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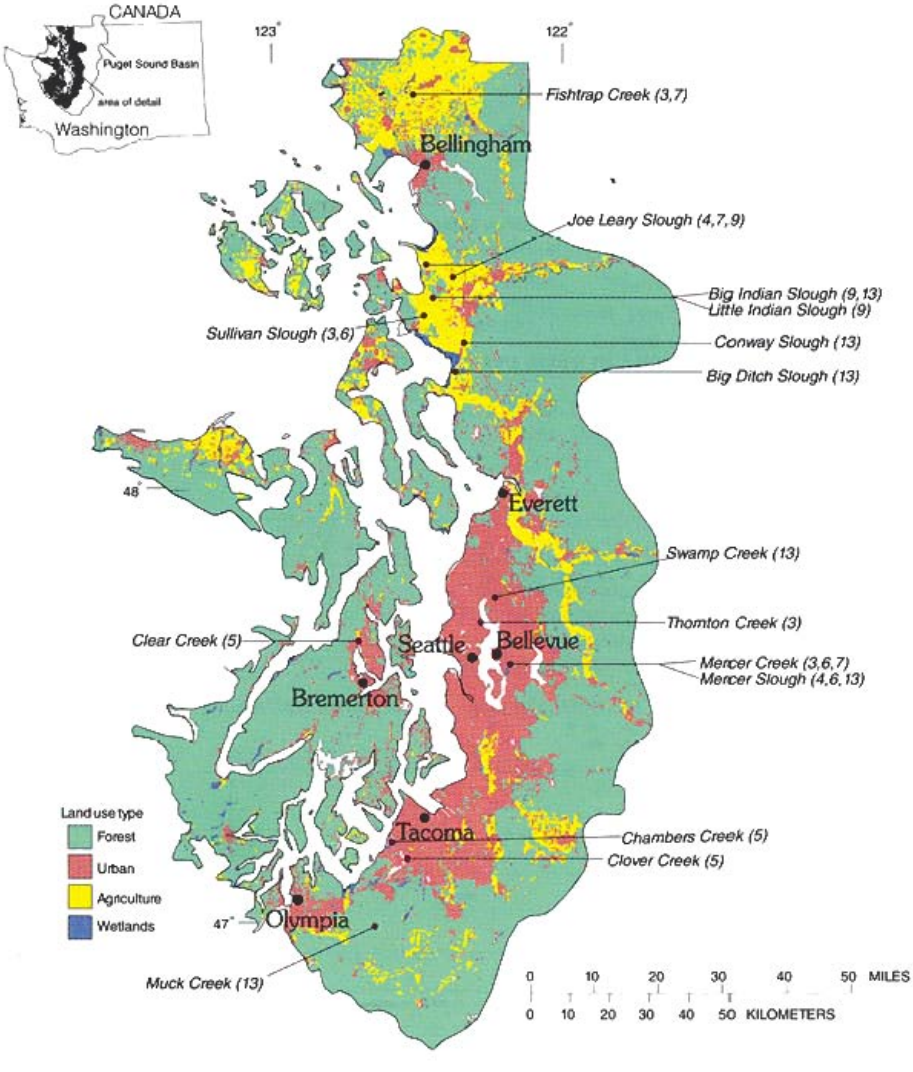
National Water-Quality Assessment Program

Pesticides in Selected Small Streams in the Puget Sound Basin, 1987-1995

by Gilbert C. Bortleson, U.S. Geological Survey, and Dale A. Davis, Washington State Department of Ecology

Pesticides in the aquatic environment are a concern because of possible effects on fish, wildlife, and human health. From 1987 to 1995, Washington State Department of Ecology (Ecology) and the U.S. Environmental Protection Agency (USEPA) conducted studies to assess the occurrence of pesticides in streams and streambed sediments in the Puget Sound Basin. Most samples were collected from small streams and sloughs (none were sources of drinking water) during the spring and summer, when pesticides were most likely to have been recently applied and therefore be detected. This fact sheet summarizes data from several of these studies.



Base from U.S. Geological Survey digital data, 1:2,000,000, 1972 Albers Equal-Area Conic Projection

Land use and location of small streams sampled for pesticides
(Numbers refer to sources of data. See References.)

Significant Findings

The most commonly detected pesticides in streams were among the most heavily used in the basin. The most frequently detected pesticide in streams was 2,4-D, the most heavily used herbicide in the Puget Sound Basin. Other commonly detected and heavily used pesticides were the herbicide dicamba and the insecticide diazinon.

