

Risk assessment for polychlorinated pollutants in South and Central Vietnam

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History of the project

- The war in Vietnam- huge quantities of herbicides (Agent Orange) applied as defoliants
- Some concentrations of them suspected to be still retained in the environment and human bodies
- Vietnamese authorities - decision to realize risk assessment for polychlorinated aromatics - dioxins- as highly toxic persistent organic pollutants (POPs)
- Czech Ministry of Environment - financial and material help
- DEKONTA comp. - sampling of selected materials in Vietnam
- Analyses and risk assessment in the Czech Republic - significant participation of Institute of Chemical Technology Prague

Rehabilitation of Thua Thien Hue Province Affected by AO/dioxin Contamination - project identification

- implemented within the framework of Czech ODA
- funded by the Ministry of the Environment
- implemented by DEKONTA and DWW in cooperation with ICT
- partner in VN is Thua Thien Hue Foreign Affairs Department



Goals of the project

1. Identification of polychlorinated contaminants distributed in one of the Vietnam regions during 1961 – 71 war period (Agent Orange)
2. Assessment of risks following from the contaminant identified
3. Reduction of environmental and human health risks by implementation of preventive measures
4. Ensuring an access to clean/potable water by means of local infrastructure support.

Military use of defoliants during Vietnam War



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Military use of defoliants during Vietnam War

Agent Orange - code name for a powerful defoliant (a mixture of two herbicides based on 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T)), about 80 000 m³ of Agent Orange was sprayed across South Vietnam within 1962 – 71.

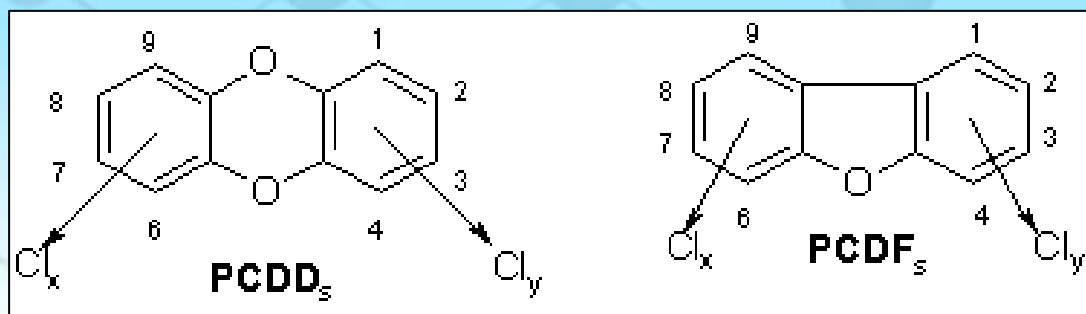
The aim of military use of herbicides was the forests defoliation – removal of the natural shelter for military techniques and men and further the destruction of agricultural growth leading to the food shortage.

one of **Agent Orange** herbicides (butylester of 2,4,5-T) was produced in the Czech Republic (Spolana Neratovice), **dioxins** were identified as minor component of 2,4,5-T butylester

