


MASARYK UNIVERSITY
Brno – Czech Republic RECETOX


 Research centre
for toxic compounds
in the environment

HUMAN HEALTH RISK ASSESSMENT

Pavel Čupr


-Risk assessment methodology
(basic introduction of this approach, main equations,
exposure model, important WEB data sources)

Research group
Human Exposure Assessment and Risks




Human Health Risk Assessment
– exposure assessment tool for risk prediction

-Important tool for better interpretation
of contamination levels
in the environment (food, air, etc).



Human health risk assessment is the process to estimate the probability of adverse health effects in humans who may be exposed to chemicals/stressors in contaminated environmental media (soil, water, air, food), now or in the future (prospective and retrospective).

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Lecture: RISK ASSESSMENT METHODOLOGY

HAZARD / RISK

Hazards and Risk

- Hazard - something with the potential to cause harm
- Risk - the likelihood that harm will occur



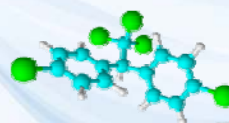
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...explanation of important terminology and differences

RISK ASSESSMENT METHODOLOGY

HAZARD –

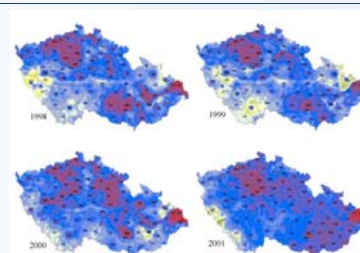
'A Hazard is a potential source of harm or adverse health effect on a person or persons'.



RISK -

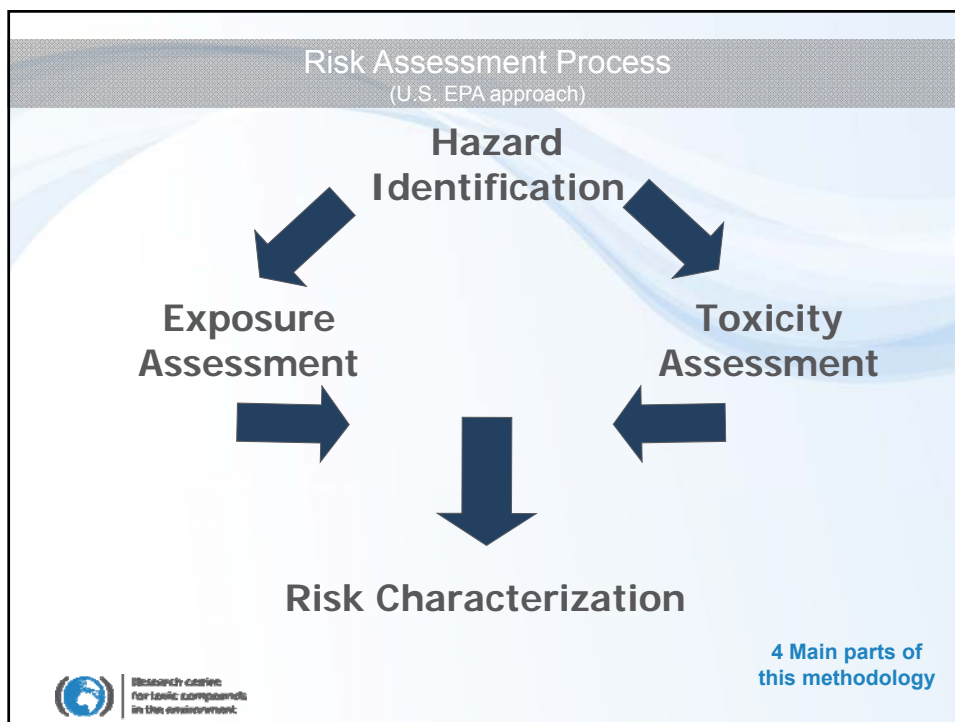
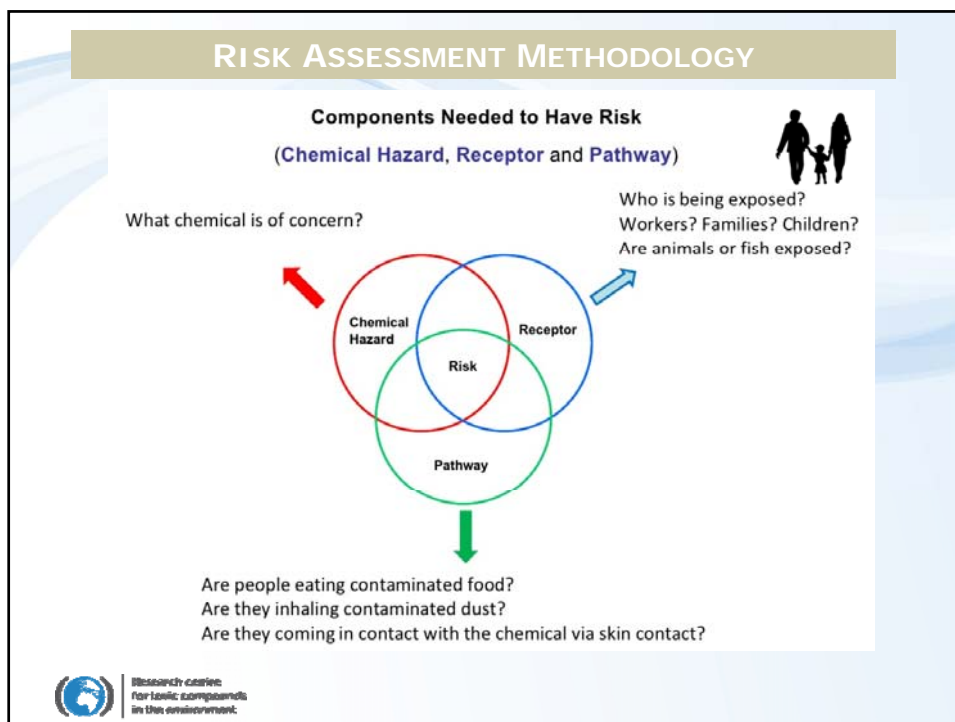


