UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

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Memorandum to the File

SUBJECT: Regulatory Update on the Registration Review of Atrazine

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OVERVIEW

The purpose of this memorandum is to articulate EPA's risk management approach for aquatic plant communities and anticipated timeline for completion of registration review for atrazine. While atrazine's registration review is currently ongoing, the Environmental Protection Agency (EPA or the agency) has received over 100,000 public comments on the atrazine draft risk assessments, some concerns, and several inquiries related to registration review status and the level of regulation for aquatic plants. This memorandum provides additional context regarding EPA's proposed regulatory levels for aquatic plants for atrazine, and memorializes EPA's decision to use the concentration of 15 µg/L as a 60-day average for the purposes of determining the need for any potential mitigation to protect aquatic plant communities during Registration Review.

BACKGROUND

Atrazine is the second most widely used herbicide in the U.S. for control of a variety of grasses and broadleaf weeds. It is used on 75,000,000 acres annually[1] and is most applied to corn, sorghum, and sugarcane. Atrazine is a chlorinated triazine herbicide; this group also includes simazine and propazine.

Atrazine is currently undergoing registration review, the EPA's periodic re-evaluation program for existing pesticide registrations. In June 2016, EPA released the *Refined Ecological Risk Assessment for Atrazine*[2], and in July 2018, the Agency released the *Atrazine. Draft Human*

[1] Market Research Data, 2013-2017. Data collected on pesticide use for about 60 crops by annual surveys of agricultural users in the continental United States. Survey methodology provides statistically valid results, typically at the state level.
[2] https://www.regulations.gov/document?D=EPA-HQ-OPP-2013-0266-0315

Health Risk Assessment for Registration Review[3] and the *Chlorotriazines: Cumulative Human Health Risk Assessment - Atrazine, Propazine, and Simazine*[4]. The agency received over 100,000 comments[5] on the atrazine draft risk assessments, which the agency is currently evaluating.

The next step in registration review is to release the proposed interim decision, which may propose risk mitigation measures, if needed, along with the agency's response to comments on the human health and ecological risk assessments and its use benefits and mitigation impact analysis. EPA anticipates publishing these documents in December 2019. There will be a 60-day public comment period associated with the proposed interim decision, and EPA will release an interim decision after consideration of the comments on the proposed interim decision.

In addition, EPA will make an Endangered Species Determination by 2021 pursuant to a joint stipulation filed on October 18, 2019 in Center for Biological Diversity et al. v. Environmental Protection Agency et al. (N.D. Ca) (3:11-cv-00293) requesting that the court enter the agreed upon partial settlement.

RECONSIDERATION OF RISK ASSESSMENT METHODOLOGY AND RISK MANAGEMENT APPROACH

A recurring theme within the public comments that EPA received on the atrazine draft ecological risk assessment is concern about the data, assumptions, and interpretations used in the assessment, particularly as they relate to the aquatic plant community equivalent level of concern (CE-LOC). The agency acknowledges that differences in the interpretation of effects, scoring methodology, and splitting of functional groups can greatly influence the resulting CE-LOC. There are also sources of uncertainty inherent in the models used to calculate the CE-LOC.

Based on these and all other public comments, public interest, and the recommendations of the 2012 Scientific Advisory Panel (SAP), the EPA has considered alternate approaches for inclusion, evaluating/scoring, and interpretation of the atrazine ecosystem and related studies for the determination of the CE-LOC.

EPA's Re-evaluation of the Atrazine Aquatic Plant Community Level of Concern (Concentration Equivalent Level of Concern or CE-LOC) and Effects to Aquatic Plants

Commenters and stakeholders have raised concerns about the CE-LOC in the 2016 preliminary risk assessment, stating that the value is predicated on a dataset that 1) contains numerous fundamentally flawed, inconsistent and misinterpreted micro/mesocosm (cosm) studies; 2) ignores recommendations made by the 2012 FIFRA Scientific Advisory Panel (SAP) ; and 3) does not consider the relevance of the individual studies. Commenters conclude that the CE-LOC of 3.4 µg/L presented in the risk assessment is too conservative and propose a CE-LOC of 18-30 µg/L based on alternative methods for weighing and scoring the individual cosm studies.

