ESTIMATING PESTICIDE CONCENTRATIONS IN DRINKING WATER: OPP'S CURRENT APPROACH TO DRINKING WATER ASSESSMENTS

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The Food Quality Protection Act (FQPA) of 1996 directs EPA to consider "all anticipated dietary exposures and all other exposures for which there is reliable information" when setting tolerances for pesticide residues in food. Because a number of pesticides have been found in ground water and surface water throughout the United States, including water bodies that are used for drinking water, EPA considers drinking water to be an anticipated dietary exposure pathway for certain pesticides.

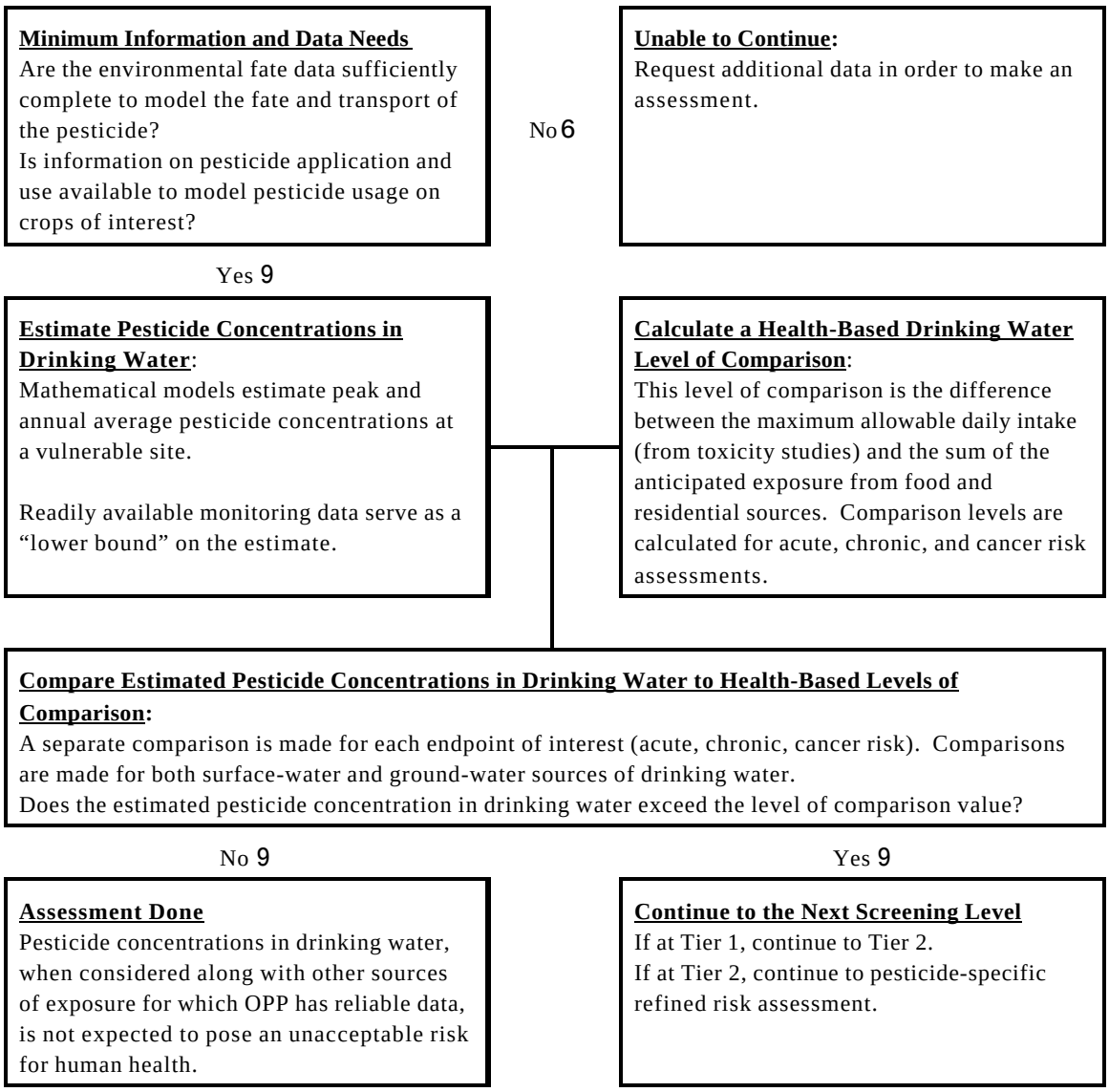
Prior to FQPA, the Office of Pesticide Programs (OPP) did not routinely incorporate drinking water exposure into the quantitative dietary human health risk assessment. Rather, OPP's strategy for managing pesticides which had the potential to contaminate water was to emphasize prevention – requiring mitigation measures such as geographic restrictions on pesticide use and buffer zones near water bodies where pesticide use is prohibited. Since the enactment of FQPA, OPP has routinely considered exposure to pesticides in drinking water as a part of its dietary risk assessment process.

