFFECTS ug/liter	NO EFFECT ug/liter	REFERENCE
AMINOCARB	CRUSTACEAN					
MATACIL	*Gammarus lacustris*	12	96			Sanders, 1969
ZECTRAN	CRUSTACEANS					
	Gammarus lacustris	46	96			Sanders, 1969
	Gammarus fasciatus	40	96			Sanders, in press
	Palaemonetes kadiakensis	83	96	25 (20-day LC-50)		Sanders, in press
	Simocephalus serrulatus	13	48			Sanders and Cope, 1966
	Daphnia pulex	10	48			Sanders and Cope, 1966
	INSECT					
	Pteronarcys californica	10	96			Sanders and Cope, 1968
	FISHES					
	Pimephales promelas	17000	96			Macek and McAllister, 1970
	Lepomis macrochirus	11200	96			Macek and McAllister, 1970
	Lepomis microlophus	16700	96			Macek and McAllister, 1970
	Micropterus salmoides	14700	96			Macek and McAllister, 1970
	Salmo gairdneri	10200	96			Macek and McAllister, 1970
	Salmo trutta	8100	96			Macek and McAllister, 1970
	Oncorhynchus kisutch	1730	96			Macek and McAllister, 1970
	Perca flavescens	2480	96			Macek and McAllister, 1970
	Ictalurus punctatus	11400	96			Macek and McAllister, 1970
	Ictalurus melas	16700	96			Macek and McAllister, 1970

APPENDIX TABLE 2 (continued)

HERBICIDES, FUNGICIDES, DEFOLIANTS

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50 ug/liter	hours	SUB-ACUTE EFFECTS ug/liter	NO EFFECT ug/liter	REFERENCE
ACROLEIN	FISHES					
AQUALIN	*Lepomis macrochirus*	80	24			Bond, et al., 1960
	Salmo trutta	46	24			Burdick, et al., 1964
	Lepomis macrochirus	79	24			Burdick, et al., 1964
AMINOTRIAZOLE	CRUSTACEANS					
AMITROL	*Gammarus fasciatus*				100,000 ug/l 48 hr.	Sanders, 1970
	Daphnia magna	30000	48			Sanders, 1970
	Cypridopsis vidua	32000	48			Sanders, 1970
	Asellus brevicaudus				100,000 ug/l 48 hr.	Sanders, 1970
	Palaemonetes kadiakensis				100,000 ug/l 48 hr.	Sanders, 1970
	Orconectes nais				100,000 ug/l 48 hr.	Sanders, 1970
	FISHES					
	Lepomis macrochirus	100	48			Sanders, 1970
	Oncorhyncus kisutch	325000	48			Bond, et al., 1960
BALAN	CRUSTACEAN					
	Gammarus fasciatus	1100	96			Sanders, 1970
BENSULFIDE	CRUSTACEAN					
	Gammarus fasciatus	1400	96			Sanders, 1970
CHLOROXURON	FISH					
	Lepomis macrochirus	25000	48			Hughes and Davis, 1964
CIPC	FISH					
	Lepomis macrochirus	8000	48			Hughes and Davis, 1964
DACTHAL	FISH					
	Lepomis macrochirus	700000	48			Hughes and Davis, 1964

APPENDIX TABLE 2 (continued)

HERBICIDES, FUNGICIDES, DEFOLIANTS

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50 ug/liter	hours	SUB-ACUTE EFFECTS ug/liter	NO EFFECT ug/liter	REFERENCE
DALAPON (SODIUM SALT)	CRUSTACEANS					
	Simocephalus serrulatus	16000	48			Sanders and Cope, 1966
	Daphnia pulex	11000	48			Sanders and Cope, 1966
	INSECT					
	Pteronarcys californica				100,000 ug/l 96 hr.	Sanders and Cope, 1968
	FISHES					
	Pimephales promelas	290000	96			Surber and Pickering, 1962
	Lepomis macrochirus	290000	96			Surber and Pickering, 1962
	Oncorhynchus kisutch	340000	48			Bond, et al., 1960
DEF	CRUSTACEAN					
	Gammarus lacustris	100	96			Sanders, 1969
	INSECT					
	Pteronarcys californica	2100	96			Sanders and Cope, 1968
DEXON	CRUSTACEAN					
	Gammarus lacustris	3700	96			Sanders, 1969
	INSECT					
	Pteronarcys californica	24000	96			Sanders and Cope, 1968

