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Review of the Draft Report: Cyfluthrin Criteria Derivation
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Overview
Freshwater criteria for cyfluthrin defined in this draft report was derived using methodology recently developed by Tenbrook *et al*. (2009)[1]. The methodology considers relevance of the endpoints and quality of the data in derivation of the criteria. This methodology was motivated by the California Regional Water Quality Control Board's desire to employ rigorous methods to develop criteria for protection of the Sacramento and San Joaquin River Watershed.

Basic information and physical-chemical data
The report provides a comprehensive summary of the physical-chemical data for cyfluthrin. This data set indicates that this pesticide has high Kow, low volatility, high potential to bioaccumulate, high potential to sorb to sediments, and may persist in aqueous environments (i.e., hydrolysis is significant at high pH and photolysis is possible). Accordingly, this pesticide's physical-chemical characteristics make its exposure to aquatic organisms a relevant concern, primarily due to its and high potential for bioaccumulation and food-web transfer.

Human and wildlife dietary values
The FDA has not set action levels for cyfluthrin in fish tissue but has set a level for cattle and hog meat at 0.1 mg/kg and goat, horse and sheep meat at 0.05 mg/kg. The reason for this 2-fold difference in action levels is not clear and should be addressed.

Toxicity to mallard ducks is low, with an LC_{50} (which should be reported as an LD_{50}) value for food >5,000 mg/kg in 16-day old ducks. An NOEC and NOEL of 250 mg/kg have been reported and were based on reproductive endpoints, which appear to be the more sensitive indicator of toxicity reported.

Ecotoxicity data and data reduction
The authors evaluated approximately 53 published studies of cyfluthrin toxicity to develop the proposed criteria. Relevance was determined using the aforementioned methods[1] and only data for studies that were deemed acceptable were used in the criteria derivation. Adequate and reliable data was available for determining acute toxicity using animal studies and exclusion criteria appear to have been applied properly. Sixteen acute, 3 chronic and 5 microcosm and ecosystem studies were used to support criteria development calculations. Three studies of effects on wildlife were reviewed for relevance to bioaccumulation.
Data was excluded using proper criteria ensuring analysis of properly conducted experiments and sensitive life stages.

[1] P. Tenbrook *et al*. (2009). *Methodology for derivation of pesticide water quality criteria for the protection of aquatic life in the Sacramento and San Joaquin River basins. Phase II: Methodology development and derivation of chloropyriphos criteria.* Report prepared for the Central Valley Regional Water Quality Control Board, Rancho Cordova, CA.

Acute criterion calculation
The acute criterion for cyfluthrin was calculated using methods defined by Tenbrook *et al*. (2009). Data for four of the five required taxa was available (insect missing) and the Assessment Factor (AF) method was used to derive the acute criterion. A criterion of 0.2 ng/L was derived using acceptable calculations and rounding to significant digits.

Chronic criterion calculation
The acute-to-chronic ratio (ACR) method was used to derive the chronic criterion using data for only three of the five required taxa. The chronic values for these taxa (i.e., salmonid, warm water fish and planktonic crustacean) were paired with appropriate acute data.

A final chronic criterion of 0.04 ng/L was calculated using the median 5^{th} percentile value that was divided by the multi-species ACR. This calculation appears to have been performed correctly.

Bioavailabilty
Because cyfluthrin has a high Kow, it will have a high affinity for dissolved organic and particulate phases in aquatic environments. The statement is made that toxicity is believed to occur primarily from the *portion* of the compound that is dissolved in the water. The phrasing of this sentence implies that a molecule of cyfluthrin can be partially dissolved. Instead, the authors should use the word *fraction* when distinguishing between soluble and sorbed phases. The conclusion that the dissolved phase of cyfluthrin is the primary bioavailable phase is consistent with data for compounds with similar physical/chemical characteristics. Many studies support the conclusion that sorption of cyfluthrin to organic phases that are present in aquatic environments reduces its bioavailability to aquatic organisms. This effect is consistent with the behavior of other compounds that have similarly high Kows.

The authors are correct in stating that it is not practical to recommend that the "freely-dissolved" phase of cyfluthrin be used for compliance purposes. Instead, isolation of the dissolved phase by solid-phase micro-extraction presents a practical approach for approximating the bioavailable phase of cyfluthrin. Determination of site-specific dissolved concentrations of cyfluthrin is not practical due to the need for accurate measurements of dissolved organic compounds and suspended solids, which require significant effort to acquire. The fact that these parameters can vary spatially and temporally further complicates such assessments and should be mentioned here.

The authors recommend that criteria compliance be based on whole-water concentrations of cyfluthrin, as this will provide a conservative (i.e., over-protective) estimate of this compound's availability. This is a prudent recommendation given uncertainties in bioavailability and reported exposure concentrations.

Mixtures
Because cyfluthrin often occurs in the presence of other pyrethroid insecticides that have a similar mode of action, the toxic unit or relative potency factor approaches are appropriate to use. However, compounds that have dissimilar modes of action may exhibit additive, synergistic, or antagonistic effects in the presence of cyfluthrin. The conclusion that non-

additive effects cannot be used for criteria compliance is appropriate due to the lack of a robust predictive model.

