CALIFORNIA DEPARTMENT OF TOXIC SUBSTANCES CONTROL HUMAN AND ECOLOGICAL RISK OFFICE (HERO)*

HERO ECOLOGICAL RISK ASSESSMENT NOTE NUMBER 2

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ISSUE: Calculation of a range of intakes for vertebrate receptors in a Phase I Predictive Assessment for use with EPA Region IX BTAG Toxicity Reference Doses (TRVs) to obtain a range of hazard quotients.

GUIDANCE: Use a two-step process. Calculate an adult intake and juvenile intake with ingestion rate separately correlated to body weight for adults and juveniles. Calculate the hazard quotient for the adult and juvenile in two ways. First, calculate an area wide hazard quotient based on the 95th upper confidence limit of the mean for all samples. Second, calculate a point estimate hazard quotient for each sample to identify any localized areas of elevated concentration (i.e., a 'hot spot') which might be masked by a large number of other soil samples from the site.

In addition, a further range of hazard quotients may be calculated using intake rates correlated with individual measurements of vertebrate body weight. Individual vertebrate body weights for selected species are available on the HERO web page.

BACKGROUND

The TRVs for vertebrate receptors were developed in a cooperative effort between the U.S. EPA Region IX Biological Technical Assistance Group (BTAG), Engineering Field Activity-West (EFA-West) and consultants for the U.S. Navy. The numerically low TRV is meant to represent an intake which the developers of the TRVs believed presents a dose unlikely to produce adverse effects. The numerically high TRV is meant to represent an intake which the developers of the TRVs believed presents a dose which would produce adverse population effects.

Some ecological risk assessments performed in the past several years, which assessed the potential threat to vertebrate receptors, have calculated up to four hazard quotients for each receptor for each contaminant. These four hazard quotients are based on the lowest and highest estimate of intake in $mg_{chemical}/kg_{body\ weight}$-day and two toxicity reference values (TRVs) for vertebrate receptors.

The two estimates of intake for vertebrate receptors have been developed in the following manner:

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High Intake	The lowest adult body weight (kg) The highest ingestion rate ($mg_{food\ or\ soil}$/day)A higher estimate of site use factor (SUF) (unitless) The maximum concentration in tissue or thehighest estimate of tissue concentration ($mg_{chemical}/kg_{tissue}$) The maximum soil concentration ($mg_{chemical}/kg_{soil}$)
Low Intake	The highest adult body weight (kg) The lowest ingestion rate ($mg_{food\ or\ soil}$/day) A lower estimate of site use factor (SUF) (unitless) The median concentration in tissue ($mg_{chemical}/kg_{tissue}$) The median soil concentration ($mg_{chemical}/kg_{soil}$)

The food ingestion rate, water ingestion rate and inhalation rate are frequently estimated using the body weight-based allometric regression equations summarized by the U.S. EPA (EPA, 1993, Nagy, 1987, Calder and Braun, 1983, Lasiewski and Calder,1971).

The numerically high TRV represents an intake at which the regulatory agencies would expect there to be adverse ecological effects. Whether daily intake between the numerically high TRV and the numerically low TRV are likely to produce adverse effects is uncertain. However, the probability of adverse effects increases as the daily intake approaches the numerically high TRV.

The low and high intake estimates are both used to calculate a hazard quotient, which is the intake divided by the TRV. Of the four arithmetically-possible vertebrate hazard quotients which can be calculated, two were originally proposed (EFAWEST, 1997) as the basis for decisions:

Intake Level	Low TRV	High TRV
Low Intake	NA	HQ_1
High Intake	HQ_2	NA

An HQ_1 greater than one was proposed as indicating likely ecological hazard. An HQ_2 less than one was proposed as indicating little or no ecological hazard.

ANALYSIS

The method of calculating a range of doses based on a solely mathematical pairing of body weight and ingestion rate has no biological basis. It is biologically impossible for the lowest body weight to be associated with the highest food and sediment ingestion rate (high intake) or the highest body weight to be associated with the lowest food and

sediment ingestion rates. To put it plainly, there are no emaciated cormorants with insatiable appetites.

INTAKE GUIDANCE

All intakes should be correlated with body weight. For a low body weight and high body weight, which are useful to provide some range of exposure, the low body weight should represent a juvenile organism and the high body weight an adult. The ingestionrate of a juvenile will be higher per unit body weight than the ingestion rate of a non- breeding adult. In the event an independent estimate of juvenile body weight is unavailable, the ingestion rate of an adult adjusted for the juvenile body weight should be used as a default.

