Organic or conventional wheat: what is the best choice to limit the environmental impact, especially human toxicity?

Saïcha Gerbinet, F. Van Stappen, S. Belboom, E. Pezennec and A. Léonard
saicha.gerbinet@uliege.be
Products, Environment, and Processes (PEPs)
Chemical Engineering
Université de Liège
https://www.chemeng.uliege.be

PEPs CHEMICAL ENGINEERING

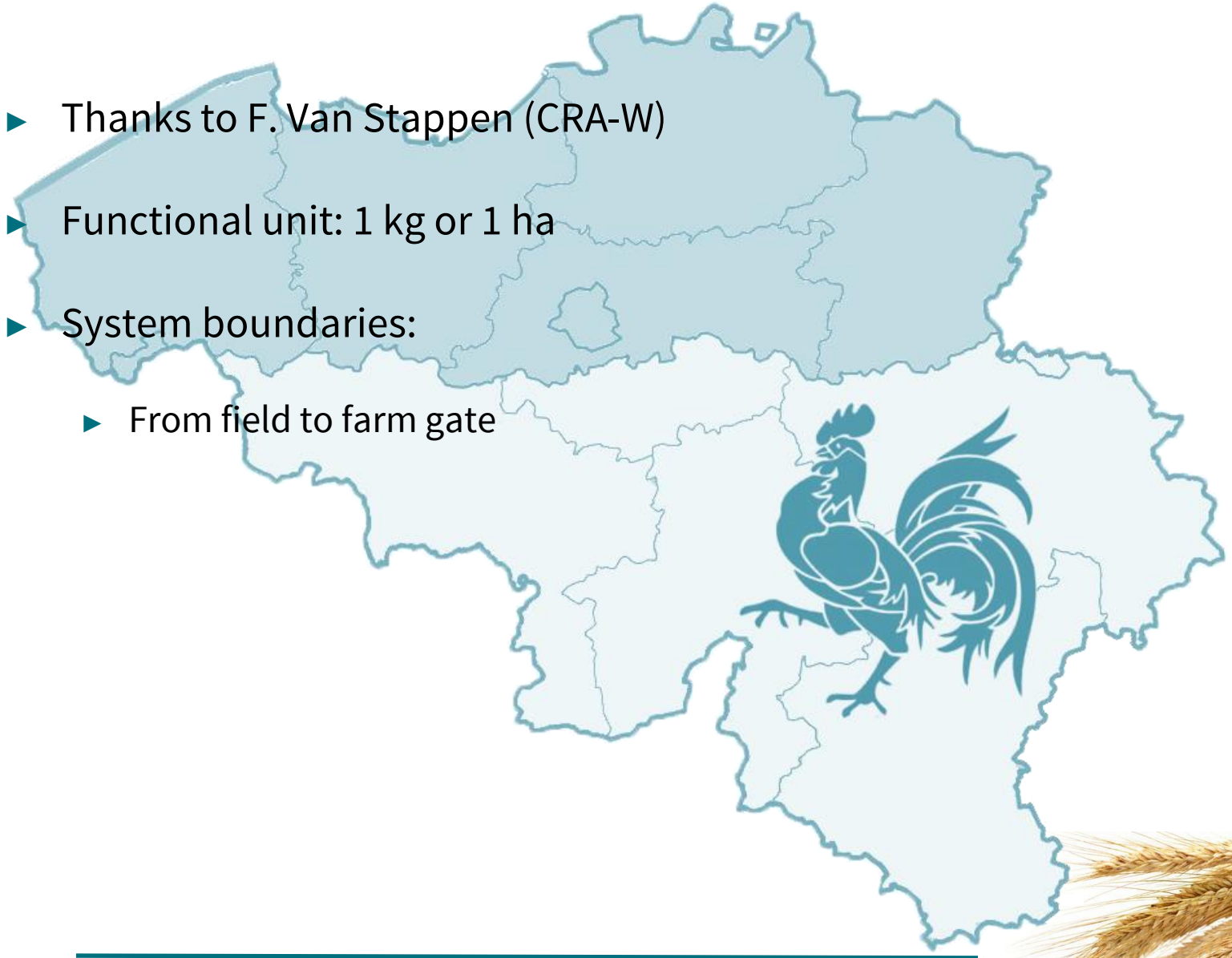
LIÈGE université 200

Introduction

- Context
  - Study of biobased products
  - From cereals

Wheat production in Wallonia

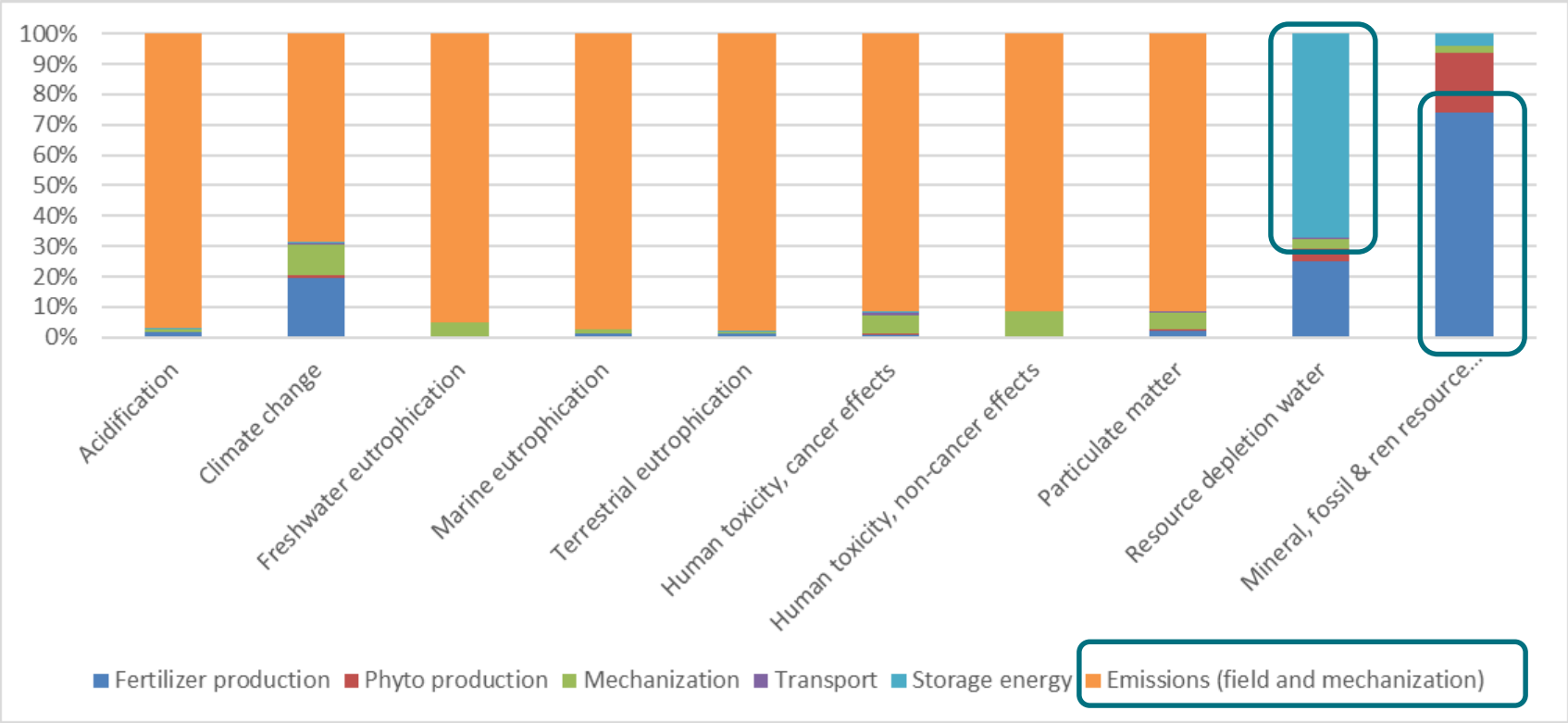
- Thanks to F. Van Stappen (CRA-W)
- Functional unit: 1 kg or 1 ha
- System boundaries:
  - From field to farm gate



Wheat production – Main hypothesis

- Fertilizer consumptions: farms bills
- Share between all the fertilizer types: statistics of fertilizers sales in Wallonia
- Background data: GaBi
  - Check/Comparison with Ecoinvent
- ILCD methods
  - Categories selection based on the studied biobased product

Wheat production in Wallonia



- Large contribution of field emissions due to fertilizers used

➔ Organic wheat to reduce the impact?

Water consumption – nuclear electricity

- Belgium nuclear electricity, low voltage
  - GaBi dataset in GaBi
  - Ecoinvent dataset in GaBi (v3.3) or Simapro (v3.2)
- ILCD recommended methods (m^3 eq)

	GaBi dataset in GaBi	Ecoinvent in GaBi	Ecoinvent in Simapro
Total	0.0886	0.00353	0.0002
Water input	0.0886	0.00353	0.0703
Water output	0	0	-0.0701

- Inventory (m^3)