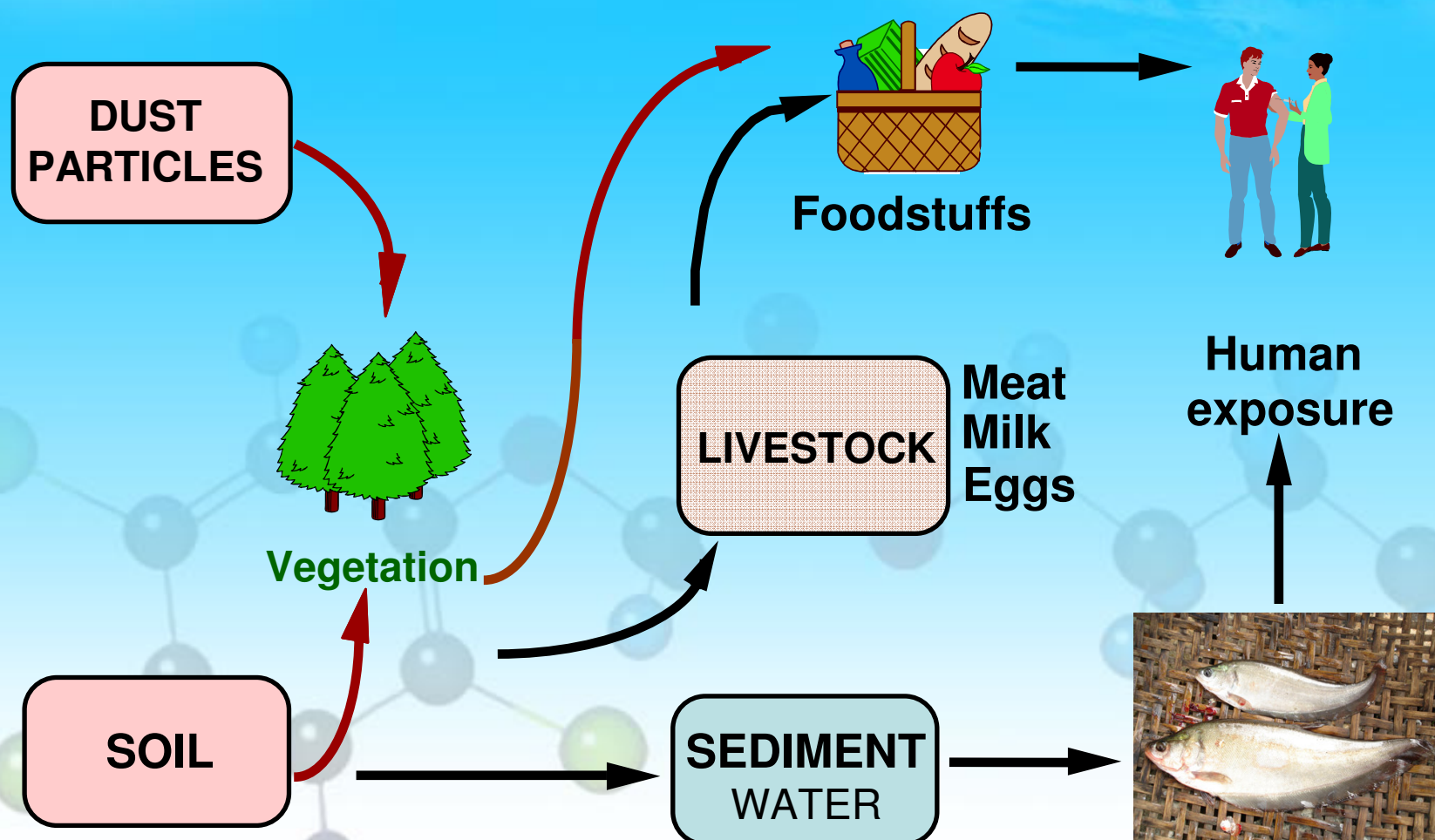
Dioxins

(group of 75 PCDD isomers and 175 isomers of PCDF)

- quantification by means of TEQ
- very low solubility in water, high lipophility
- highly persistent and bioaccumulative
- dioxins may cause cancer, immune deficiencies, reproductive and developmental changes, chloracne