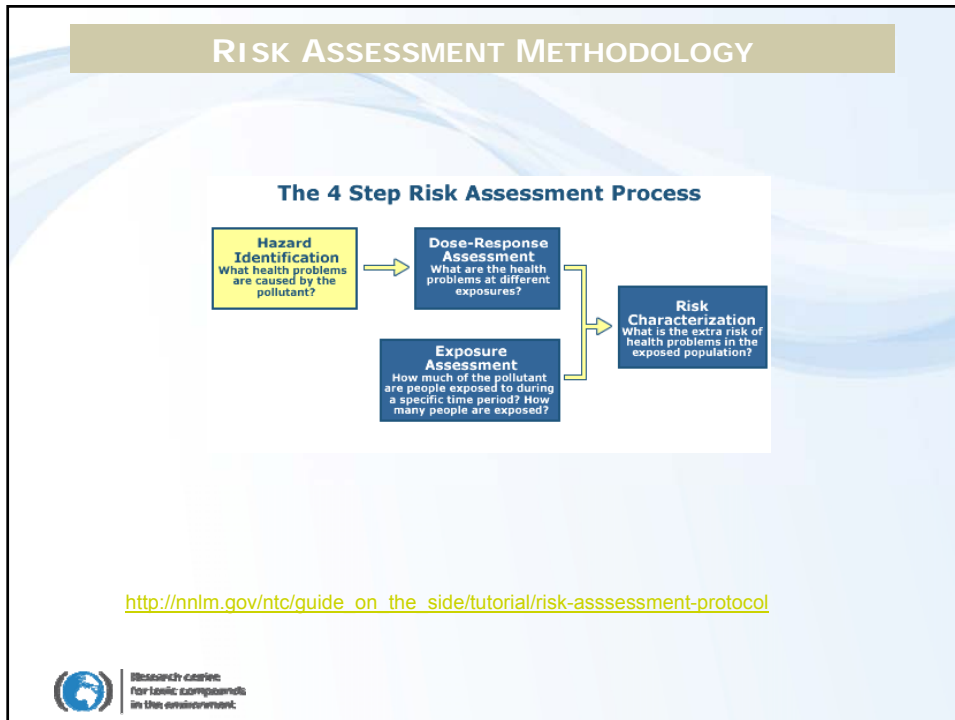
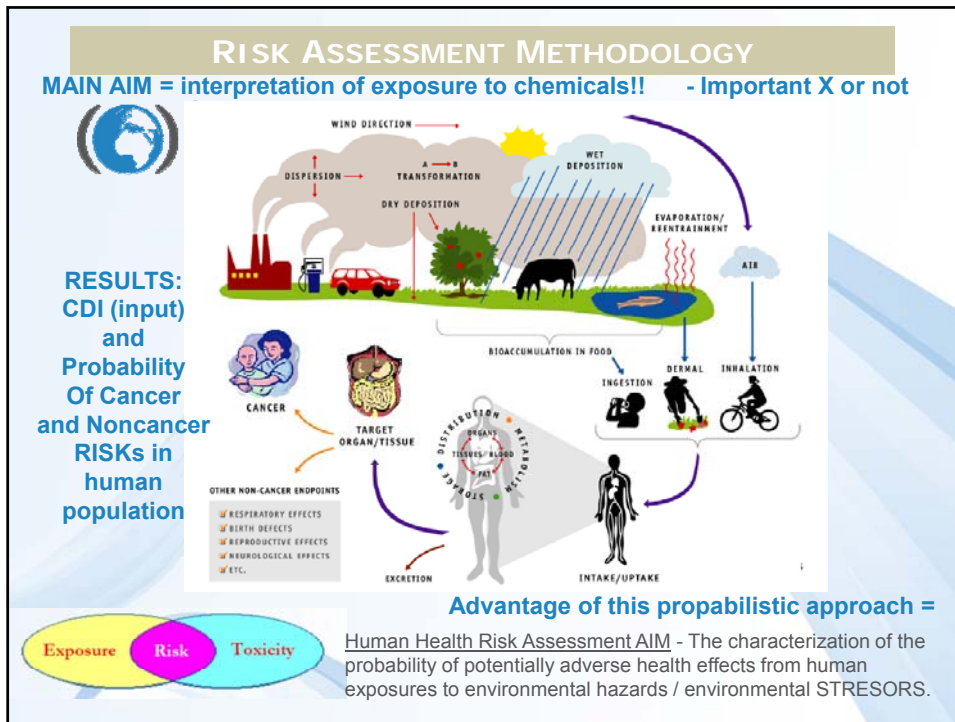
'Risk is the likelihood that a person may be harmed or suffers adverse health effects if exposed to a hazard'.



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...practical definition





Step 1: Hazard Identification

The first step in the RA is the Hazard identification. The hazard identification defines the problem (problem formulation), identifies the components like:

- chemical concentrations of pollutants in selected matrices (from evaluated sites)
 - obtained by sampling (air, drink. water, food..etc)
- To identify available data about toxicity of these identified chemicals
- To develop model of how chemical may move through environment (to the next exposure media)



AFCEE, 2002



© Vermont DPS, 2000



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Step 2: Exposure Assessment

What is Exposure?

Exposure is contact made between a chemical, physical, or biological agent and the outer boundary of an organism.