APPENDIX TABLE 2 (continued)

HERBICIDES, FUNGICIDES, DEFOLIANTS

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50 ug/liter	ACUTE TOXICITY LC-50 hours	SUB-ACUTE EFFECTS ug/liter	NO EFFECT ug/liter	REFERENCE
DICAMBA	CRUSTACEANS					
	Gammarus lacustris	3900	96			Sanders, 1969
	Gammarus fasciatus				100,000 ug/l 48 hr.	Sanders, 1970
	Daphnia magna				100,000 ug/l 48 hr.	Sanders, 1970
	Cypridopsis vidua				100,000 ug/l 48 hr.	Sanders, 1970
	Asellus brevicaudus				100,000 ug/l 48 hr.	Sanders, 1970
	Palaemonetes kadiakensis				100,000 ug/l 48 hr.	Sanders, 1970
	Orconectes nais				100,000 ug/l 48 hr.	Sanders, 1970
	FISH					
	Lepomis macrochirus	20	48			Hughes and Davis, 1964
DICHLOBENIL	CRUSTACEANS					
CASARON ®	*Gammarus lacustris*	11000	96			Sanders, 1969
	Gammarus fasciatus	10000	96			Sanders, 1970
	Hyallella azteca	8500	96			Wilson and Bond, 1969
	Simocephalus serrulatus	5800	48			Sanders and Cope, 1968
	Daphnia pulex	3700	48			Sanders and Cope, 1968
	Daphnia magna	10000	48			Sanders, 1970
	Cypridopsis vidua	7800	96			Sanders, 1970
	Asellus brevicaudus	34000	96			Sanders, 1970
	Palaemonetes kadiakensis	9000	96			Sanders, 1970
	Orconectes nais	22000				Sanders, 1970
	INSECTS					
	Pteronarcys californica	7000	96			Sanders and Cope, 1968
	Tendipedid	7800	96			Wilson and Bond, 1969
	Callibrates sp.	10300	96			Wilson and Bond, 1969
	Limnephilus sp.	13000	96			Wilson and Bond, 1969
	Enallegma sp.	20700	96			Wilson and Bond, 1969
	FISH					
	Lepomis macrochirus	20000	48			

APPENDIX TABLE 2 (continued)

HERBICIDES, FUNGICIDES, DEFOLIANTS

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50		SUB-ACUTE EFFECTS	NO EFFECT	REFERENCE
		ug/liter	hours	ug/liter	ug/liter	
DICHLONE	CRUSTACEANS					
PHYGON XL	*Gammarus lacustris*	1100	96			Sanders, 1969
	Gammarus fasciatus	100	96			Sanders, 1970
	Daphnia magna	125	48			Sanders, 1970
	Cypridopsis vidua	120	48			Sanders, 1970
	Asellus brevicaudus	200	48			Sanders, 1970
	Palaemonetes kadiakensis	450	48			Sanders, 1970
	Orconectes nais	3200	48			Sanders, 1970
	FISHES					
	Lepomis macrochirus	120	48			Bond, et al., 1960
	Micropterus salmoides	70	48			Hughes and Davis, 1962
DIQUAT	CRUSTACEAN					
	Hyallella azteca	48	96			Wilson and Bond, 1969
	INSECTS					
	Callibrates sp.	16400	96			Wilson and Bond, 1969
	Limnephilus sp.	33000	96			Wilson and Bond, 1969
	Tendipedid	100	96			Wilson and Bond, 1969
	Enallagma sp.	100	96			Wilson and Bond, 1969
	FISHES					
	Pimephales promelas	14000	96			Surber and Pickering, 1962
	Lepomis macrochirus	35000	96			Gilderhaus, 1967
	Micropterus salmoides	7800	96			Surber and Pickering, 1962
	Esox lucius	16000	48			Gilderhaus, 1967
	Stizostedion vitreum vitreum	2100	96			Gilderhaus, 1967
	Salmo gairdneri	11200	48			Gilderhaus, 1967
	Oncorhynchus kisutch	28500	48			Bond, et al., 1960

