Health Based Guidance for Water
Health Risk Assessment Unit, Environmental Health Division
651-201-4899

Adopted as Rule: November 2023

Toxicological Summary for: Benzo[a]pyrene

CAS: **50-32-8**

Synonyms: BaP, Benzo[pqr]tetraphene, 3,4-Benz[a]pyrene, Benzo(d,e,f)chrysene

Acute Non-Cancer Health Risk Limit ($nHRL_{Acute}$) = Not Derived

Short-term Non-Cancer Health Risk Limit ($nHRL_{Short\text{-}term}$) = 0.5 µg/L

$$\frac{\text{(Reference Dose, mg/kg-d) x (Relative Source Contribution) x (Conversion Factor)}}{\text{(Short-term Intake Rate, L/kg-d)}}$$

$$= \frac{\text{(0.00031 mg/kg-d) x (0.5)}^{*} \text{ x (1000 µg/mg)}}{\text{(0.290 L/kg-d)}^{**}}$$

= 0.53 rounded to **0.5 µg/L**

*Relative Source Contribution: MDH 2008, Section IV.E.1.
**Intake Rate: MDH 2008, Section IV.E.1. and US EPA 2019, Exposure Factors Handbook, Tables 3-1, 3-3 and 3-5

Reference Dose/Concentration:	Administered Dose/Total UF = 0.0917/300 = 0.00031 mg/kg-d (SD rats)
Source of toxicity value:	Determined by MDH in 2018
Point of Departure (POD):	0.0917 mg/kg-d ($BMDL_{1SD}$, Chen, 2012)
Dose Adjustment Factor (DAF):	Not calculated due to temporal differences in human and rodent brain developmental stages
Human Equivalent Dose (HED):	Not applicable
Total uncertainty factor (UF):	300
Uncertainty factor allocation:	10 for interspecies differences, 10 for intraspecies variability, and 3 for database uncertainty due to lack of adequate developmental and multigenerational studies that include exposure throughout gestation and early life.
Critical effect(s):	Functional test of neurological changes in neonatal rats (elevated maze)
Co-critical effect(s):	Functional test of neurological changes in neonatal rats (open field and water maze testing)
Additivity endpoint(s):	Developmental, Nervous system

Subchronic Non-Cancer Health Risk Limit ($nHRL_{Subchronic}$) = $nHRL_{Short\text{-}term}$ = 0.5 µg/L

$$\frac{\text{(Reference Dose, mg/kg-d) x (Relative Source Contribution) x (Conversion Factor)}}{\text{(Subchronic Intake Rate, L/kg-d)}}$$

$$= \frac{\text{(0.00031 mg/kg-d)}^{\#} \text{ x (0.2)}^{*} \text{ x (1000 µg/mg)}}{\text{(0.074 L/kg-d)}^{**}}$$

= 0.83 rounded to 0.8 µg/L

[#]No Subchronic RfD was calculated due to study limitations. Therefore, the developmental-based Short-term RfD was applied to the subchronic duration.
[*]Relative Source Contribution: MDH 2008, Section IV.E.1.
[**]Intake Rate: MDH 2008, Section IV.E.1. and US EPA 2019, Exposure Factors Handbook, Tables 3-1, 3-3 and 3-5

The Subchronic nHRL must be protective of the short-term exposures that occur within the subchronic period and therefore, the Subchronic nHRL is set equal to the Short-term nHRL of 0.5 µg/L. Additivity endpoints: Developmental and Nervous system

Chronic Non-Cancer Health Risk Limit ($nHRL_{Chronic}$) = $nHRL_{Short\text{-}term}$ = 0.5 µg/L

$$\frac{\text{(Reference Dose, mg/kg-d) x (Relative Source Contribution) x (Conversion Factor)}}{\text{(Chronic Intake Rate, L/kg-d)}}$$

$$= \frac{\text{(0.00031 mg/kg-d) x (0.2)}^{*} \text{ x (1000 µg/mg)}}{\text{(0.045 L/kg-d)}^{**}}$$

= 1.37 rounded to 1 µg/L

[#]No Chronic RfD was calculated due to study limitations. Therefore, the developmental-based Short-term RfD was applied to the chronic duration.
[*]Relative Source Contribution: MDH 2008, Section IV.E.1.
[**]Intake Rate: MDH 2008, Section IV.E.1. and US EPA 2019, Exposure Factors Handbook, Tables 3-1, 3-3 and 3-5

The Chronic nHRL must be protective of the short-term exposures that occur within the chronic period and therefore, the Chronic nHRL is set equal to the Short-term nHRL of 0.5 µg/L. Additivity endpoints: Developmental and Nervous system

