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Human Health Risk Assessment

Risk assessment is an **iterative process leading to the quantification of potential risk**. For the POPs Toolkit, the **emphasis is on assessing health risks to humans resulting from exposure to persistent organic chemicals**. However, contaminated sites can also result in unacceptable risks to the **natural environment**. Risk Assessments that assess unacceptable risks to the natural environment are called **Environmental Risk Assessments**.

This section of the POPs Toolkit provides an [introduction to Human Health Risk Assessment](#) as well as several interactive tools:

- o [Problem Formulation Tool](#)
- o [Risk Calculation Tools](#)

 POPs Toolkit users who are looking to prioritize and manage their pesticide stockpiles should view more information about the [FAO's obsolete pesticide programme](#).



Pesticides can be hazardous to human health
(click to enlarge)

Next Steps

 start the [Human Health Risk Assessment Training Module](#)

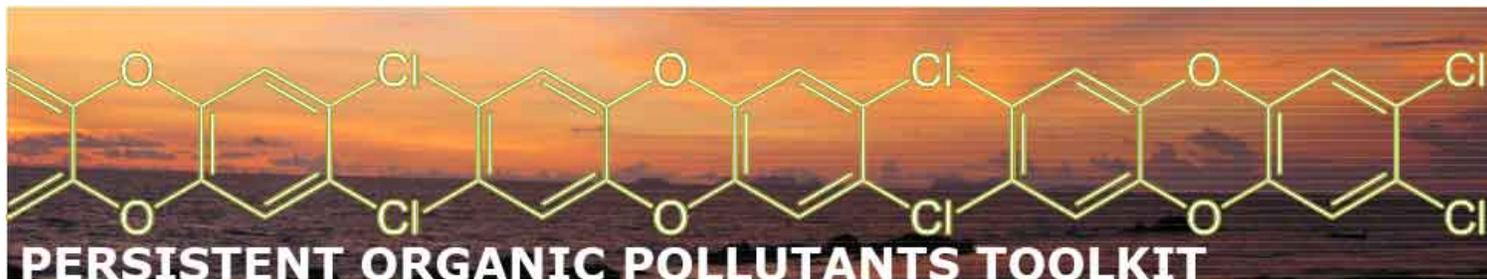
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Human Health Risk Assessment Overview

Risk assessment is an iterative process leading to the quantification of potential risk. For the POPs toolkit, the emphasis is on assessing health risks to humans resulting from exposure to persistent organic chemicals (although other hazardous chemicals can be analyzed in a similar fashion). The assessment looks at **multiple exposure scenarios** and calculates the incremental risks associated with each scenario, as well as the **overall risk** attributable to all the scenarios combined.

Information provided by risk assessments is needed before appropriate risk management measures can be selected and implemented.

Risk assessments start off very simple, using a minimum of data, making simple assumptions and using simple calculations. At this initial stage, all assumptions should err on the side of caution. If the earliest iterations of the risk assessment predicts elevated risk, it doesn't necessarily mean that there is elevated risk, but additional work needs to be done to refine the risk assessment. In Canada, the earliest iteration is called a **Preliminary Quantitative Risk Assessment (PQRA)** (Health Canada 2004). Subsequent refinements are often called Detailed Site-Specific **Risk Assessments**.



Transformer Storage Depot in Vientiane, Lao PDR

Source: Hatfield Consultants
(click to enlarge)

More Details

➔ Details about [Preliminary Quantitative Risk Assessment \(PQRA\)](#)

Next Steps

➔ the [Risk Assessment Framework](#)

References:

[Health Canada PQRA - 2004](#) (external link)

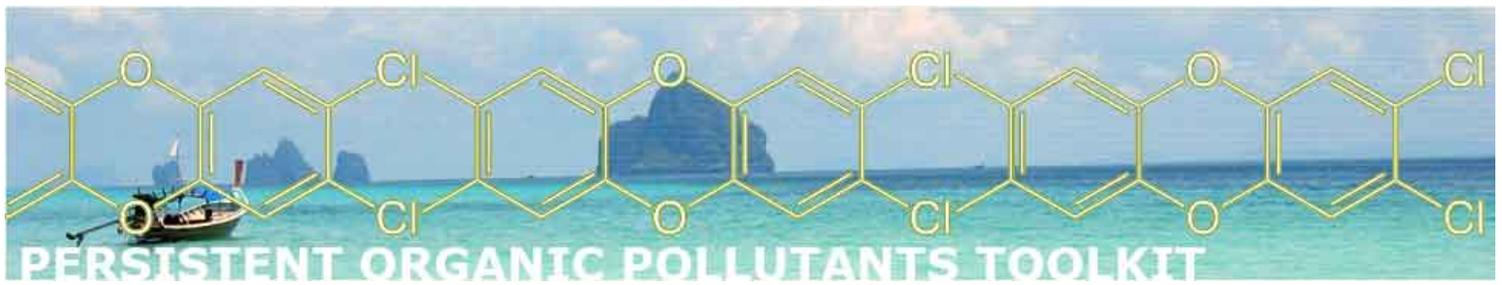
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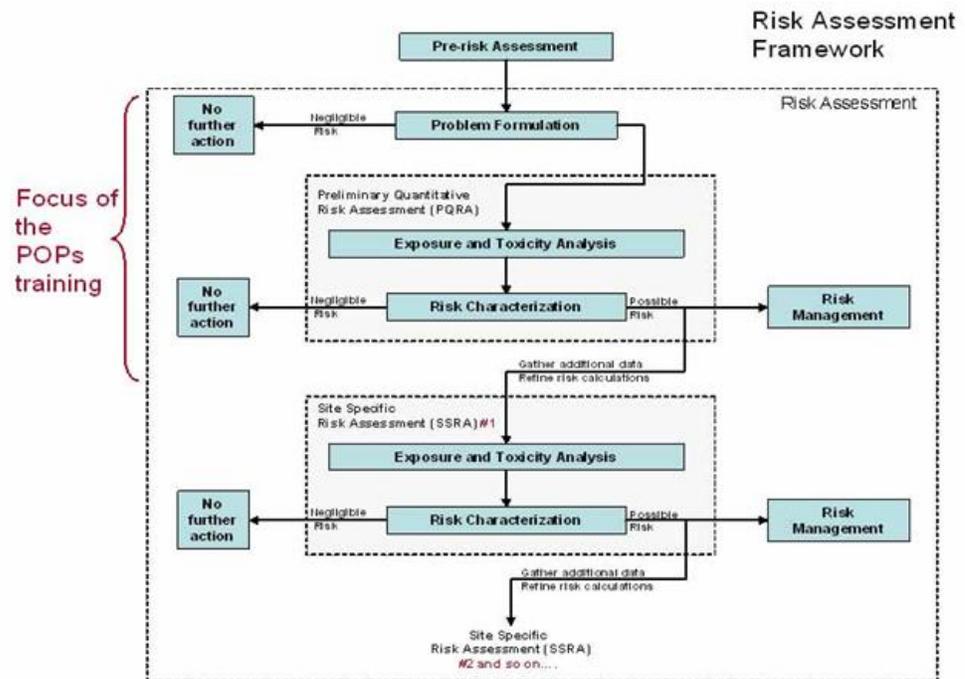
Risk Assessment Framework

Risk assessments can be broken down into several component parts. The framework utilized in the POPs Toolkit has been adopted primarily from Health Canada's **PQRA** (Preliminary Quantitative Risk Assessment) guidance for conducting human health risk assessments (Health Canada, 2004). The framework used is similar to those approaches used elsewhere in North America and in Europe.