Exposure Assessment is the determination or estimation (qualitative or quantitative) of the magnitude, frequency, duration, and route of exposure.

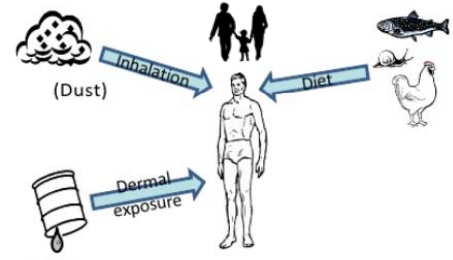
!! Without exposure there can be no toxicity.



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Step 2: Exposure Assessment

- ➡ - to quantify the exposure of the receptor (selected population) to chemicals via a given pathway.
- ➡ - to predict the daily intake of a contaminant by selected individual pathways as total chronic daily intake CDI (mg/kg/day).
- ➡ - CDI can be calculated by using of contaminant concentrations in environmental samples (water, food-diet, sediments, soils, air..) and human behavior information (=exposure parameters = from exposure surveys, questionnaires approaches,...).
- ➡ Alternatively, total exposure (POPs,...) can be estimated by collecting human tissue samples for chemical analysis (i.e., blood and breast milk samples) by using if toxikokinetic modeling.




Dose Reconstruction for Exposure Assessment

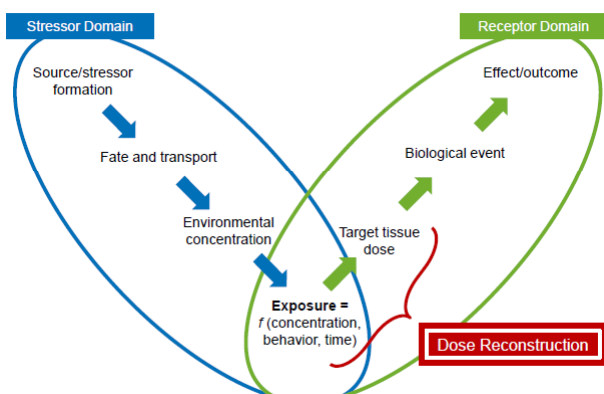
Exposure scenarios

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Step 2: Exposure Assessment

Dose reconstruction uses pharmacokinetic (PK) models to estimate exposure from body burden data collected by biomonitoring






Exposure = $f(\text{concentration, behavior, time})$

Dose Reconstruction

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Step 2: Exposure Assessment




- **Who is Exposed?**
 - Adult, Child, Special Populations
- **How Are They Exposed?**
 - Ingestion, Inhalation, Skin Contact
- **What is the Concentration of Chemical to Which They are Exposed?**
 - ng.l⁻¹,...
- **How Often Are They Exposed?**
 - Days per year, Number of years

= Prediction of Exposure Scenarios and Exposure factors

Exposure = f (Concentration, Time, Behavior)

What is Dose? • **Dose:** The amount of substance available for interactions with metabolic processes or biologically significant receptors after crossing the outer boundary of an organism





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Putting it all together (general exposure equation)
– exposure parameters

$$\text{Intake Dose } CDI (\text{mg/kg} - \text{day}) = \frac{C \times CR \times EF \times ED}{BW \times AT}$$

- Intake Equation for Drinking Water Example
 - C= Chemical Concentration (Obtain from sampling)
 - CR= Contact Rate (...2 liters water/day)
 - EF= Exposure Frequency (350 days/year)
 - ED= Exposure Duration (30 years)
 - BW=Body Weight (70 kg.)
 - AT= Averaging Time (10,950 days)

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What Are Exposure Factors?

- **Exposure factors** are quantifications of human behaviors and characteristics that affect exposure to environmental contaminants
 - Examples: body weight, inhalation rates, ingestion rates for specific types of food



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Step 2: Exposure Assessment

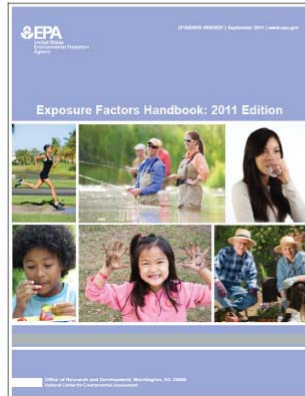
- Exposure factors provide information on human behavior and characteristics that allow us to quantitatively estimate exposure and dose
- EPA's recommended values for exposure factors can be found in EPA's *Exposure Factor's Handbook*
 - Updated 2011 version of EFH now available
- Assessor must consider data variability



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Sources of Updated Exposure Factor Data

Which value for selected exposure parameter we can use?

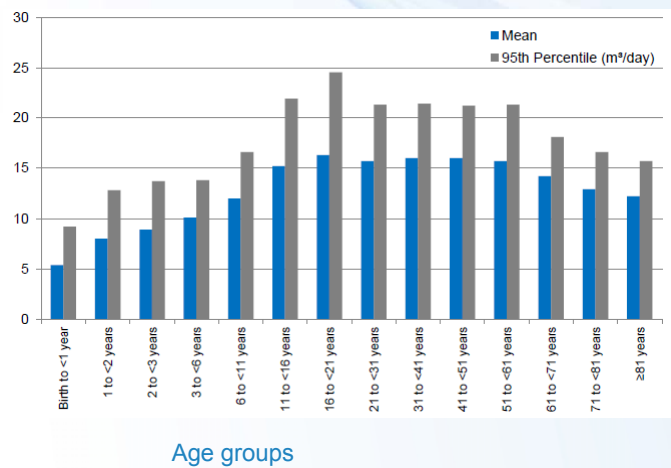


All exposure factors and parameters!!!!
<http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=20563>

