Explanation of the new EPA freshwater invertebrate imidacloprid endpoints: Implications for hemlock woolly adelgid management

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Hemlock Management Issue

In December 2016 the EPA published the "Preliminary Aquatic Risk Assessment to Support the Registration Review of Imidacloprid," which contained new acute and chronic endpoints for freshwater invertebrates (EPA 2016). The new acute and chronic endpoints for imidacloprid are 0.39 and 0.01 ppb, respectively. Imidacloprid is the most commonly used insecticide for hemlock woolly adelgid management. Imidacloprid concentrations documented in some streams associated with hemlock imidacloprid treatments exceed these endpoints (Churchel et al. 2012, Benton et al. 2016, Wiggins et al., in review). Do the new EPA endpoint values mean that insecticide use in hemlock systems is causing a problem for water quality?

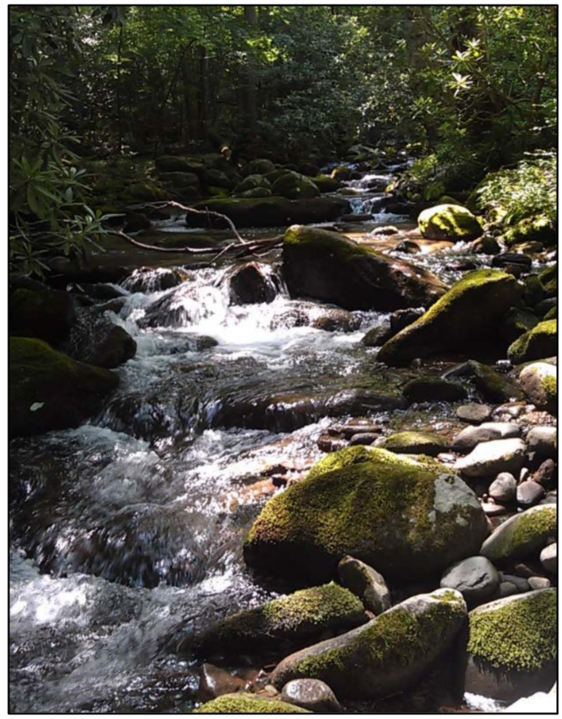
Take home points:

The EPA imidacloprid aquatic invertebrate endpoints and benchmarks are not regulatory limits. Based on recent field studies conducted at the community level, HWA imidacloprid treatments applied according to the label do not result in detectable impacts on aquatic macroinvertebrate communities, despite some imidacloprid detections above the aforementioned EPA risk assessment acute and chronic endpoints. Use imidacloprid according to the current product label until label changes are made as a result of the imidacloprid reregistration review process. If the imidacloprid label changes, then follow the most updated product label.

What is a preliminary risk assessment, an EPA endpoint, and EPA benchmark? What do these terms mean?

The "Preliminary Aquatic Risk Assessment to Support the Registration Review of Imidacloprid" is part of the imidacloprid reregistration review process (USEPA 2004). The purpose of this process is to "update labeling and use requirements and reduce risks associated with older pesticides" (USEPA 2004). From a management perspective, the end goal will be an updated label that may change how imidacloprid is used.

The EPA uses a model to calculate the environmental risks of a pesticide in aquatic systems. The model used is a farm pond with the following considerations: the pesticide input is the highest labeled application rate; the entire watershed is assumed to be treated with the pesticide; no buffer is assumed between the pond and the field; spray drift is assumed to occur directly to the farm pond; runoff and erosion reflect soil, meteorological, chemical properties over a 30-year simulation. “The geographic location of use is regarded as representative of high-end potential for pesticide runoff and is not necessarily representative of runoff conditions for the labeled use” (USEPA 2004). The EPA calculates risk as a highly exposed (near worst-case scenario) to assess the potential for risk to aquatic ecosystems. If a potential for risk is identified, then this information is considered among other factors for supporting label changes and/or additional refinements are made to the risk assessment to better reflect expected exposures and effects in the field.


Stream flowing through hemlock forest in Great Smoky Mountains National Park.
Photo: Elizabeth Benton, University of Georgia

The new acute and chronic endpoints, 0.39 and 0.01 ppb, respectively, were developed based on the above risk model and lab toxicity tests. The toxicity tests used for endpoint determination were from studies that documented the most sensitive responses to imidacloprid, thus a worst-case scenario. The acute endpoint is based on the effect concentration (EC_{50}) from a 96-hour imidacloprid exposure for the mayfly, *Epeorus longimanus*. The acute endpoint concentration is the concentration at which 50% of the mayflies were immobilized in a 96-hour exposure - divided by two. The chronic (long-term) endpoint is based on the 28-day no adverse effect concentration (NOAEC), i.e., the concentration at which no negative effects were observed, in a 28-day exposure (USEPA 2016). It is important to understand that these endpoints reflect effects to individual organisms tested at constant concentrations in the laboratory, not communities of organisms in the field. This differs markedly from exposures in the field, where concentrations are constantly fluctuating and other factors are influencing populations and communities (e.g., immigration, emigration, predation, competition, recovery, etc.).

The “Preliminary Aquatic Risk Assessment to Support the Registration Review of Imidacloprid” was up for public comment in early 2018. The EPA considers multiple factors in the registration review of a pesticide, including (but not limited to): risk to the environment, risk to human health, benefits associated with the pesticide use, input from the public comment, and importantly, the availability and risks associated with pesticide alternatives. As appropriate, the

EPA may or may not propose options for mitigating risk (e.g., label restrictions, buffers, changes in application rates or methods, etc.).