The **main components** of a risk assessment are:

- o **Preliminary data collection**
- o **Problem formulation**
- o **Exposure and toxicity analysis**
- o **Risk characterization**

A PQRA will contain each of these components. More complicated risk assessments, site specific risk assessments (SSRAs), will contain additional exposure and toxicity analysis, and risk characterization.



More Details

➡ Details about [Preliminary Quantitative Risk Assessment \(PQRA\)](#)

➡ Details about [Site Specific Risk Assessment \(SSRA\)](#)

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[Health Canada PQRA - 2004](#) (external link)

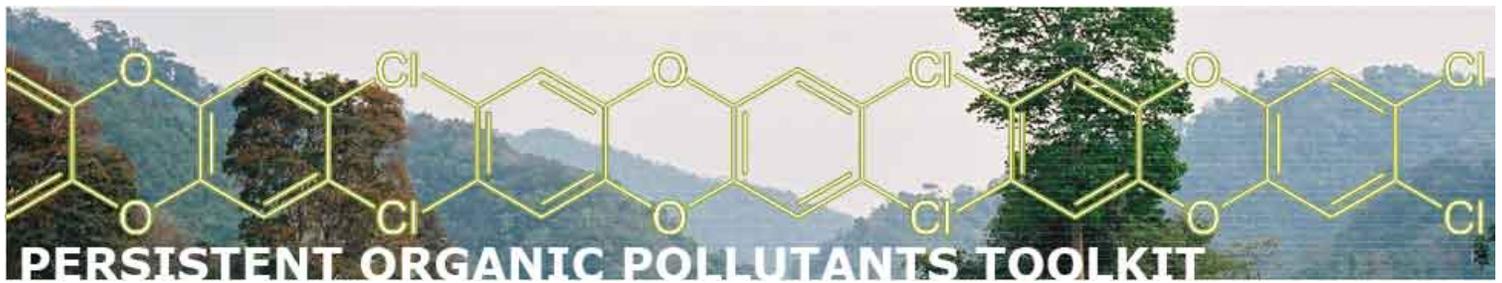
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Preliminary Quantitative Risk Assessments

As its name suggests, a **Preliminary Quantitative Risk Assessment (PQRA)** is generally the **first iteration of a risk assessment**. The methods and assumptions prescribed in a PQRA are conservative and generally ensure that **risks are not underestimated**. Thus, if acceptable or negligible risks are predicted, then it is almost certain that risks are either acceptable or negligible.

However, **if a PQRA suggests the potential for unacceptable risks, it does not mean that unacceptable risks are present. Instead, further assessment may be necessary to resolve conservatism and uncertainty in risk calculations before the actual health risk can be defined.**

When risk management activities are implemented based on a PQRA, the result will generally be a greater reduction of risk than was necessary. A more detailed risk assessment will usually result in risk management activities that are more in line with actual risks. The complexity of a risk assessment is often decided based on cost and the feasibility of the proposed risk management approach.

More detailed risk assessments are called **detailed Site Specific Risk Assessments, SSRAs**. Generally in a risk assessment there is only one PQRA iteration. However, there **may be multiple SSRA iterations**, each building upon the last one (Health Canada 2004). **The POPs Toolkit presents a risk assessment approach consistent with a PQRA**. Additional reading and/or training will be required before participants can successfully conduct a SSRA.



Agent Orange Storage Drums On Johnston Atoll

(click to enlarge)

More Details

➔ Details about [Site Specific Risk Assessments \(SSRA\)](#)

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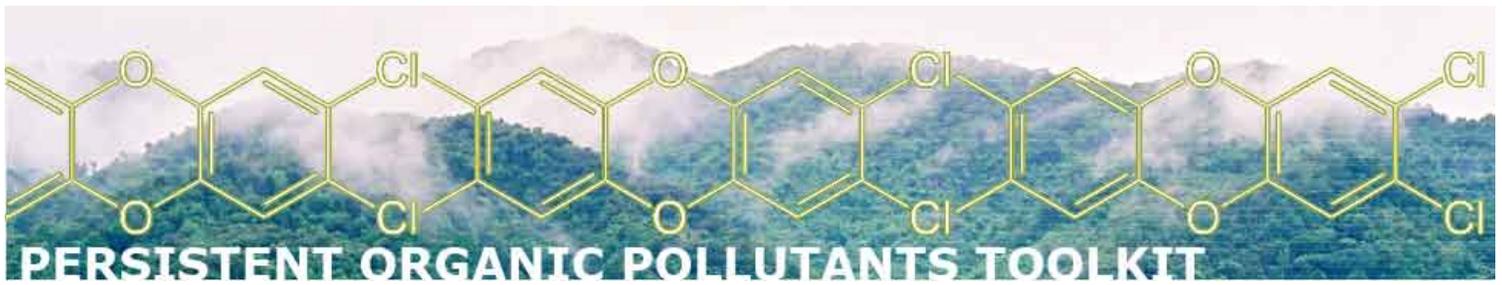
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Detailed Site Specific Risk Assessments

In subsequent iterations of the risk assessment, more data is required, assumptions become more refined, and calculations may become more complicated. These subsequent iterations are each called **detailed Site Specific Risk Assessments (SSRA)**. The iterations/refinements to the risk assessment continue until it is apparent that:

- a) the risk is negligible/tolerable, or
- b) there is a verified unacceptable risk, the risk assessment can not be refined further, and it warrants mitigation and management.

The refinement provides compelling evidence that elevated/unacceptable risks warrant mitigation.



Agent Orange Storage Drums On Johnston Atoll

(click to enlarge)

More Details

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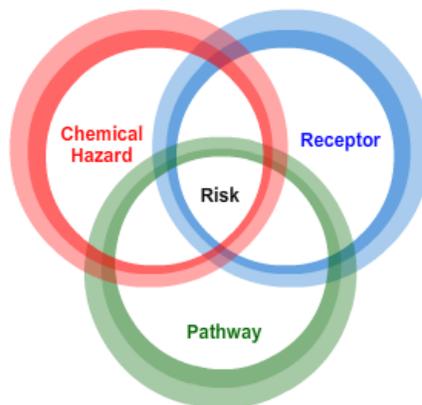
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Problem Formulation

The very first step in the risk assessment is problem formulation which defines the problem. This process explicitly identifies the **components** and sets the stage for the Risk Assessment (Environment Canada 2003, Health Canada 2004). **All three components are essential in order for a contaminant-based health risk to exist. Absence of any one will remove the possibility of an unacceptable health risk.**

Components of Risk

(click on a component of risk to see questions raised by that component)