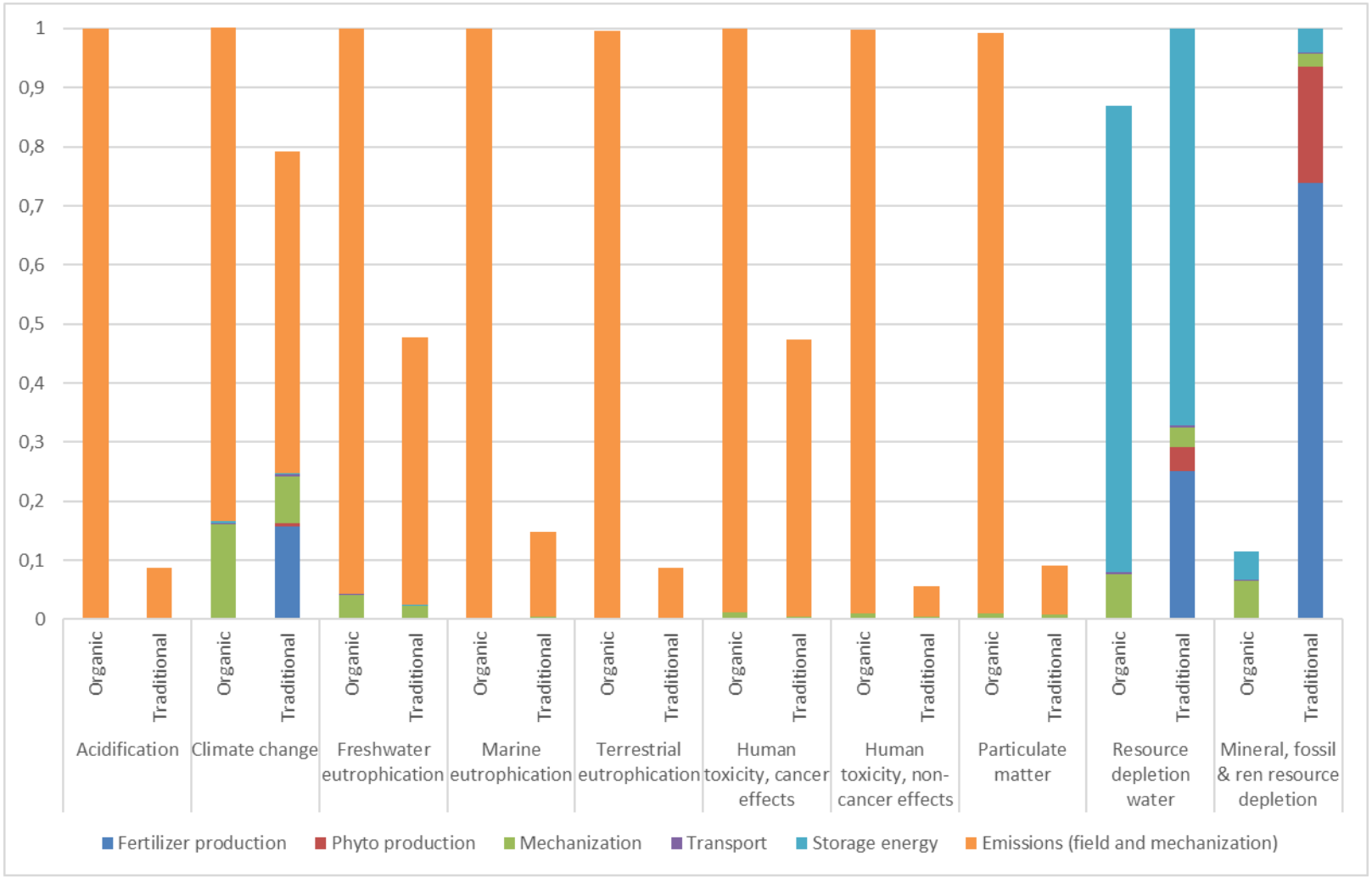
2.82 (CF of Belgium) ✕ 0.162 (CF of unspecified natural origin) ½ from Belgium

	GaBi dataset in GaBi	Ecoinvent in GaBi	Ecoinvent in Simapro
Water input	0.0319	0.0486	0.0513
Water output	0.0314	0.0478	-0.0504

