Environmental Consequences of Lindane Production

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Objectives

- Make you aware of this problem;
- We know only a little now and we will be confronted with the huge inheritage in the coming years!!
- No accusation but helping to solve!!
- Stimulate a new co-operation for solutions with industry and authorities in the framework of the POPs convention

Starting remarks

- **Most of the productions in Western countries have been stopped long time ago and documentation material is very scarce!**
- **Many of the HCH residuals are covered and as such often not visible anymore!**
- **We have to consider the historical situation and the way lindane has been produced at that time**

Starting remarks - II

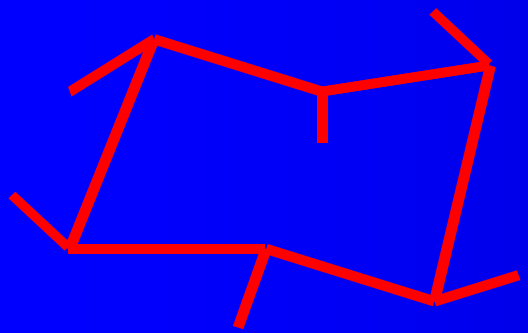
- **The photomaterial was collected in close co-operation with authorities and industries who have been formerly involved with the production**
- **Only due to this joint-effort the material could be obtained**

HCH production process

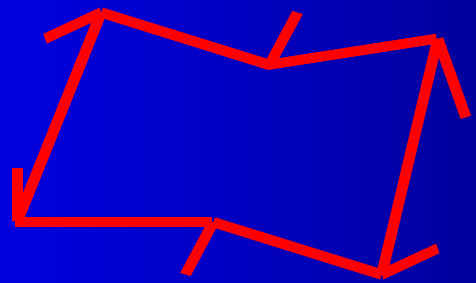
- **Photochemical reaction *adding 3 chlorine moles to benzene ring*.**
  HCH=Hexachlorocyclohexane ($C_6H_6Cl_6$) is left in solution due to excess of benzene. Via destillation towers benzene excess is eliminated, impurities eliminated by melting equipment. Finally HCH is solidified.

HCH consists of various isomers

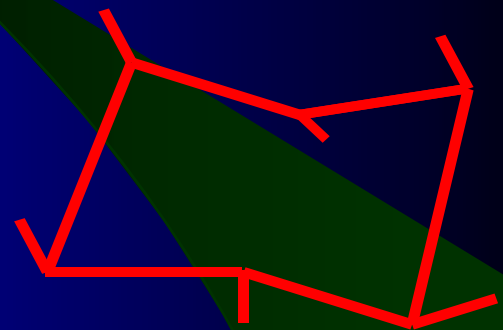
Alpha-HCH

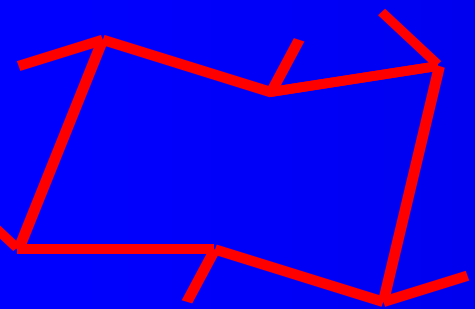


Beta-HCH

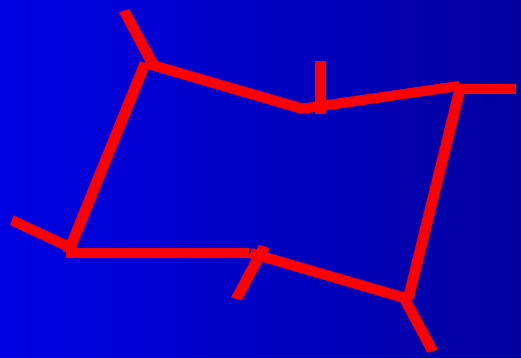


Gamma-HCH





Delta-HCH



Epsilon-HCH

Average composition of HCH obtained from the synthesis reaction

Compound	%
Alpha-HCH	65-70
Beta-HCH	7-9
Gamma-HCH	14-15
Delta-HCH	6-8
Epsilon-HCH	1-2
Other HCH isomers	0-1
Chlorobenzenes (monochlorobenzene mainly)	0-1
Products of incomplete chloration of the superchloration of the ring	0-2
Benzene	0.5-5