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[3] https://www.regulations.gov/document?D=EPA-HQ-OPP-2013-0266-1159
[4] https://www.regulations.gov/document?D=EPA-HQ-OPP-2013-0266-1160
[5] https://www.regulations.gov/docketBrowser?rpp=25&so=DESC&sb=postedDate&po=0&dct=PS&D=EPA-HQ-OPP-2013-0266

EPA acknowledges that differences in the interpretation of effects, scoring methodology, and splitting of functional groups can greatly influence the resulting CE-LOC. The biggest impacts to the CE-LOC come from changes made to the cosm endpoint database. Through the years EPA has re-reviewed the available cosm data, added or excluded studies based on the selection criteria, and changed the classification of endpoints (effects/no-effects). These refinements to the cosm endpoint database have been made in response to the suggestions and recommendations made by the multiple SAPs. Differences in the CE-LOCs that have been presented at public meetings (e.g., Giddings 2012) are based primarily on differing interpretations of effects or no-effects at each endpoint and how endpoints are derived from each study.

In public comments, several commenters suggested that the Agency revisit the 11 cosm studies identified by the 2012 SAP as deserving a more in-depth evaluation (see Appendix A of this memorandum for details on the studies and SAP recommendations). While the agency did include a discussion of each of those 11 cosm studies in the 2016 risk assessment, it did not include a quantitative analysis. Therefore, based on public comment and concerns raised by stakeholders, the agency has conducted a quantitative analysis evaluating the impact of including those studies on the CE-LOC.

For this quantitative analysis, in addition to evaluating SAP recommendations on the 11 cosm studies, there are also sources of uncertainty inherent in the models used to calculate the CE-LOC that should be considered. These sources include how the Plant Assemblage Toxicity Index (PATI) distribution is created, how the 50th percentile of the effects/no effects distribution (LOC_{PATI}) is estimated, and how the resulting values are converted to the CE-LOC. As recommended by the 2012 SAP, EPA conducted a series of analyses to evaluate the sources of potential uncertainty in the model to evaluate the impact on the resulting CE-LOC. As part of the uncertainty analyses, thousands of PATI distributions are created by varying the input parameters derived from the individual species toxicity data. The PATI distributions are then sampled thousands of time to develop a distribution of LOC_{PATI} values, which is related to the atrazine ecological monitoring data (AEEMP) through linear regression. The resulting distribution of values consists of multiple CE-LOC estimates that account for the different sources of uncertainty. The population of CE-LOC estimates derived from the uncertainty analysis can be considered as a distribution of potential CE-LOC values and can be described with minimum, median and maximum concentrations (as well as various percentiles along the distribution). Each CE-LOC value within that distribution represents a concentration at which there is a 50% chance of a biologically significant effect on the aquatic plant community. Effects may include reductions in biomass, productivity, or changes is species diversity. Details on how EPA ran this uncertainty analysis are discussed in Section 12.2.5 of the 2016 risk assessment.

Utilizing the cosm scoring and study exclusions recommended by the 2012 SAP and accounting for model sources of uncertainty discussed above, the resulting CE-LOC ranges from 1.9 to 26 µg/L with a median of 8.5 µg/L (**Table 1**). 90% of the values, as represented by the 5th and 95th %tiles of the distribution, are within a factor of ~3x.