Tiered Approach to Drinking Water Assessments

When developing FQPA risk assessments, OPP uses a tiered system of exposure modeling to evaluate the risks posed to human health from the presence of pesticides in drinking water. Currently OPP uses a two-tiered screen for drinking water assessments. Each tier is designed to screen out pesticides by requiring higher, more complex levels of investigation only for those that have not passed the next lower tier. Mathematical models simulate vulnerable surface- or ground-water sources of drinking water to estimate concentrations of a pesticide in drinking water. These estimates are compared to human health-based drinking water levels of comparison. The drinking water level of comparison is a theoretical maximum concentration of a pesticide in drinking water that, when combined with exposures through food, residential, and other uses, would not exceed the maximum allowable dose for that pesticide.

If the estimated concentration of the pesticide in drinking water exceeds the level of comparison, the pesticide fails the screen and moves to the next tier of the assessment. A pesticide that fails the first screen moves to the second screen. If that pesticide fails the second screen, then OPP currently takes a pesticide-specific approach to refining the drinking water assessment. If the estimated drinking water concentration is less than the level of comparison, the pesticide passes the screen and OPP concludes with reasonable certainty that exposure to the pesticide in water, in combination with other sources of exposure, is not expected to exceed a level of concern. No further assessment is conducted. Figure 1 illustrates the general framework used for the drinking water screening process.

FIGURE 1: GENERAL FRAMEWORK FOR THE DRINKING WATER SCREENING PROCESS



The intent of the screening approach is to separate pesticides that pose minimal, if any, risk to human health from those pesticides that may be in drinking water at a level of potential concern. To accomplish this, the screens provide conservative estimates of pesticide concentrations in water so that the Agency can be confident that any pesticide that passes a screening tier (i.e., the estimated drinking water concentration is less than the health-based level of comparison) is unlikely to pose a risk to human health. At the same time, the screen should not be so conservative that those pesticides that are truly not expected to pose a risk to human health fail the screen. This balance is achieved through the following assumptions in the drinking water estimates:

(1) **Pesticide Application:** OPP assumes that the pesticide is applied to the treated crop at

maximum application rates for the maximum number of applications with the minimum allowable interval between applications.

(2) **Site Characteristics:** The screening models simulate pesticide application on cropped sites that are highly vulnerable to runoff (in the case of surface water assessments) or leaching (in the case of ground water assessments).

(3) **Weather Conditions:** Pesticide movement to surface water or ground water is driven to a large degree by amount and intensity of rainfall events. The pesticide concentrations estimated by the screening models result from rainfall events that are likely to result in extensive runoff and/or leaching.

The sections that follow describe how these elements are used in the specific screening models.