Estimation of vertebrate intake would be more biologically relevant if the lower body weight of a juvenile were paired with the higher intake per body weight ($mg_{food}/kg_{bodyweight}$) typical of a juvenile. The potential adverse effect associated with adult intake should be addressed using the average or median adult intake for the vertebrate species. In the event the body size of the vertebrate species being assessed is sexually dimorphic, an adult intake calculation should be made for both sexes. This results in the following potential hazard quotients:

TRV Type	Juvenile Intake	Adult Intake
Numerically-Low TRV	Hq juvenile low	HQ adult low
Numerically-High TRV	Hq juvenile high	HQ adult high

Interpretation of this range of hazard quotients is fairly simple. As a population cannot continue if adverse effects occur for either the juveniles or the adults, $HQ_{juvenile\ high}$ or $HQ_{adult\ high}$ in excess of 1.0 are cause for concern and further investigation or consideration of remedial alternatives. Pairing of either $HQ_{juvenile\ low}$ in excess of 1.0 with $HQ_{adult\ low}$ less than 1.0, or $HQ_{adult\ low}$ greater than 1.0 with $HQ_{juvenile\ low}$ less than 1.0 would require further evaluation of the status of the vertebrate species (i.e., are these rare, threatened, or endangered species) or further evaluation of the population effects due to potential loss of juveniles or adults. This may include a Phase II Validation Study to reduce the uncertainty in the exposure parameters used to estimate the intake.

In the case of sexually dimorphic species an $HQ_{adult\ high}$ greater than one for either sex would be an indication of potential adverse effects.

POINT ESTIMATES OF HAZARD

A second calculation of ecological hazard for vertebrate species should be performed in addition to the estimate based on the area wide 95th upper confidence limit on the mean.

A point estimate of hazard should be prepared based on the individual soil concentration of each sample. The purpose of this procedure is to identify any small

areas of elevated soil concentration (i.e., a 'hot spot') which are hidden by an overlylarge number of samples from the other areas of the site.

The same range of hazard quotients described for the area wide calculation should be developed and presented on maps of the site. Contouring the hazard quotients (e.g., mapping the individual hazard quotients) may aid in identification of areas of concern.

TOXICITY REFERENCE VALUE USE

The toxicity information used to develop the TRV, particularly the toxic endpoint used to set the TRV, should first be reviewed to determine whether the toxic endpoint is appropriate for the measurement endpoint being evaluated. Changes in enzyme level,for example, may not be appropriate for assessing the hazard to common (i.e., not rare, threatened, or endangered) species.

The TRVs developed cooperatively by the BTAG and the NAVY are meant to address the range of intake from no-effect to potential adverse effect. HERO does not recommend allometric conversion of TRVs for body weights which differ by less than 2 orders of magnitude. However, if the generalized BTAG mammalian TRVs are allometrically adjusted for differences in body weight, the allometric adjustment of the generalized mammal and avian TRVs should use a mammalian allometric relationshipsof body weight $^{0.66}$ or body weight $^{0.75}$ (Sample, 1996) with sufficient written justification. An avian allometric relationship of body weight $^{1.15}$ (Mineau, et al., 1996) should be used. The result should indicate that smaller mammals are less sensitive if the mammal tested had a higher body weight, while smaller birds should be fairly similar in sensitivity to birds with higher body weights.

FURTHER PRESENTATION OF THE RANGE OF HAZARD QUOTIENTS

Development of a further range of hazard quotients beyond those described above can be provided only with biologically relevant exposure parameters. The most useful approach would be to collect a sample of body weights, either from the literature or from field-collected specimens, for the vertebrate species being assessed and base the food intake, water intake, and if applicable, the respiration rate on the individual body weights. The distribution of intake, and therefore hazard quotient, would be reflective of the range of juvenile and adult hazard as presented above.

In support of this effort, HERO has collected individual body weights for several avian species. Individual body weight measurements for the American kestrel, American robin, Cooper's hawk, great blue heron, northern harrier, mourning dove, red tailed hawk, and sharp shinned hawk are available on the HERO web page. Individual bodyweights for California mammalian species should be available on the HERO web page in the near future. All of these body weight files will be augmented, as more body weight data becomes available.

Assumption of parametric distributions for all parameters or uniform distributions for parameters of unknown distribution is not useful. Distributions should not be assumed for exposure parameters based on minimal data.

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