Table 1. Description of the distribution of CELOC values (μg/L) based on SAP recommendations considering model uncertainties

	CELOC incorporating SAP suggestions on 11 cosm studies
Median	8.5
5th Percentile	4.6
25th Percentile	6.7
75th Percentile	10.9
95th Percentile	15.7
Range	1.9 to 26

Potential for Aquatic Plant Community Recovery

Another consideration when setting the CE-LOC is the potential for recovery of the aquatic plant community following an exposure period. Triazine herbicides such as atrazine bind with a protein complex of the Photosystem II in chloroplast photosynthetic membranes (Schulz *et al.*, 1990). The result is an inhibition in the transfer of electrons that in turn inhibits the formation and release of oxygen, effectively halting photosynthesis. Recovery from the effects of atrazine exposure and the development of resistance to the effects of atrazine exposure in some vascular and non-vascular aquatic plant species have been documented in various single species studies (*e.g.*, Abou-Waly et al., 1991, Desjardin et al. 2003, Brain et al. 2012a, Brain et al. 2012b). The ability of a species to recover from atrazine exposure depends on the rate at which it can metabolize or detoxify the chemical (Shimabukuro et al. 1970, Brain et al. 2002b) and the duration of exposure.

Documented recovery in the available cosm study dataset was only reported in a few studies and was variable in terms of the definition of recovery used. For example, a single endpoint measurement (*e.g.*, chlorophyll A) may have shown recovery, but other significant changes, such as community composition shifts, may have also occurred in the study and recovery was not documented or observed. This variability in the dataset makes it difficult to identify a range of exposure values and exposure durations from which the aquatic plant community would be expected to recover. However, the potential for recovery of the aquatic plant community exists, especially for low dose exposure to atrazine over relatively short durations (Huber 1993, Eisler 1989).

Interpretation of Monitoring Data

The Atrazine Ecological Exposure Monitoring Program (AEEMP) assesses atrazine levels in streams in watersheds that are exposed to atrazine runoff from corn and sorghum production (small streams, high atrazine use areas, and vulnerable soils). This monitoring program is required by the 2003 Atrazine Interim Reregistration Eligibility Decision and the Memorandum of Agreement (2004) and uses the 60-day average CELOC as the threshold for requiring watershed-based mitigation measures to reduce atrazine exposure. These mitigation activities can include, for example, education, stewardship and outreach programs for growers and distributors. A watershed can be decommissioned from the monitoring program if the 60-day running average falls below the CE-LOC for two consecutive years. Therefore, the selection of the CE-LOC has the potential to impact growers through required stewardship measures. **Table 2** provides the percent of 60-day average concentrations measured from 2004 to 2014 as part of the AEEMP monitoring program that exceed CE-LOC values from the distribution incorporating SAP suggestions on 11 cosm studies.

Table 2. Percent of 60-d average concentrations from AEEMP monitoring sites that exceed the CE-LOC

	CELOC incorporating SAP suggestions on 11 cosm studies	# of AEEMP site-years exceeding CELOC	% of AEEMP site-years exceeding CELOC
Median	8.5	55	23
5th Percentile	4.6	114	48
25th Percentile	6.7	80	34
75th Percentile	10.9	44	19
95th Percentile	15.7	20	8

Impact on the ESA Assessment

Atrazine is one of the chemicals that is scheduled to have a Biological Evaluation (BE). EPA recently released the Proposed Revised Method for National Level Endangered Species Risk Assessment Process for Biological Evaluations of Pesticides for public comment and is currently reviewing that input for incorporation as appropriate. It is EPA's intent to use this revised methodology after public input is incorporated to complete the BE for atrazine. In addition, the draft atrazine BE will be available for public comment prior to being finalized.

To more accurately represent where and to what extent a pesticide is likely to be applied, the proposed revised ESA methods include an approach for incorporating pesticide-specific usage data into the listed species consultation process and a probabilistic analysis to determine the likelihood of a species to be adversely affected by a pesticide. Although comments are being evaluated, the goal of the probabilistic analysis is to more fully capture and characterize the variability in the range of potential exposures and toxicological effects by utilizing the entire distribution of exposure and effects values. Under this approach, quantitative use of the CE-LOC will not be the basis for final effects determinations. The proposed method also incorporates a weight of evidence framework to distinguish those listed species that are likely to be adversely affected (LAA) from those that are not likely to be adversely affected (NLAA), based on criteria (*e.g.,* dietary preferences, migration patterns, extent of range potentially exposed) associated with the likelihood that an individual will be exposed and affected.