APPENDIX TABLE 2 (continued)

HERBICIDES, FUNGICIDES, DEFOLIANTS

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50		SUB-ACUTE EFFECTS	NO EFFECT	REFERENCE
		ug/liter	hours	ug/liter	ug/liter	
DIURON	CRUSTACEAN					
	Gammarus lacustris	160	96			Sanders, 1969
	Gammarus fasciatus	700	96			Sanders, 1970
	Simocephalus serrulatus	2000	48			Sanders and Cope, 1966
	Daphnia pulex	1400	48			Sanders and Cope, 1966
	INSECT					
	Pteronarcys californica	1200	96			Sanders and Cope, 1968
	FISH					
	Oncorhynchus kisutch	33000	48			Bond, et al., 1960
DIFOLITAN	CRUSTACEAN					
	Gammarus lacustris	800	96			Sanders, 1969
	INSECT					
	Pteronarcys californica	40	96			Sanders and Cope, 1968
DINITROBUTYL PHENOL	CRUSTACEAN					
	Gammarus fasciatus	1800	96			Sanders, 1970

APPENDIX TABLE 2 (continued)

HERBICIDES, FUNGICIDES, DEFOLIANTS

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50 ug/liter	hours	SUB-ACUTE EFFECTS ug/liter	NO EFFECT ug/liter	REFERENCE
DIPHENAMID	CRUSTACEANS					
	Gammarus fasciatus				100,000 ug/l 48 hr.	Sanders, 1970
	Daphnia magna	56000	48			Sanders, 1970
	Cypridopsis vidua	50000	48			Sanders, 1970
	Asellus brevicaudus				100,000 ug/l 48 hr.	Sanders, 1970
	Palaemonetes kadiakensis	58000	48			Sanders, 1970
	Orconectes nais				100,000 ug/l 48 hr.	Sanders, 1970
DURSBAN	CRUSTACEAN					
	Gammarus lacustris	110	96			Sanders, 1969
	INSECTS					
	Pteronarcys californica	10	96			Sanders and Cope, 1968
	Pteronarcella badia	0.38	96			Sanders and Cope, 1968
	Claassenia sabulosa	0.57	96			Sanders and Cope, 1968
2-4, D (PGBE)	CRUSTACEANS					
	Gammarus lacustris	1600	96			Sanders, 1969
	Gammarus fasciatus	2500	96			Sanders, 1970
	Daphnia magna	100	48			Sanders, 1970
	Cypridopsis vidua	320	48			Sanders, 1970
	Asellus brevicaudus	2200	48			Sanders, 1970
	Palaemonetes kadiakensis	2700	48		100,000 ug/l 48 hr.	Sanders, 1970
	Orconectes nais				100,000 ug/l 48 hr.	Sanders, 1970

APPENDIX TABLE 2 (continued)