Lindane Production

- HCH is introduced in reactor with an appropriate solvent, heated and *selective solution of gamma isomer* carried out.
- *Alpha residues are eliminated* by filtration, dried and sent to cracking unit
- Solution is cooled by precipation a product enriched in gamma isomers, being recrystallized, filtred dried etc
- Solvents regained obtaining delta isomer

Lindane Production

- **Lindane: Active ingredient with insecticides properties with a content of HCH gamma isomer higher than 99%**
- **HCH residues: Mixture of HCH isomers with a low content of gamma isomer**

What does this mean?

- For each ton lindane produced ca. 6 upto 10-12 tons of residuals were created that could not be used and became later hazardous waste
- Total prod. of lindane: 720.000 t (-1993)
- Total HCH residuals: 3-7 Mill ???
- Tot. prod HCH: 10 million tons -1948-1997

Re-use of HCH-Residuals

<u>Some</u> producers in Western Europe:

- **Production of Trichlorphenol, basis for productionof T-acid, main ingredient of ”agent Orange” used in the Vietnam war**
- **Chloracne for labourers damages by 2,3,7,8 TCDD=Tetrachlordibenzodioxin**

Re-use of HCH-Residuals

One producer in Russia

- Production of 1,2,4-trichlorobenzene used as a component of sovtol (mixture of 1,2,4 trichlorobenzene with mixture of tetra- and pentachlorinated PCBs in proportion 1:9), hexachlorobenzene and pentachlor containing salts (Na)

The Netherlands-1

- Small factory HCH-residuals piled up around factory
- 60s-70s HCH waste illegally spread over complete region and filled into sand and clay pits in agricultural area
- HCH residuals found in Dutch milk

The Netherlands-2

- Fish catastrophe in canal next to store
- Under supervision of Dutch government action: HCH pile repacked in 22000 drums (4000 t) and transported to German Kali and Salt mines
- End of 80s ca 100 contaminated sites gathered as one National priority project in the official Soil remediation program.

The Netherlands-3

- 200.000 tons of soil contaminated with HCH collected and stored at temporary storage site
- In 10 years development of soil remediation techniques
- Now still remaining 200.000 tons
- Costs till present 15-20 Mill €