BENEFITS OF ATRAZINE

Consistent with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), EPA considers the economic, social, and environmental costs and benefits of a pesticide's use when making Registration Review decisions about ecological risks, including potential risks to aquatic plant communities.

Atrazine is used for the postemergence and preemergence control of broadleaf weeds and grasses. An average of about 72 million pounds is used annually in agriculture. Three crops, corn, sorghum and sugarcane, account for over 98 percent of this use. Corn accounts for the majority of use with approximately 59 to 64 million pounds applied annually. Annual use of atrazine on sorghum is estimated between 5.4 and 7.2 million pounds; annual sugarcane use is estimated between 1.6 and 2.6 million pounds; and annual sweet corn use is estimated around 300,000 pounds. Total use has remained relatively constant over the past decade. Use rates per acre have decreased, while total acres treated with atrazine have remained relatively stable.

Atrazine is the preferred herbicide for warm-season grass crops, such as corn, sorghum, and sugarcane, because it is economical, has a flexible use pattern, long residual, crop safety, and is highly effective against a broad spectrum of weeds. Although other herbicides are available for these crops, these alternatives result in increased herbicide expenditures and possible yield losses due to lower efficacy of alternatives, which would substantially increase the impacts on users in the absence of atrazine. Additionally, growers may incur additional costs if the use of alternatives require upgrades in equipment to make directed postemergence sprays due to phytotoxicity concerns. Other, non-quantifiable impacts include increased managerial effort, for example additional scouting and weed identification skills to select the correct alternative.

Field Corn

Approximately 84 million acres of field corn were grown on average each year worth an estimated average total value of $53 million per year. About 60 percent of this crop is treated with atrazine. The majority of atrazine use on corn occurs in the Corn Belt (Illinois, Indiana, Iowa, Missouri, and Ohio) and the Northern Plains (Colorado, Nebraska, North Dakota, South Dakota).

Sorghum

Nationally, sorghum is grown on about 7.2 million acres annually, with an estimated 68 percent of the crop treated with atrazine. The major sorghum growing states (Kansas and Texas) account for 81% of all sorghum acres treated.

Sugarcane

Sugarcane is grown on 890,000 acres annually. Ninety percent of sugarcane is grown in Florida and Louisiana. Nearly all of sugarcane grown in Florida and about one-third of Louisiana sugarcane are treated with atrazine.

Sweet Corn

An average of 500,000 acres of sweet corn were grown annually in the United States, of which, over 75 percent was treated with atrazine. Atrazine is used on both corn grown for processing and fresh market. The main areas of atrazine use on sweet corn are the Northeast, including Michigan and Wisconsin; the Pacific Northwest, and the Southeast.

CONCLUSION

In response to significant public comments, concerns, and inherent uncertainty related to the data, assumptions, and interpretations used to arrive at the aquatic plant CE-LOC in the 2016 draft atrazine ecological risk assessment, EPA has considered alternate approaches for inclusion, evaluating/scoring, and interpretation of the atrazine ecosystem and related studies. The agency acknowledges that differences in the interpretation of effects, scoring methodology, and splitting of functional groups can greatly influence the resulting CE-LOC. There are also sources of uncertainty inherent in the models used to calculate the CE-LOC. Utilizing the cosm scoring and study exclusions recommended by the 2012 SAP and accounting for model sources of uncertainty, the resulting CE-LOC ranges from 1.9 to 26 µg/L with a median of 8.5 µg/L.