Dioxins in human food chains

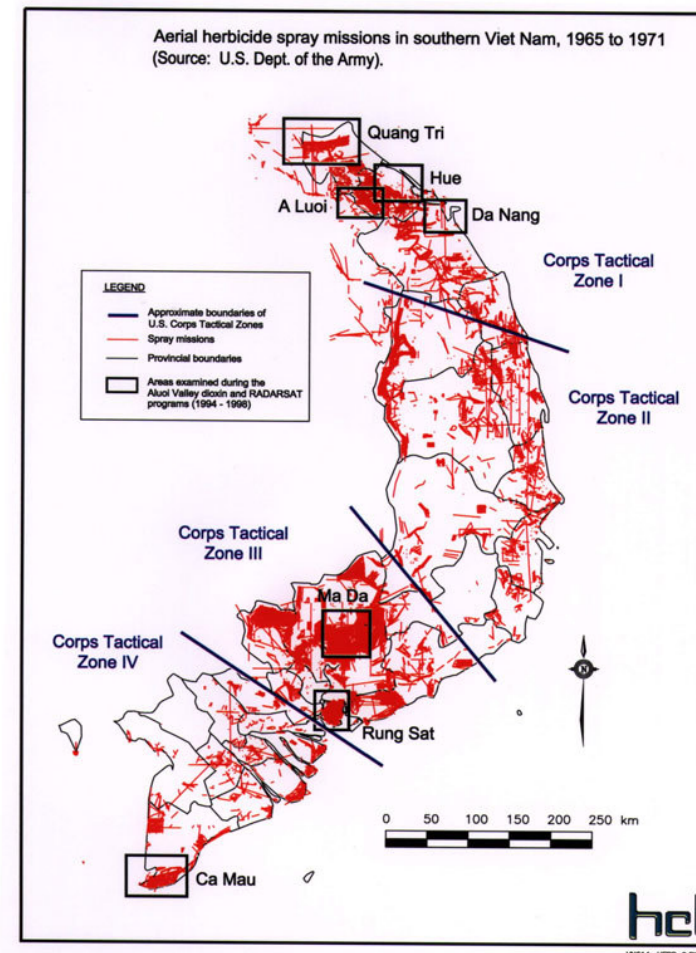
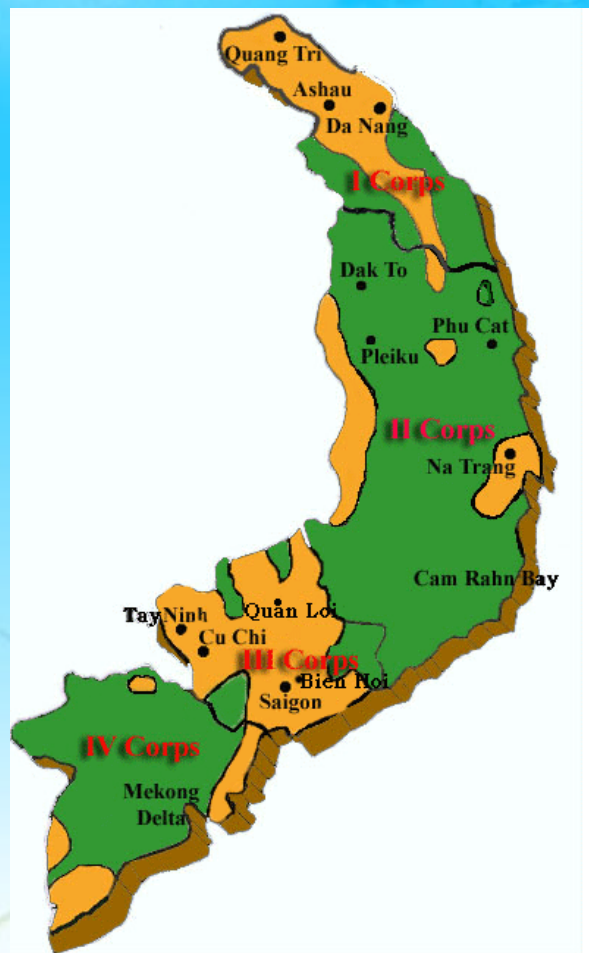


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Thua Thien Hue province, Phong My community



Thua Thien Hue province, Phong My community



Phong My community

- total area 394 km²
- 50 km² used for agriculture, no industry
- population: 5 200 inhabitants in 15 villages

Community was heavily impacted by Agent Orange during Vietnam War

From technical and financial reasons it was not possible to solve this problem in the whole province Thua-Thien-Hue. Therefore the project was focused to the Phong My community identified by Vietnamese authorities as one of the most contaminated community of this province.