The Netherlands-4

- Total problem ca 400.000 tons of with HCH contaminated soil

East and West Germany

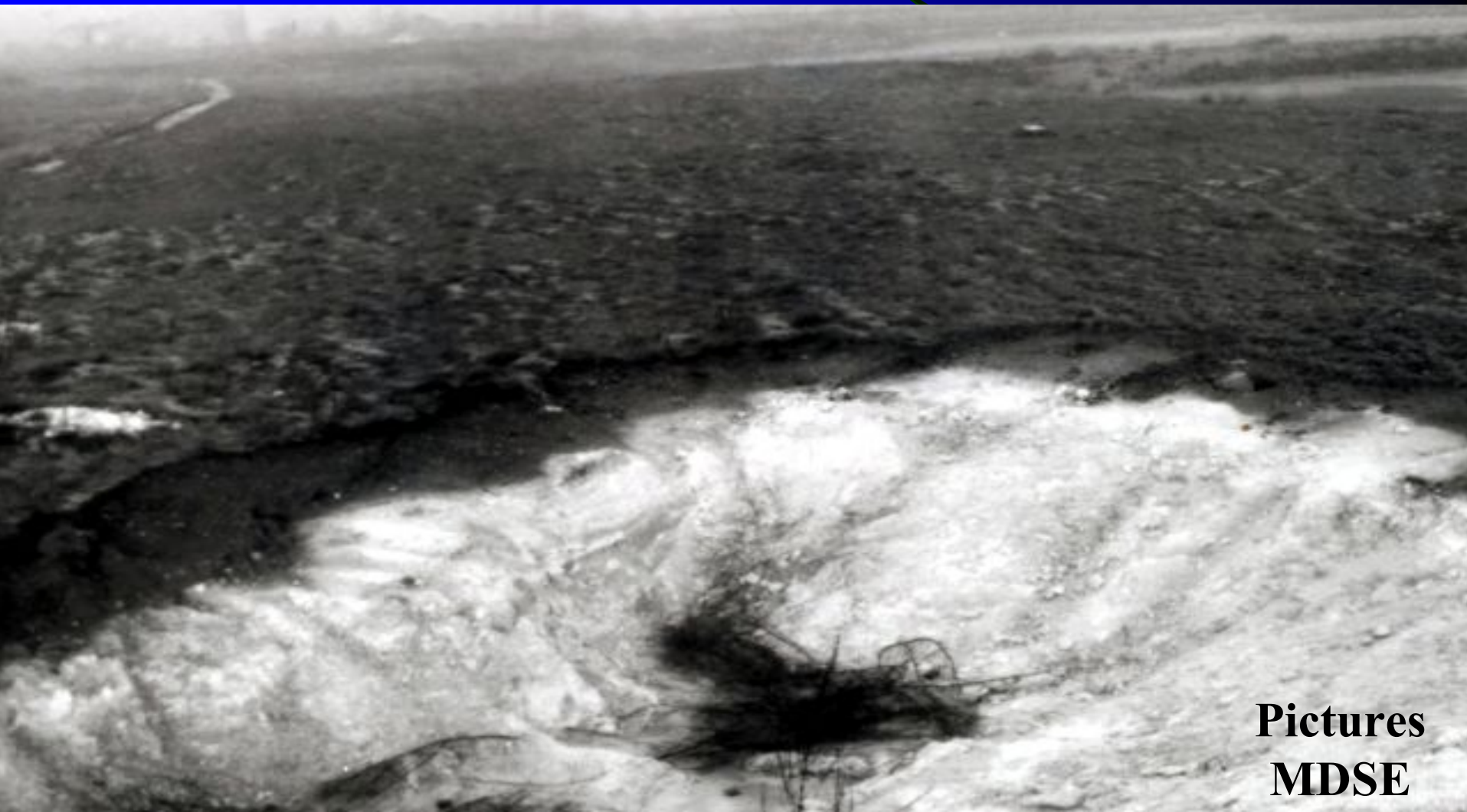
Impression how at that time one has been dealing with residuals during production

