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Health-Based Screening Levels and their Application to Water-Quality Data

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Background

Studies by the U.S. Geological Survey (USGS) National Water-Quality Assessment (NAWQA) Program characterize the quality of the Nation's ambient water resources, including the occurrence of numerous organic contaminants in ground water. Many ground-water resources sampled by USGS are used as drinking-water sources, and water-quality conditions historically have been assessed, where appropriate, by comparing measured contaminant concentrations to established State and U.S. Environmental Protection Agency (USEPA) drinking-water standards and guidelines. Such comparisons are useful for local, State, and Federal water-resource managers and others charged with protecting and managing drinking-water resources. For example, these comparisons can provide an early indication of when contaminant concentrations in ambient water resources may warrant further study or monitoring.

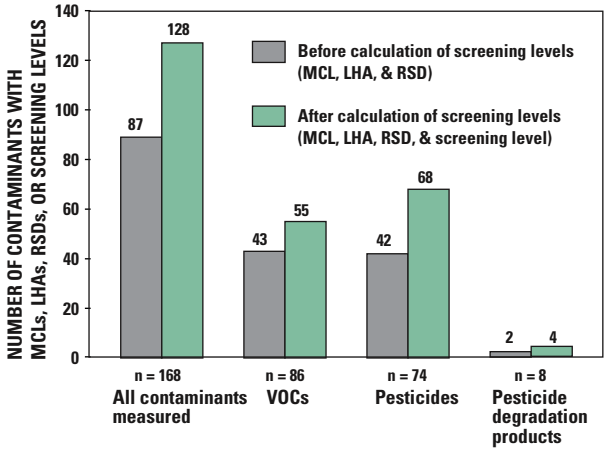
USEPA has established drinking-water standards and guidelines for approximately 150 organic contaminants. The Federal drinking-water standards, or Maximum Contaminant Levels (MCLs), are legally enforceable, whereas the drinking-water guidelines, including Lifetime Health Advisory (LHA) and Risk-Specific Dose (RSD) values, are not. These USEPA standards and guidelines are not available, however, for 81 of the 168 volatile organic compounds (VOCs), pesticides, and pesticide degradation products measured in water by NAWQA.

To supplement existing Federal drinking-water standards and guidelines, thereby providing a basis for a more comprehensive evaluation of contaminant-occurrence data in a human-health context, USGS began a collaborative project in 1998 with USEPA, the New Jersey Department of Environmental Protection, and the Oregon Health & Science University to calculate non-enforceable health-based screening levels. Screening levels were calculated for contaminants that do not have MCL values using a consensus approach that entailed (1) standard USEPA Office of Water methodologies (equations) for establishing LHA and RSD values for the protection of human health, and (2) existing USEPA human-health toxicity information.

Screening Levels Expand Human-Health Context for NAWQA Findings

Screening levels were calculated for 41 of the 81 contaminants measured by NAWQA that lack Federal drinking-water standards and guidelines; screening levels were not calculated for the remaining 40 contaminants because USEPA human-health toxicity information was not available. The screening levels increased the number of contaminants (from 87 to 128) for which measured concentrations can be evaluated in a human-health context (fig. 1). Examples include the solvent acetone and the herbicides acetochlor and linuron. Most (27) of the 41 contaminants are pesticides, resulting in large part from new toxicity information that became available after USEPA reviews of health and safety information for pesticides to determine if they meet safety standards of the 1996 Food Quality Protection Act (FQPA). The FQPA requires consideration of all pesticide exposures, including exposures through drinking water, in determining allowable levels of pesticides in food.

The screening-level methodology also was applied to 50 contaminants that have USEPA drinking-water guidelines (LHA or RSD values), but not MCLs. Because screening levels are calculated using standard USEPA methodologies, they are equivalent to existing LHA and RSD values, except for six contaminants for which more recent USEPA human-health toxicity information has become available. Screening levels, therefore, have an added benefit of providing a mechanism for the timely incorporation of updated toxicity information in the interpretation of water-quality data. Detailed information on the consensus approach and equations used for calculating screening levels is in a USGS report (Toccalino and others, 2003).



MCL, Maximum Contaminant Level; LHA, Lifetime Health Advisory; RSD, Risk-Specific Dose

Figure 1. Screening levels increase the number of contaminants measured by NAWQA that can be evaluated in a human-health context from 87 to 128, a 24-percent increase.

