BIOHEALTH COMPUTING
Erasmus Mundus programme

Human Risk assessment of Chlorinated hydrocarbons (DNAPLs) in contaminated groundwaters

UNIVERSITAT DE BARCELONA

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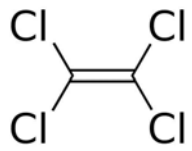
Introduction

- Industrial utilization since middle 20th century
  - Dry cleaning
  - Metal degreasing
  - Pharmaceutical production
- Soil and groundwater contaminants
- Exposed people
  - Workers (producer and user)
  - General population: Drinking water

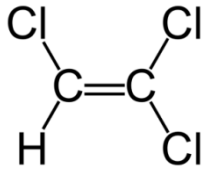
→ Public Health issue

DNAPLs' chemical properties

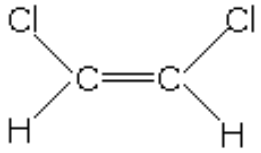
- Chlorinated hydrocarbons
- DNAPLs : Denser-than water No Aqueous-Phase Liquid



Tetrachloroethene



Trichloroethene



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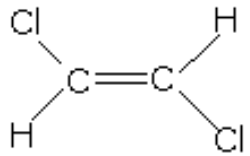
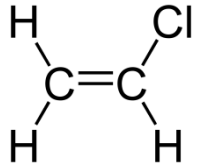
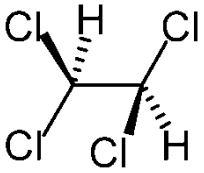