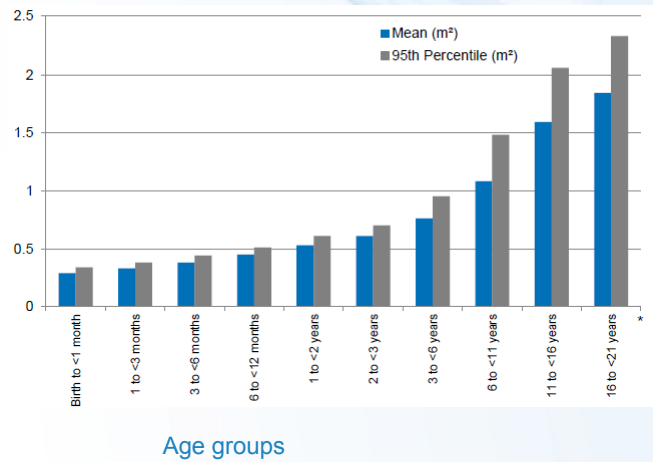
- All population statistics



Recommendations for Inhalation Rates (Long-Term)



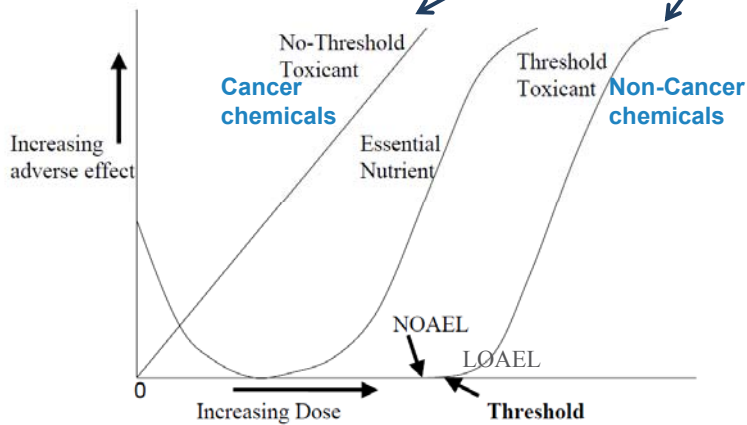
Recommendations for Total Skin Surface Area for Dermal Exposure

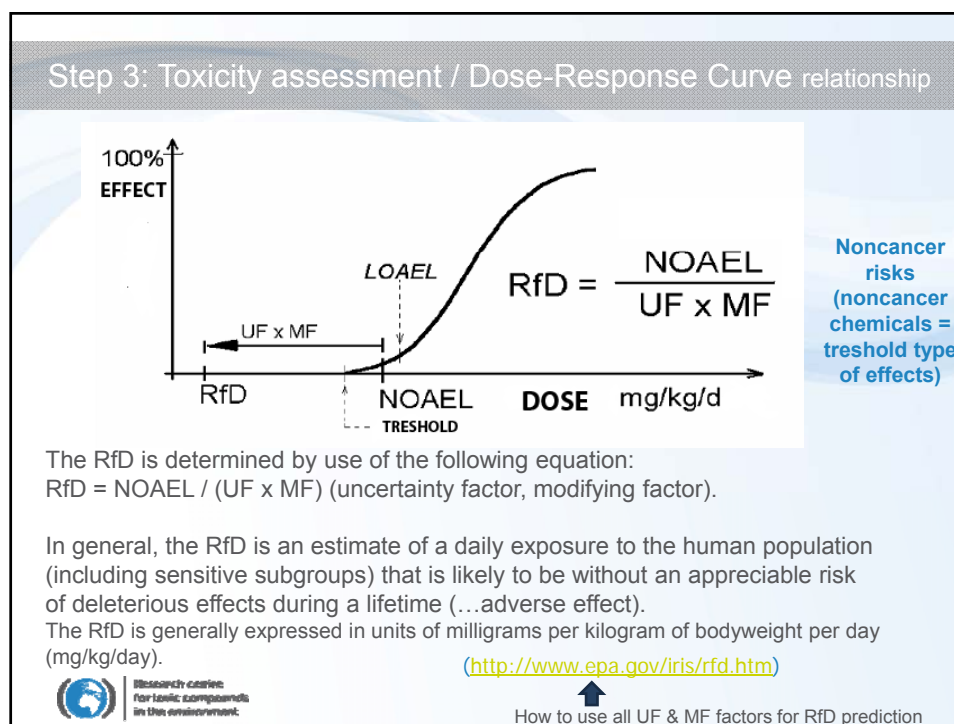
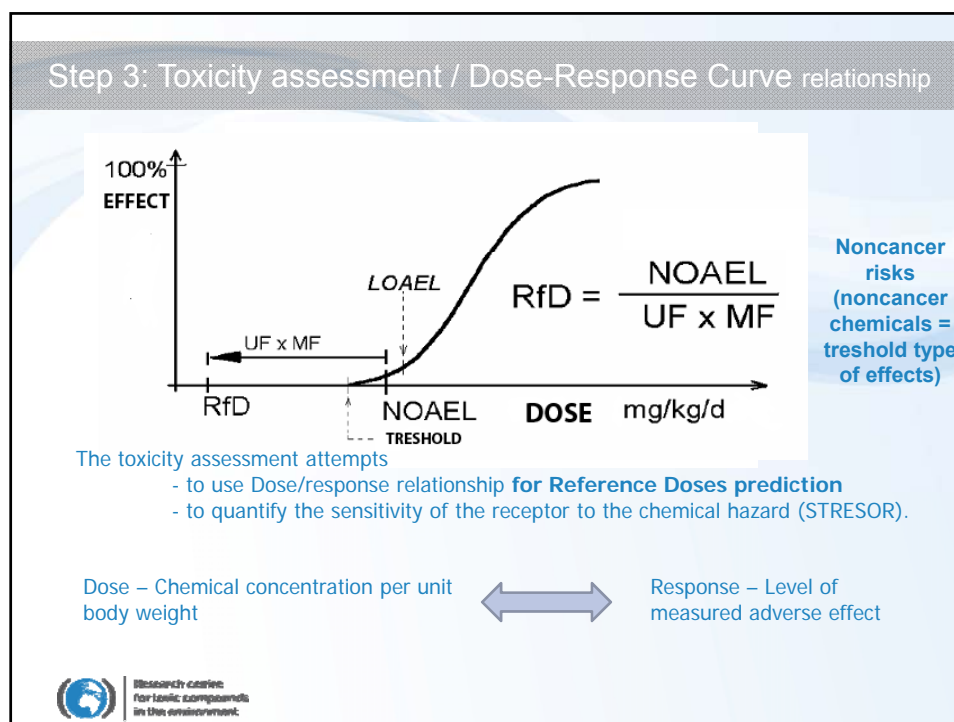