Pesticide concentrations generally were small. None of the detected pesticides in streams exceeded existing State or Federal freshwater aquatic life criteria; however, criteria have been established for only two of the pesticides detected. Diazinon, mevinphos, malathion, and diuron were found in streams exceeding maximum concentrations recommended by the National Academy of Sciences for the protection of aquatic life (National Academy of Sciences, 1973). None of the detected pesticides exceeded the USEPA's standards or guidelines for drinking water.

Pesticides that are currently banned in the U. S. were found in streambed sediments. The pesticide most commonly found in streambed sediments was the fungicide PCP (pentachlorophenol); the insecticides DDT and chlordane were also detected. These compounds are organochlorine pesticides that were heavily used in the past, but are now banned from use in the U. S. However, detection of organochlorine pesticides is common in sediments across the U. S. because these compounds degrade slowly and bind strongly to soil particles. No State freshwater sediment-quality criteria exist for these compounds, but the USEPA has proposed guidelines for DDT and chlordane to protect benthic organisms.

Number and Type of Pesticides Detected

	In water	In bed sediments
Herbicide	17	2
Insecticide	5	4
Fungicide	1	1
Degradation products of DDT	0	2
Total	23	9

Studies Reviewed

A USEPA inventory in 1988 of contemporary pesticide usage in the Puget Sound Basin (Tetra Tech, 1988) indicates that approximately 2.8 million pounds of pesticides are used annually (the table on the facing page lists 18 pesticides that are estimated to be applied in amounts greater than 20,000 pounds/year in the basin.) Following this inventory, the USEPA conducted a reconnaissance study of five small streams draining various land uses (PTI Environmental Services, 1991). Since 1992, Ecology has collected water or bed-sediment samples from nine streams. Mayer and Elkins (1990) from Western Washington State University collected samples from small sloughs in agricultural areas in the northern part of the basin. Although these studies varied in design and analytical methods used, the data generally characterize the occurrence of pesticides in small streams in the Puget Sound Basin.