trans

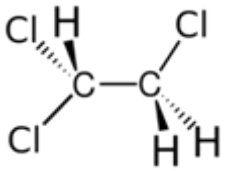
1,2 Dichloroethene



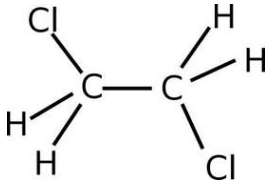
Vinylchloride



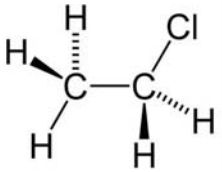
Tetrachloroethane



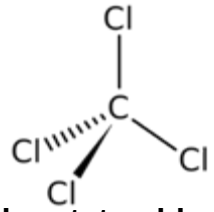
1,1,2 Trichloroethane



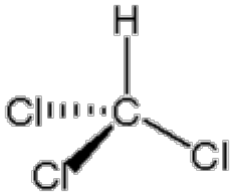
1,2 Dichloroethane



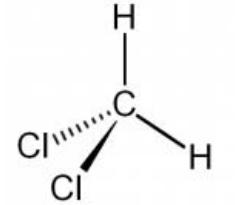
Chloroethane



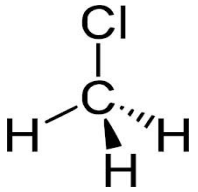
Carbon tetrachloride



Cloroform



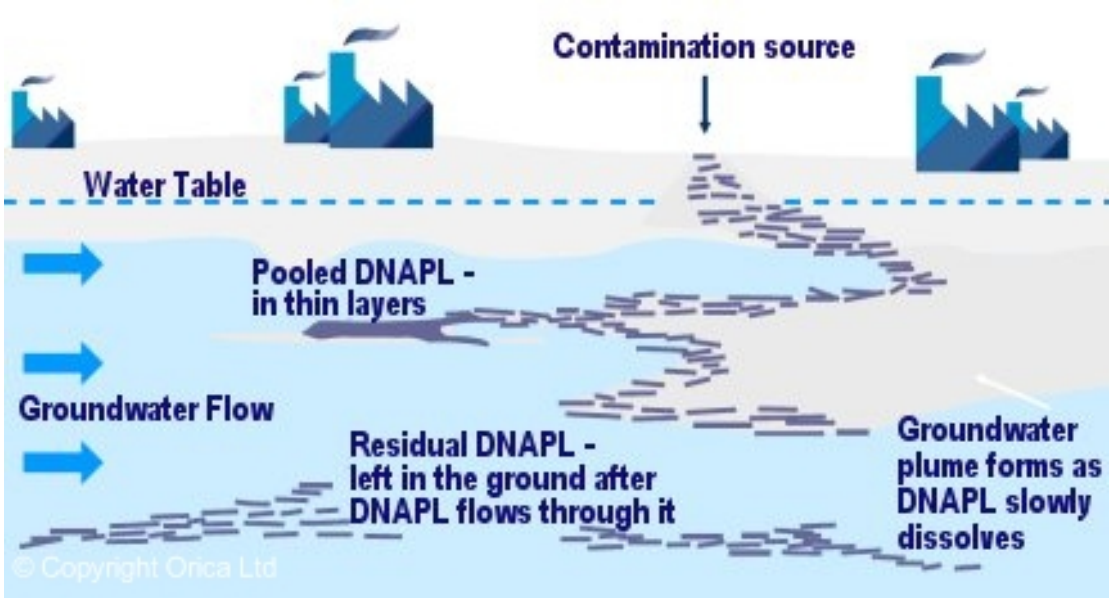
Dichloromethane



Chloromethane

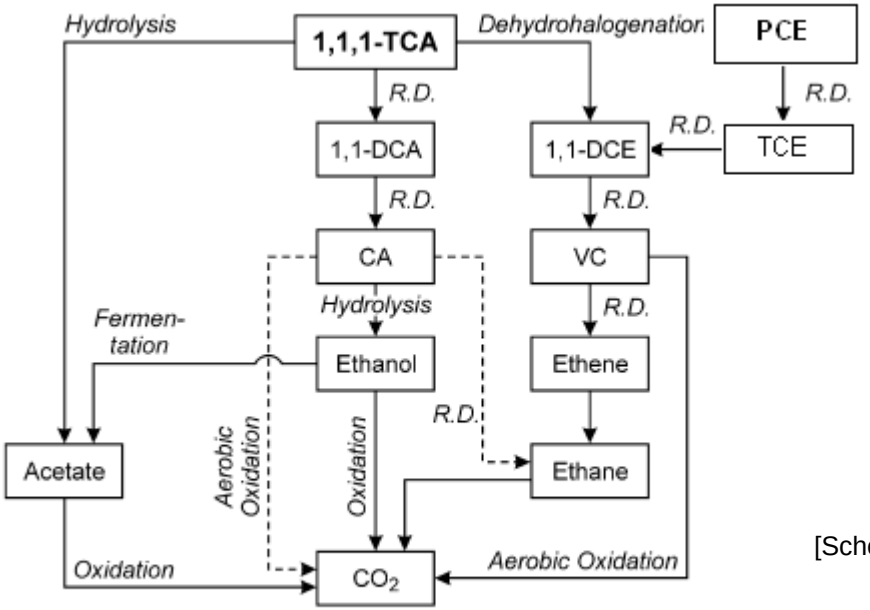
DNAPLs' physical properties

- Denser than water
- Volatile
- Mobile in the soil
- Poorly soluble in water
- Form pools in soils and plumes in groundwater



Biodegradation

- Degradation by microorganism



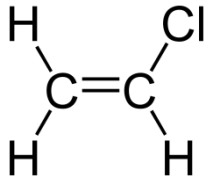
[Scheutz C and Al., 2011]

- But possibility that daughter molecules are
  - more persistent in environment
  - more toxic

Human Toxicity

- High toxicity in low concentration
- Targets organs
  - Central Nervous System
  - Liver
  - Heart
  - Lung
  - Kidneys
  - Skin
- Toxicity Acute or Chronic
- Carcinogenicity (IARC classification)
  - Vinyl chloride : Group 1 → Angiosarcoma

T+ - Très toxique



Vinylchloride

Objectives

- **To assess human risk of contaminated groundwater by Chlorinated Hydrocarbons with RBCA model.**
- To verify the correct toxicological and exposure values to be used in the model.
- To establish representative exposure scenarios.

Methodology

- RBCA: Risk Based Corrective Action

  → Tool for determining the amount and urgency of action necessary regarding to the human health

- Uses
  - Identify exposure pathways and receptors at a site
  - Determine the level and urgency of response required at a site
  - Determine the level of surveillance appropriate for a site
  - Incorporate risk analysis into all phases of the corrective action process

Methodology

- Steps of the risk assessment with RBCA
  - Exposure assessment
    - Identification of source
    - Identification population exposed
    - Determination of the exposure scenario and pathway exposure
    - Exposure factors
    - Exposure dose

