Adjusting Monitoring, Assessment and Remediation Measures to the Real Exposure Scenarios

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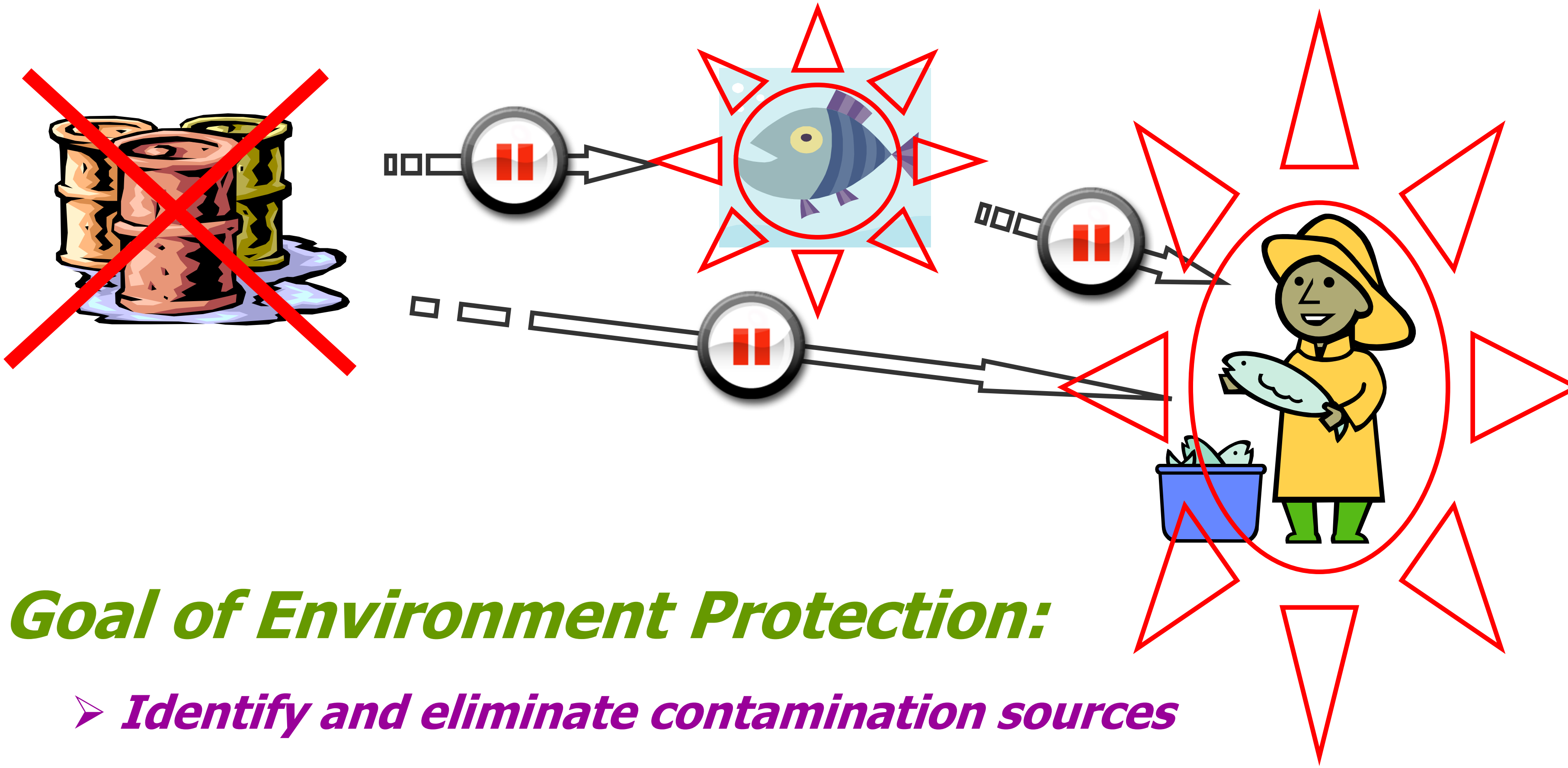
Introduction

The usual approach for setting the concentration limits for monitoring or remediation of contaminated sites is to adopt already existing criteria, either given by national regulations or by international standards.