HERBICIDES, FUNGICIDES, DEFOLIANTS

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50 ug/liter	hours	SUB-ACUTE EFFECTS ug/liter	NO EFFECT ug/liter	REFERENCE
2-4, D (BEE)	CRUSTACEANS					
	Gammarus lacustris	440	96			Sanders, 1969
	Gammarus fasciatus	5900	48			Sanders, 1970
	Daphnia magna	5600	48			Sanders, 1970
	Cypridopsis vidua	1800	48			Sanders, 1970
	Asellus brevicaudus	3200	48			Sanders, 1970
	Palaemonetes kadiakensis	1400	48		100,000 ug/l 96 hr.	Sanders, 1970
	Orconectes nais	60000	48			Sanders, 1970
	INSECT					
	Pteronarcys californica	1600	96			Sanders and Cope, 1968
	FISH					
	Pimephales promelas	5600	96	1500 ug/l lethal to eggs in 48 hour exposure	300 ug/l 10 mo.	Mount and Stephan, 1967
2-4, D (IOE)	CRUSTACEAN					
	Gammarus lacustris	2400	96			Sanders, 1969
2-4, D (DIETHYLAMINE SALT)	CRUSTACEANS					
	Gammarus lacustris	100000	96			Sanders, 1969
	Gammarus fasciatus				100,000 ug/l 48 hr.	Sanders, 1970
	Daphnia magna	4000	48			Sanders, 1970
	Crypidopsis vidua	8000	48			Sanders, 1970
	Asellus brevicaudus				100,000 ug/l 48 hr.	Sanders, 1970
	Palaemonetes kadiakensis				100,000 ug/l 48 hr.	Sanders, 1970
	Orconectes nais				100,000 ug/l 48 hr.	Sanders, 1970

APPENDIX TABLE 2 (continued)

HERBICIDES, FUNGICIDES, DEFOLIANTS

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50 ug/liter	hours	SUB-ACUTE EFFECTS ug/liter	NO EFFECT ug/liter	REFERENCE
ENDOTHALL DI SODIUM SALT						
	FISHES					
	Pimephales notatus	10000	96			Walker, 1964
	Lepomis macrochirus	125000	96			Walker, 1964
	Micropterus salmoides	120000	96			Walker, 1964
	Notropis umbratilus	95000	96			Walker, 1964
ENDOTHALL DIPOTASSIUM SALT	CRUSTACEAN					
	Gammarus lacustris				100,000 ug/l 96 hr.	Sanders, 1969
	FISHES					
	Pimephales promelas	320000	96			Surber and Pickering, 1962
	Lepomis macrochirus	160000	96			Surber and Pickering, 1962
	Micropterus salmoides	200000	96			Bond, et al., 1960
	Oncorhynchus tschawytscha	136000	96			Bond, et al., 1960
EPTAM	CRUSTACEAN					
	Gammarus fasciatus	23000	96			Sanders, 1970
FENAC (SODIUM SALT)	CRUSTACEANS					
	Gammarus lacustris	12000	96			Sanders, 1969
	Gammarus fasciatus				100,000 ug/l 48 hr.	Sanders, 1970
	Daphnia pulex	4500	48			Sanders and Cope, 1966
	Simocephalus serrulatus	6600	48			Sanders and Cope, 1966
	Daphnia magna				100,000 ug/l 48 hr.	Sanders, 1970
	Cypridopsis vidua				100,000 ug/l 48 hr.	Sanders, 1970
	Asellus brevicaudus				100,000 ug/l 48 hr.	Sanders, 1970
	Palaemonetes kadiakensis				100,000 ug/l 48 hr.	Sanders, 1970
	Orconectes nais					

APPENDIX TABLE 2 (continued)

HERBICIDES, FUNGICIDES, DEFOLIANTS

PESTICIDE	ORGANISM	ACUTE TOXICITY LC 50		SUB-ACUTE EFFECTS	NO EFFECT	REFERENCE
		ug/liter	hours	ug/liter	ug/liter	
	INSECT					
	Pteronarcys californica	55000	96			Sanders and Cope, 1968
	FISH					
	Lepomis	15000	96			Hughes and Davis, 1962
HYAMINE 1622						
	FISHES					
	Pimephales promelas	1600	96			Surber and Pickering, 1962
	Lepomis macrochirus	1400	96			Surber and Pickering, 1962
	Oncorhynchus kisutch	53000	96			Bond, et al., 1960
HYAMINE 2389						
	FISHES					
	Pimephales promelas	2400	96			Surber and Pickering, 1962
	Lepomis macrochirus	1200	96			Surber and Pickering, 1962
HYDROTHAL 47						
	CRUSTACEAN					
	Gammarus fasciatus	510	96			Sanders, 1970
HYDROTHAL 191						
	CRUSTACEANS					
	Gammarus lacustris	500	96			Sanders, 1969
	Gammarus fasciatus	480	96			Sanders, 1970