Surface Water Screening Tools

In 1996, OPP had available two surface water models that were designed to provide estimates of pesticide concentrations in water for ecological risk assessments. Initially, OPP focused on modifying the available surface water models for use in drinking water assessments. On several occasions, OPP consulted with the FIFRA Scientific Advisory Panel (SAP) concerning its screening tools for drinking water assessments. The contents of the consultations for December 1997, July 1998, and May 1999, along with the SAP recommendations, are available on EPA's web site at http://www.epa.gov/scipoly/sap.

As a result of these consultations, OPP made the following refinements to the initial surface water screening tools:

- an index drinking water reservoir replaced the standard field pond scenario for screening models of surface-water sources of drinking water; and

- screening model results are adjusted with a percent crop area factor to account for the area of the watershed that may potentially be in the crop or crops being modeled.

These revisions improve OPP's initial screening assessments by incorporating into the model a more realistic watershed and reservoir that are capable of supporting a drinking water facility. The crop area factor accounts for the fact that such watersheds are not likely to be covered entirely in one crop.

OPP currently uses two tiers to develop initial estimates of pesticide concentrations in surface-derived sources of drinking water. In the first tier, GENEEC (GENeric Estimated Environmental Concentrations) estimates peak and longer-term average concentrations of pesticides in water from a few basic chemical parameters and pesticide label application information. In the second tier, the coupled PRZM (Pesticide Root Zone Model) and EXAMS (EXposure Analysis Modeling System)

models allow for more flexibility in site-specific information, application methods and timing, distribution of weather, and chemical-specific parameters. Passing either of the initial tiers indicates a low possibility of significant risk to human health. Because these are screening assessments which incorporate conservative assumptions, failing the early tiers only implies that more refinements on the exposure are needed. At this point in the assessment, no conclusions or assumptions can be made as to how this impacts the human health risk assessment.

Tier 1 Screening Model

GENEEC, developed as an initial screening tool for ecological impact assessments, models pesticide concentrations in a large farm pond. The model considers adsorption of the pesticide to soil or sediment, incorporation of the pesticide at application, direct deposition of spray drift into the water body, and degradation of the pesticide in soil before runoff and within the water body. GENEEC is expected to overestimate pesticide concentrations in drinking water for most sites because it uses maximum pesticide application rates, assumes that no buffer exists between the pond and the treated field, simulates runoff from a 6-inch rainfall over a 24-hour period, represents a water body that is smaller than a drinking water reservoir, and assumes that the entire watershed is cropped and the pesticide is applied to the entire crop.

GENEEC estimates the peak value which occurs on the day of a single large rainstorm and the average value for the next 56 days. The peak value is used for acute exposure assessments and the average value is used for chronic exposure assessments. It is important to note that, if a pesticide fails this tier (i.e., either the estimated peak or average drinking water concentration exceeds the appropriate drinking water level of comparison), the Agency does not take risk mitigation action. Instead, the assessment moves to a higher screening tier. This initial screen provides a rapid, inexpensive assessment that screens out those pesticides that are not likely to occur in drinking water sources at concentrations that are of concern.

OPP is in the process of revising this screening model to replace the current farm pond with a drinking water reservoir. The model will also adjust the estimated pesticide concentrations in drinking water by the maximum fraction of the watershed which would be planted in the crop or crops of concern.

Tier 2 Screening Model

The coupled PRZM and EXAMS models include more site-specific information regarding application method and temporal distribution with weather, and better accommodate chemical-specific parameters. Using best professional judgment and information gathered from USDA Extension Service experts and grower groups, OPP selects a combination of site, soil, management, and weather factors for each modeled crop use that, taken together, represent a vulnerable, but not worst-case, watershed on which the crop is actually grown. As a screening tool, it simulates maximum application rates and frequencies for a vulnerable drinking water reservoir. PRZM/EXAMS generates daily pesticide concentrations using actual weather data, typically covering 36 years, from a station representative of

use area. This distribution of daily concentrations is analyzed to provide:

- Peak concentrations for each year of simulation: From these yearly peaks, OPP derives the peak concentration from the 1-in-10-year event for use in acute exposure assessments.

