Review of Draft - Water Quality Criteria Report for Imidacloprid

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Conclusions addressed: 1, 2, 5, 6 and the Big Picture topics

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Conclusion 1 - The physical-chemical data for imidacloprid is accurate and complete.

[Section 3 (Physical-Chemical Data) of the Draft Water Quality Criteria Report]

The physical-chemical data was gathered mainly from scientific reports by the manufacturer, a few databases and reference books as well as several publications in the scientific literature. The information presented in the Draft is correct, but for a couple of minor errors:

Page 5: the Henry's constant geometric mean (5.8×10^{-12} Pa m^3 mol^{-1}) is incorrectly estimated from the three values shown: the correct value is 2.68×10^{-9} Pa m^3 mol^{-1}

Page 7: in Table 1 (Bioconcentration factors), the study by Paraiba 2008 refers to modelling in potatoes, and this should be indicated under the 'species' column. Also, average values for the fish Australoheros facetus (Iturburu 2017, Table 1) should be 1.0, 0.7, 0.6, 0.6, 0.5 and 0.3; all BCF values for this fish are from a formulation tested under static conditions.

Page 8: Table 2 contains information from very old references and is clearly incomplete. Although the data presented are correct, this table should be updated and include new data from field and laboratory studies; although this information is not pertinent to the determination of aquatic benchmarks, it is important for the risk assessment of this compound, which is the main practical use of this Water Quality Criteria Report. Suggest including in this table the following data:

Hydrolysis: 20 d (pH 10.8) and 2.85 d (pH 11.8) as determined by Zheng & Liu 1999. Kinetics and mechanism of the hydrolysis of imidacloprid. Pestic. Sci. 55, 482-485.

Aqueous photolysis:

1. half-life of 0.314 hours in deionized water, as determined by Lavine et al. 2010. LC-PDA-MS studies of the photochemical degradation of imidacloprid. Anal. Lett. 43, 1812-1821.
2. half-life of 2.3 hours in aqueous solution, reported by Kurwadkar et al. 2016. Modeling photodegradation kinetics of three systemic neonicotinoids—dinotefuran,

imidacloprid, and thiamethoxam—in aqueous and soil environment. Environ. Toxicol. Chem. 35, 1718-1726.

Soil photolysis: half-life of 830 h in dry soil, determined by Graebing & Chib 2004. Soil photolysis in a moisture- and temperature-controlled environment. 2. Insecticides. J. Agric. Food Chem. 52, 2606 -2614.

Soil degradation:

1. half-lives of 990 d (red brown earth), 1080 d (quarry sand) and 1230 d (sand-dolomite) in dry soils, reported by Baskaran et al. 1999. Degradation of bifenthrin, chlorpyrifos and imidacloprid in soil and bedding materials at termiticidal application rates. Pestic. Sci. 55, 1222-1228.
2. half-lives of 50 -132 d in soils, reported by Broznić & Milin 2013. Mathematical prediction of imidacloprid persistence in two Croatian soils with different texture, organic matter content and acidity under laboratory conditions. J. Environ. Sci. Health B 48, 906-918.

Biodegradation: half-lives of 54-130 d (sterilized soil) and 36-87 days (non-sterilized soil) reported by Zhang et al. 2018. Sorption, desorption and degradation of neonicotinoids in four agricultural soils and their effects on soil microorganisms. Sci. Total Environ. 615, 59-69.

Conclusion 2 - Ecotoxicity data screening resulted in a high quality (relevant and reliable) data set for criteria derivation and did not result in removal of pertinent high quality data from the data set used for criteria derivation.

The screening performed is adequate but stringent, as it excluded some data points and species that did not comply with the evaluation criteria established in the methods (TenBrook et al. 2009). Most of the reasons given for exclusion, however, are reasonable (e.g. short duration of the tests, inexact derived value) and justified, while others (e.g. not a standard test method, or chemical purity not reported) seem unjustified to me because they tend to exclude data that are very likely trustworthy.