However, the real objective of any remediation is not to reach the required limits/indicators but to minimize the risks for human health, ecosystems, or for local development in general.

Introduction

The remediation plan must be based on risk assessment which takes into consideration site specific exposure scenarios. These scenarios must assess the natural migration pathways, potential technological leakages, and location and behavior of potential recipients. Especially in the case of dioxins the main danger relates to the food chain: contaminated sediments → contaminated fish or poultry → endangered people → transfer from mother to the child.



Goal of Environment Protection:

- *Identify and eliminate contamination sources*
- *Recognize and interrupt exposure pathways*
- *Protect environment and people*

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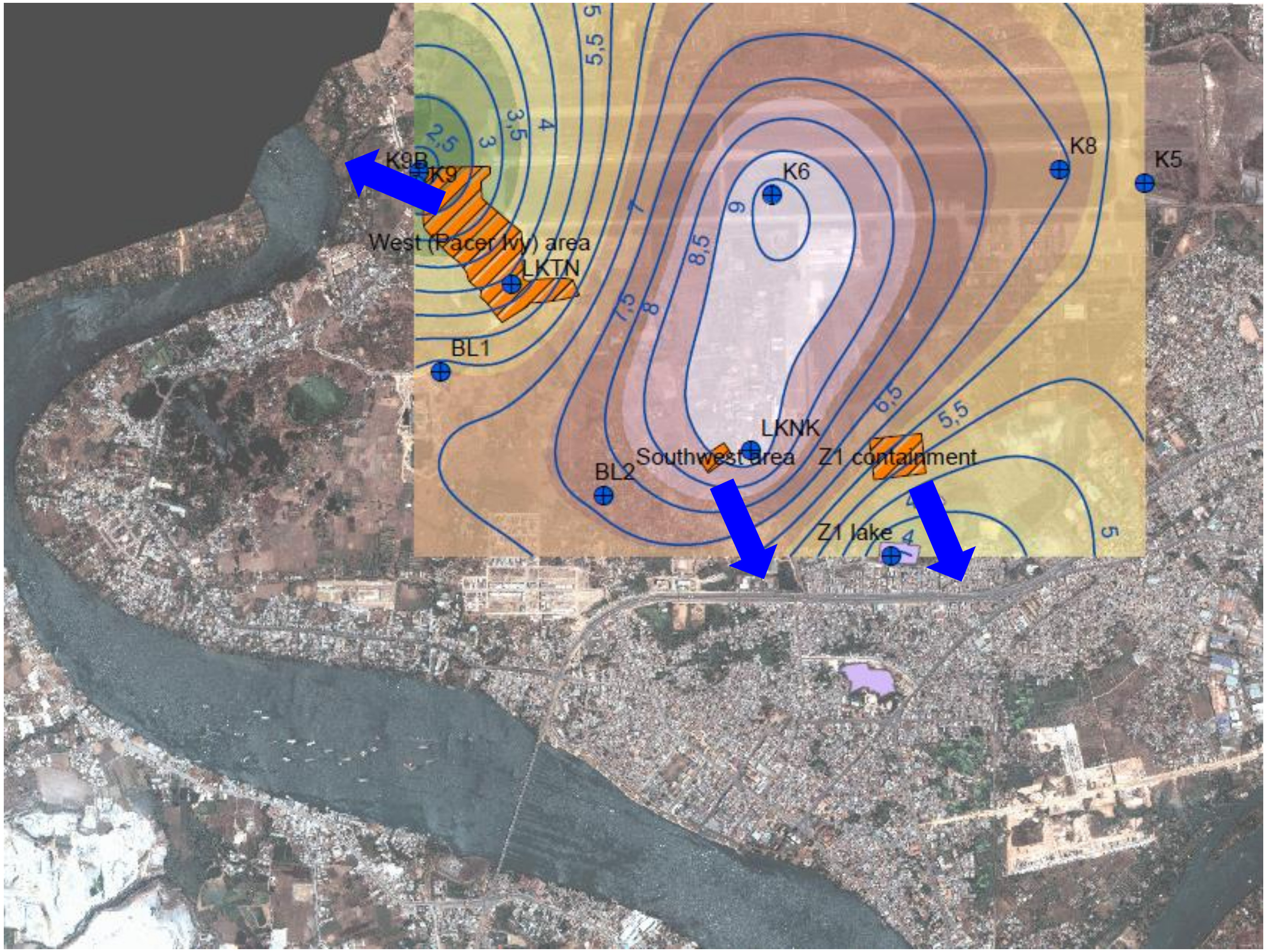
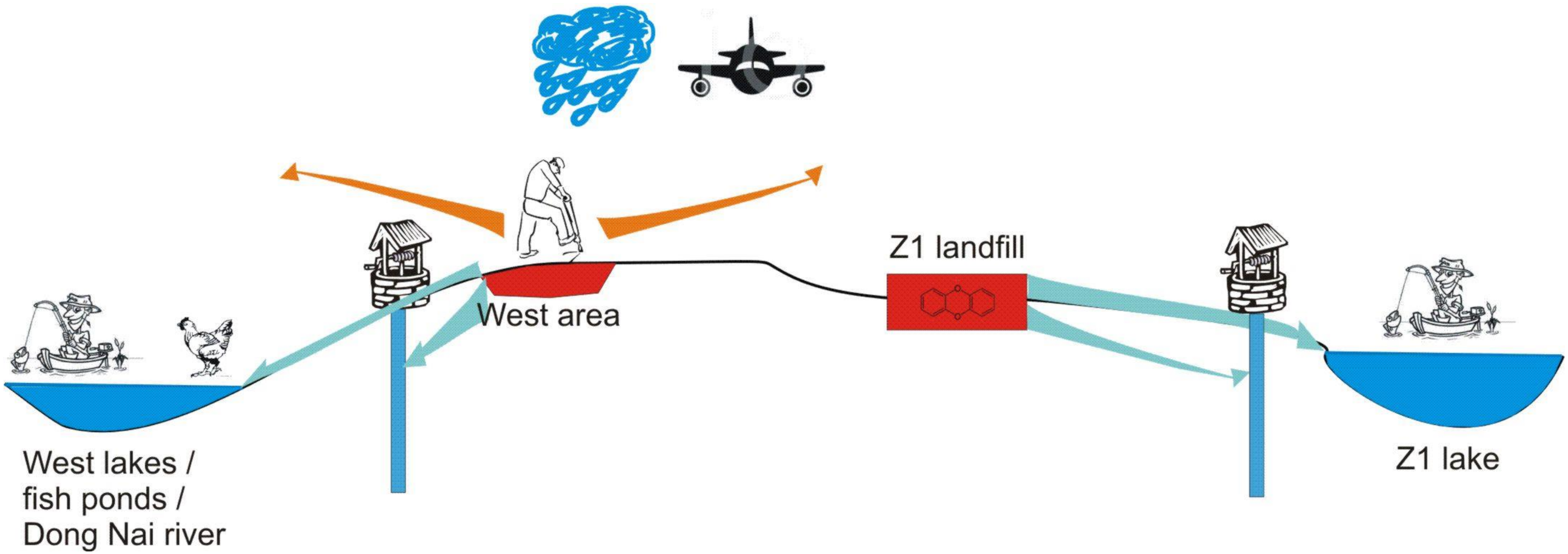
Local conditions