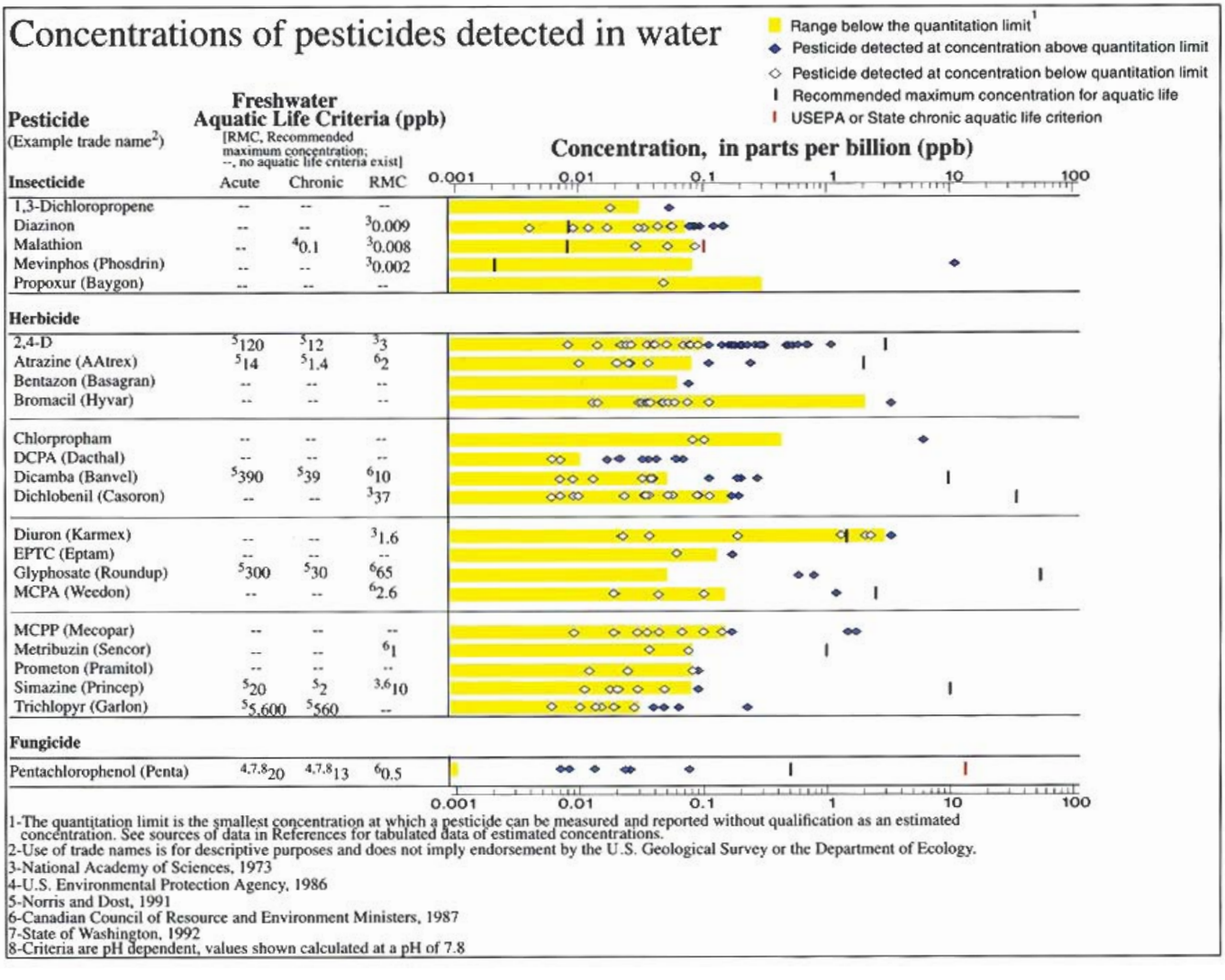
Pesticides Detected in Small Streams

Herbicides were detected more frequently than insecticides. Seventeen of 23 pesticides detected in water were herbicides. The commonly used herbicide 2,4-D was found in 12 of 13 streams. Other herbicides—bromacil, DCPA, dicamba, dichlobenil, diuron, and MCPP—were found at five or more streams. The insecticide diazinon was found in six streams, and three other insecticides—malathion, mevinphos, and propoxur—were detected in one or two streams. **In general, more pesticides were detected in urban streams than in agricultural streams.** Eighteen pesticides were detected in Mercer Creek, an urban stream, whereas 13 pesticide detections in Joe Leary Slough were the greatest number of pesticides found in an agricultural stream. Seven pesticides were detected exclusively in urban streams, five were found only in agricultural streams, and 11 were common to both. Few of these pesticides are used exclusively in urban or agricultural areas. Their occurrences probably reflect local application practices.

The graph below shows that 23 pesticides were detected at mostly small concentrations either as estimated or quantifiable values.

Pesticides Detected in Streambed Sediments

Of the total number of compounds detected in streambed sediments, most were insecticides or insecticide degradation products. Six of the nine pesticides detected in streambed sediments were insecticides (or their degradation products), two were herbicides, and one a fungicide. The most frequently detected compounds in sediments, found in both urban and agricultural streams, were PCP, detected in five streams, and DDT



1-The quantitation limit is the smallest concentration at which a pesticide can be measured and reported without qualification as an estimated concentration. See sources of data in References for tabulated data of estimated concentrations.
2-Use of trade names is for descriptive purposes and does not imply endorsement by the U.S. Geological Survey or the Department of Ecology.
3-National Academy of Sciences, 1973
4-U.S. Environmental Protection Agency, 1986
5-Norris and Dost, 1991
6-Canadian Council of Resource and Environment Ministers, 1987
7-State of Washington, 1992
8-Criteria are pH dependent, values shown calculated at a pH of 7.8

and/or its degradation products DDD and DDE, detected in three streams. Chlordane was also detected in sediments. DDT, PCP, and chlordane are currently banned from use in the U. S., but were heavily used in the past. Because of their slow degradation rates, these pesticides are likely to be present in sediments for many years. DDT was used as an insecticide; PCP was used primarily as a fungicide, but also as an insecticide and herbicide. Other pesticides found in bed sediments from at least two streams were the herbicides dichlobenil and dicamba. The insecticides chlordane, diazinon, and endosulfan were identified in one stream each. The graph below shows that nine compounds were detected at concentrations either as estimated or quantifiable values. Pesticides in bed sediments do not have any State freshwater sediment-quality criteria, but USEPA guidelines to protect benthic organisms are proposed for DDT, chlordane, and endosulfan in bed sediments (Nowell and Resek, 1994). These guidelines, which are based on the amount of organic carbon in the sediments, do not apply to concentrations shown in the graph.

Factors Influencing Pesticide Concentrations and Detections

Detections and concentrations of pesticides in streams are influenced by many factors, including the amount of pesticide used, the environmental persistence of the pesticide, and the analytical methods used.