For determination of the acute criterion this strict selection prevented the analysis of a species sensitivity distribution that would have been preferable to the Assessment Factor (AF) procedure used. Nevertheless, the latter method is considered adequate and valid.

However, such a reduction of data may have hampered the estimation of an accurate chronic criterion, which was restricted to consider data only from two species, one of which (Daphnia magna) is notoriously insensitive to this compound – see Morrissey et al. 2015, Neonicotinoid contamination of global surface waters and associated risk to aquatic invertebrates: a review. Environ. Int. 74, 291-303. For the chronic criterion the data by Roessink et al. 2013 and van den Brink et al. 2016 are deemed essential, but these and other relevant work on toxicity have been omitted. See below a number of relevant publications that should be consulted for the estimation of both the acute and chronic benchmarks:

- Alexander, A.C., Culp, J.M., Liber, K., Cessna, A.J., 2007. Effects of insecticide exposure on feeding inhibition in mayflies and oligochaetes. Environ. Toxicol. Chem. 26, 1726-1732.
- Bottger, R., Schaller, J., Mohr, S., 2012. Closer to reality - the influence of toxicity test modifications on the sensitivity of Gammarus roeseli to the insecticide imidacloprid. Ecotoxicol. Environ. Saf. 81, 49-54.
- Chen, X.D., Culbert, E., Hebert, V., Stark, J.D., 2010. Mixture effects of the nonylphenyl polyethoxylate, R-11 and the insecticide, imidacloprid on population growth rate and other parameters of the crustacean, Ceriodaphnia dubia. Ecotoxicol. Environ. Saf. 73, 132-137.
- Kreutzweiser, D., Good, K., Chartrand, D., Scarr, T., Thompson, D., 2007. Non-target effects on aquatic decomposer organisms of imidacloprid as a systemic insecticide to control emerald ash borer in riparian trees. Ecotoxicol. Environ. Saf. 68, 315-325.
- Kreutzweiser, D.P., Good, K.P., Chartrand, D.T., Scarr, T.A., Thompson, D.G., 2008. Toxicity of the systemic insecticide, imidacloprid, to forest stream insects and microbial communities. Bull. Environ. Contam. Toxicol. 80, 211-214.
- LeBlanc, H.M.K., Culp, J.M., Baird, D.J., Alexander, A.C., Cessna, A.J., 2012. Single versus combined lethal effects of three agricultural insecticides on larvae of the freshwater insect Chironomus dilutus. Arch. Environ. Contam. Toxicol. 63, 378-390.
- Roessink, I., Merga, L.B., Zweers, H.J., van den Brink, P.J., 2013. The neonicotinoid imidacloprid shows high chronic toxicity to mayfly nymphs. Environ. Toxicol. Chem. 32, 1096-1100.
- Song, M.Y., Stark, J.D., Brown, J.J., 1997. Comparative toxicity of four insecticides, including imidacloprid and tebufenozide, to four aquatic arthropods. Environ. Toxicol. Chem. 16, 2494-2500.
- van den Brink, P.J., Smeden, J.M.V., Bekele, R.S., Dierick, W., Gelder, D.D., Noteboom, M., Roessink, I., 2016. Acute and chronic toxicity of neonicotinoids to nymphs of a mayfly species and some notes on seasonal differences. Environ. Toxicol. Chem. 35, 128-133.

Conclusion 5 - The water quality criteria were not adjusted based on water quality effects, specific ecotoxicity data, or effects in other environmental compartments; the derived criteria are scientifically sound and technically valid based on the available information on these topics.

[Sections 9, 10, and 11 of each Draft Water Quality Criteria Report]

That's correct: no adjustments were made based on water quality effects, specific ecotoxicity data, or effects in other environmental compartments.