APPENDIX TABLE 2 (continued)

HERBICIDES, FUNGICIDES, DEFOLIANTS

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50		SUB-ACUTE EFFECTS	NO EFFECT	REFERENCE
		ug/liter	hours	ug/liter	ug/liter	
HYDROTHAL PLUS	FISH					
	Lepomis macrochirus	3500	48			Hughes and Davis, 1964
IPC	CRUSTACEANS					
	Gammarus lacustris	10000	96			Sanders, 1969
	Gammarus fasciatus	1900	96			Sanders, 1970
	Simocephalus serrulatus	10000	48			Sanders and Cope, 1966
	Daphnia pulex	10000	48			Sanders and Cope, 1966
KURON	CRUSTACEANS					
	Simocephalus serrulatus	2400	48			Sanders and Cope, 1966
	Daphnia pulex	2000	48			Sanders and Cope, 1966
MCDA	FISH					
	Lepomis macrochirus	1500	48			Hughes and Davis, 1964
MOLINATE	CRUSTACEANS					
	Gammarus lacustris	4500	96			Sanders, 1969
	Gammarus fasciatus	390	48			Sanders, 1970
	Daphnia magna	600	48			Sanders, 1970
	Asellus brevicaudus	400	48			Sanders, 1970
	Palaemonetes kadiakensis	1000	48			Sanders, 1970
	Orconectes nais	5600	48			Sanders, 1970

APPENDIX TABLE 2 (continued)

HERBICIDES, FUNGICIDES, DEFOLIANTS

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50		SUB-ACUTE EFFECTS	NO EFFECT	REFERENCE
		ug/liter	hours	ug/liter	ug/liter	
MONURON	FISH					
	Oncorhynchus kisutch	110000	48			Bond, et al., 1960
PARAQUAT	CRUSTACEANS					
	Gammarus lacustris	110000	96			Sanders, 1969
	Simocephalus serrulatus	4000	48			Sanders and Cope, 1966
	Daphnia pulex	3700	48			Sanders and Cope, 1966
	INSECT					
	Pteronarcys californica				100,000 ug/1 96 hr.	Sanders and Cope, 1968
PEBULATE	CRUSTACEAN					
	Gammarus fasciatus	10000	96			Sanders, 1970
	INSECT					
	Pteronarcys californica	48000	96			Sanders and Cope, 1968
PROPANIL	CRUSTACEAN					
	Gammarus fasciatus	16000	96			Sanders, 1969
SILVEX	CRUSTACEANS					
(BEE)	*Gammarus fasciatus*	250	96			Sanders, 1970
	Daphnia magna	2100	48			Sanders, 1970
	Cypridopsis vidua	4900	48			Sanders, 1970
	Asellus brevicaudus	40000	48			Sanders, 1970
	Palaemonetes kadiakensis	8000	48			Sanders, 1970
	Orconectes nais	60000	48			Sanders, 1970

APPENDIX TABLE 2 (continued)