In a separate effort, the EPA Office of Pesticide Programs (OPP) publishes Aquatic Life "benchmarks" (USEPA 2018) and updates these values from time to time to reflect the latest science. The endpoints developed in the imidacloprid "preliminary assessment" are a precursor to the "benchmarks". The current acute and chronic freshwater invertebrate aquatic life benchmarks for imidacloprid are 34.5 and 1.05 ppb, respectively (USEPA 2008). The new endpoints are based on research that occurred between the "Problem Formulation For The Imidacloprid Environmental Fate And Ecological Risk Assessment" (USEPA 2008) at the beginning of the reregistration review process and the Preliminary Aquatic Risk Assessment that was published toward the end of the review process.

The endpoint and benchmark values are not "water quality standards" (i.e., not enforceable limits for water quality), rather they reflect the most sensitive effect levels considered acceptable for use in OPP risk assessments. In contrast, water quality standards are regulatory standards that are determined by EPA's Office of Water, EPA Regions, or State environmental agencies that are then used to set limits on discharges to waterbodies. Therefore, water quality standards are legally enforceable limits, whereas the OPP aquatic life benchmarks are not.

What do the endpoint and benchmark values mean for HWA management programs?

According to the EPA "Aquatic Life Benchmarks and Ecological Risk Assessments for Registered Pesticides" webpage (USEPA 2018):

"Comparing a measured concentration of a pesticide in water with an aquatic life benchmark can be helpful in interpreting monitoring data and in identifying and prioritizing sites and pesticides that may require further investigation."

Imidacloprid concentrations in surface water in hemlock systems exceeding these endpoints would indicate that further investigation is needed. Fortunately, that "further investigation" has already happened. We already have the answer to the question "Is there a problem?"

What do we know about imidacloprid concentrations and aquatic insect assessments in streams associated with HWA treatments?

Three studies have documented imidacloprid in streams associated with HWA treatments. The following imidacloprid concentrations have been documented: <1 ppb (Churchel et al. 2011), 0.029 – 0.379 ppb (Benton et al. 2016), and 0.028 – 0.833 ppb (Wiggins et al. in review).

Rainfall event sampling yielded interesting results regarding persistence of imidacloprid associated with peak rainfall flows (Wiggins et al. in review). Imidacloprid concentrations up to

0.833 ppb were documented in a stream during a 1.8 inch rainfall event that occurred six months after HWA imidacloprid treatments. However, imidacloprid was not detected in two succeeding rainfall events of similar or greater magnitude. Imidacloprid likely was transported downstream and diluted so quickly that concentrations were no longer detectable when the post-rain event sampling occurred. In addition, when imidacloprid enters surface water it begins to break down by biotic metabolism (USEPA 2016) and photodegradation (Agüera et al. 1998, Wamhoff and Schneider 1999). Thus, rainfall-associated peak concentrations of imidacloprid in streams likely do not persist very long. This is in contrast to the constant exposures over 28 days associated with the NOAEC of 0.01 ppb.

Aquatic macroinvertebrate communities in four streams associated with HWA treatment areas were assessed by Churchel et al. (2011). Comparisons of three community metrics were made between the four “treatment” streams and a control stream: taxa richness, number of Ephemeroptera, Plecoptera, and Trichoptera (EPT) (sensitive aquatic taxa), and the North Carolina Biotic Index (NCBI), a water quality measure used by many regulatory agencies. Community metric comparisons indicated that imidacloprid was not negatively affecting aquatic macroinvertebrate communities, and the NCBI values for all streams ranked them in the “excellent water quality” class (Churchel et al. 2011).

Aquatic macroinvertebrate communities in nine streams in locations downstream from HWA treatment areas were assessed in a study in Great Smoky Mountains National Park. The downstream communities were compared to communities upstream from imidacloprid treatment areas and pre-HWA treatment baseline data (two controls) (Benton et al. 2017). Thirty-six comparisons were made between downstream communities and control communities. Comparisons included the following metrics: abundance, richness, dominance, evenness, Shannon diversity, tolerance values, as well as the abundance, richness, and proportion of both functional feeding groups and life habits. Downstream communities were not negatively affected by imidacloprid HWA treatments. Communities located downstream from imidacloprid treatment areas did not have significantly different community diversity metrics compared to control communities. In addition, communities had similar functional feeding groups and life habits. Thus, communities were not impaired by the imidacloprid treatments in the surrounding forest (Benton et al. 2017).

Caddisfly, Anisocentropus pyraloides (Trichoptera: Calamoceratidae).
Photo: Elizabeth Benton, University of Georgia

Tolerance values indicate the ability of an aquatic macroinvertebrate to survive in stressful water quality conditions. Tolerance values are scaled from 0 – 10. Lower values mean that organisms require pristine water quality for survival. The mean downstream tolerance value for EPT taxa was 1.7, so aquatic macroinvertebrates found in the streams included organisms that could not survive in poor water quality (Benton et al. 2017).

The mayfly taxa used for the EPA acute endpoint determination was from the genus Epeorus. Taxa from this genus were collected from seven downstream locations and five upstream locations (Benton et al. 2017). The species collected were *E. dispar*, *E. vitreus*, and *E. pleuralis.* Although these species may not have the exact same sensitivity to imidacloprid as *E. longimanus*, finding taxa from the same genus as the taxa used in EPA acute endpoint determination is positive.

In conclusion, EPA imidacloprid aquatic invertebrate endpoints and benchmarks are not regulatory limits, rather they indicate the need for further investigation. Researchers and federal HWA management personnel have already conducted detailed / peer reviewed investigations of aquatic macroinvertebrate communities. Thorough community data analyses indicate that HWA imidacloprid treatments applied according to the label do not have a negative effect on aquatic macroinvertebrate communities. Imidacloprid applications according to the product label are valid and responsible uses of insecticide for hemlock conservation.

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