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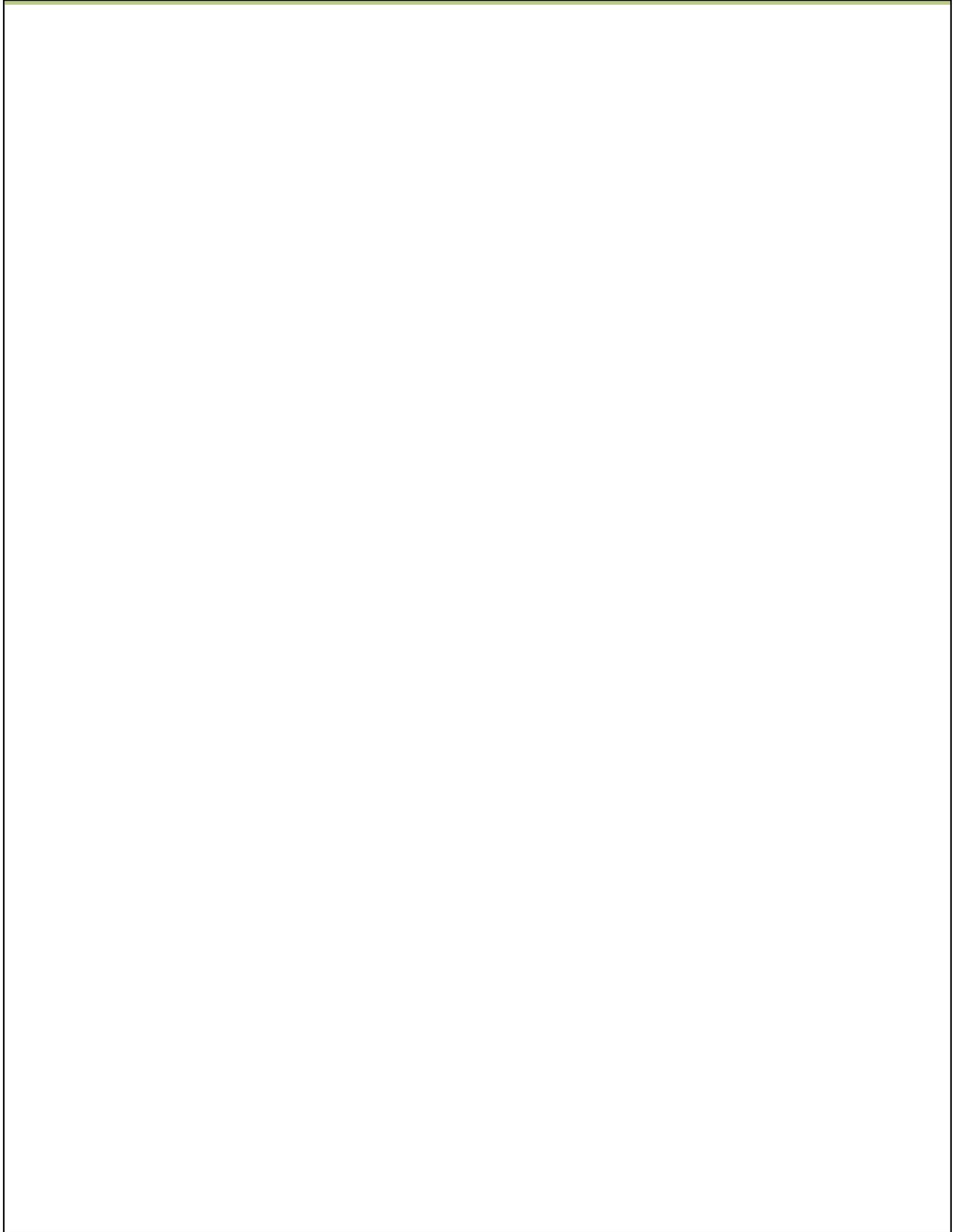
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Chemical Hazards

To determine if a Chemical Hazard exists, **site chemical data are screened against environmental quality guidelines** (e.g., the [CCME Environmental Quality Guidelines](#) (external link) and [Health Canada Drinking Water Guidelines](#) (external link)). **Concentration data is first summarized by calculating the mean, 95% upper confidence limit of the mean (UCLM), 95th percentile and maximum concentration.** The summary statistics are then screened against the environmental quality guidelines. In addition to statistical summaries of concentrations, other information may need to be collected (e.g., for soil data).



Recreational Fishing at Xuan Lake, Viet Nam
Source: Hatfield Consultants
(click to enlarge)

More Details

➔ Details about [Environmental Quality Guidelines](#)

➔ Details about [Screening](#)

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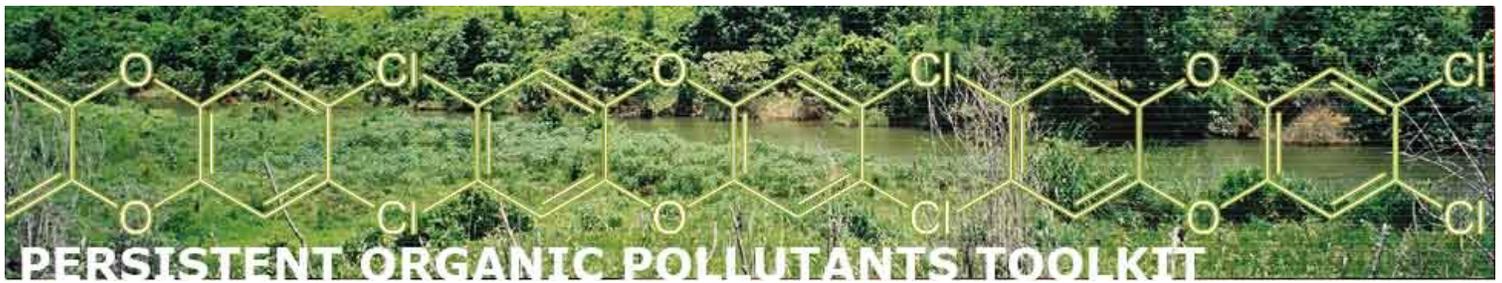
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Screening of Chemical Hazards

Chemicals found at a site must be screened against environmental guidelines. To do this screening, the chemical measurement is compared against the **CCME Environmental Quality Guidelines for protection of human health** should be used. Where CCME human health guidelines are not available, other human health-based guidelines from reliable sources may be used. One source is the U.S. Environmental Protection Agency's (US EPA) preliminary remediation goals (PRGs). Another is US EPA risk based concentrations (RBCs). When compared against guidelines, Contaminants of Potential Concern (COPC) are identified.

Adjusting US EPA risk based concentrations

For non-carcinogens, PRG's or RBC's may be adjusted to reflect 20% of the US EPA toxicological reference value (TRV). A TRV is the maximum safe dose a human can be exposed to each day over a life time (mg/kg body weight/day). 20% of the TRV is taken to allow for exposure from other media and pathways.

Screening when a guideline is not available

In the event that a contaminant has no corresponding health-based soil quality guideline, the contaminant should be included as a Chemical of Potential Concern (COPC) for further risk assessment, unless the measured concentrations are consistent with natural or background concentrations.

Background Concentrations

Before a site is considered contaminated, concentrations of contaminants at the site, particularly natural elements (e.g., metals), should also be compared to background soil and groundwater concentrations (and surface water concentrations, if relevant), if data are available. **If it is found that concentrations of contaminants at the site are representative of background levels, then the site may not be contaminated even though measured concentrations are greater than the guidelines.** A further discussion of background levels is provided in [Appendix A](#) (external link) of the PQRA guidance document (Health Canada 2004).