Commonly used pesticides in the Puget Sound Basin

[Data from Tetra Tech, 1988; some data from Farm Chemicals Handbook, 1994 and Davis, 1993; I = Insecticide; Fu = Fungicide; H = Herbicide; Ac = Acaracide (kills mites, ticks); M = Molluscicide (kills snails); SS = Soil Sterilant; Y, yes; N, no; lb/yr, pounds per year; --, not analyzed]

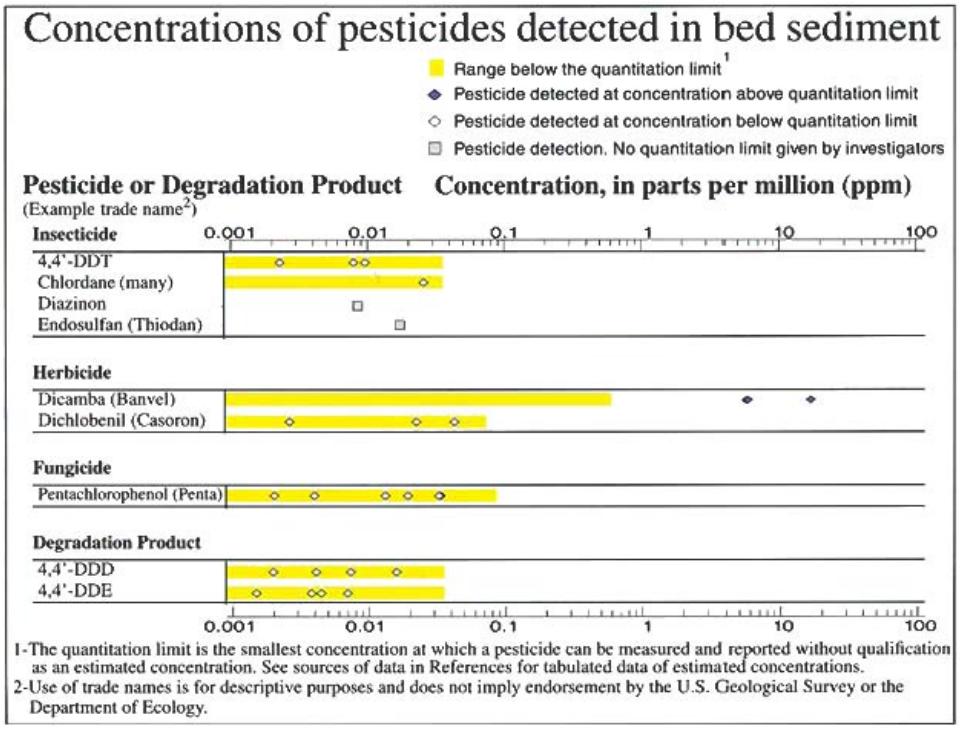
Pesticide (Example trade name)	Estimated amount applied (thousands of lbs/yr)	Pesticide use	Detected in surface water, bed sediment?
	Primarily Non-Urban		
2,4-D	>200	H	Y, N
Prometon (Pramitol)	101-200	H,SS	Y, N
Diazinon	51-100	I	Y, Y
Simazine (Princep)	51-100	H	Y, N
Dicamba (Banvel)	51-100	H	Y, Y
Trichlopyr (Garlon)	51-100	H	Y, N
Atrazine (AAtrex)	21-50	H	Y, N
Bromacil (Hyvar)	21-50	H	Y, N
Carbaryl (Sevin)	21-50	I	N, N
Diuron (Karmex)	21-50	H	Y, N
Tebuthiuron (Spike)	21-50	H	N, N
	Mixed Urban and Agriculture		
Malathion	>200	I, Ac	Y, N
Methyl bromide (Celfume)	101-200	I, Ac, Fu	--, --
Sulfuryl fluoride (Vikane)	101-200	I, Ac	--, --
Chlorpyrifos (Lorsban)	21-50	I	N, N
Glyphosate (Roundup)	21-50	H	Y, N
Metaldehyde (Metason)	21-50	M	--, --
Sulfur (Sulphotox)	21-50	Fu	--, --

In the Puget Sound Basin, the most commonly detected pesticides were among the most heavily applied. Eleven of the 18 pesticides that are most heavily used were detected in water or bed sediments (see table above). Application practices in urban and agricultural areas are important in determining whether pesticides reach streams. Pesticides are used around urban households, businesses, and parks, and application practices of urban users differ widely. **Urban use of pesticides (about 1.1 million pounds/year) was more than three times greater than agricultural use** (Tetra Tech, 1988). This may explain in part why the number of different pesticides found in urban streams is greater than in agricultural streams.