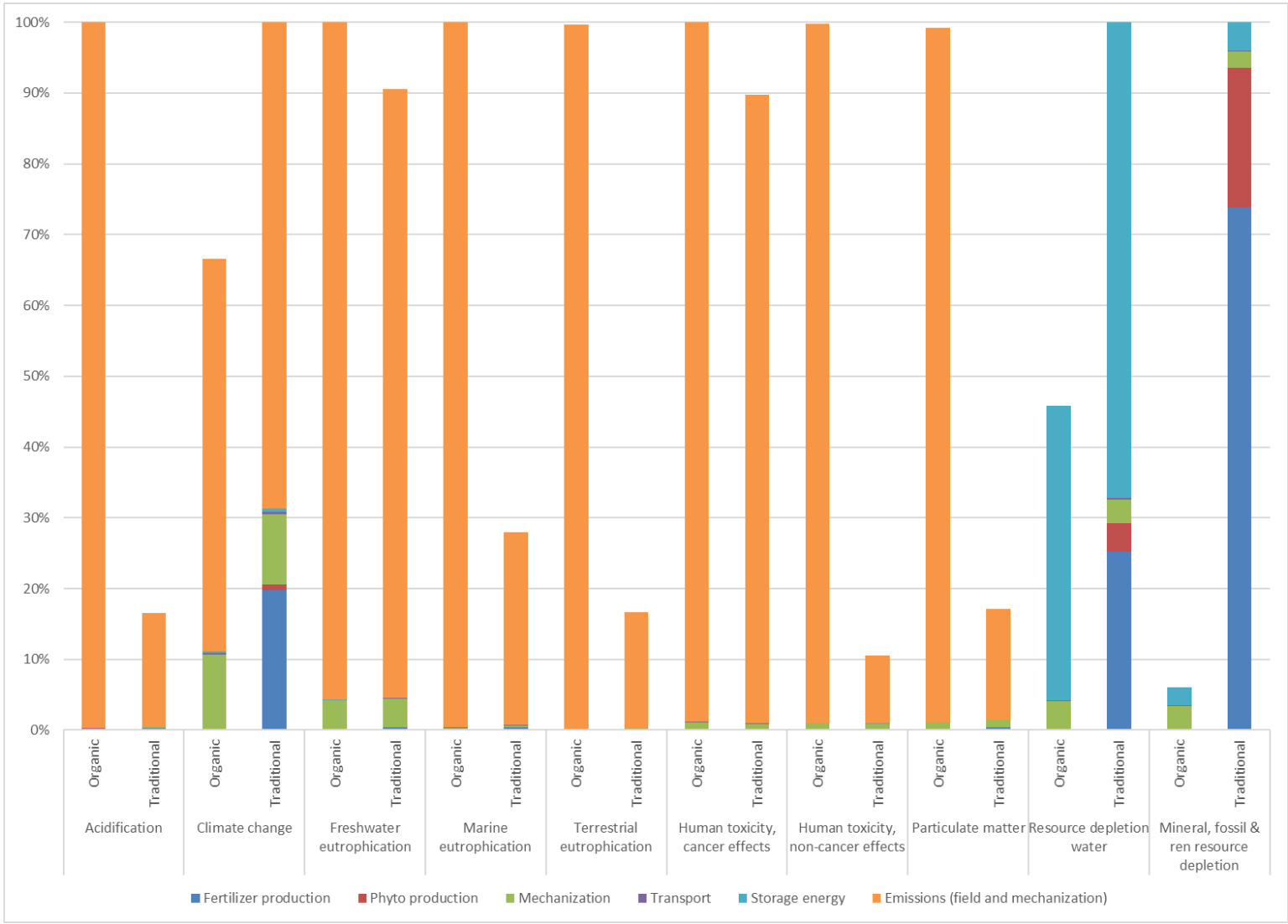
Same dataset, different software ➔ different results