More Details

↔ about [Environmental Quality Guidelines](#)

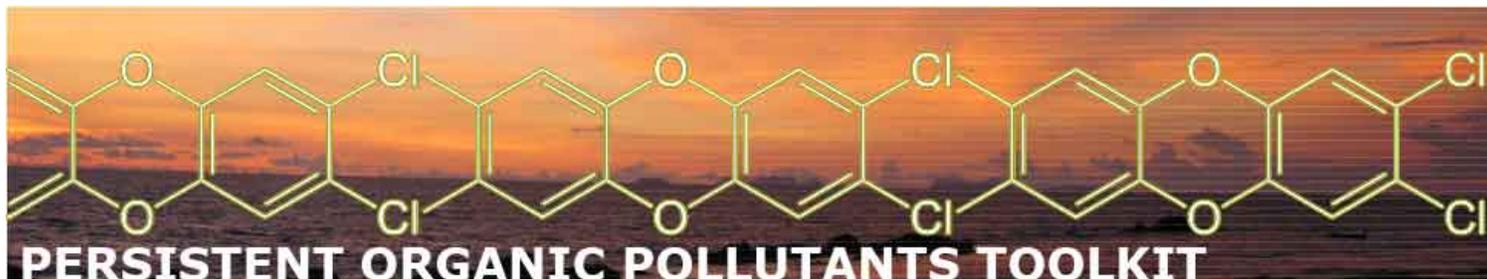
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Receptors

Receptors are the living organisms (humans, animals and plants) that may be affected by exposure to a chemical hazard. Receptors are unique for a given contaminated site and exposure scenario. **It is the receptor that is affected by the risk that is being assessed.**

Humans as Receptors

Humans are often subdivided on the basis of age group (Health Canada 2004). Typical age groups are as follows:

- o **infants (0 to 6 months),**
- o **toddlers (7 months to 4 years),**
- o **child (5 years to 11 years),**
- o **teen (12 – 19 years)** and
- o **adults (20+ years).**

Age groups are assessed separately because many of the factors determining the degree of exposure are different. In addition, certain age groups are more susceptible to chemically mediated effects (i.e., infants, toddlers and pregnant woman are often the most sensitive to chemical exposure)(Health Canada 2004).

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Receptors are the living organisms that may be affected by exposure to chemical hazards

Source: *Hatfield Consultants*
(click to enlarge)

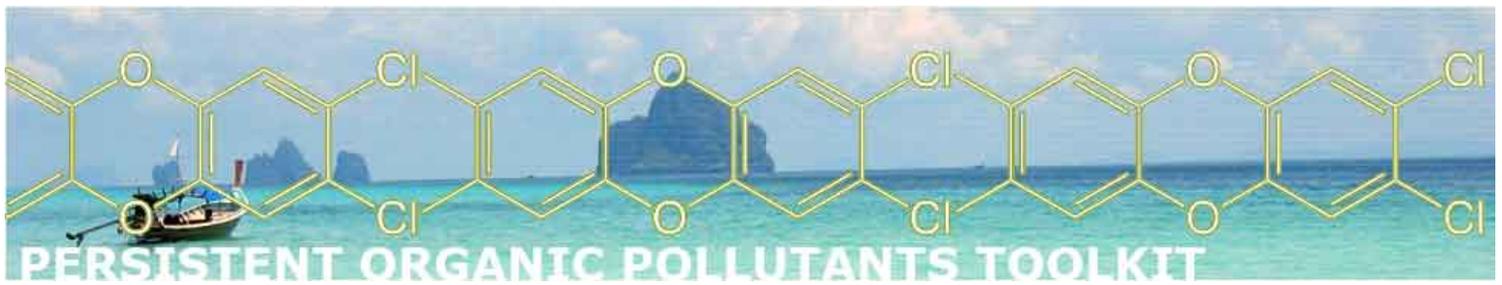
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Exposure Pathways

An exposure pathway is the route a chemical **hazard** takes to reach (and potentially affect) a **receptor** (Environment Canada 2003, Health Canada 2004). Exposure pathways include:

- **Physical Mechanisms** – e.g. contaminated soil being washed into a nearby creek and potentially affecting sediment dwelling organisms.
- **Human Behavior** – e.g. contaminated material moved by people from one location to another; contaminated soil on a truck's tires or people bring PCB containing oils home to be burned in cooking fires.
- **Biological Mechanisms** – e.g. dermal contact with contaminated soil, ingestion of contaminated food, inhalation of dust, etc.



An exposure pathway is the route a chemical hazard takes to reach a receptor

Source: *Hatfield Consultants*
(click to enlarge)

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↔ view problem formulation [conceptual diagrams](#)

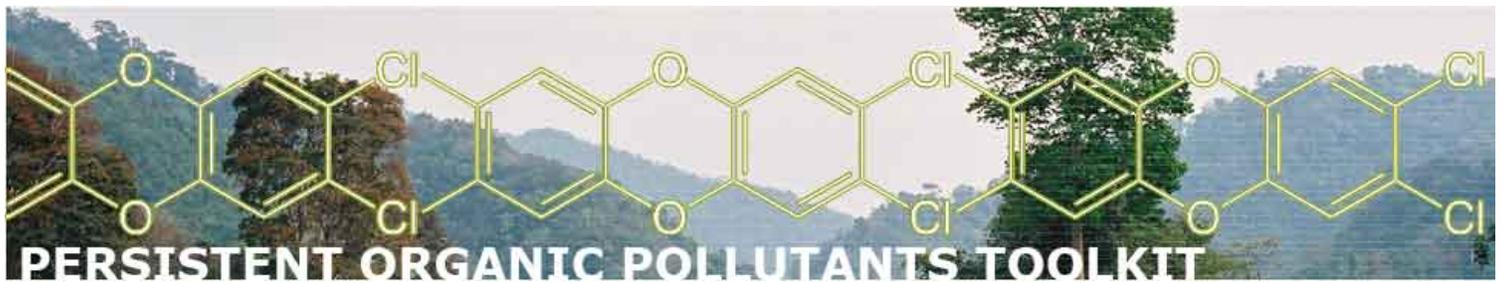
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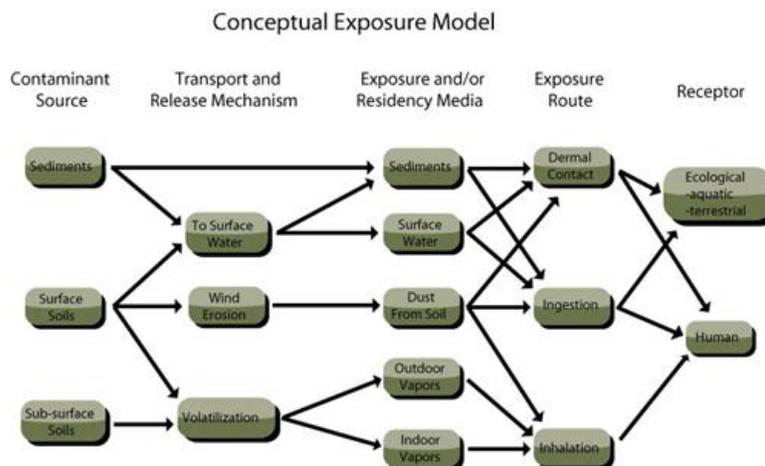
Conceptual Site Exposure Model

A conceptual site exposure model should be created to illustrate and **explain how the contaminant sources, exposure pathways and receptors are linked together to form the potential for health risk**. This step should involve a **simple diagram and short description of these interrelationships**. The conceptual exposure model provides the **basis for developing the mathematical exposure model and estimation of health risks**.

Example 1: schematic picture of conceptual exposure model.



Example 2: schematic flow diagram of conceptual exposure model.



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Exposure and Toxicity Analysis

After the Problem Formulation is the **Exposure and Toxicity Analysis**. The **Exposure and Toxicity Analysis quantifies exposure (or dose) as well as the toxic potency of the chemical hazard(s)**. Information from the Exposure and Toxicity Analysis goes directly into the last step of the risk assessment, called a **risk characterization** (Health Canada 2004).