Temperature, pH effects
An inverse relationship between pyrethroid toxicity and water temperature is well documented. This relationship is important as laboratory toxicity tests are often conducted at temperatures that are higher than those in natural ecosystems. Although sufficient data does not exist to enable accurate predictions of temperature-related toxicity due to cyfluthrin in aquatic ecosystems, this relationship should be considered in the derivation of safety factors as it is likely that criteria derived from laboratory studies conducted at relatively high temperatures will under-predict toxicity in many natural environments.

Sensitive species
The calculated acute criterion of 0.2 ng/L is below all of the acute values on the data set. However, the lowest acute value of 1.7 ng/L (for *H. azteca*) is reported as an LC_{50}, which indicates that toxic effects will occur for this species at lower concentrations. This issue must be addressed. The proposed chronic criterion of 0.04 ng/L appears to be adequately protective of aquatic species.

Ecosystem and other studies
The authors reviewed 4 studies of microcosm and ecosystem tests that had acceptable ratings. In addition, 1 study that was rated as less reliable was used in this assessment. In each of these studies, toxicity was only reported for water concentrations that were higher than the proposed acute and chronic criteria.

Threatened and endangered species
Data on cyfluthrin toxicity is available for one threatened or endangered fish species (*O. mykiss*). Toxicity values reported for this species are significantly higher that the proposed criteria. The EPA's interspecies correlation estimation method was used to estimate toxicity values for listed animals that are members of the same family or genus as organisms in the data set. These calculations produced values that were significantly higher than the proposed criteria.

Data for plants were not in the data set and specific conclusions could not be offered for these species. Overall, the proposed criteria would appear to be protective of threatened and endangered species.

Bioaccumulation
Cyfluthrin has a high K_{ow} and therefore a high potential to bioaccumulate in aquatic organisms. Reported bioconcentration factors are consistent with this K_{ow} and a bioaccumulation factor (BAF) approach was used to estimate the water concentration of cyfluthrin that would result in a lethal concentration in wildlife that would consume contaminated fish. A NOEL value of 250 mg/kg for mallard ducks was used in this calculation. Because this was the highest dose tested, a higher NOEL is probable. Using this approach, a water concentration of at least 29 µg/l would be required to produce a body burden of cyfluthrin in fish that would be below the toxic threshold for mallards. This result clearly indicates that toxicity to mallards via food web

transfer is unlikely. The high likelihood that such a water concentration would be acutely lethal to prey species, including fish, should be mentioned.

Using the low tolerance levels for cyfluthrin in meat (i.e., 0.05 mg/kg) that would be protective of human health, an equivalent concentration in fish would require a water concentration of 6 ng/L. This value is also well above the proposed criteria. As noted above, it should be mentioned that this concentrations of cyfluthrin would likely result in acute toxicity to fish and aquatic invertebrates. In other words, food-web transfer would not be likely under such a condition.

Harmonization with air and sediment criteria
Sediment and air quality standards for cyfluthrin do not exist. Partitioning into the water column could serve as a proxy for sediment burdens.

Assumptions, limitations, and uncertainties
The authors correctly point out that the major source of uncertainty in this evaluation stems from the lack of viable cyfluthrin toxicity data for 1 of the 5 required taxa for the acute calculation and 2 of 5 taxa for the chronic calculation. The approaches used (i.e., ACR and Assessment Factor) were appropriate given this limitation. As for other pyrethroids, the lack of chronic data for *H. azteca* is cause for concern as this is the most sensitive species for acute effects. Coupled with the potential heightened sensitivity of this species at low water temperatures, it is possible that the proposed chronic criterion would not be protective under all environmental conditions. Although the authors are correct to point out that an application of an additional safety factor has merit, there is little discussion of how such a factor could or should be derived. At minimum, a more thorough description of temperature effects derived from the Weston *et al*. (2008) study would be appropriate.

Comparison to national standard methods
The applicability of EPA (1985) methods were assessed for their potential to derive acute and chronic criteria for cyfluthrin. Because all taxa elements required for the EPA method could not be met (only 5 of 8 for acute and 3 of 8 for chronic), the authors concluded that it was not reasonable to apply this method. Although this appears to be a sound conclusion, greater justification should be provided. The fact that Cal Fish & Game has used this method with 7 of 8 taxa is not sufficient justification for not performing the analysis with 5 of 8 taxa. A discussion of the minimum requirements for applying this approach would be useful.

Final cyfluthrin *criteria statement*
Based on the best available data, the acute criteria of 0.2 ng/L proposed in this report should be protective of aquatic species in the Sacramento and San Joaquin River basins. The proposed chronic criterion of 0.04 ng/L would also appear to be adequately protective of aquatic life. Both criteria should be re-evaluated as soon as additional data for sensitive species (acute and chronic) and temperature effects becomes available.

Typographical errors
Page 4, 3rd line from the bottom: “eleven” should be “eleven”

Page 16, line 6: "so and acute criterion" should be "so an acute criterion."