Comparison organic vs traditional wheat

- Mass basis



Comparison on a surface basis



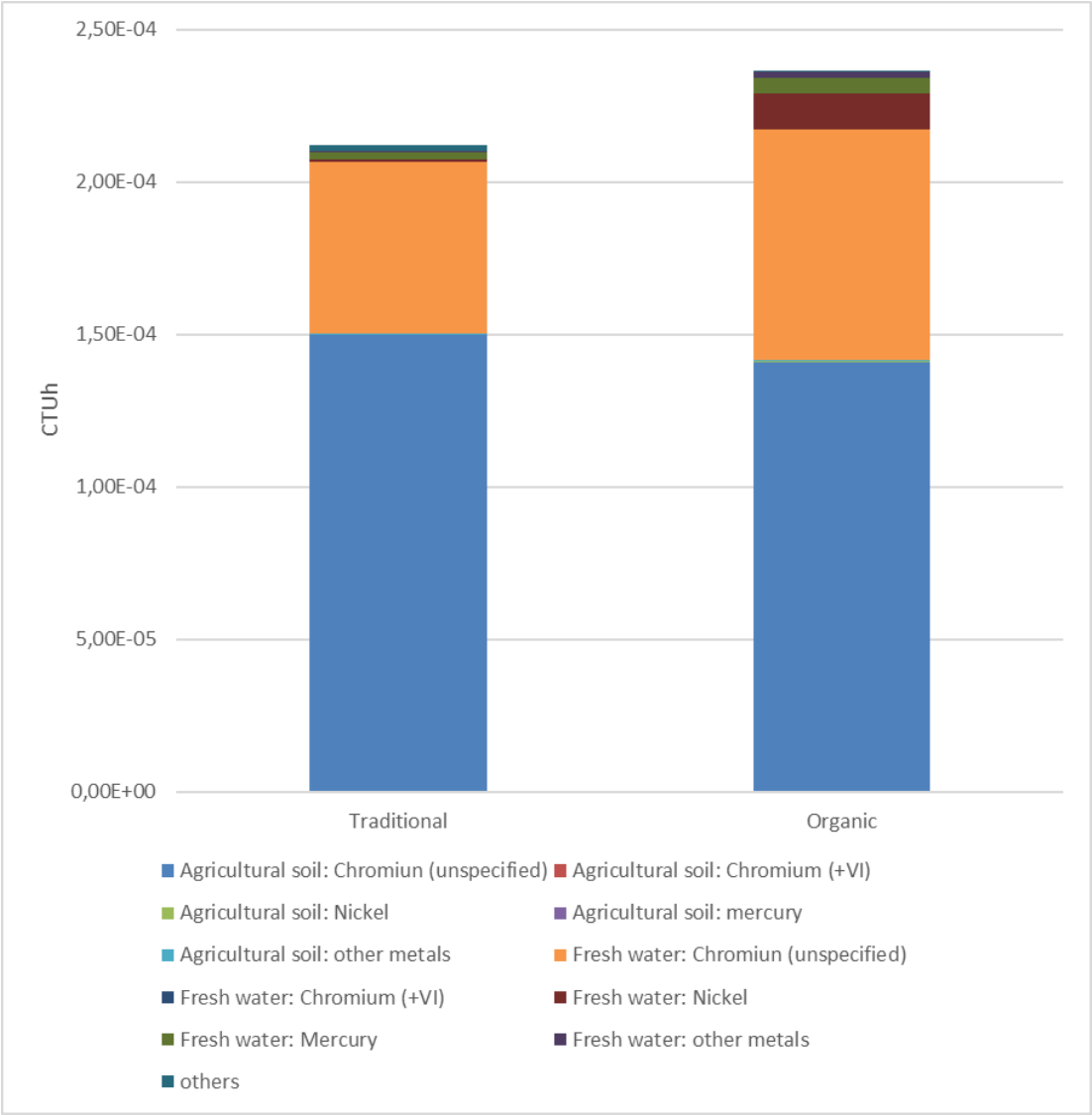
Why?

- From field emissions:
  - Organic:
    - No mineral fertilizer
    - More organic fertilization (x15)
    - Organic fertilizers have higher emissions
    - ➔ More field emissions

			Traditional wheat	Organic wheat
Grain yield (kgDM.ha^{-1})			7284	3830
Harvested straw (kgDM.ha^{-1})			3007	2130
Humidity at harvest (%)			15	15
Fertilizers (kgDM.ha^{-1})	Mineral	N	181	0
		P_2O_5	3.77	0
		K_2O	6.34	0
	Organic	N	6.84	142
		P_2O_5	3.58	65
		K_2O	6.06	145
	PPPe		2.86	0
Emissions to air (kgDM.ha^{-1})	NH_3	min	16.3	0
		org	6.22	94.8
	NOx	min	4.77	0
		org	1.80E-01	4.11
	N_2O	crop	1.85	0.926
		min	3.82	0
		org	1.55E-01	3.69
Emissions to water (kgDM.ha^{-1})	NO_3 water	crop	4.02E+01	39.7
		min	2.93E+01	0
		org	1.23E+01	2.52E+02
	P		2,18E-01	2.18E-01
	PO_4	crop	6.34E-01	6,26E-01
		min	4.25E-03	0
		org	1.12E-02	1,45E-01
Emissions to river (kgDM.ha^{-1})	Cd		9.73E-05	4.60E-05
	Cr		7.89E-03	6.41E-03
	Cu		2.58E-03	1.04E-02
	Pb		5.70E-03	2.80E-04
	Hg		4.95E-06	1.72E-05
	Ni		3.34E-03	6.39E-03
	Zn		1.14E-02	1.62E-02
Emissions to groundwater (kgDM.ha^{-1})	Cd		4.16E-05	2.74E-05
	Cr		1.94E-02	1.85E-02
	Cu		2.67E-03	3.53E-03
	Pb		4.86E-04	2.44E-05
	Hg		2.96E-07	1.07E-06
	Zn		1.85E-02	2.81E-02
Emissions to soil (kgDM.ha^{-1})	Cd		4.03E-04	1.05E-03
	Cr		2.06E-02	2.69E-02
	Cu		5.26E-03	1.00E-01
	Pb		2.14E-03	1.72E-02
	Hg		9.68E-05	2.48E-04
	Ni		7.26E-03	1.05E-01
	Zn		3.91E-02	5.28E-01

Human toxicity, cancer effect

- On a surface basis



Unspecified chromium?