Step 3: Toxicity assessment / Dose-Response Curve relationship

TWO different types of toxic chemicals

Dose-Effect Curves





Exposure equations - Exposure scenarios

http://www.epa.gov/oswer/riskassessment/raqsa/pdf/raqs_ch6.3.pdf

DRINKING WATER INGESTION

$$CDI = CW \times IR \times EF \times ED / (BW \times AT)$$

CDI	chronic daily intake (mg.kg ⁻¹ .day ⁻¹)
CW	concentration of chemical in water (mg.l ⁻¹)
IR	ingestion rate of water (l.day ⁻¹)
EF	exposure frequency (den.year ⁻¹)
ED	exposure duration (years)
BW	body weight (kg)
AT	averaging time (days)
	for non-carcinogenic: ED (years) x 365 days.year ⁻¹
	for carcinogenic: 70 years x 365 days.year ⁻¹



WATER INGESTION – SWIMMING OR SHOWERING/BATHING

$$CDI = CW \times CR \times ET \times EF \times ED / (BW \times AT)$$

CDI	chronic daily intake (mg.kg ⁻¹ .day ⁻¹)
CW	concentration of chemical in water (mg.l ⁻¹)
CR	ingestion rate of water (l.hod ⁻¹)
ET	exposure time (hours.day ⁻¹)
EF	exposure frequency (den.year ⁻¹)
ED	exposure duration (years)
BW	body weight (kg)
AT	averaging time (days)
	for non-carcinogenic: ED (years) x 365 days.year ⁻¹
	for carcinogenic: 70 years x 365 days.year ⁻¹



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Exposure equations - Exposure scenarios

DERMAL CONTACT WITH WATER

$$ADD / LADD = CW \times SA \times Kp \times ET \times EF \times ED \times CF / (BW \times AT)$$

ADD/LADD	average daily dose (mg.kg ⁻¹ .day ⁻¹)
CW	concentration of chemical in water (mg.l ⁻¹)
SA	skin surface area available for contact (cm ²)
Kp	permeability coefficient (cm.hour ⁻¹)
ET	exposure time (hours.day ⁻¹)
EF	exposure frequency (den.year ⁻¹)
ED	exposure duration (years)
CF	converting factor (0,001 l.cm ⁻³)
BW	body weight (kg)
AT	averaging time (days)
	for non-carcinogenic: ED (years) x 365 days.year ⁻¹
	for carcinogenic: 70 years x 365 days.year ⁻¹



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Exposure equations - Exposure scenarios

SOIL OR DUST INGESTION

$$CDI = CS \times IR \times CF \times FI \times EF \times ED / (BW \times AT)$$

CDI	chronic daily intake (mg.kg ⁻¹ .day ⁻¹)
CS	concentration of chemical in soil (mg.kg ⁻¹)
IR	ingestion rate of soil (mg.day ⁻¹)
CF	converting factor (10 ⁻⁶ kg.mg ⁻¹)
FI	fraction ingested from source (0 - 1, unitless)
EF	exposure frequency (den.year ⁻¹)
ED	exposure duration (years)
BW	body weight (kg)
AT	averaging time (days)
	for non-carcinogenic: ED (years) x 365 days.year ⁻¹
	for carcinogenic: 70 years x 365 days.years ⁻¹



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Exposure equations - Exposure scenarios

DERMAL CONTACT WITH SOIL

$$ADD / LADD = CS \times CF \times SA \times AF \times ABSd \times EF \times ED / (BW \times AT)$$

ADD/LADD	average daily dose (mg.kg ⁻¹ .day ⁻¹)
CS	concentration of chemical in soil (mg.kg ⁻¹)
CF	converting factor (10 ⁻⁶ kg.mg ⁻¹)
SA	skin surface area available for contact (cm ² or cm ² .event ⁻¹)
AF	soil to skin adherence factor (mg.cm ⁻²)
ABSd	absorption factor (0 - 1, unitless)
EF	exposure frequency (den.year ⁻¹)
ED	exposure duration (years)
BW	body weight (kg)
AT	averaging time (days)
	for non-carcinogenic: ED (years) x 365 days.year ⁻¹
	for carcinogenic: 70 years x 365 days.years ⁻¹





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Exposure equations - Exposure scenarios

CONTAMINATED AIR INHALATION

$$CDI = CA \times IR \times ET \times EF \times ED / (BW \times AT)$$


CDI chronic daily intake (mg.kg⁻¹.day⁻¹)
 CA concentration of chemical in air (mg.m⁻³)
 IR inhalation rate (m³.hour⁻¹)
 ET exposure time (hours.day⁻¹)
 EF exposure frequency (den.year⁻¹)
 ED exposure duration (years)
 BW body weight (kg)
 AT averaging time (days)
 for non-carcinogenic: ED (years) x 365 days.year⁻¹
 for carcinogenic: 70 years x 365 days.years⁻¹

Step 4: Risk Characterization – to predict final RISK

RISK ASSESSMENT METHODOLOGY – noncancer risk

[C] concentrations → **Exposure scenario models** → **Internal dose** / **Chronic Daily Intake**



Chemical 1

Chemical 2

Chemical 3

...