Evaluating Ground-Water Data in a Human-Health Context in New Jersey

A pilot study was conducted to demonstrate the use of the screening-level approach as a tool for evaluating water-quality data in a human-health context. Ground-water quality data collected as part of the USGS NAWQA Program in New Jersey was the focus of the study because ground water is the principal source of drinking water in the areas studied. Contaminant concentrations were compared to State and USEPA drinking-water standards (MCLs) for 41 contaminants, and to screening levels for 36 contaminants, 12 of which have no existing USEPA drinking-water guidelines (LHA or RSD values).

Comparisons of detected contaminant concentrations to MCLs or screening levels were expressed as ratios to assist with the evaluation of water-quality data in a human-health context. For example, a concentration equal to an MCL or screening level is equal to a ratio of 1; a concentration that is a factor of 10 less than an MCL or screening level is equal to a ratio of 0.1. A variety of ratios may be selected as threshold values to identify contaminants that may warrant further evaluation. Consistent with various State and Federal practices (for example, see U.S. Environmental Protection Agency, 2003), a ratio of 0.1 (maximum concentration divided by an MCL or screening level equals 0.1) was used as a threshold value in this analysis.

Concentrations of most contaminants detected in ground water in the New Jersey study were low, generally much less than MCLs or screening levels. In fact, 57 of 77 detected contaminants had ratios less than 0.1. The remaining 20 contaminants had ratios equal to or greater than 0.1. Maximum concentrations of three VOCs—trichloroethene (TCE), perchloroethene (PCE), and ethylene dibromide—and one pesticide (dieldrin) resulted in ratios of 1 or greater; these four contaminants also were frequently detected in untreated ground water that is a source of drinking water in the study area.

An important finding in the New Jersey study is that all 12 contaminants with screening levels, but with no existing USEPA drinking-water guidelines, had measured concentrations that resulted in ratios less than 0.1 (fig. 2). Ten of these 12 contaminants were detected in water sources that are used for drinking water. Prior to this study and the calculation of screening levels, the ability to provide such a human-health context for their occurrence was limited. More detailed technical information on the New Jersey study is available in a USGS report (Toccalino and others, 2004).

Plans for Application at the National Scale

It is anticipated that this screening-level approach, which increases the number of contaminants that can be evaluated in a human-health context, will be useful in other areas of the Nation. An effort has begun to apply this approach to the evaluation of ground-water data collected across the Nation during the NAWQA Program's first decade (1991-2001) of assessments. This national-scale pilot study focuses on VOCs in untreated ground water. Measured concentrations are compared to MCLs or screening levels, and the resulting ratios are examined in the context of factors such as detection frequency, land use, and water use. This study will help determine the extent to which screening levels can be used to evaluate NAWQA's water-quality findings in a more consistent human-health context across the Nation.

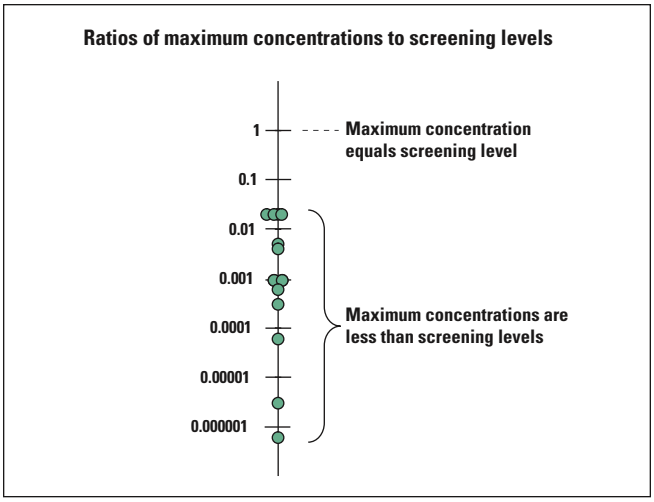


Figure 2. Maximum concentrations were less than screening levels for all 12 contaminants detected in ground water in the New Jersey study that do not have USEPA drinking-water standards and guidelines.

References

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The NAWQA Program

During the Program's first decade (1991-2001), NAWQA scientists assessed water chemistry, stream hydrology, habitat, and biological communities in 51 major river basins (referred to as "study units"; see map at http://water.usgs.gov/nawqa). During this period, NAWQA made baseline assessments of pesticides, nutrients, volatile organic compounds, trace elements, dissolved solids, and radon, as well as the condition of aquatic habitats and fish, insect, and algal communities. In the second decade of studies, 42 of the 51 study units are planned to be re-assessed to determine trends at many streams and ground-water monitoring sites; to fill critical gaps in the characterization of water-quality conditions; and to build upon earlier NAWQA findings that show how natural features and human activities affect water quality and aquatic ecosystems.