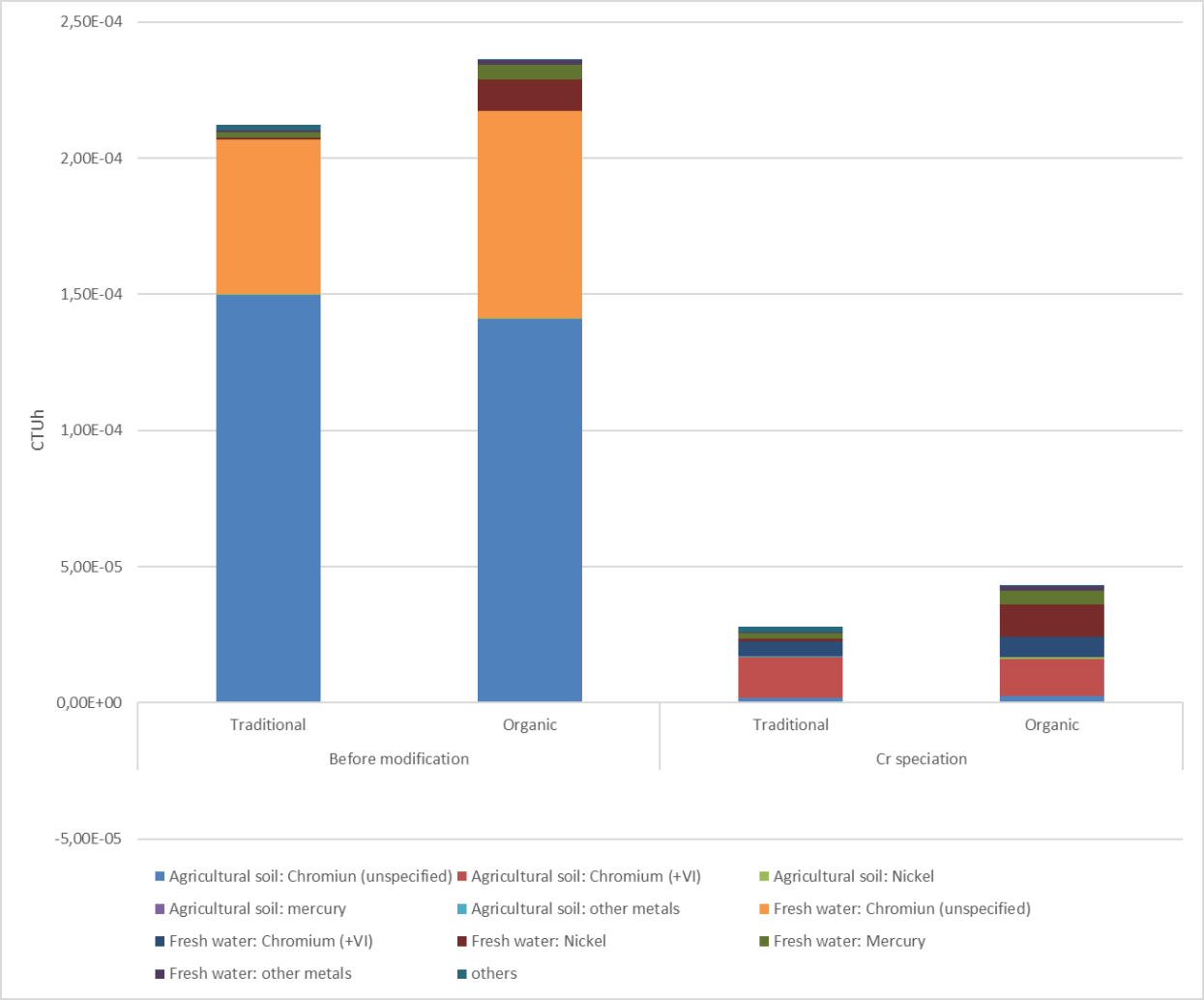
- From organic and mineral fertilizer (field emissions)
- C.F. = average of C.F. of Cr (+III) and Cr (+VI)
  - Cr (III): harmless
  - Cr (VI): very toxic
- Problem: in fertilizer only TOTAL Cr is dosed
  - no speciation: too expensive

Unspecified chromium?

- Could we predict Cr speciation?
- Cr (VI) is extremely reactive
  - Organic compounds: Cr (VI) react to Cr (III)
  - Mineral fertilizer: Cr comes from natural rock
    - in the natural environment: only Cr (III)
  - ➔ Most of the Cr = Cr (III)
  - ➔ Confirmation in literature

Unspecified chromium?