Project activities

- sampling of soils, sediments, groundwater, animal tissues, human blood
- analyses of samples (pesticides, dioxins, PCB)
- risk assessment



Sampling + analysis

Based on preliminary monitoring and personal observers experience the following number of samples were taken within the area of Phong My community:

- 39 samples of soil
- 14 samples of sediment
- 57 samples of biological tissues (fish and duck meat/liver)
- 4 samples of groundwater
- 100 human serum samples
- 4 fruit and vegetable samples (200 – 300 g)

The samples were analyzed for polychlorinated organic pollutants (only PCDD/PCDF are referred in this presentation).

Sampling



Risk assessment

Identified exposure scenarios:

- Consumption of contaminated foodstuffs
- Contact with contaminated soil and/or sediment
- Inhalation of contaminated dust



Consumption of contaminated food

Diet represents 99% contribution to PCDD/F exposure from the environment

- elevated concentrations of PCDD/F found in fishes and poultry
- 2,3,7,8-TCDD present predominantly in wild living animals
- majority of foodstuffs originate from local sources

Foodstuffs	Consumption [g.day⁻¹]	Av. Concentr. [pg.kg⁻¹]	Max. Concentr. [pg.kg⁻¹]
Fish meat	136	780 ± 1090	4800
Poultry meat	23	640 ± 450	1700
Other meat	106	57 ± 38	130
Vegetables	401	16 ± 2	18
Fruits	149	25 ± 5	30
Rice	1124	150*	-

Risk assessment parameters

Hazard Quocient (HQ) approach assumes that there is a level of exposure (RfD=Reference of Dose) for noncarcinogenic substances below which is unlikely to experience adverse health effects. HQ is defined as the ratio of a single substance exposure level to a reference dose. When HQ exceeds the unity, there may be concern for potential health effects.

Excess Lifetime Cancer Risk (ELCR) - the probability of developing cancer over a persons lifetime at a given exposure level. Accepted ELCR: $1 \cdot 10^{-6}$ (1 additional cancer per 1 000 000 people).

Risk recipients

five groups of inhabitants considered

- 1 – 2 years
- 2 – 6 years
- 6 – 10 years
- 10 – 18 years
- 18 – 75 years

questionary through the community

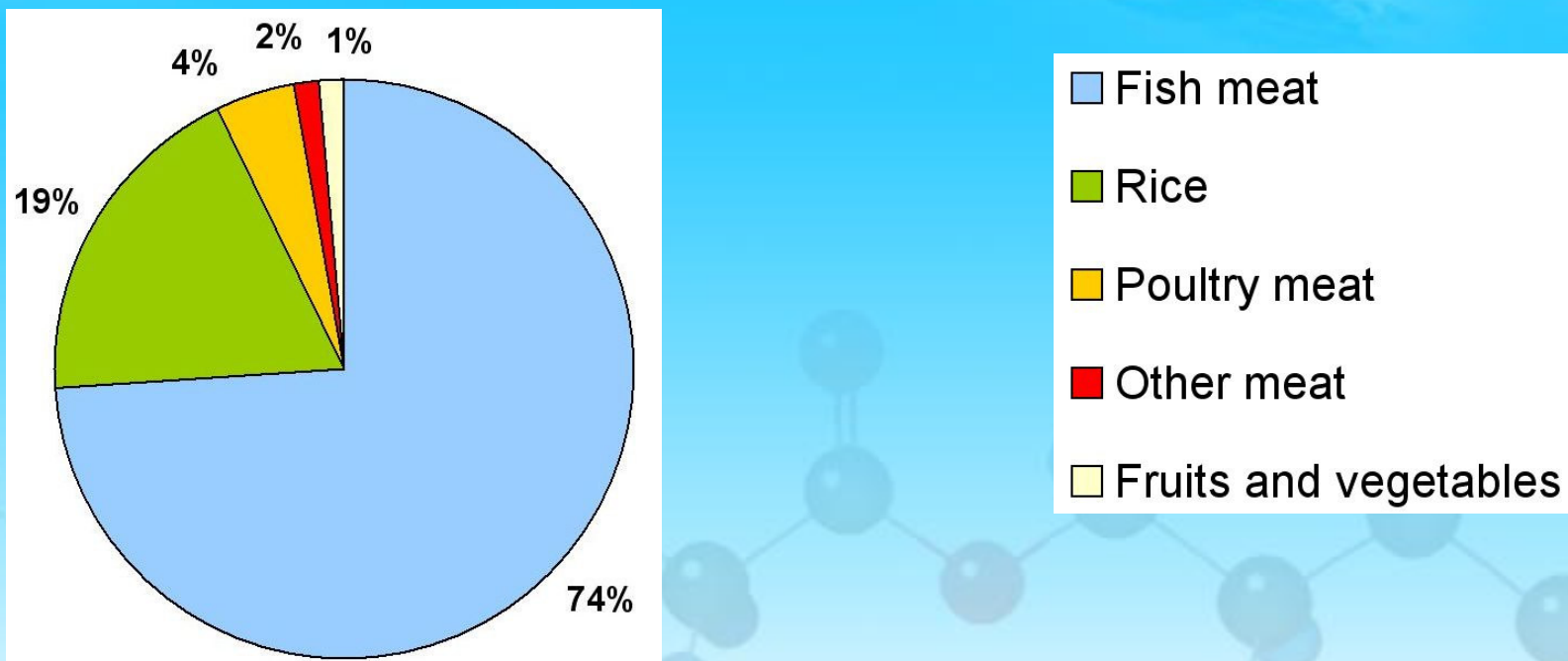
- structure and sources of food
- quantity of food