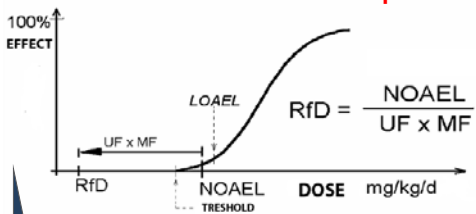
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$$RISK = CDI / RfD$$


Interpretation:
RISK > 1 Significant risk
RISK < 1 Acceptable risk

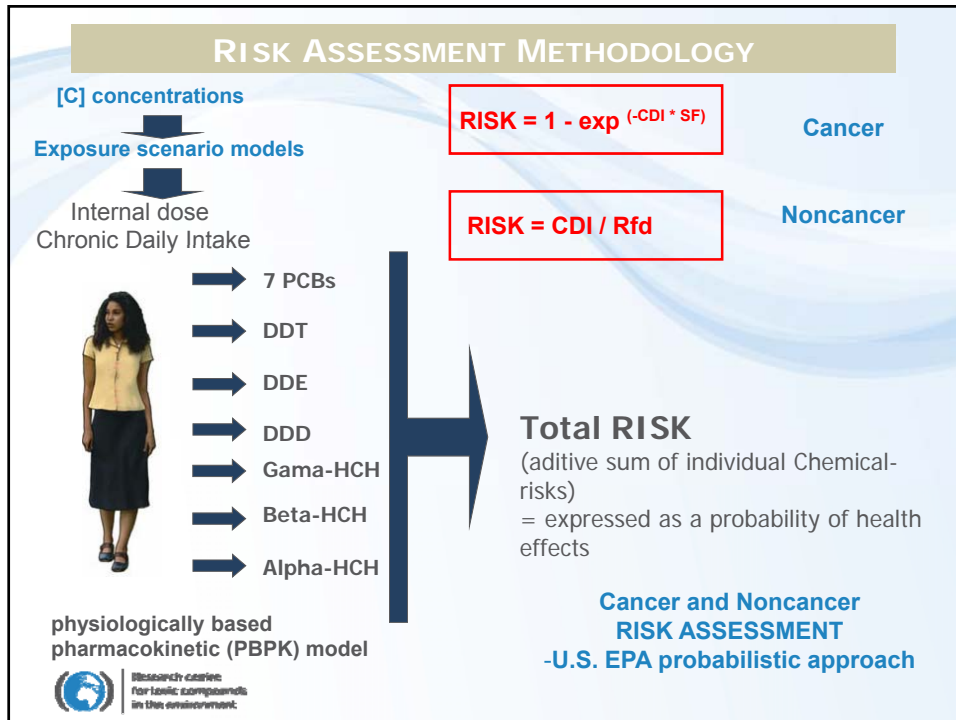
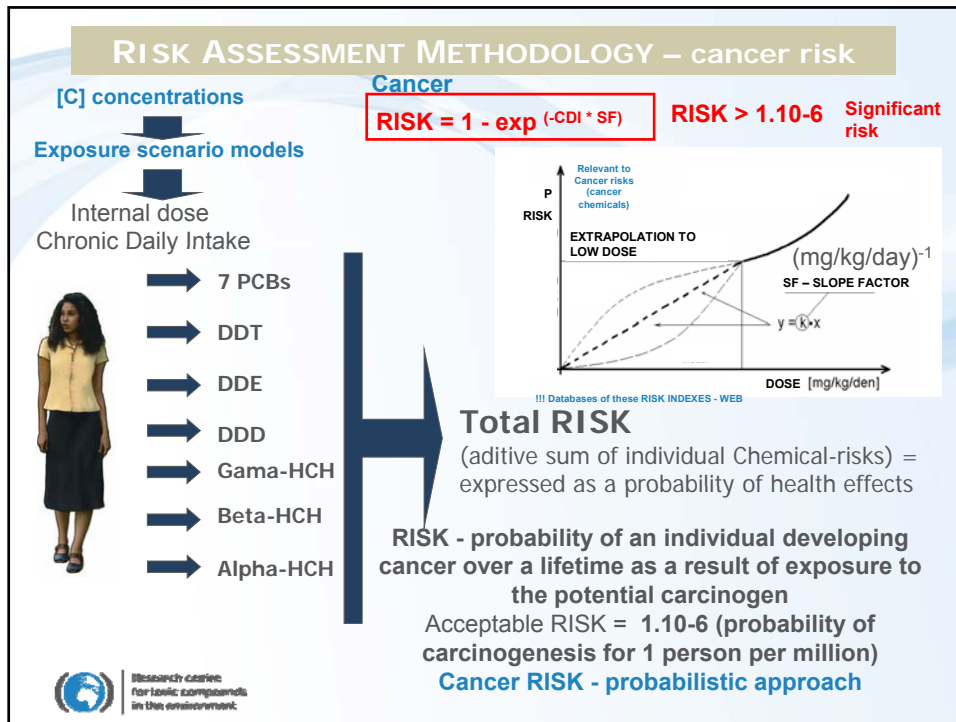