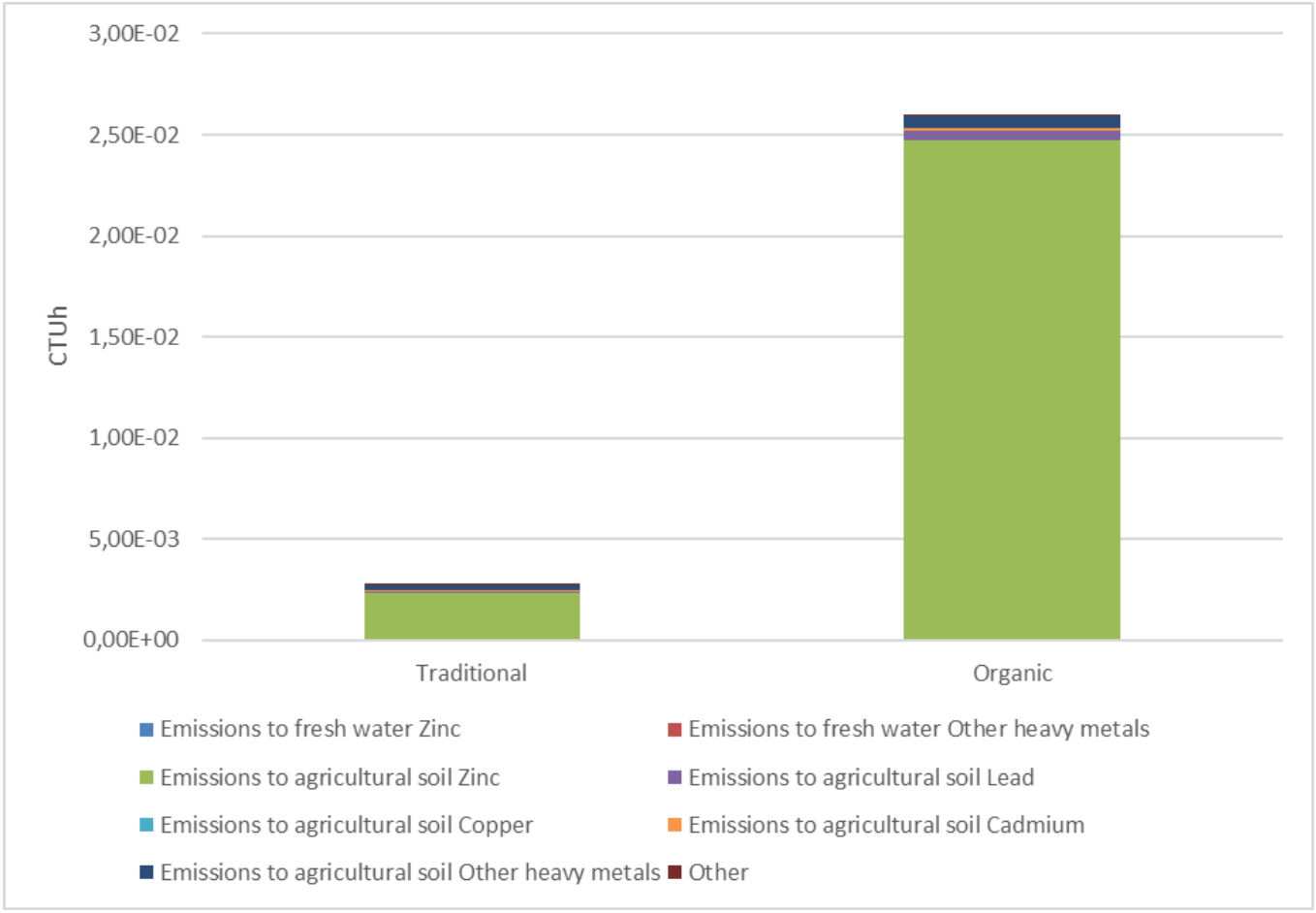
- Test with 95 % of Cr as Cr (III) and the rest as Cr (VI)



Human toxicity, Cancer effect

- Pesticide contribution negligible
  - 2.2 kg of pesticides applied by hectare: only 1.2 kg is characterized
  - Most of them have only C.F. in human toxicity non-cancer effect
    - Glyphosate: only a C.F. in human toxicity, non-cancer effect
    - Classified as probably carcinogenic by the World Health Organization
  - C.F. of the pesticide is small compared to the C.F. of metals