Chemical characteristics of pesticides are a major factor in environmental persistence. The majority of currently used pesticides break down relatively rapidly after application. Consequently, pesticide detections occur most frequently in the weeks following periods of heaviest pesticide application, which usually are in spring and early summer in the basin. Detections of pesticides have also increased over time as analytical methods improve and smaller concentrations can be measured.

Environmental Significance

Pesticides are used to control weeds and insects in a wide variety of agricultural, urban, and suburban settings. However, their use may have unintended consequences, such as contaminating drinking water and threatening a healthy habitat for wildlife, fish, and other aquatic organisms. Concentrations of pesticides detected were below USEPA standards and guidelines for drinking water. However, four pesticides—diazinon, malathion, and mevinphos (insecticides), and diuron (an herbicide)—exceeded maximum concentrations recommended by the National Academy of Sciences for the protection of freshwater organisms at seven streams. Moreover, moderately high concentrations of diazinon found in Mercer Creek at three different times of the year indicate sustained concentrations that could have long-term adverse impacts on some aquatic organisms.



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Only two of the 23 pesticides detected in streams—malathion and pentachlorophenol—have aquatic-life criteria established by the State or USEPA; neither pesticide exceeded these criteria. Aquatic-life criteria are established for some individual compounds, but no criteria exist for combinations of pesticides, and the effects from these combinations are not well understood. The data indicate that, in some of the streams sampled, multiple pesticides occur. For example, a total of 18 pesticides was detected in samples from Mercer Creek. Individual concentrations were generally small; however, the combined effects of all these pesticides may have more or less impact on aquatic organisms than would be expected from individual compounds.

Although banned organochlorine pesticides were detected in streambed sediments at small concentrations, they are probably not acutely affecting aquatic organisms. However, these small concentrations of pesticides readily accumulate in fatty tissues of organisms that are exposed to them. For example, fish exposed to sediments containing organochlorine pesticides could accumulate pesticide concentrations high enough to reduce spawning success. In addition, many of the persistent organochlorine compounds have recently been linked to reproductive problems in aquatic species, birds, and mammals (Colborn and others, 1996).

Future Pesticide Monitoring

These results indicate that pesticides do occur at generally small concentrations not exceeding aquatic life or human health criteria in small streams and streambed sediments within the Puget Sound Basin. Pesticide use and occurrence are greatest in the urban areas of the basin. Additional pesticide monitoring will be required to evaluate trends over time and to assess the occurrence and distribution of currently used and new pesticides. Further pesticide sampling will be conducted by the USGS and Ecology to better evaluate the occurrence of pesticides with respect to land use, seasonal variations, and storm runoff. The USGS Puget Sound National Water Quality Assessment (NAWQA) project will conduct intensive seasonal and storm sampling of two large rivers and two small streams in the basin to achieve the following objectives:

- evaluate pesticide occurrence in large rivers and small streams draining agricultural and urban areas,
- assess seasonal and storm-related variations of pesticide concentrations, and
- calculate estimated loads of pesticides from selected streams draining different land uses.

As part of the Washington State Pesticide Monitoring Program, Ecology will continue to assess pesticide contamination in streams throughout the basin, including cooperative sampling efforts with the USGS. The goal of this monitoring program is to characterize pesticides geographically and over time in water, bed sediments, and aquatic organisms, which will provide information to improve pesticide management in the state and ultimately help reduce the risk of pesticide exposure that can result in adverse effects on aquatic organisms and human health.

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The National Water Quality Assessment (NAWQA) Program of the U.S. Geological Survey is designed to describe the current water-quality conditions for a large part of the Nation's ground and surface water, to describe how water quality is changing over time, and to improve our understanding of the national and human factors that affect our water quality.

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by Gilbert C. Bortleson and Dale A. Davis
Illustrations: Donna R. Tarver, USGS, WA District
Banner: Karen A. Lonsdorf, USGS, WI District
For further information, contact:
Project Chief,
U.S. Geological Survey
Puget Sound Basin NAWQA
1201 Pacific Ave., Suite 600
Tacoma, WA 98402
(253) 593-6510
E-mail:nawqa_puget_wa@usgs.gov
World Wide Web:
http://wwwdwatcm.wr.usgs.gov/ps.nawqa.html

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