Contaminated food

Age range (years)	Hazard Quocient (limiting value = 1)	Excess Lifetime Cancer Risk (limiting value = 10^{-6})
1 - 2	13.27	$2.8 \cdot 10^{-5}$
2 - 6	14.68	$1.3 \cdot 10^{-4}$
6 - 10	16.69	$1.4 \cdot 10^{-4}$
10 - 18	17.70	$3.0 \cdot 10^{-4}$
18 - 75	13.30	$1.5 \cdot 10^{-3}$

Contaminated food

Contribution of particular foodstuffs to the total dietary intake of PCDD/F



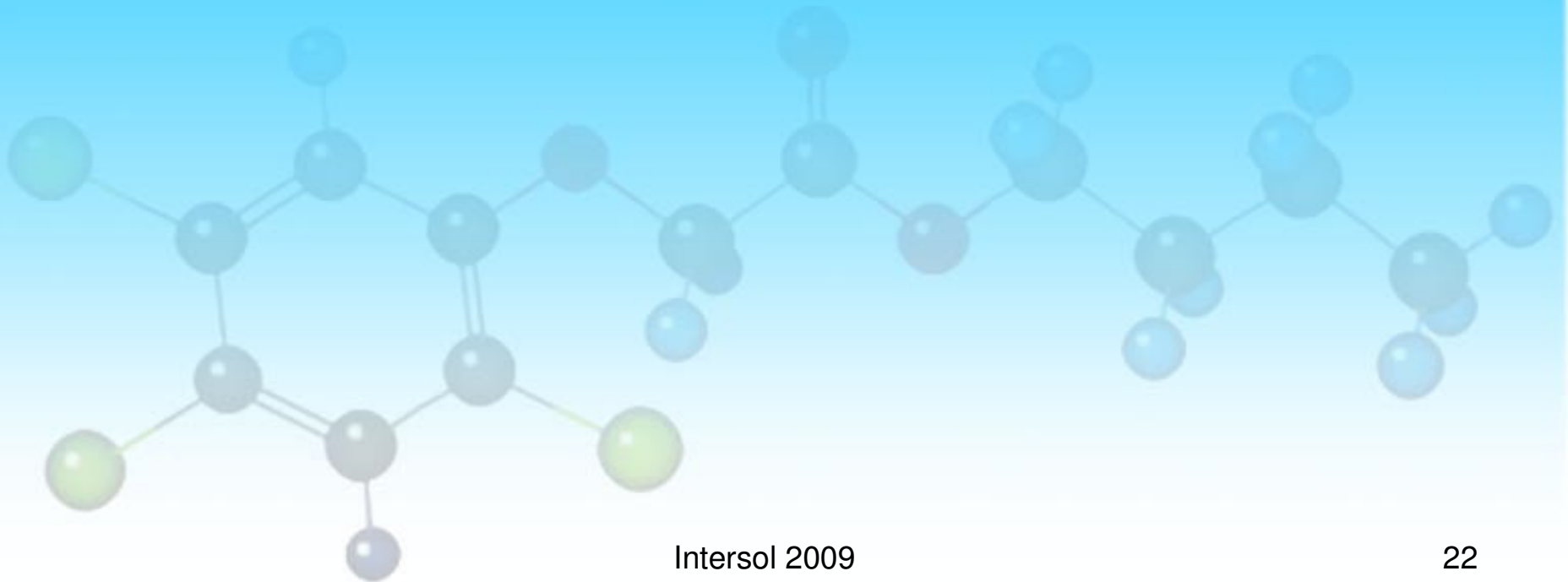
Longterm consumption of contaminated food results in:
LCDI = 13.9 $\text{pg.kg}^{-1}.\text{day}^{-1}$ WHO-TEQ (maximum concentrations)
LCDI = 4.8 $\text{pg.kg}^{-1}.\text{day}^{-1}$ WHO-TEQ (average concentrations)