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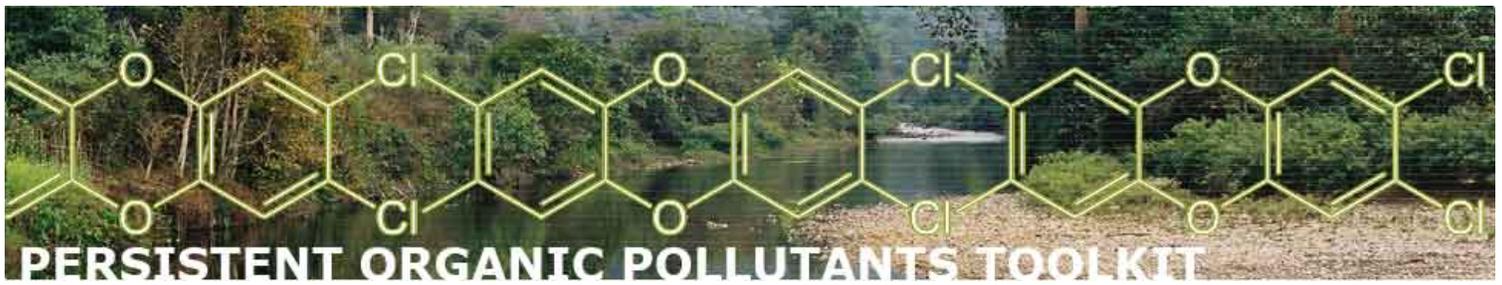
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Risk Characterization

The final component of the risk assessment is the risk characterization. The risk characterization integrates the information from the exposure and toxicity analysis to derive a **quantitative estimate of human health risk**.

This is normally accomplished by calculating an exposure ratio called a **Hazard Quotient (HQ) for threshold contaminants or an Incremental Life-time Cancer Risk (ILCR) for non-threshold contaminants**.

If unacceptable risks are predicted at the risk characterization stage, the risk assessment process is repeated using additional data, refined assumptions and more complex equations and/or risk management measures are taken.

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[Hazard Quotient](#)

[Incremental lifetime cancer risk](#)

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Hazard Quotient

For [threshold contaminants](#), the risk to a human receptor from being exposed to a chemical via a single pathway can be expressed as an **Exposure Ratio, commonly called a Hazard Quotient (HQ)**.

$$HQ = \frac{\text{Dose Rate}}{\text{Reference Dose}} = \frac{\text{Exposure Concentration}}{\text{Reference Concentration}} = \frac{\text{Estimated Dose } (\mu\text{g/kg/day})}{\text{Tolerable Daily Intake } (\mu\text{g/kg/day})}$$

The reference dose is interpreted as the Tolerable Daily Intake (**TDI**; mg/kg/day).

A Hazard Index (HI) is the sum of HQ's for all pathways and similar toxic effects. A HQ of <0.2 for any given pathway is often considered acceptable; while an HI of <1.0 is considered acceptable (Health Canada 2004).

For purposes of preliminary quantitative risk assessment, **exposures associated with a HQ = 0.2 will be deemed negligible**. This is consistent with the CCME (1996) and the OMEE (1996a), and has become accepted as common practice (Health Canada 2004). If the HQ is greater than 0.2, or the HI is greater than 1, the risk assessment should either be refined and/or risk management measures should be taken.

Online Tool

You can calculate a Hazard Quotient using the [Risk Calculation Tools](#).

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[information about \[Threshold contaminants\]\(#\)](#)

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Incremental Lifetime Cancer Risk

For carcinogens, the estimated exposure will be multiplied by the appropriate **Cancer Slope Factor or Unit Risk** to derive an estimate of the potential Incremental Lifetime Cancer Risk (ILCR) associated with that exposure (Health Canada 2004).

The ILCR is derived as:

$$\text{ILCR} = \text{Exposure } (\mu\text{g/kg/d}) \times \text{Cancer Slope Factor } (\mu\text{g/kg/day})^{-1}$$

Where pathway-specific slope factors or unit risks exist, the risks via inhalation and the risks via oral + dermal exposure should be estimated separately. In other cases, the cancer risks posed by simultaneous inhalation/dermal/oral exposure can be estimated.

Cancer risks will be considered “essentially negligible” where the estimated ILCR is 1-in-100,000 ($\leq 1 \times 10^{-5}$) (Health Canada 2004).

If the ILCR is greater than 1×10^{-5} , the risk assessment should either be refined and/or risk management measures should be taken.

Online Tool

You can calculate an ILCR value using the [Risk Calculation Tools](#).

More Details

↔ information about [Non-Threshold Contaminants](#)

Next Steps

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A brief comparison of Human Health and Ecological Risk Assessments

This page outlines the similarities and differences between Ecological and Human Health Risk Assessments

Similarities

- Similar structure – both types of risk assessments consist of a problem formulation, hazard assessment, exposure assessment and risk characterization.
- Both can use models to estimate exposure to receptors (i.e., human health risk assessment assess exposure to humans via ingestion, inhalation and dermal contact, while **ecological risk assessments may assess exposure to terrestrial animals via ingestion**).
- **Both compare measured environmental chemical concentrations against environmental quality guidelines in the problem formulation phase.**

Differences

- **Human health risk assessment are usually concerned with protecting life of individual human beings. Ecological risk assessment are more concerned about populations of organisms (i.e., individual species of fish in a river) or ecological integrity (i.e., will the types of species living in the river change over time?)**
- Ecological risk assessment exposure models are like human health risk assessment exposure models, but only consider ingestion pathways to terrestrial animals. The same models also consider foraging range for animals. Foraging range not considered in human health risk assessments.
- Larger reliance on signs of impacts (i.e., toxicity studies, measurements of fish health, aquatic insect surveys, visible abnormalities on animals or discoloration of plants).

Next steps

➔ start the [Human Health Risk Assessment Training Module](#)

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Risk Assessment Problem Formulation Worksheet Tool

The purpose of this worksheet is to help the risk assessor identify the components of the risk assessment. Use this worksheet to think through all parts of the problem formulation ([see the problem formulation training module](#)). A filled-in version of this worksheet should be included in your Risk Assessment report.

Potential land uses of the site

In this section, briefly describe the past, current and planned future land use of the site. Several categories are provided because some sites may have had more than one land use. Having this background information will help identify the types of chemical hazards possibly present at the site, the potential receptors and the pathways linking the chemical hazards with the receptors.

	Potential?	Explanation
Agricultural	<input type="checkbox"/>	<input type="text"/>
Residential/urban parkland	<input type="checkbox"/>	<input type="text"/>
Commercial	<input type="checkbox"/>	<input type="text"/>
Industrial - indoors	<input type="checkbox"/>	<input type="text"/>
Industrial - outdoors	<input type="checkbox"/>	<input type="text"/>
Recreational	<input type="checkbox"/>	<input type="text"/>
Other	<input type="checkbox"/>	<input type="text"/>

Humans receptors and pathways

Use this section to identify and describe the receptors (human and non-human) and pathways possibly present at the site.

Human receptor group

	On Site?	Explanation
General public or resident	<input type="checkbox"/>	<input type="text"/>
Employees	<input type="checkbox"/>	<input type="text"/>
School Children	<input type="checkbox"/>	<input type="text"/>
Other	<input type="checkbox"/>	<input type="text"/>

Human receptor ages

	On Site?	Explanation
Infant	<input type="checkbox"/>	<input type="text"/>
Toddler	<input type="checkbox"/>	<input type="text"/>

Child	<input type="checkbox"/>	
Teen	<input type="checkbox"/>	
Adult	<input type="checkbox"/>	
Other	<input type="checkbox"/>	

Human exposure pathways

	<i>On Site?</i>	<i>Explanation</i>
Accidental ingestion of soil	<input type="checkbox"/>	
Inhalation of soil particles	<input type="checkbox"/>	
Inhalation of indoor contaminant vapours	<input type="checkbox"/>	
Inhalation of outdoor contaminant vapours	<input type="checkbox"/>	
Ingestion of drinking water	<input type="checkbox"/>	
Dermal contact with soil	<input type="checkbox"/>	
Dermal contact with water	<input type="checkbox"/>	
Ingestion of contaminated food	<input type="checkbox"/>	