- Average annual concentrations for each year of simulation: OPP then derives the 1-in-10-year average annual concentration for use in chronic, noncancer exposure assessments.

- Average concentration over the entire simulation period: The average of the entire distribution of daily values is used in cancer exposure assessments.

It is important to note that these particular concentration endpoints were originally selected for use in ecological risk assessments. The Agency is evaluating the significance of these concentration endpoints for use in human health risk assessments and anticipates revising the approach.

The index drinking water reservoir and the percent crop area adjustment, discussed in the sections that follow, have been applied to the second screening tier.

Index Drinking Water Reservoir

In order to provide a more realistic screening assessment of surface water sources of drinking water, OPP replaced the "field pond" scenario originally used in its Tier 2 screen with an index drinking water reservoir. The index reservoir is based on the properties of Shipman City (IL) Lake, which is representative of a number of reservoirs in the central Midwest that are known to be vulnerable to pesticide contamination. These reservoirs tend to be small and shallow with small watersheds, and frequently have Safe Drinking Water Act (SDWA) compliance problems with atrazine, a herbicide widely used on corn grown in these watersheds. The index drinking water reservoir characteristics have been incorporated into the PRZM and EXAMS models and are used in conjunction with the percent cropped area adjustment factor.

While estimates of pesticide concentrations in drinking water based on a Midwestern index drinking water reservoir may not be representative of residue levels in drinking water sources in other parts of the country, the scenario provides an effective screening tool to determine the need for more extensive refinements. The modeling scenarios currently account for region-specific rainfall, soil, and hydrologic/runoff factors. Steps to develop scenarios for regional reservoirs for advanced tiers of modeling have been hampered by the lack of monitoring data outside of the Midwest that is of sufficient quality and extent to develop scenarios for additional reservoirs.

Percent Crop Area Adjustments

The percent crop area adjustment represents the maximum percent of any watershed planted to the crop or crops being modeled and, thus, may potentially be treated with the pesticide in question. Estimated pesticide concentrations generated from the screening model are multiplied by the maximum

decimal fraction of cropped area in any watershed generated for the crop or crops of interest. The percent crop area still serves as a screen because it represents the highest percentage of crop cover for any large watershed in the U.S. and assumes that the entire crop is being treated.

The May 1999 SAP agreed that the percent crop area approach was appropriate for the following four major crops, based on comparisons with available monitoring data:

- Corn: 46% crop area
- Soybeans: 41% crop area
- Wheat: 56% crop area
- Cotton: 20% crop area

OPP has also derived percent crop areas for the watersheds which have the highest percentage of any combination of these crops. Rather than taking the sum of the maximum percent crop area for each individual crop, OPP summed the total acreage of the particular crop combinations to find the watershed with the greatest combined total percentage of cover. For example, highest percent areas of corn (46%) and soybeans (41%) occur in different watersheds. Thus, it is incorrect to sum the individual crop area percentages to come up with a maximum crop area (87%). Instead, the highest combined percentage of corn and soybeans in a single watershed is 83%. For other crops, the SAP recommended using a simple screening approach, a default percent crop area, or targeted monitoring for other crops. This year, OPP added an interim default adjustment factor of 87% for other crops, which represents the watershed with the greatest percentage of all combined agricultural lands. OPP continues to collect data to develop and evaluate additional percent crop area factors.

This adjustment applies only to pesticides applied to agricultural crops. Currently-available models that estimate pesticide concentrations in surface water do not capture non-agricultural uses such as residential applications. Thus, non-agricultural uses are not included in the screening model assessments for drinking water.

Ground Water Screening Tools

When FQPA was enacted, OPP had no screening tool that could provide quantitative estimates of pesticide concentrations in ground water. SCI-GROW (Screening Concentration In GROund Water) was developed using data from perspective ground water monitoring studies to provide screening estimates of pesticide concentrations in shallow, vulnerable ground-water. This model estimates ground water concentrations arising from labeled uses of a pesticide at a vulnerable agricultural site based on the chemical's affinity to adsorb to soil and its persistence. The model assumes pesticide application at the maximum label rate to a field that has rapidly permeable soils overlying shallow ground water. Pesticide concentrations estimated by SCI-GROW are expected to represent high-end values because the model is based on ten prospective ground-water monitoring studies which were conducted by applying the pesticide at maximum allowed rates and frequency to vulnerable sites (i.e., shallow aquifers, sandy, permeable soils, and substantial rainfall and/or irrigation to maximize leaching).