- Historical site use
- Geology and hydrogeology
- The contaminants of concern
- Contaminated area
- Migration pathways
- Pathways of exposure
- Exposure scenarios

Local conditions



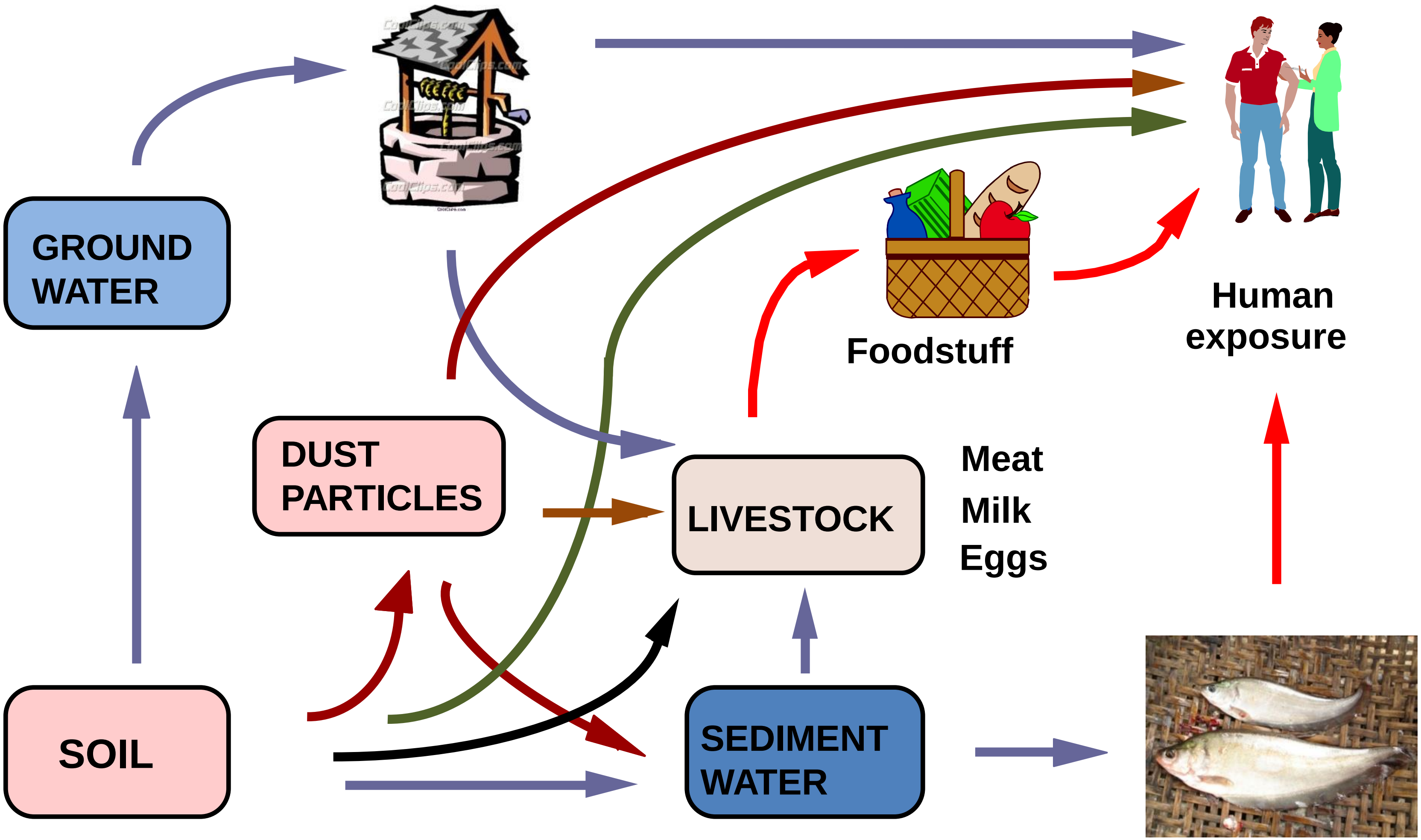
Conceptual model



Exposure scenarios
Exposure pathways

- **Accidental ingestion of dioxins (in soil, dust, surface water and groundwater) by people and animals living close or downstream to the landfill and the contaminated areas**
- **Inhalation of dioxins (in dust and water vapors) by workers and inhabitants**
- **Dermal contact (with soil or water)**
- **Food ingestion (e.g. consumption of fish)**

Exposure via food chain



Exposure scenarios
Endangered population

- **People living inside the airbase – around 1,200 people in the area of 750 ha. They are exposed to contaminated soil and sediments, contaminated dust and water. In addition, people might also be exposed to dioxins by using contaminated groundwater for washing, washing dishes, bathing/showering and/or direct consumption.**

Exposure scenarios
Endangered population

- **<u>People living outside the airbase</u> – In four wards in densely populated area surrounding the airbase, there are around 111,000 inhabitants and these can be exposed to dioxins by water, sediments and soil particles that flow from the contaminated sites to residential and agricultural areas and also reach the river (which serves as a water source for part of the city), the fishing ponds and other water bodies.**

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Water ingestion
Exposure parameters

For calculating the human health risks, we must consider the real behavior models of potentially affected people / local inhabitants.