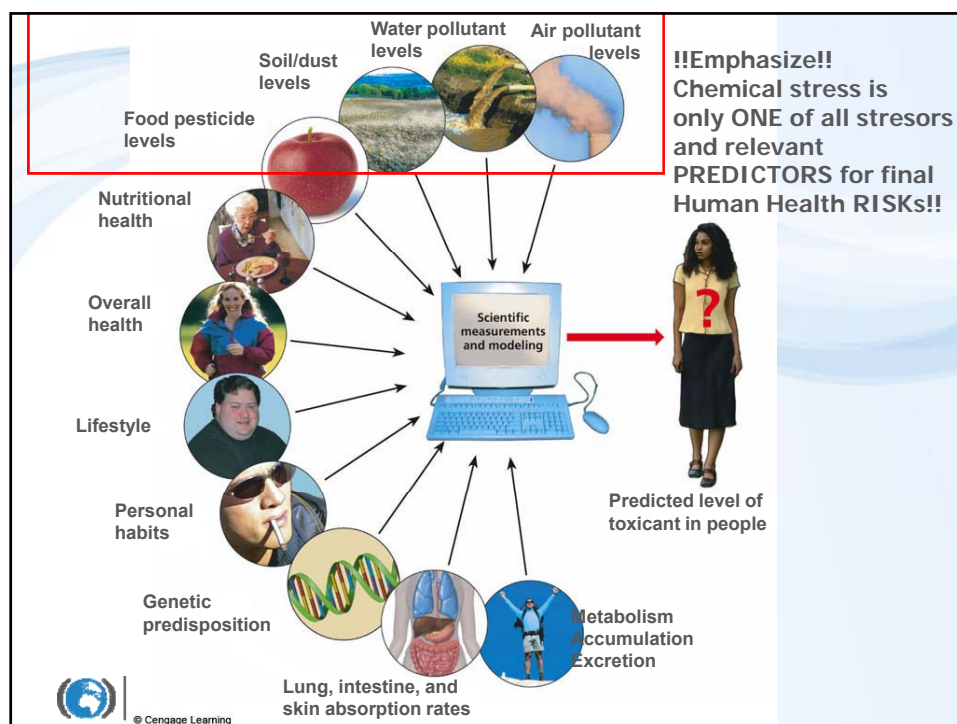
Total RISK
(aditive sum of individual Chemical-risks)

Noncancer RISK ASSESSMENT
RfD – reflect the worst type of noncancer health outcomes from these exposure

RfD is only for noncancer (threshold) chemicals!







RISK ASSESSMENT METHODOLOGY

Detail description of Risk assessment method:

1) Quantitative Environmental Risk Analysis for Human Health – detail description of Risk assessment method with many exercises - case studies.

(Robert A. Fjeld et al., 2007)

Robert A. Fjeld; Norman A. Eisenberg; Compton, K. L. Eds.) (2007): *Quantitative Environmental Risk Analysis for Human Health*. Chapter 9 Exposure Assessment, chapter 10 Basic Human Toxicology, chapter 11 Dose–Response and Risk Characterization, (pp 199-314). John Wiley & Sons, Inc. Hoboken, New Jersey.

Download from IS.MUNI.CZ: (teaching materials):

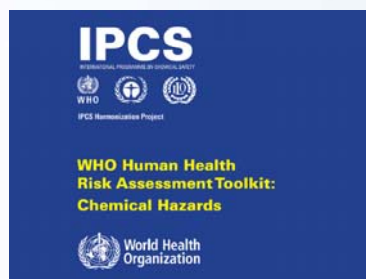
https://is.muni.cz/auth/el/1431/jaro2015/C2003/um/55931844/Field_2007.pdf

2) Risk Assessment Guidance for Superfund, (U.S. EPA)

[Part A](#) (1989) [Part B](#) (1991) [Part C](#) (1991) [Part D](#) (2001) [Part E](#) (2004) [Part F](#) (2009)

3) WHO toolkit:

[DOWNLOAD](#)



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RISK ASSESSMENT METHODOLOGY

Where we can get these informations
SOURCES ? DATABASES?

Source of important toxicological data:
RfD, Slope Factor, ...
<http://www.epa.gov/reg3hwmd/risk/index.htm>

example: 309-00-2
<http://www.epa.gov/iris>

<http://toxnet.nlm.nih.gov/>

NIH U.S. National Library of Medicine **TOXNET** TOXICOLOGY DATA NETWORK

Mobile | Help | FAQs | TOXNET Fact Sheet | Training Manual & Schedule

Share

Welcome to TOXNET

Your resource for searching databases on toxicology, hazardous chemicals, environmental health, and toxic releases

SEARCH TOXNET Search all or select specific databases

BROWSE ADVANCED SEARCH

e.g. benzene, endocrine disruptor **ALL DATABASES** Search

TOXNET Databases

MOST VISITED BY TOXNET USERS

HSDB
Hazardous Substances Data Bank. Peer-reviewed toxicology data for over 5,000 hazardous chemicals

TOXLINE
4 million references to literature on biochemical, pharmacological, physiological, and toxicological effects of drugs and other chemicals

ChemIDplus
Database of chemical substances

Environmental Health & Toxicology
Resources on environmental health and toxicology
Visit Site

Did you know

There is a guide to choosing a database

Which Resource Should I Use can help you pick the right resource for your search.