The calculated acute and chronic criteria (0.07 μg/L and 0.014 μg/L, respectively) are scientifically sound and valid based on the methodology used; they are comparable to those derived in other jurisdictions, and this adds confidence in their determination. They are protective of threatened or endangered species and freshwater ecosystems in California and probably elsewhere.

In regard to water quality effects (Section 9), the studies by Ding et al. 2004 and Iturburu et al. 2017 specifically refer to bioavailability and bioconcentration of imidacloprid in fish kept in aquaria, so unless I am missing something the statement "No studies were found concerning the bioavailability of imidacloprid to organisms in the water column" (p. 13) is incorrect.

I was also surprised to read that "No acceptable mesocosm, microcosm or ecosystem (field and laboratory) studies were identified" (p. 15). I am of the opinion that these studies cannot be screened using the same reliability criteria used for acute and chronic laboratory studies. The fact is there are at least 15 microcosms and mesocosm available in the public literature, the most recent being Rico et al. 2018 (Effects of imidacloprid and a neonicotinoid mixture on aquatic invertebrate communities under Mediterranean conditions. Aquat. Toxicol. 204, 130-143). Some of those studies may not be reliable, but I very much doubt than none of them are acceptable or pertinent. For example, Smit et al. (2015) used 6 of these studies to evaluate the toxicity to freshwater ecosystems, although these authors used the method of De Jong et al. (2008) to screen the available data, not the method of TenBrook et al. 2009.

Conclusion 6 - The assumptions, limitations, and uncertainties regarding derivation of the water quality criteria are accurate and include all factors that significantly affect the resulting criteria.

[Section 12.1 (Assumptions, Limitations, and Uncertainties) of the Draft Water Quality Criteria Report]

Indeed, the assumptions, limitations and uncertainties used by the authors followed a well-defined and valid method (TenBrook et al. 2009) that provides full confidence in the derived criteria. As mentioned above, I think this screening method resulted in the exclusion of some studies reporting reliable data, thus preventing the use of SSD methods for the calculation of the acute criterion, while the chronic data was reduced to a minimum of two species, even if reliable data for more species exists. However, the applied methodology is certainly robust and the resulting criteria are accurate and acceptable.

A final comment: a reference should be cited regarding the environmental monitoring data for the State of California, which is described in detail in pp. 20-21. Suggestion: Starner and Goh, 2012. Detections of the neonicotinoid insecticide imidacloprid in surface waters of three agricultural regions of California, USA, 2010–2011. Bull. Environ. Contam. Toxicol. 88, 316-321.

The "Big Picture" questions

a) In reading the Draft Water Quality Criteria Report, are there any additional scientific issues that should be part of the scientific portion of the water quality criteria derivation that are not described above? If so, comment with respect to the derivation of water quality criteria.

One issue very relevant to the chronic criterion is the delayed mortality observed with aquatic invertebrates exposed to imidacloprid over long periods. This unusual toxic behaviour has been reported by several authors, including myself, and basically results in acute/chronic ratios of LC50s much greater than 10 (it is 34 for D. magna), which can be as large as 800 for mayfly nymphs after 4 weeks exposure (Sanchez-Bayo et al. 2016, Contamination of the aquatic environment with neonicotinoids and its implication for ecosystems. Front. Environ. Sci. 4, 71). By contrast, it is noted that the acute and chronic criteria derived here differ only by a factor of 5, whereas a larger factor of 24 is found between acute and chronic benchmarks derived for Europe (Smit et al. 2015).

A section discussing this point would be worth including, because it is pertinent to the derivation of the chronic criterion. A recent publication explaining this point is: Pisa et al., 2017. An update of the Worldwide Integrated Assessment (WIA) on systemic insecticides. Part 2: Impacts on organisms and ecosystems. Environ. Sci. Pollut. Res. doi: 10.1007/s11356-017-0341-3.

b) Taken as a whole, are the scientific portions of the water quality criteria derivations based upon sound scientific knowledge, methods, and practices?

Yes, the methods used are valid and scientifically sound, and the resulting criteria are trustworthy.