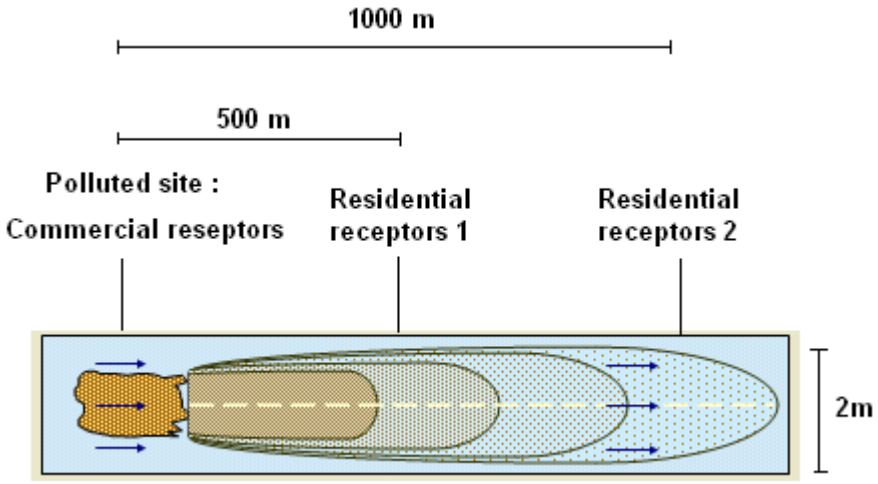
Booth P, 2011

  - Toxicity assessment
    - For non-carcinogenic : Exposure dose without significant effect
      - According to the entrance way (dermal, oral, inhalation)
    - For carcinogenic : Slope Factor (SF)
      - According to the entrance way (dermal, oral, inhalation)
  - Risk Analysis
    - For non-carcinogenic : Hazard Ratio (HR) >1 = Risk
      HR = Exposure Dose / Exposure dose without significant effect
    - For carcinogenic : Exposure Calculated x SF > $10E^{-5}$ = Risk

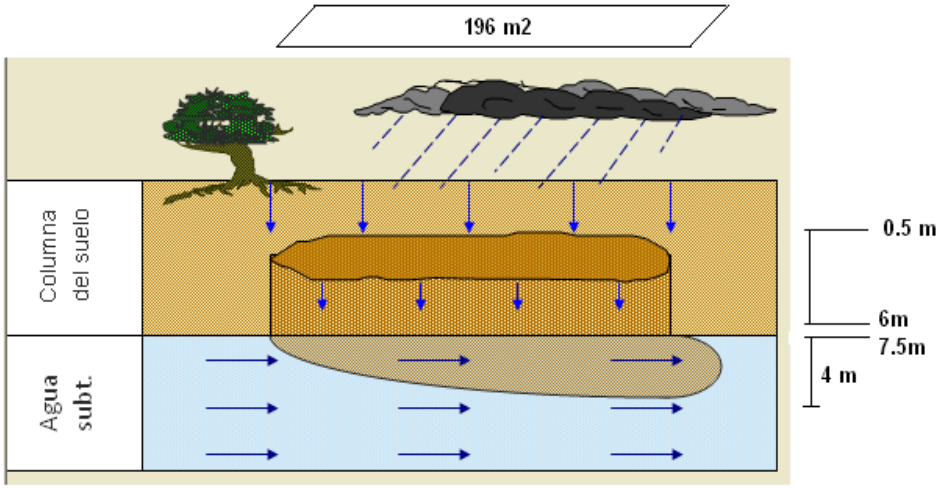
- Uncertainties
  - Values use

Study area

- Tarragona, Spain
  - Industry
  - Pollution detected in 1996
  - CT and CF



- Groundwater characteristics polluted plume:
  - 4 m of thickness
  - 2 m big
  - 7.5 m : depth of water table



Scenarios

- Play with the different value of :
  - Toxicological parameters
  - Exposure parameters
    - According the ages
    - According the genders
    - According the life style
  - Soil parameters
    - pH
    - Concentration of Organic Carbon
  - Groundwater parameters
    - pH
    - Concentration of Organic Carbon

Results: Water pollution

Mean Groundwater concentrations used for the risk analyses (in µg L-1)

Chloromethane				Chloroethene					Chloroethane			
CT	**CF**	**CM**	**DCM**	**PCE**	**TCE**	**tDCE**	**cDCE**	**VC**	**1,1,1 TCA**	**1,1,2 TCA**	**DCA**	**CA**
164.08	103.71	1.96	0.46	0.35	9.23	0.20	0.36	0.35	0.02	26.74	DDL	DDL

Drinking water WHO guideline (in µg L-1) (WHO 2004)