1975

Pictures
MDSE

1976

1988



Pictures
MDSE

Spain

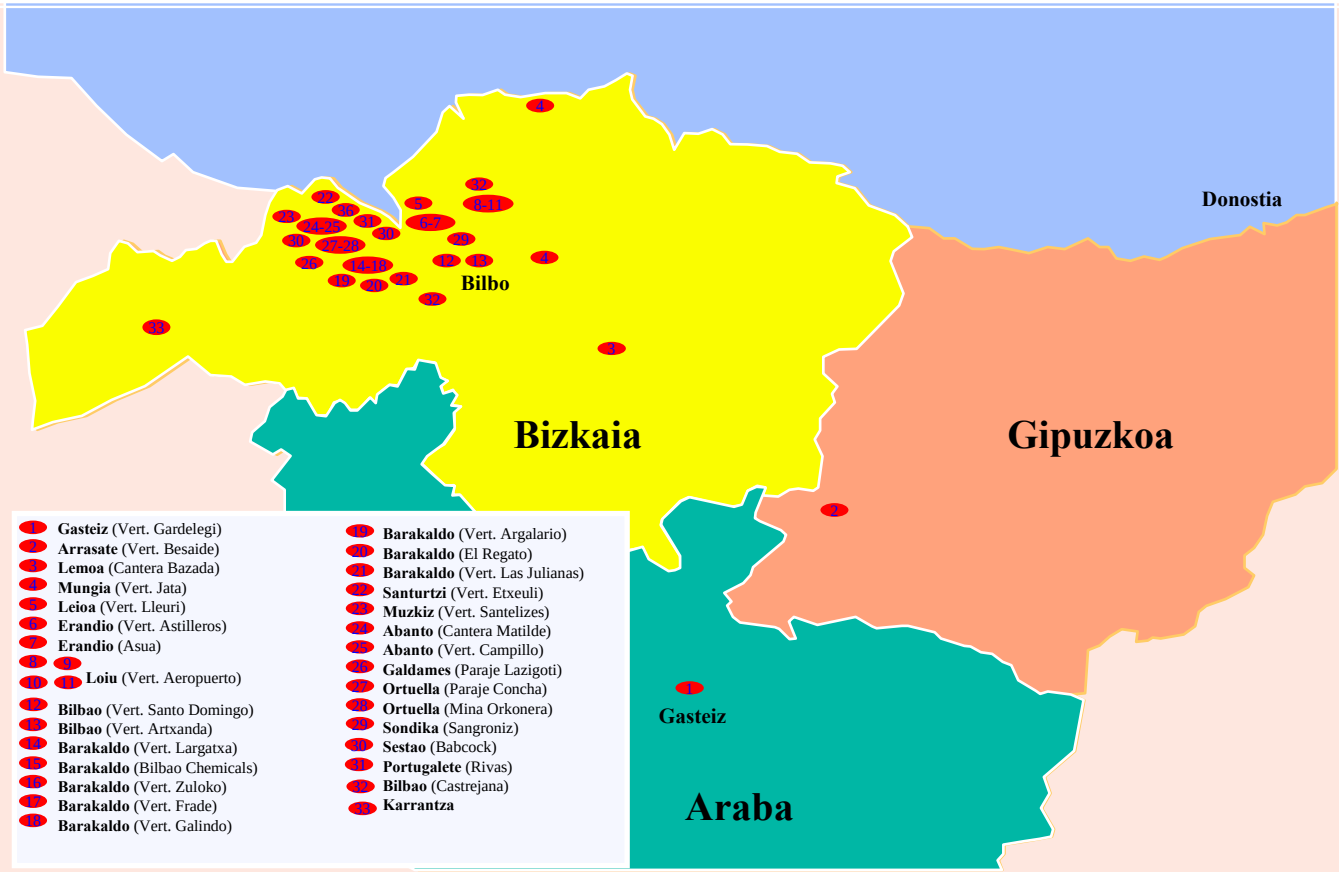
At least 3 regions:

- Basque country
- Galicia
- Aragon

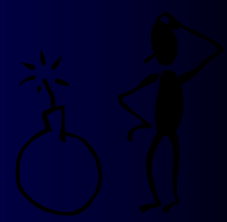
HCH in Basque Country

- Most important environmental issue in the last decade
- Estimated that between 0,5 and 1 Million tons of soils are contaminated with HCH spread over the region

Basque Country HCH-contaminated sites



Main Figures for HCH



HCH producers	2 companies
Production period	1947-1987
Estimated waste generated	82.000 t.
Pure waste	5.000 t.
Waste dumped without control leading to soil contamination	**77.000 t.**
Contaminated sites	33

Site characterisation studies	21 for 23 points
Sites subject to leachate monitoring	11

Costs in Basque Country

- Costs solution of HCH-problem:
- ca 50 Mill € →
- Treatment plant for destruction of 3500 t HCH waste
- Bilbao airport safety cell 113.000 m³ soil
- Barakaldo safety cell: 300.000 m³ soil

Desolated factory with HCH waste inside

Inside the former factory 1992

HCH in Galicia

- Ca. 1000 tons of HCH-waste dumped near factory
- Lindane production stopped mid 60s
- Closure and sale of company
- Waste probably moved due to building activities
- 375.000 m3 soil polluted with HCH

HCH in Galicia

Solutions:

- 864,000 m3 encapsulated vertical wall
- Volume encapsulated polluted soil
- 150 000 m3 → 5 Mill €
- Investigation costs → 0.5 Mill €
- Costs bioremediation research
- 400.000 €

Aragon

- Ca. 115.000 Tons of HCH-residuals produced, most of it deposited at dumping sites in the neighbourhood of the production plant.
- Costs: ca 4.2 Mill € but more costs still to come

HCH-Wastes before actions have been taken

Albania: one of the most polluted sites in Europe

Former lindane plant Albania – end of 2001

Catastrophic surrounding

Inside the former production plant

Macedonia

- **ca. 30.000-35.000 tonnes mixture of alpha + beta isomer of HCH properly stored**
- **3.000 tonnes delta paste (delta isomer)**
- **High groundwater contaminations**
- **Several wild dumps recently found!**
- **Although company has done lots of efforts to store waste as good as possible this is a ”time bomb”**