Non-human receptors and pathways

Non-human receptors

	<i>On Site?</i>	<i>Explanation</i>
Aquatic Animals	<input type="checkbox"/>	
Terrestrial Animals	<input type="checkbox"/>	
Plants	<input type="checkbox"/>	

Non-human exposure pathways

	<i>On Site?</i>	<i>Explanation</i>
Aquatic organism exposed via water	<input type="checkbox"/>	
Aquatic organism exposed via food	<input type="checkbox"/>	
Aquatic organism exposed via sediments	<input type="checkbox"/>	

	<i>On Site?</i>	<i>Explanation</i>
Terrestrial organism exposed via water	<input type="checkbox"/>	
Terrestrial organism exposed via food	<input type="checkbox"/>	
Terrestrial organism exposed via soil	<input type="checkbox"/>	

	<i>On Site?</i>	<i>Explanation</i>
	<input type="checkbox"/>	

Plants exposed via surface water or groundwater

Plants exposed via soils

Contaminant concentrations (highest measured concentrations)

To fill-in this section:

- replace the column header "Chemical A, Chemical B, Chemical C..etc.", with a chemical contaminant name.
- enter the maximum concentration of that contaminant measured in the applicable row. Note that the concentration units of the concentration entered must match those shown in the first column.
- The maximum contaminant concentration can then be compared to environmental quality guidelines. If the measured maximum concentration exceeds the guidelines, then the contaminant is a Contaminant of Concern.

	Chemical A	Chemical B	Chemical C	Chemical D
Soil (mg/kg)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Groundwater - source (mg/L)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Drinking water (mg/L)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Bathing/swimming water (mg/L)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Outdoor air - particulate (mg/m ³)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Root vegetables (mg/kg wet weight)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Other vegetables (mg/kg wet weight)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Fish (mg/kg wet weight)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Wild game (mg/kg wet weight)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

[add column](#)

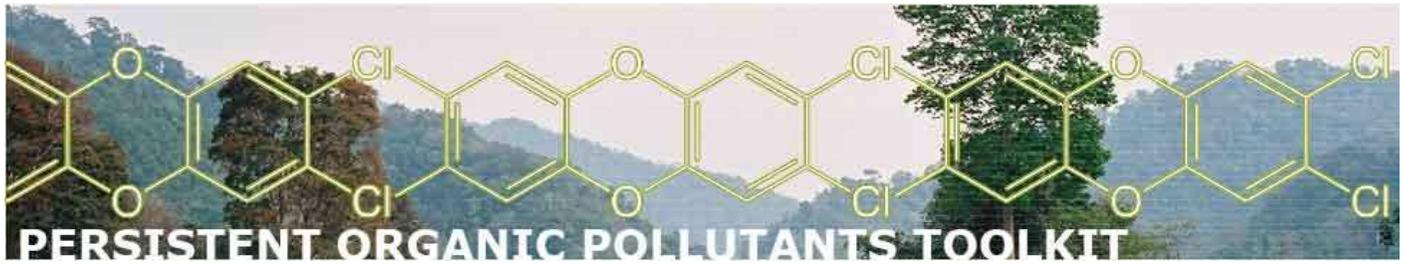
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- [Cambodia Outside Employee](#)
- [Cambodia Adult Local Resident](#)
- [Cambodia Child Local Resident](#)

Hazard Quotient Risk Calculation Tool

Use this tool to calculate the Hazard Quotient (HQ) for a threshold contaminant ([see training material for more information](#)).
 If a Hazard Quotient greater than 0.2 is calculated, a risk to human health potentially exists.

▼ Accidental Soil Ingestion Dose Calculation [\(hide\)](#)

$$\text{Dose}_{\text{SoilIngestion}} = \frac{C_s \times IR_s \times AF_{\text{GIT}} \times D_{\text{Hours}} \times D_{\text{Days}} \times D_{\text{Weeks}} \times D_{\text{Years}}}{BW \times 16 \times 365 \times LE} = \text{[Input Box]}$$

- | | |
|--|---|
| $C_s =$ <input type="text"/> mg/kg | Concentration of contaminant in soils, usually 90th percentile or maximum. |
| $IR_s =$ <input type="text"/> kg/day | Accidental soil ingestion rate for adult (see Table: Receptor Characteristics) |
| $AF_{\text{GIT}} =$ <input type="text"/> (unitless) | Absorption Factor for the gastrointestinal tract. Use a value of 1 for a preliminary risk assessment (as recommended by Health Canada, 2004) |
| $D_{\text{Hours}} =$ <input type="text"/> # of hours | Hours per-day with exposure (0 - 16) (16 is the maximum assumed awake hours per day) |
| $D_{\text{Days}} =$ <input type="text"/> # of days in a week | Days in a week with exposure (0 - 7) |
| $D_{\text{Weeks}} =$ <input type="text"/> # of weeks in a year | Weeks in a year with exposure (0 - 52) |
| $D_{\text{Years}} =$ N/A years | Number of years of exposure (not used for non-carcinogens) |
| $BW =$ <input type="text"/> kg | Body Weight of Receptor (see Table: Receptor Characteristics) |
| $LE =$ N/A years | Life expectancy. The number of year that the person is likely to live. Not used for non-carcinogens. |

Note: dusts can be trapped by the nose and later ingested, soils can also be ingested from hands if hands are not regularly washed or if dusts deposit on foods eaten at the site.

▼ Water Ingestion Dose Calculation [\(hide\)](#)

$$\text{Dose}_{\text{WaterIngestion}} = \frac{C_w \times IR_w \times AF_{\text{GIT}} \times D_{\text{Days}} \times D_{\text{Weeks}} \times D_{\text{Years}}}{BW \times 365 \times LE} = \text{[Input Box]}$$

- | | |
|--|---|
| $C_w =$ <input type="text"/> mg/kg | Concentration of contaminant in drinking water, usually 90th percentile or maximum. |
| $IR_w =$ <input type="text"/> L/day | Water ingestion rate for adult (see Table: Receptor Characteristics - adapted from Health Canada, 2004) |
| $AF_{\text{GIT}} =$ <input type="text"/> (unitless) | Absorption Factor for the gastrointestinal tract. Use a value of 1 for a preliminary risk assessment (as recommended by Health Canada, 2004) |
| $D_{\text{Days}} =$ <input type="text"/> # of days in a week | Days in a week with exposure (0 - 7) |
| $D_{\text{Weeks}} =$ <input type="text"/> # of weeks in a year | Weeks in a year with exposure (0 - 52) |
| $D_{\text{Years}} =$ N/A years | Number of years of exposure (not used for non-carcinogens) |
| $BW =$ <input type="text"/> kg | Body Weight of Receptor (see Table: Receptor Characteristics) |
| $LE =$ N/A years | Life expectancy. The number of year that the person is likely to live. Not used for non-carcinogens. |

▼ Food Ingestion Dose Calculation [\(hide\)](#)

$$\text{Dose}_{\text{FoodIngestion}} = \frac{C_{\text{food}} \times IR_{\text{food}} \times AF_{\text{GIT}} \times D_{\text{Days}} \times D_{\text{Years}}}{BW \times 365 \times LE} = \text{[Input Box]}$$

- | | |
|--|--|
| $C_{\text{food}} =$ <input type="text"/> mg/kg | Concentration of contaminant in soils, usually 90th percentile or maximum. |
| $IR_{\text{food}} =$ <input type="text"/> kg/day | Food ingestion rate (see Table: Receptor Characteristics) |

$AF_{GIT} =$ (unitless) Absorption Factor for the gastrointestinal tract. **Use a value of 1 for a preliminary risk assessment** (as recommended by Health Canada, 2004)

$DDays =$ # of days in a year food item is ingested Number of days in a year food from the site is ingested (0 - 365)

$DYears =$ N/A years Number of years of exposure (not used for non-carcinogens)

$BW =$ kg Body Weight of Receptor (see Table: [Receptor Characteristics](#))

$LE =$ N/A years Life expectancy. The number of year that the person is likely to live. Not used for non-carcinogens.