Chloromethane				Chloroethene					Chloroethane			
CT	**CF**	**CM**	**DCM**	**PCE**	**TCE**	**tDCE**	**cDCE**	**VC**	**1,1,1 TCA**	**1,1,2 TCA**	**DCA**	**CA**
4	200	-	20	40	70	30	30	**0.30**	2000	2000	DDL	DDL

- CT and CF : majority compounds

- Carcinogenic compounds : no threshold
- CT and VC in excess according the guideline

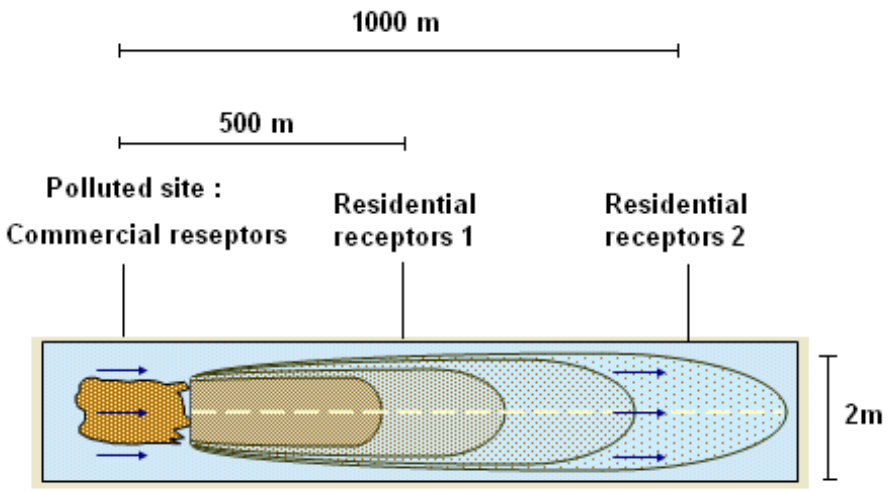
Results: Risk assessment for Catalonia

Excess cancer risk and HR by exposition to the polluted groundwater for commercial and residential receptors

Excess cancer risk: GW Expo	Study area			Acceptable value
	Commercial	Res 1	Res 2	
Female	1.9E-04	7.4E-07	1.9E-07	1.0E-05
Male	1.9E-04	6.8E-07	1.7E-07	1.0E-05

Hazard ratio : GW	Study area			Acceptable value
	Commercial	Res 1	Res 2	
Female	1.2	8.6E-03	2.2E-03	1
Male	1.2	8.6E-03	2.2E-03	1

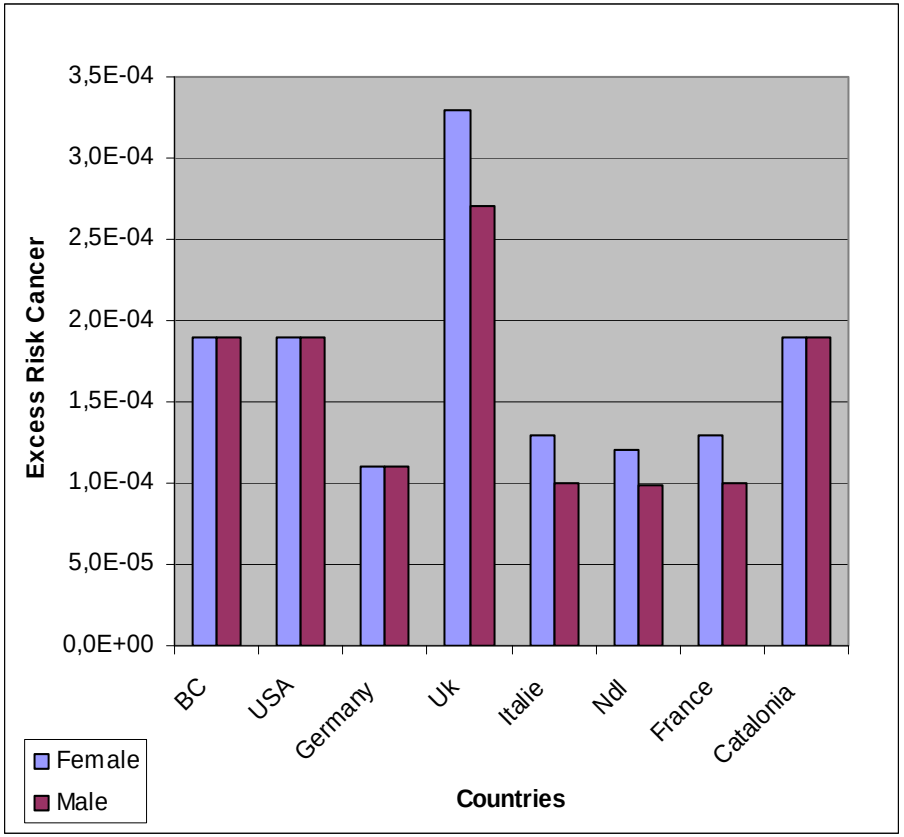
- Excess risk of cancer and toxicological effect
  - Commercial receptors
- Acceptable risk:
  - Residential receptors
- Low variation between genders