Macedonia: **Alpha and Beta HCH Storage**

Romania: 250.000 tons HCH residuals

South Africa
70.000 tons HCH-residuals

South Africa

India Lindane wild deposit

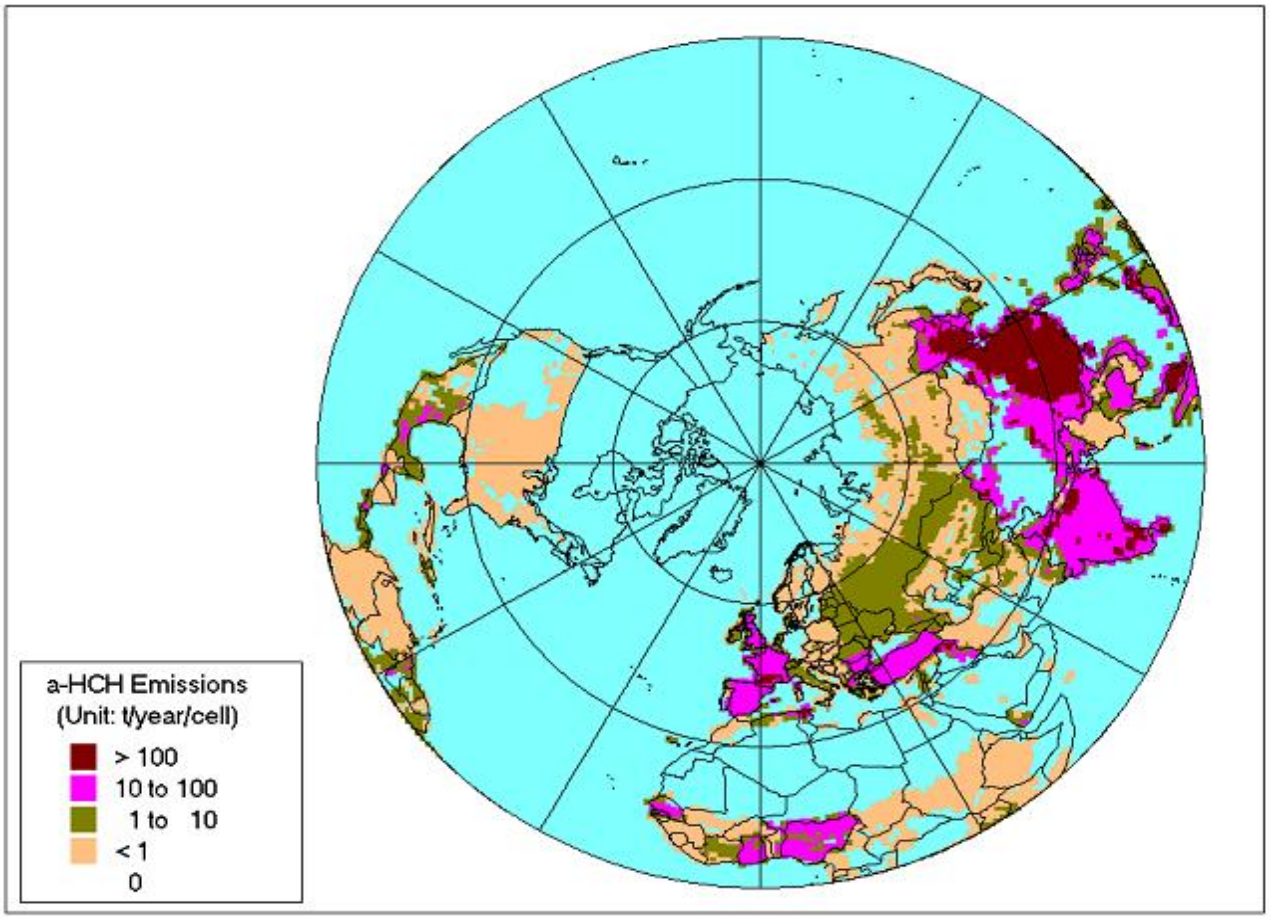
huge amounts expected!!