Given the complex nature of mesocosm and microcosm studies, the various protocols used in the conduct of these studies, the model uncertainty described in the 2016 risk assessment, the recommendation of the SAP, the potential for recovery of the aquatic plant community following exposure, and the high agricultural benefits provided by atrazine, the Agency considers it appropriate to present a range of concentrations that accounts for these factors for risk management purposes under Registration Review. In view of the range of 1.9 to 26 µg/L presented in Table 1, the Agency believes it is reasonable to focus on the upper end of the range as recovery is more likely at lower concentrations. For the purposes of determining the need for any potential mitigation to protect aquatic plant communities during Registration Review, EPA will use the concentration of 15 µg/L as a 60-day average, which is at the upper end of the distribution of values presented in Table 1. However, as discussed on page 5 of this memorandum, the CE-LOC will not be used in the ESA assessment.

ANTICIPATED TIMELINE

Registration Review for Atrazine – Projected Timeline for Completion of Registration Review	
Activity	**Date**
Publication of Proposed Interim Decision for 60-day public comment • Will include Response to Comments on Draft Risk Assessments • Will include OPP's Impacts/Benefits Analysis	December 2019
Publication of Interim Decision	Summer 2020
Publication of Draft ESA Biological Evaluation (BE)	August 2020
Final ESA Biological Evaluation (BE)	August 2021
Statutory Deadline for Registration Review	October 2022

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Appendix A. Cosm studies identified by 2012 Scientific Advisory Panel

Study (endpoint #s)	Test Concentrations (µg/L)	Scoring from 2016 DRA	Recommendation of 2012 SAP	2019 Quantitative Impact Analysis
Lampert et al. 1989 (58, 58b)	0.1, 1	Scored all endpoints as “Effect”	Endpoints from study should be excluded from analysis of CELOC	Excluded study from analysis
deNoyelles et al. 1982 (1, 2, 3, 4, 5, 41, 42, 52)	20, 100, 200, 500	Scored all endpoints as “Effect”	All endpoints should be classified as “No Effect”	Classified all endpoints as “No Effect”
Carney and deNoyelles 1986 (1, 2, 3, 4, 5, 41, 42, 52)	20, 100, 200, 500	Scored all endpoints as “Effect”	Endpoints from study should be excluded from analysis of CELOC	Excluded study from analysis
Dewey et al. 1986 (1, 2, 3, 4, 5, 41, 42, 52)	20, 100, 200, 500	Scored all endpoints as “Effect”	Endpoints from study should be excluded from analysis of CELOC	Excluded study from analysis
Kettle et al. 1987 (1, 2, 3, 4, 5, 41, 42, 52)	20, 100, 200, 500	Scored all endpoints as “Effect”	Endpoints from study should be excluded from analysis of CELOC	Excluded study from analysis
deNoyelles et al. 1989 (1, 2, 3, 4, 5, 41, 42, 52)	20, 100, 200, 500	Scored all endpoints as “Effect”	All endpoints should be classified as “No Effect”	Classified all endpoints as “No Effect”
Detenbeck et al. 1996 (22, 23, 24, 25)	15, 25, 50, 79	Scored all endpoints as “Effect”	Endpoints from study should be excluded from analysis of CELOC	Excluded study from analysis
Kosinski 1984 (28, 44)	10, 100	Scored all endpoints as “Effect”	All endpoints should be classified as “No Effect”	Classified all endpoints as “No Effect”
Seguin et al. 2001a (83, 84)	2, 30	Scored all endpoints as “Effect”	30 µg/L concentration should be classified as “No Effect”	Classified 30 µg/L concentration as “No Effect”
Seguin et al. 2001b (85, 86)	2, 30	Scored 30 µg/L concentration as “Effect”	30 µg/L concentration should be classified as “No Effect”	Classified 30 µg/L concentration as “No Effect”
Seguin et al. 2002 (87)	30	Scored all endpoints as “Effect”	30 µg/L concentration should be classified as “No Effect”	Classified 30 µg/L concentration as “No Effect”

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