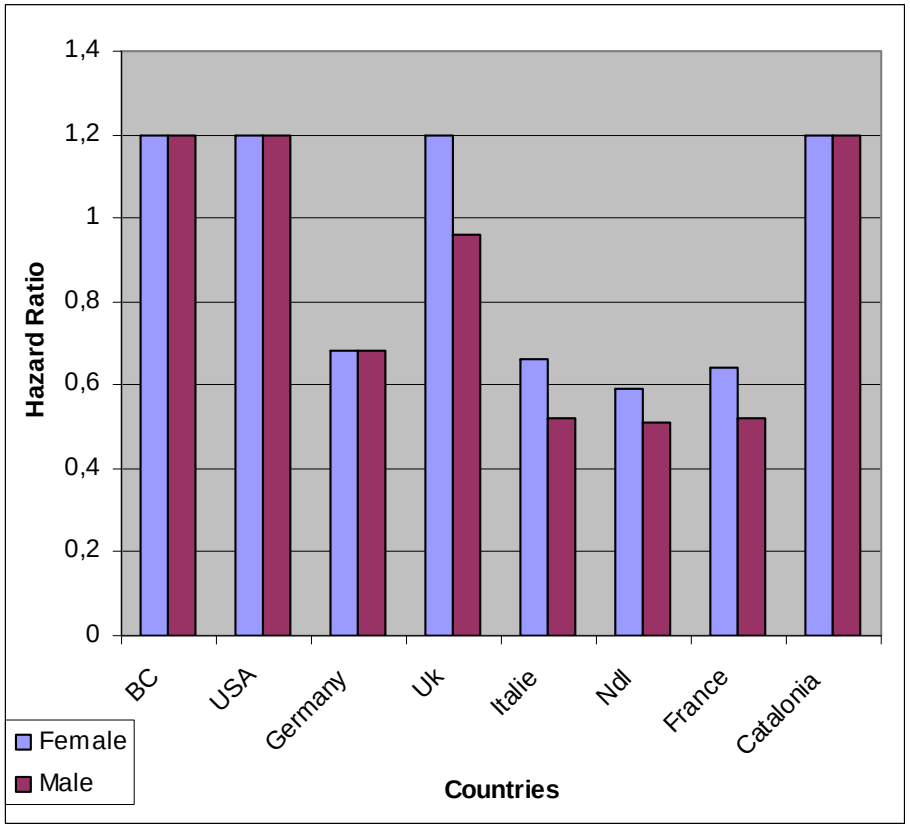
Results: European exposure parameters

Excess cancer risk and HR by exposition to the polluted groundwater according different life style in European countries and USA for commercial receptors