More FAQs

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<http://www.inchem.org/>

IPCS INCHEM - Windows Internet Explorer

Search: Úvraty Zobraziť Dobré položky História Favority

Dobré položky | IPCS INCHEM | CHLORANILE-F (DSC)

Stránka Zabezpečení História

IPCS International Programme on Chemical Safety

INCHEM

Chemical Safety Information from Intergovernmental Organizations

Search options:

Full-text Search
Example: Benzene **Search**

Chemical Identity Search
CAS Number:
Example: 100-80-3
or
Chemical Name or Synonym:
Example: Benzene **Search**
Advanced Search

Browse content using links below:

- Concise International Chemical Assessment Documents (CICADs)
- Environmental Health Criteria (EHC) Monographs
- Harmonization Project Publications
- Health and Safety Guides (HSGs)

Rapid access to internationally peer reviewed information on chemicals commonly used throughout the world, which may also occur as contaminants in the environment and food. It consolidates information from a number of intergovernmental organizations whose goal it is to assist in the sound management of chemicals.

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<http://cfpub.epa.gov/ecotox/> **ECOTOX Database**

U.S. ENVIRONMENTAL PROTECTION AGENCY
ECOTOX Database
 Search: All EPA This Area Go
 You are here: [EPA Home](#) > [ECOTOX](#)

Quick Database Query Advanced Database Query

Welcome to ECOTOX Release 4.0. The ECOTOX (ECOTOXology) database provides single chemical toxicity information for aquatic and terrestrial life.

The Advanced Database Query option is now available.

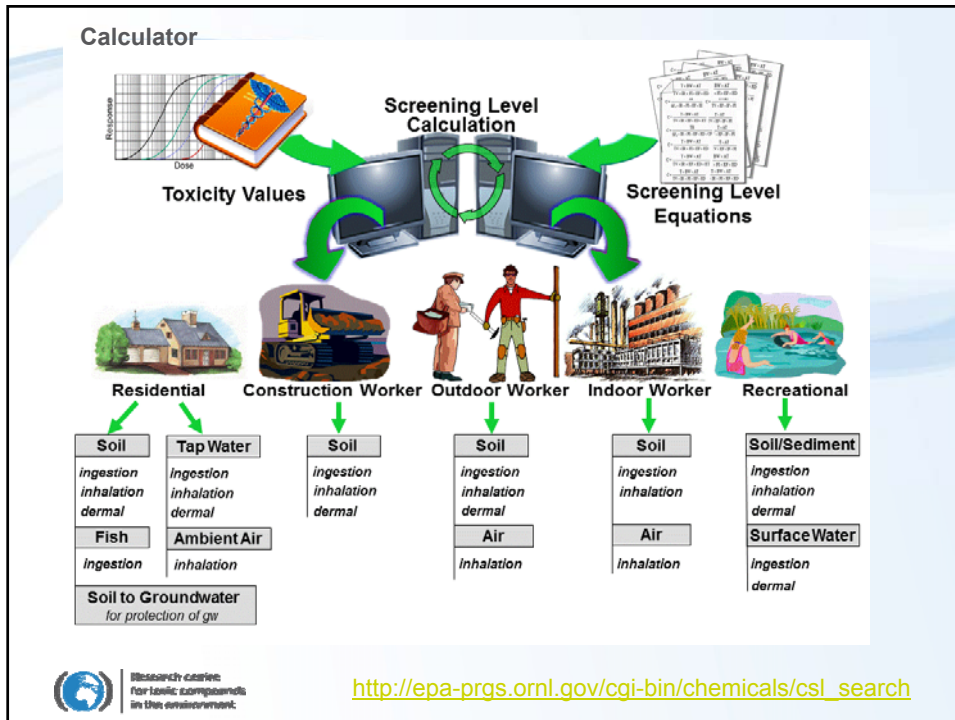
Please review the following items before using ECOTOX Release 4.0

- You will need to turn off pop-up blockers for this site. You will have limited access to the features of the site if you do not allow popups.
- Please view all updated features in the [Recent Additions page](#)

If you are new to the ECOTOX web site, please consult the ECOTOX "Help Center" prior to conducting a search.

You should consult the original scientific paper to ensure an understanding of the context of the data retrieved from the ECOTOX database.


[Office of Research and Development](#) | [National Health and Environmental Effects Research Laboratory](#) | [Mid-Continent Ecology Division](#)
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 Last updated on Tuesday, April 09th, 2008.
http://cfpub.epa.gov/ecotox/ecotox_home.dfm
[0208_04_09](#)



SOFTWARE

Risk-Related Software

<http://www.riskworld.com/risk-software/>





Up-todate list

US EPA soft:


<http://www.weblakes.com/products/iraph/protocol.html>

commercial

Spatial Analysis and Decision Assistance (SADA)

Freeware



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SOFTWARE

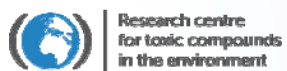
<http://www.sadaproject.net/download.html>



The screenshot shows a web browser window displaying the SADA project website. The browser's address bar shows the URL <http://www.sadaproject.net/download.html>. The website features a navigation menu on the left with links such as 'SADA Main Page', 'Free Downloads', 'Visualization', 'Data Exploration', 'Geospatial Analysis', 'Risk Assessment', 'Decision Analysis', 'Cost Benefit Analysis', 'Secondary Sampling', 'Technical Support', 'Documentation', 'Coming Soon', 'Training', 'Applications', 'Join SADA User Group', 'RAIS', 'Bugs', and 'Email Us'. The main content area is titled 'Spatial Analysis and Decision Assistance' and includes a 'Home Page' section, a 'Download Now' section with a version update notice, 'Training Opportunities', and a 'Quick Overview' section. The 'Quick Overview' section describes SADA as free software that integrates tools for environmental assessment, including visualization, geospatial analysis, statistical analysis, human health risk assessment, ecological risk assessment, cost/benefit analysis, sampling design, and decision analysis. It also lists target users: Statisticians, Risk Assessors, and GIS Users.

Thank you for your attention

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