Note: If multiple animals are consumed from the site (i.e., crabs, chickens, snakes, snails etc.), the dose from eating these items should be calculated separately using the same formula.

▼ Inhalation of contaminated particles Dose Calculation ([hide](#))

$$Dose_{ParticleInhalation} = \frac{(C_s \times P_{Air} \times IR_A \times AF_{Inh} \times DHours \times DDays \times DWeeks \times DYears)}{BW \times 365 \times LE \times 10e^{-9}} =$$

$C_s =$ mg/kg Concentration of contaminant in soils, usually 90th percentile or maximum.

$P_{Air} =$ $\mu g/m^3$ Concentration of particles in the air. **Use 0.76 $\mu g/m^3$** for typical conditions as per USEPA (1992)

$IR_A =$ $m^3/hour$ Inhalation rate (see Table: [Receptor Characteristics](#))

$AF_{Inh} =$ (unitless) Absorption Factor for the lungs. **Use a value of 1** for a preliminary risk assessment (as recommended by Health Canada, 2004)

$DHours =$ # of hours in a day Hours of a day with exposure (0 - 24)

$DDays =$ # of days in a week Days in a week with exposure (0 - 7)

$DWeeks =$ # of weeks in a year Weeks in a year with exposure (0 - 52)

$DYears =$ N/A years Number of years of exposure (not used for non-carcinogens)

$BW =$ kg Body Weight of Receptor (see Table: [Receptor Characteristics](#))

$LE =$ N/A years Life expectancy. The number of year that the person is likely to live. Not used for non-carcinogens.

Note: the concentration of respirable dust may be much higher in certain circumstances. Examples would include locations next to dirt roads and inside workshops or storage facilities.

▼ Dermal contact with contaminated soil Dose Calculation ([hide](#))

$$Dose_{DermalContact} = \frac{(C_s \times SA_H \times SL_H \times AF_{Skin} \times EF \times DDays \times DWeeks \times DYears)}{BW \times 365 \times LE} =$$

$C_s =$ mg/kg Concentration of contaminant in soils, usually 90th percentile or maximum.

$SA_H =$ cm^2 Surface area of hands (assumes only hands are exposed, see Table: [Receptor Characteristics](#))

$SL_H =$ kg/cm^2 - event Soil loading to exposed skin (see Table: [Receptor Characteristics](#)). For a given area of skin, hands will be exposed to a greater mass of contaminated soil than skin on other parts of the body. Health Canada (2004) give hands a 10x greater loading (SLH) than other skin covered portions of the body.

$AF_{Skin} =$ (unitless) Absorption Factor for the skin (see Table: [Relative Dermal Absorption Factors](#))

$EF =$ events/day number of dermal exposures per day

$DDays =$ # of days in a week Days in a week with exposure (0 - 7)

$DWeeks =$ # of weeks in a year Weeks in a year with exposure (0 - 52)

$DYears =$ N/A years Number of years of exposure (not used for non-carcinogens)

$BW =$ kg Body Weight of Receptor (see Table: [Receptor Characteristics](#))

$LE =$ N/A years Life expectancy. The number of year that the person is likely to live. Not used for non-carcinogens.

Note: For a given area of skin, hands will be exposed to a greater mass of contaminated soil than skin on other parts of the body. Health Canada (2004) give hands a 10x greater loading (SLH) than other skin covered portions of the body. Please refer to Exposure Table.

Calculation of Hazard Quotient:

$$HQ = \frac{(Dose_{SoilIngestion} + Dose_{WaterIngestion} + Dose_{FoodIngestion} + Dose_{ParticleInhalation} + Dose_{DermalContact})}{TDI} =$$

$TDI =$ mg/kg - day Tolerable daily intake (TDI) (see Table: [Health Canada's TDIs](#), or [US](#)

[EPA's TDIs](#)).

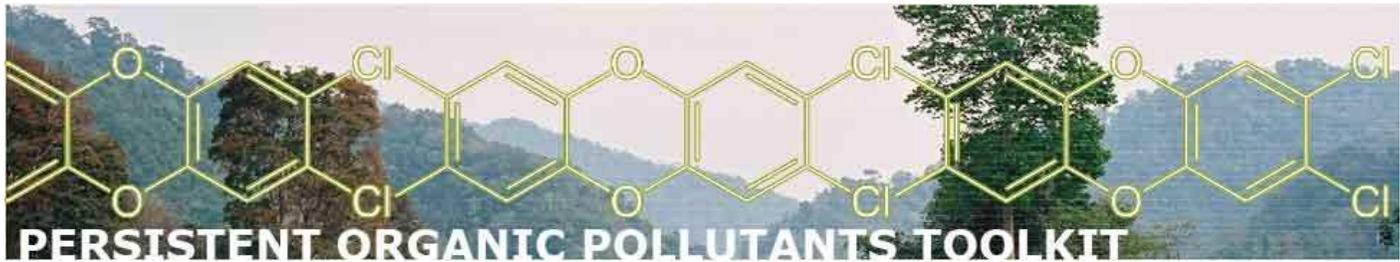
DoseSoilIngestion = mg/kg - day
DoseWaterIngestion = mg/kg - day
DoseFoodIngestion = mg/kg - day
DoseParticleInhalation = mg/kg - day
DoseDermalContact = mg/kg - day
Total Dose = mg/kg - day

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Incremental Lifetime Cancer Risk (ILCR) Risk Calculation Tool

Use this tool to calculate the Incremental Lifetime Cancer Risk (ILCR) for a non-threshold contaminant (see [training material for more information](#)).

If an Incremental Lifetime Cancer Risk greater than 1×10^{-5} is calculated, a cancer risk potentially exists.

Accidental Soil Ingestion Dose Calculation [\(hide\)](#)

$$\text{Dose}_{\text{SoilIngestion}} = \frac{(C_s \times IR_s \times AF_{\text{GIT}} \times D_{\text{Hours}} \times D_{\text{Days}} \times D_{\text{Weeks}} \times D_{\text{Years}})}{BW \times 16 \times 365 \times LE} = \text{[Input Box]}$$

- C_s = mg/kg Concentration of contaminant in soils, usually 90th percentile or maximum.
- IR_s = kg/day Accidental soil ingestion rate for adult (see Table: [Receptor Characteristics](#))
- AF_{GIT} = (unitless) Absorption Factor for the gastrointestinal tract. **Use a value of 1** for a preliminary risk assessment (as recommended by Health Canada, 2004)
- D_{Hours} = # of hours Hours per-day with exposure (0 - 16) (16 is the maximum assumed awake hours per day)
- D_{Days} = # of days in a week Days in a week with exposure (0 - 7)
- D_{Weeks} = # of weeks in a year Weeks in a year with exposure (0 - 52)
- D_{Years} = years Number of years of exposure
- BW = kg Body Weight of Receptor (see Table: [Receptor Characteristics](#) - adapted from Health Canada, 2004)
- LE = years Life expectancy. The number of year that the person is likely to live.

Note: dusts can be trapped by the nose and later ingested, soils can also be ingested from hands if hands are not regularly washed or if dusts deposit on foods eaten at the site.