Contaminated soil

- similar age groups as for food contamination
- two exposition scenarios considered
 - dermal contact with contaminated soil
 - incidental ingestion of contaminated soil

Contaminated soil – dermal contact

- I-TEQ (PCDD/PCDF) in top soil layer: 18 ng/kg
- skin area in contact with soil: 400 cm²/day
- annual exposition: 300 days per year

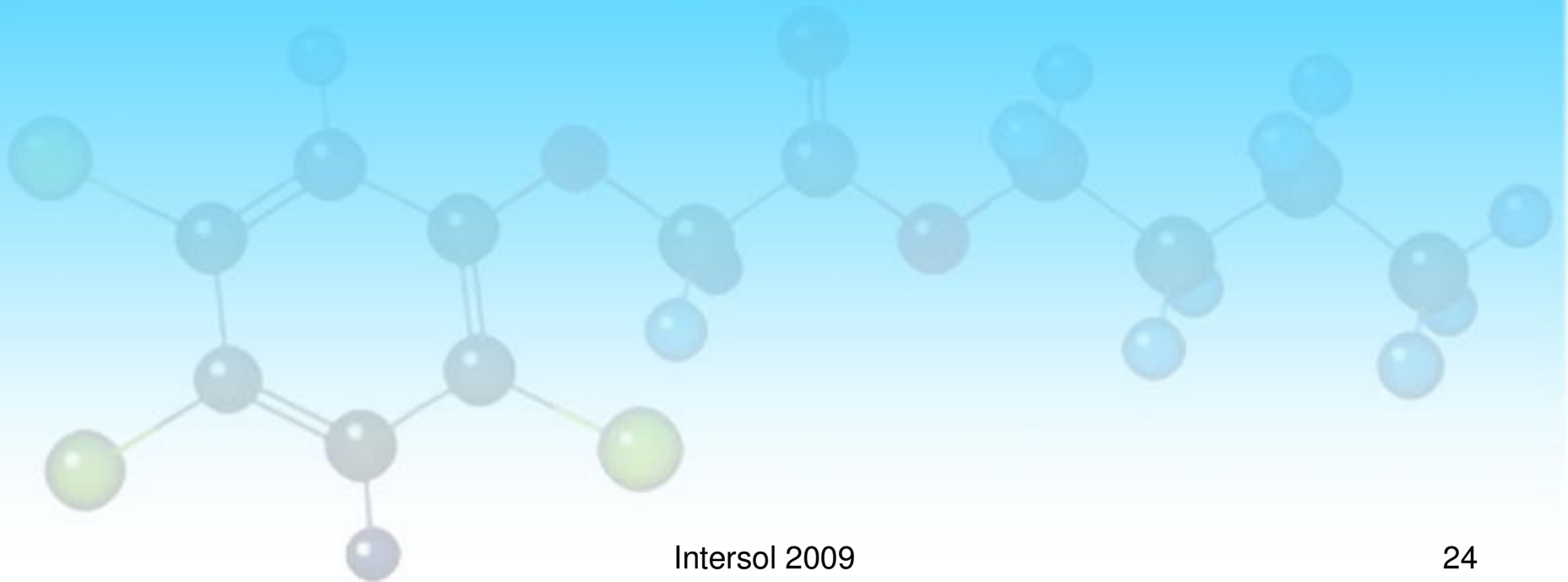


Contaminated soil – dermal contact

Age range (years)	Hazard Quocient (limiting value = 1)	Excess Lifetime Cancer Risk (limiting value = 10^{-6})
0 - 0.5	0.004	$4.8 \cdot 10^{-9}$
0.5 - 1.0	0.008	$8.2 \cdot 10^{-9}$
1 - 2	0.021	$4.6 \cdot 10^{-8}$
2 - 6	0.018	$1.5 \cdot 10^{-7}$
6 - 10	0.027	$2.3 \cdot 10^{-7}$
10 - 18	0.015	$2.5 \cdot 10^{-7}$
18 - 70	0.009	$1.0 \cdot 10^{-6}$

Contaminated soil – incidental ingestion

- I-TEQ (PCDD/PCDF) in top soil layer: 18 ng/kg
- amount of soil ingested by a person: 10 mg/day
- annual exposition: 300 days per year



Contaminated soil – incidental ingestion

Age range (years)	Hazard Quocient (limiting value = 1)	Excess Lifetime Cancer Risk (limiting value = 10^{-6})
0 - 0.5	0.01	$1.2 \cdot 10^{-8}$
0.5 - 1.0	0.01	$6.8 \cdot 10^{-9}$
1 - 2	0.09	$1.9 \cdot 10^{-7}$
2 - 6	0.06	$5.1 \cdot 10^{-7}$
6 - 10	0.02	$1.9 \cdot 10^{-7}$
10 - 18	0.01	$1.3 \cdot 10^{-7}$
18 - 70	0.002	$2.5 \cdot 10^{-7}$

Inhalation of contaminated dust

- I-TEQ (PCDD/PCDF) in top soil layer: 18 ng/kg
- amount of contaminated air by a person: 0.3 m³/hour
- dust particles concentration: 0.03 g/m³