<u>Formula for daily intake by water ingestion</u>:

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

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Water ingestion
Exposure parameters

CDI chronic daily intake (mg/kg/day)

CW contaminant concentration in water (mg/l) – let us use **the proposed monitoring limit: 1×10^{-9} mg/l**

IR usual water consumption adults: 2 l/day; children (up to 6 years): 1 l/day

EF usual exposure frequency: 350 days/year

ED exposure duration: lifetime exposure for carcinogens: 70 years; maximum duration of exposure for non-carcinogens (length of stay at a locality): 30 years

BW average weight adults: 70 kg, children: 15 kg

AT averaging time (days): 70 years x 365 days/year for carcinogens; ED x 365 days/year for non-carcinogens

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

Water ingestion
Chronic daily intake

The result for carcinogens (dioxin):

CDI adults = 2.7×10^{-11} mg/kg/day

CDI children = 6.4×10^{-11} mg/kg/day

(The Chronic oral reference dose is 7×10^{-10} mg/kg/day)

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Water ingestion
Risk level

The cancer risk can be calculated by a simple formula:

ELCR = CDI x SF

ELCR excessive lifetime cancer risk

CDI chronic daily intake (mg/kg/day)

SF slope factor, for TCDD = 1.3×10^{5} $(mg/kg/day)^{-1}$

The estimated level of risk:

ELCR for adults = 2.1×10^{-6}; ELCR for children = 4.9×10^{-6}

This means cancer probability for 2 adults or 5 children out of a million. However, this can still be an acceptable threshold for the potentially exposed people around the airbase (111,000 inhabitants in 4 wards).

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Soil ingestion
Exposure parameters

<u>Accidental ingestion of soil or dust</u>:

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

CS contaminant concentration in soil (mg/kg)
let us use **TCVN 8183:2009 limit: 1.5 x 10^{-7} mg/kg**

CF conversion factor (10^{-6} kg/mg)

FI ratio of ingestion from contaminated sources
let us use 0.5 (50%)

IR accidental ingestion of soil adults: 100 mg/day;
children (up to 6 years): 200 mg/day

EF exposure frequency: 220 days/year (not in rainy season)

Other parameters do not differ

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

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Soil ingestion
Chronic daily intake and risk level

The result for dioxin intake: CDI adults = 6.5×10^{-14} mg/kg/day; CDI children = 6.0×10^{-13} mg/kg/day.

The result for level of risk: ELCR adults = 5.0×10^{-9}; ELCR for children = 4.6×10^{-8}. This can be considered acceptable for the potentially exposed people within or around the airbase; however, for the Southern Z1 area with maximum concentration 13.3×10^{-6} mg/kg the ELCR for adults would be 4.4×10^{-7} and for the Pacer Ivy area with maximum concentration 9.6×10^{-4} mg/kg the ELCR for adults would reach unacceptable level of 3.2×10^{-5} (three people out of 100,000).

Ingestion of contaminated fish
Exposure parameters

Ingestion of contaminated fish:

CDI = C x IR x FI x EF x ED / (BW x AT)

C contaminant concentration in fish (mg/kg) – let us use the reported concentration: 4.04×10^{-6} mg/kg

IR average quantity of consumed fish: 0,136 kg/meal

FI ratio of consumption of contaminated fish – let us use 0.5 (50%)

EF usual exposure frequency: 365 meals/year

Other parameters do not differ

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

Ingestion of contaminated fish
Chronic daily intake and risk level

The result for dioxin intake:

CDI adults = 3.9×10^{-9} mg/kg/day

The level of risk ELCR adults = 3×10^{-4}

This means unacceptable cancer risks for 3 people out of 10,000.

The consumption of contaminated fish is the most dangerous exposure pathway.

Proposed measures

Based on the screening risk assessment, the monitoring and risk prevention measures must focus on preventing the contamination of fish ponds and the contamination of the exploited groundwater sources.

Alternative measures can include preventing consumption of contaminated fish and water.

Proposed measures

The technical remediation measures should focus on primary or secondary sources of contamination (namely highly contaminated soil and sediments) and on interrupting the migration pathways.

The proposed monitoring/target limits ensure acceptable level of residual risks, except for the missing indicator for fish and for the sediments in the lakes and river…

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The Risk Assessment Information System (RAIS):
http://rais.ornl.gov/cgi-bin/tools/TOX_search?select=chem