If a pesticide does not pass the initial screen for ground water, OPP relies on monitoring data to make a refined assessment of the potential impact of the pesticide in ground water on human health. If adequate monitoring data are not available, the Agency requests that the registrant conduct targeted monitoring studies, such as prospective ground water monitoring studies.

Use of Monitoring Data in the Screening Assessment

During the screening stage, OPP compares the model-estimated drinking water concentrations with available monitoring data. Typical sources of monitoring data include:

- US Geological Survey (USGS)'s National Water Quality Assessment (NAWQA), National Stream Quality Accounting Network (NASQAN), and Toxic Substances Hydrology programs
- EPA Office of Water's STOrage and RETrieval (STORET) database and Safe Drinking Water Information System (SDWIS)
- OPP's Pesticides in Ground Water Data Base
- EPA's National Pesticide Survey for ground water
- Chemical-specific monitoring studies, if available.

If monitoring data show concentrations greater than the estimated model values, then the monitoring value will be incorporated into the screening process. Otherwise, the estimated model values will be used. In some instances, the monitoring data will serve as a "lower bound" on the screening estimates while the estimated model values serve as the "upper bound."

Advanced Screening Tools

If the pesticide fails the second screen (i.e., model estimates exceed the drinking water level of comparison), OPP assumes that the pesticide may have some potential to reach surface- and/or ground-water sources of drinking water at levels that may be of concern to human health. The Agency then takes additional steps to reduce the uncertainty in the drinking water estimates, including requesting chemical or usage information to refine model estimates, more fully analyzing existing monitoring data, or requesting additional monitoring data that can be related to drinking water sources. Monitoring studies targeted toward a specific pesticide, when available, are valuable in evaluating and reducing the uncertainty in the drinking water component of the exposure assessment. Such efforts to reduce the uncertainty in estimates of pesticide concentrations in drinking water have been chemical-specific, driven by the nature of the chemical, the available data, and the usage patterns.

Impact of the Screening Approach

The Environmental Fate and Effects Division (EFED) evaluated the impact of the current screening process on 74 chemicals for which screening level assessments have been completed. The results are current to February 2000. Of these 74 chemicals, 45 (60%) passed the screening at the Tier 2 level. Ten chemicals (13%) had estimated surface water concentrations that exceeded the drinking water level of comparison and two (3%) had estimated ground water concentrations that

exceeded the level of comparison. For 17 (23%) pesticides, the maximum allowable intake was exceeded entirely on food and/or residential exposure alone and no drinking water level of comparison could be calculated. Although a specific breakdown was not made, the majority of the pesticides that failed the screen did so for the chronic exposure assessments rather than for acute exposure.

Next Steps in Improving OPP's Drinking Water Assessments

The Agency is taking the following steps to improve its current drinking water assessment approach:

- Modify the current tiered screening approach for surface water sources of drinking water
  - Incorporate the index drinking water reservoir and percent crop area adjustments into the tier 1 screen
  - Add a third screening tier
- Evaluate of existing ground water models for use in developing a second screening tier for pesticides in ground water
- Develop regression-based models that would provide estimates of pesticide distributions in water for use in human health exposure assessments
- Shift to population-weighted estimates of pesticide concentrations in drinking water for use in human health exposure assessments
- Form an intergovernmental steering committee to obtain the necessary monitoring data to advance the development and validation of more refined predictive regression-based models
- Assess the impacts of water treatment on pesticides in drinking water in order to develop a policy on factoring treatment into the drinking water exposure assessment.