HERBICIDES, FUNGICIDES, DEFOLIANTS

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50		SUB-ACUTE EFFECTS	NO EFFECT	REFERENCE
		ug/liter	hours	ug/liter	ug/liter	
	FISH					
	Lepomis macrochirus	1200	48			Hughes and Davis, 1963
SILVEX (PGBE)	CRUSTACEANS					
	Gammarus fasciatus	840	96			Sanders, 1970
	Daphnia magna	180	48			Sanders, 1970
	Cypridopsis vidua	200	48			Sanders, 1970
	Asellus brevicaudus	500	48			Sanders, 1970
	Palaemonetes kadiakensis	3200	48			Sanders, 1970
	Orconectes nais				100,000 ug/l 48 hr.	Sanders, 1970
	FISH					
	Lepomis macrochirus	16600	48			Hughes and Davis, 1963
SILVEX (IOE)	FISH					
	Lepomis macrochirus	1400	48			Hughes and Davis, 1963
SILVEX (POTASSIUM SALT)	FISH					
	Lepomis macrochirus	83000	48			Hughes and Davis, 1963
SIMAZINE	CRUSTACEANS					
	Gammarus lacustris	13000	96			Sanders, 1969
	Gammarus fasciatus				100,000 ug/l 48 hr.	Sanders, 1970
	Daphnia magna	1000	48			
	Cypridopsis vidua	3200	48			
	Asellus brevicaudus				100,000 ug/l 48 hr.	Sanders, 1970
	Palaemonetes kadiakensis				100,000 ug/l 48 hr.	Sanders, 1970
	Orconectes nais				100,000 ug/l 48 hr.	Sanders, 1970
	FISH					
	Oncorhynchus kisutch	6600	48			Bond, et al., 1960

APPENDIX TABLE 2 (continued)

HERBICIDES, FUNGICIDES, DEFOLIANTS

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50		SUB-ACUTE EFFECTS	NO EFFECT	REFERENCE
		ug/liter	hours	ug/liter	ug/liter	
TRIFLURALIN	CRUSTACEANS					
	Gammarus lacustris	2200	96			Sanders, 1969
	Gammarus fasciatus	1000	96			Sanders, 1970
	Daphnia magna	560	48			Sanders, 1970
	Daphnia pulex	240	48			Sanders and Cope, 1966
	Simocephalus serrulatus	450	48			Sanders and Cope, 1966
	Cypridopsis vidua	250	48			Sanders, 1970
	Asellus brevicaudus	200	48			Sanders, 1970
	Palaemonetes kadiakensis	1200	48			Sanders, 1970
	Orconectes nais	50000	48			Sanders, 1970
	INSECT					
	Pteronarcys californica	3000	96			
VERNOLATE	CRUSTACEANS					
	Gammarus lacustris	1800	96			Sanders, 1969
	Gammarus fasciatus	13000	96			Sanders, 1970
	Daphnia magna	1100	48			Sanders, 1970
	Cypridopsis vidua	240	48			Sanders, 1970
	Asellus brevicaudus	5600	48			Sanders, 1970
	Palaemonetes kadiakensis	1900	48			Sanders, 1970
	Orconectes nais	24000	48			Sanders, 1970

APPENDIX TABLE 2 (continued)

BOTANICALS

PESTICIDE	ORGANISM	ACUTE TOXICITY LC-50 ug/liter	ACUTE TOXICITY LC-50 hours	SUB-ACUTE EFFECTS ug/liter	NO EFFECT ug/liter	REFERENCE
ALLETHRIN	CRUSTACEANS					
	Gammarus lacustris	11	96			Sanders, 1969
	Gammarus fasciatus	8	96			Sanders, in press
	Simocephalus serrulatus	56	48			Sanders and Cope, 1966
	Daphnia pulex	21	48			Sanders and Cope, 1966
	INSECT					
	Pteronarcys californica	2.1	96			Sanders and Cope, 1968
	FISHES					
	Lepomis macrochirus	56	96			FPRL
	Salmo gairdneri	19	96			FPRL
PYRETHRUM	CRUSTACEANS					
	Gammarus lacustris	12	96			Sanders, 1969
	Gammarus fasciatus	11	96			Sanders. 1969
	Simocephalus serrulatus	42	48			Sanders and Cope, 1966
	Daphnia pulex	25	48			Sanders and Cope, 1966
	INSECT					
	Pteronarcys californica	1.0	96			Sanders and Cope, 1968
ROTENONE	CRUSTACEANS					
	Gammarus lacustris	2600	96			Sanders, 1969
	Simocephalus serrulatus	190	48			Sanders and Cope, 1966
	Daphnia pulex	100	48			Sanders and Cope, 1966
	INSECT					
	Pteronarcys californica	380	96			Sanders and Cope, 1968

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