Excess risk



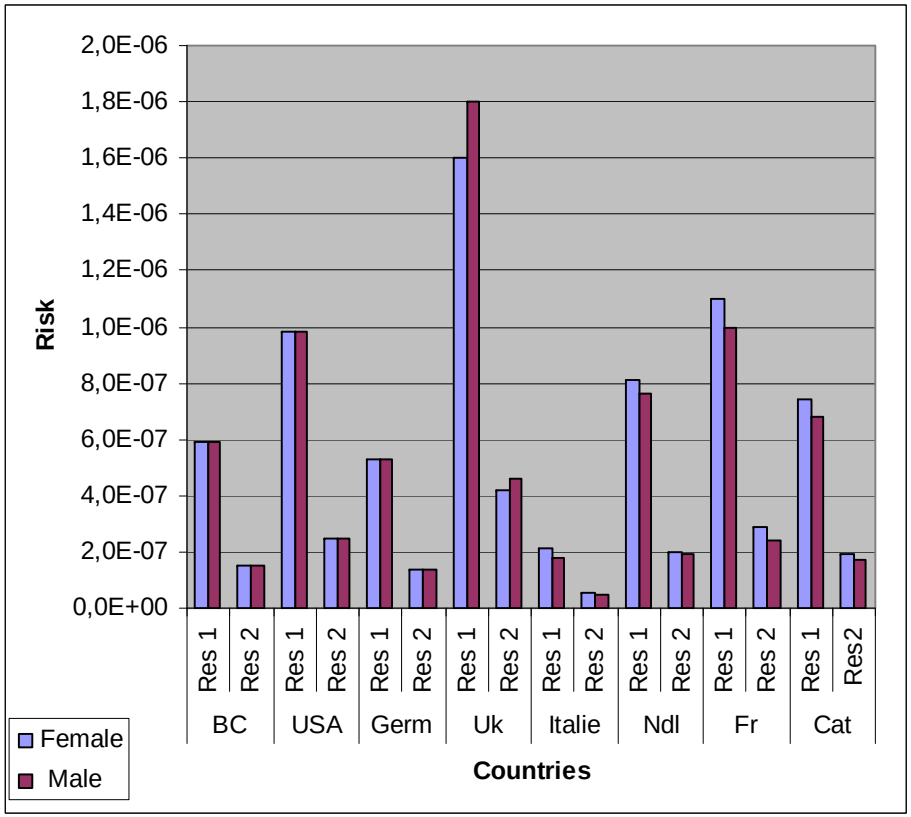
HR



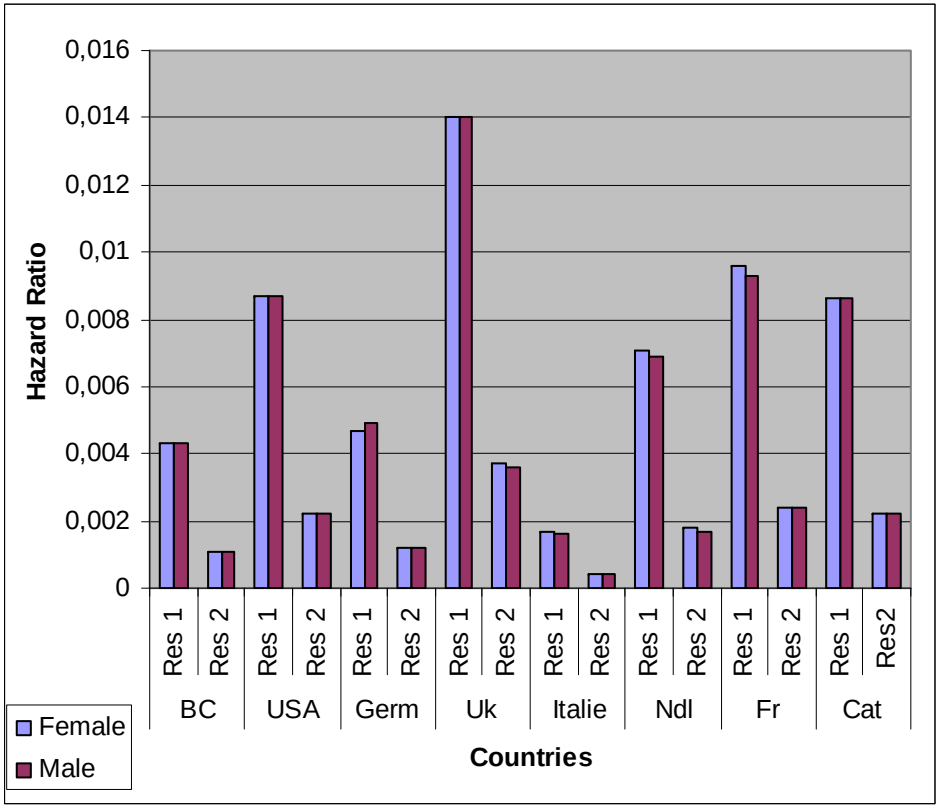
Results: European exposure parameters

Excess risk of cancer and HR by exposition to the polluted groundwater according different life style in European countries and USA for residential receptors

Excess risk



HR



Conclusion

- Risk :
  - Excess risk : commercial receptor
  - Acceptable risk :receptors residential

- Variation of the risk with exposure factors
  - Excess risk : commercial receptor (BC, Cat, USA, UK female)
  - Acceptable risk : receptors residential + commercial receptors (Ndl, Fr, It, Uk male)

- No risk variation with water and soil parameters

→ Carcinogenic compounds = Risk

→ But acceptable risk by exposure to polluted water after 500 m from the polluted site

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Thank you for your attention