Cancer Health Risk Limit (cHRL) = 0.1 µg/L

$$\frac{\text{(Additional Lifetime Cancer Risk) x (Conversion Factor)}}{[(SF \times ADAF_{<2\ yr} \times IR_{<2yr} \times 2) + (SF \times ADAF_{2\text{-}<16\ yr} \times IR_{2\text{-}<16yr} \times 14) + (SF \times ADAF_{16+\ yr} \times IR_{16+yr} \times 54)] / 70}$$

$$= \frac{\text{(1E-5) x (1000 µg/mg)}}{[(1 \times 10^{*} \times 0.155\ \text{L/kg-d}^{**} \times 2) + (1 \times 3^{*} \times 0.040\ \text{L/kg-d}^{**} \times 14) + (1 \times 1^{*} \times 0.042\ \text{L/kg-d}^{**} \times 54)] / 70}$$

= 0.099 rounded to **0.1 µg/L**

*ADAF (Age-dependent adjustment factor) and Lifetime Adjustment Factor: MDH 2008, Section IV.E.2.
**Intake Rate: MDH 2008, Section IV.E.2. and US EPA 2019, Exposure Factors Handbook, Tables 3-1, 3-3 and 3-5

Cancer classification:	Carcinogenic to humans (US EPA, 2017a)
Slope factor (SF):	1 $(mg/kg\text{-}d)^{-1}$ (Forestomach and oral cavity tumors in female mice, Beland and Culp, 1998 aci US EPA, 2017a)
Source of cancer slope factor (SF):	US EPA, 2017a
Tumor site(s):	Digestive tract, liver, skin, lung

Volatile: Yes (low)

Summary of Guidance Value History:

A cancer HBV of 0.05 µg/L was derived in 1995. Acute, Short-term, Subchronic, and Chronic nHBVs of 2, 0.3, 0.3, and 0.3 µg/L were derived in 2012, along with a cancer HBV of 0.06 µg/L. In 2018, MDH derived nHBVs of 0.5 µg/L for Short-term, Subchronic, and Chronic durations and a cHBV of 0.1 µg/L. The 2018 values changed as a result of: 1) using MDH's most recent risk assessment methodology; 2) incorporating more recent toxicological information; and 3) rounding to one significant digit. In 2020 MDH incorporated updated intake rates (US EPA 2019). Use of the updated intake rates did not result in any changes to the final 2018 HBVs. In November 2023, the guidance values were adopted into Minnesota Rules, 4717.7860, as Health Risk Limits (HRLs).

Summary of toxicity testing for health effects identified in the Health Standards Statute (144.0751):

Even if testing for a specific health effect was not conducted for this chemical, information about that effect might be available from studies conducted for other purposes. MDH has considered the following information in developing health protective guidance.

	Endocrine	Immunotoxicity	Development	Reproductive	Neurotoxicity
Tested for specific effect?	Yes	Yes	Yes	Yes	Yes
Effects observed?	Yes[1]	Yes[2]	Yes[3]	Yes[4]	Yes[5]

Comments on extent of testing or effects:

[1] Endocrine effects were assessed following laboratory exposures to BaP. Changes in testosterone, estradiol, and estrous cycles were noted at doses far in excess (greater than1,800 times) of the Short-term RfD.

[2] Immune system effects were seen at high doses in comparison to the short-term RfD. Changes in immune cell populations and decreased thymic weights were noted in multiple studies at doses greater than 5,000 times higher than the Short-term RfD.

[3] A developmental neurobehavioral effect forms the basis of the Short-term RfD. Altered blood pressure and heart rate following in utero exposure were reported at doses 400-800 times higher than the Short-term RfD. Other observed developmental toxicities include decreased weight gain in early life, stillbirth, and birth defects. These effects occurred at the lowest dose tested, however, these

doses are greater than 30,000 times higher than the Short-term RfD. A database uncertainty factor of 3 was applied in deriving the Short-term RfD in order to address outstanding concerns regarding developmental effects.

[4] Most reproductive effects were noted at doses much higher than the Short-term RfD. Histopathological changes in the cervix and sperm alterations of mice were observed at the lowest doses tested in two studies (300-400 times higher than the Short-term RfD). In other studies, reduced fertility, decreased ovary weights, and decreased follicle number were reported at doses over 1,800 times higher than the Short-term RfD. A database uncertainty factor of 3 was applied in deriving the Short-term RfD in order to address concerns regarding reproductive effects that would be tested in a standard multigenerational study.

[5] Neurodevelopmental effects form the basis of the Short-term RfD. Neurotoxicity was also observed after high dose acute exposure. Three acute oral studies observed suppressed motor activity and other changes at doses nearly 2,000 times higher than the Short-term RfD. A study in adult animals reported alterations in mobility during tail suspension testing at a dose 10 times higher than the Short-term RfD, however this effect's significance was unclear and did not display a dose response. Other studies examining neurotoxicity in adult laboratory animals noted effects at doses greater than 1,000 times higher than the Short-term RfD.

Resources Consulted During Review:

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