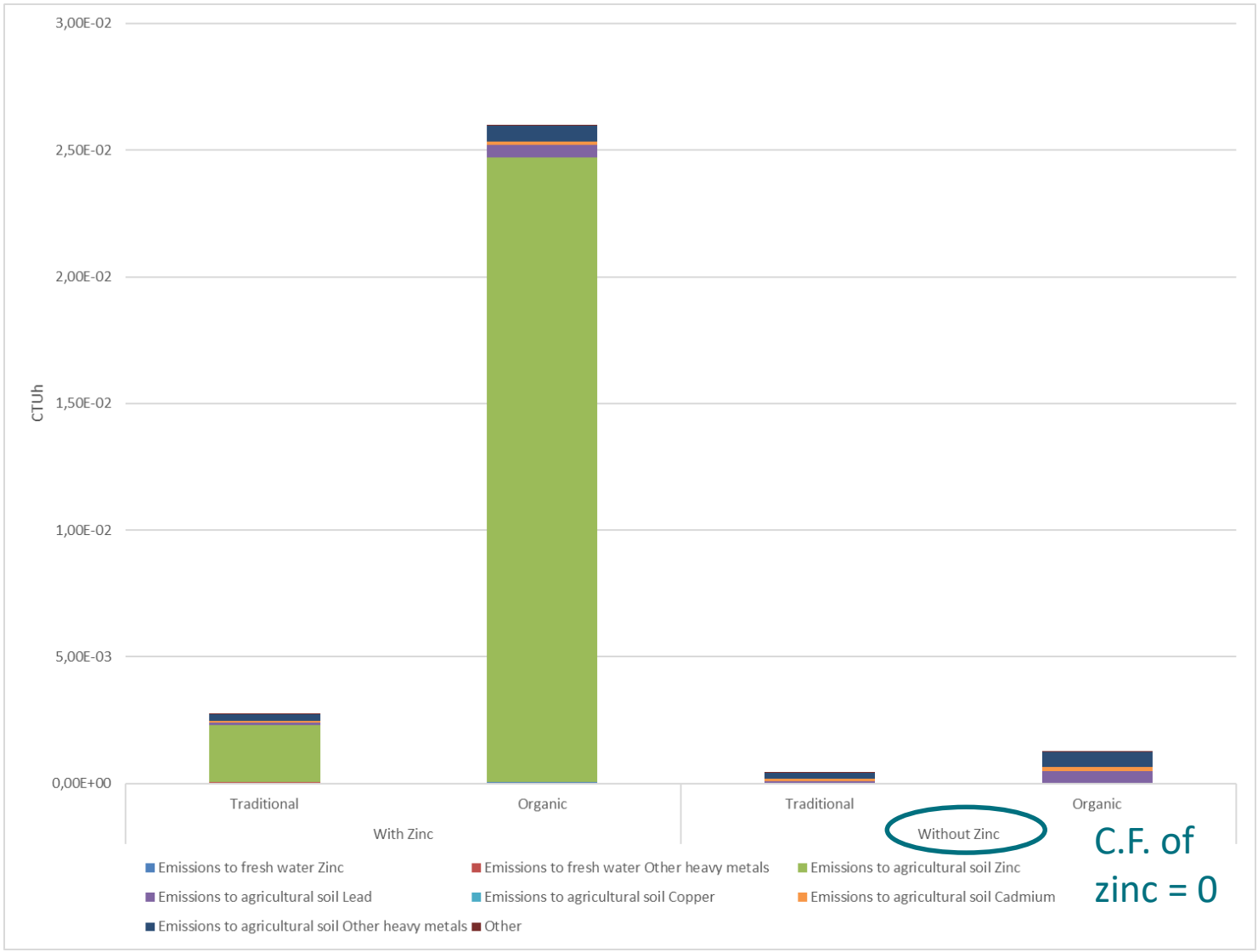
Human toxicity, non cancer effect



Zinc?

- From organic fertilizers (pig manure)
- Zinc: abundant/ important trace element in the human body
  - Useful for growth, bone and brain development, etc.
- European commission recommends: 7- 10 mg/person/day
- We are able to eliminated the zinc to maintain a constant level
- Only the exposure to high doses can have toxic effects
  - Interferes with the uptake of copper

Zinc?



C.F. of zinc = 0

Conclusion

Organic vs traditional wheat

- Results specific to Belgium context
- Benefit if use as food?
- Field emissions: large uncertainties
- Method interpretation by software: example of water resource depletion

Conclusion

Human toxicity

- Small contribution of pesticides
  - No difference between organic and traditional agriculture
- Some CF are surprising: zinc? Cr (unspecified)?
- Guidance for interpretation
- Importance of the speciation of some metals!

Thank you for you attention!

Saïcha Gerbinet
saicha.gerbinet@ulg.ac.be
Products, Environment, and Processes (PEPs)
Department of Chemical Engineering
Université de Liège
www.chimapp.ulg.ac.be

Zinc?

- USEtox:
  - CF= the effects [cases/kg_{intake}] * the intake fraction [kg_{intake}/$kg_{emmitted}$]
- Zinc
  - effect factor: small in comparison to other metals
  - intake fraction: high
  - ➔ a substance that is relatively harmless obtains a large impact in toxicity.
- But is the exposition so high that we are in a toxic case?
- And pesticides?

USEtox 2.01

- Only recommended
  - No impact of heavy metals ➔ large contribution of pestice
  - Organic wheat, on a surface basis
    - 100 time smaller in cancer effect
    - 1000 time smaller in non cancer effect
- Recommended + interim
  - Same conclusion than in this study