- exposition
 - 4 hours per day
 - 200 days per year



Inhalation of contaminated dust

Age range (years)	Hazard Quocient (limiting value = 1)	Excess Lifetime Cancer Risk (limiting value = 10^{-6})
0 - 0.5	0.0009	$1.3 \cdot 10^{-7}$
0.5 - 1.0	0.0008	$1.3 \cdot 10^{-7}$
1 - 2	0.0009	$1.4 \cdot 10^{-7}$
2 - 6	0.002	$3.0 \cdot 10^{-7}$
6 - 10	0.002	$2.9 \cdot 10^{-7}$
10 - 18	0.002	$3.1 \cdot 10^{-7}$
18 - 70	0.002	$3.6 \cdot 10^{-7}$

CONCLUSIONS

- HQ for the non-carcinogenic risk of the monitored age categories range between 13.3 and 17.7 for maximum PCDD/PCDF concentrations in foodstuffs
- ELCR values (lifetime increase in probability of tumor disease development) for the investigated population groups ranged between $2.8 \cdot 10^{-5}$ and $1.5 \cdot 10^{-3}$;
- dioxins content in food (mainly fish) produced in Phong My does not satisfy current EU environmental standards
- ELCR related to consumption to local food (76% of fish meat) are in order of 10^{-3} - 10^{-5}
- Soil contamination does not bring considerable risks
- Excess Lifetime Cancer Risks related to incidental ingestion and/or inhalation of contaminated soil are not significant

Thank You for attention

- **Project:** Rehabilitation of Thua Thien Hue Province Contaminated with Agent Orange/Dioxins (years 2006 -2008)
project funded in the framework of Czech ODA (official development assistance.
The ordering party of works is the Ministry of Environment of the Czech Republic,
Section of Development and Project Co-operation