Water Ingestion Dose Calculation [\(hide\)](#)

$$\text{Dose}_{\text{WaterIngestion}} = \frac{(C_w \times IR_w \times AF_{\text{GIT}} \times D_{\text{Days}} \times D_{\text{Weeks}} \times D_{\text{Years}})}{BW \times 365 \times LE} = \text{[Input Box]}$$

- C_w = mg/kg Concentration of contaminant in drinking water, usually 90th percentile or maximum.
- IR_w = L/day Water ingestion rate for adult (see Table: [Receptor Characteristics](#) - adapted from Health Canada, 2004)
- AF_{GIT} = (unitless) Absorption Factor for the gastrointestinal tract. **Use a value of 1** for a preliminary risk assessment (as recommended by Health Canada, 2004)
- D_{Days} = # of days in a week Days in a week with exposure (0 - 7)
- D_{Weeks} = # of weeks in a year Weeks in a year with exposure (0 - 52)
- D_{Years} = years Number of years of exposure
- BW = kg Body Weight of Receptor (see Table: [Receptor Characteristics](#))
- LE = years Life expectancy. The number of year that the person is likely to live. Not used for non-carcinogens.

Food Ingestion Dose Calculation [\(hide\)](#)

$$\text{Dose}_{\text{FoodIngestion}} = \frac{(C_{\text{food}} \times IR_{\text{food}} \times AF_{\text{GIT}} \times D_{\text{Days}} \times D_{\text{Years}})}{BW \times 365 \times LE} = \text{[Input Box]}$$

- C_{food} = mg/kg Concentration of contaminant in soils, usually 90th percentile or maximum.
- IR_{food} = kg/day Food ingestion rate (see Table: [Receptor Characteristics](#))

AF _{GIT} = <input type="text"/> (unitless)	Absorption Factor for the gastrointestinal tract. Use a value of 1 for a preliminary risk assessment (as recommended by Health Canada, 2004)
D _{Days} = <input type="text"/> # of days in a year food item is ingested	Number of days in a year food from the site is ingested (0 - 365)
D _{Years} = <input type="text"/> years	Number of years of exposure (not used for non-carcinogens)
BW = <input type="text"/> kg	Body Weight of Receptor (see Table: Receptor Characteristics - adapted from Health Canada, 2004)
LE = <input type="text"/> years	Life expectancy. The number of year that the person is likely to live. Not used for non-carcinogens.

 *Note: If multiple animals are consumed from the site (i.e., crabs, chickens, snakes, snails etc.), the dose from eating these items should be calculated separately using the same formula.*

▼ Inhalation of contaminated particles Dose Calculation ([hide](#))

$$\text{Dose}_{\text{ParticleInhalation}} = \frac{(C_s \times P_{\text{Air}} \times IR_A \times AF_{\text{Inh}} \times D_{\text{Hours}} \times D_{\text{Days}} \times D_{\text{Weeks}} \times D_{\text{Years}})}{BW \times 365 \times LE \times 10e^{-9}} = \text{[input box]}$$

C _s = <input type="text"/> mg/kg	Concentration of contaminant in soils, usually 90th percentile or maximum.
P _{Air} = <input type="text"/> µg/m ³	Concentration of particles in the air. Use 0.76µg/m³ for typical conditions as per USEPA (1992)
IR _A = <input type="text"/> m ³ /hour	Inhalation rate (see Table: Receptor Characteristics)
AF _{Inh} = <input type="text"/> (unitless)	Absorption Factor for the lungs. Use value of 1 for a preliminary risk assessment (as recommended by Health Canada, 2004)
D _{Hours} = <input type="text"/> # of hours in a day	Hours of a day with exposure (0 - 24)
D _{Days} = <input type="text"/> # of days in a week	Days in a week with exposure (0 - 7)
D _{Weeks} = <input type="text"/> # of weeks in a year	Weeks in a year with exposure (0 - 52)
D _{Years} = <input type="text"/> years	Number of years of exposure
BW = <input type="text"/> kg	Body Weight of Receptor (see Table: Receptor Characteristics)
LE = <input type="text"/> years	Life expectancy. The number of year that the person is likely to live. Not used for non-carcinogens.

 *Note: the concentration of respirable dust may be much higher in certain circumstances. Examples would include locations next to dirt roads and inside workshops or storage facilities.*

▼ Dermal contact with contaminated soil Dose Calculation ([hide](#))

$$\text{Dose}_{\text{DermalContact}} = \frac{(C_s \times SA_H \times SL_H \times AF_{\text{Skin}} \times EF \times D_{\text{Days}} \times D_{\text{Weeks}} \times D_{\text{Years}})}{BW \times 365 \times LE} = \text{[input box]}$$

C _s = <input type="text"/> mg/kg	Concentration of contaminant in soils, usually 90th percentile or maximum.
SA _H = <input type="text"/> cm ²	Surface area of hands (assumes only hands are exposed, see Table: Receptor Characteristics)
SL _H = <input type="text"/> kg/cm ² - event	Soil loading to exposed skin (see Table: Receptor Characteristics). For a given area of skin, hands will be exposed to a greater mass of contaminated soil than skin on other parts of the body. Health Canada (2004) give hands a 10x greater loading (SLH) than other skin covered portions of the body.
AF _{Skin} = <input type="text"/> (unitless)	Absorption Factor for the skin (see Table: Relative Dermal Absorption Factors)
EF = <input type="text"/> events/day	number of dermal exposures per day
D _{Days} = <input type="text"/> # of days in a week	Days in a week with exposure (0 - 7)
D _{Weeks} = <input type="text"/> # of weeks in a year	Weeks in a year with exposure (0 - 52)
D _{Years} = <input type="text"/> years	Number of years of exposure
BW = <input type="text"/> kg	Body Weight of Receptor (see Table: Receptor Characteristics)
LE = <input type="text"/> years	Life expectancy. The number of year that the person is likely to live. Not used for non-carcinogens.

 *Note: For a given area of skin, hands will be exposed to a greater mass of contaminated soil than skin on other parts of the body. Health Canada (2004) give hands a 10x greater loading (SLH) than other skin covered portions of the body. Please refer to Exposure Table.*

Total Calculation of Incremental Lifetime Cancer Risk:

$$\text{ILCR} = ((\text{Dose}_{\text{SoilIngestion}} + \text{Dose}_{\text{WaterIngestion}} + \text{Dose}_{\text{FoodIngestion}}) \times \text{SF}_{\text{Oral}}) + (\text{Dose}_{\text{ParticleInhalation}} \times \text{SF}_{\text{Inhalation}}) + (\text{Dose}_{\text{DermalContact}} \times \text{SF}_{\text{Dermal}}) = \text{[input box]}$$

SF_{Oral} = (kg day)/mg Oral slope factor for contaminant (see Table: [Health Canada's Slope](#))

SF_{Inhalation} =

(kg day)/mg

[Factors](#), or [US EPA's Slope Factors](#)).

Oral slope factor for contaminant (see Table: [Health Canada's Slope Factors](#), or [US EPA's Slope Factors](#)).

SF_{Dermal} =

(kg day)/mg

Dermal slope factor for contaminant (see Table: [Health Canada's Slope Factors](#), or [US EPA's Slope Factors](#)). **Where SF_{Dermal} is not available, use the SF_{Oral} value.**

Dose_{SoilIngestion} = mg/(kg day)

Dose_{WaterIngestion} = mg/(kg day)

Dose_{FoodIngestion} = mg/(kg day)

Dose_{ParticleInhalation} = mg/(kg day)

Dose_{DermalContact} = mg/(kg day)

Total Dose = mg/(kg day)

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