Brazil: at least 50-100.000 tons

Here estimate 33000 tons

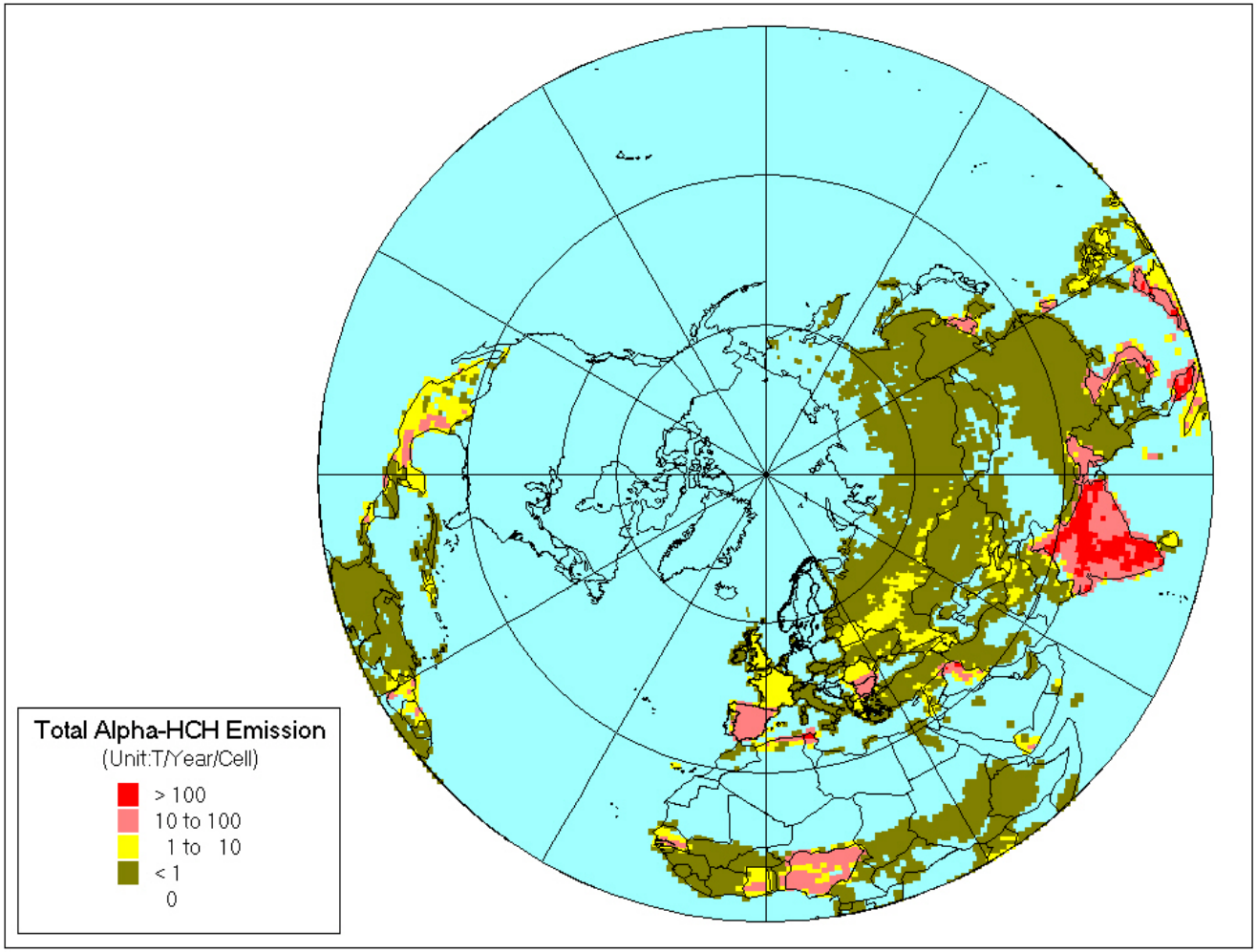

3'96

Global α-HCH emissions in 1980 with 1° by 1° lat/long resolution



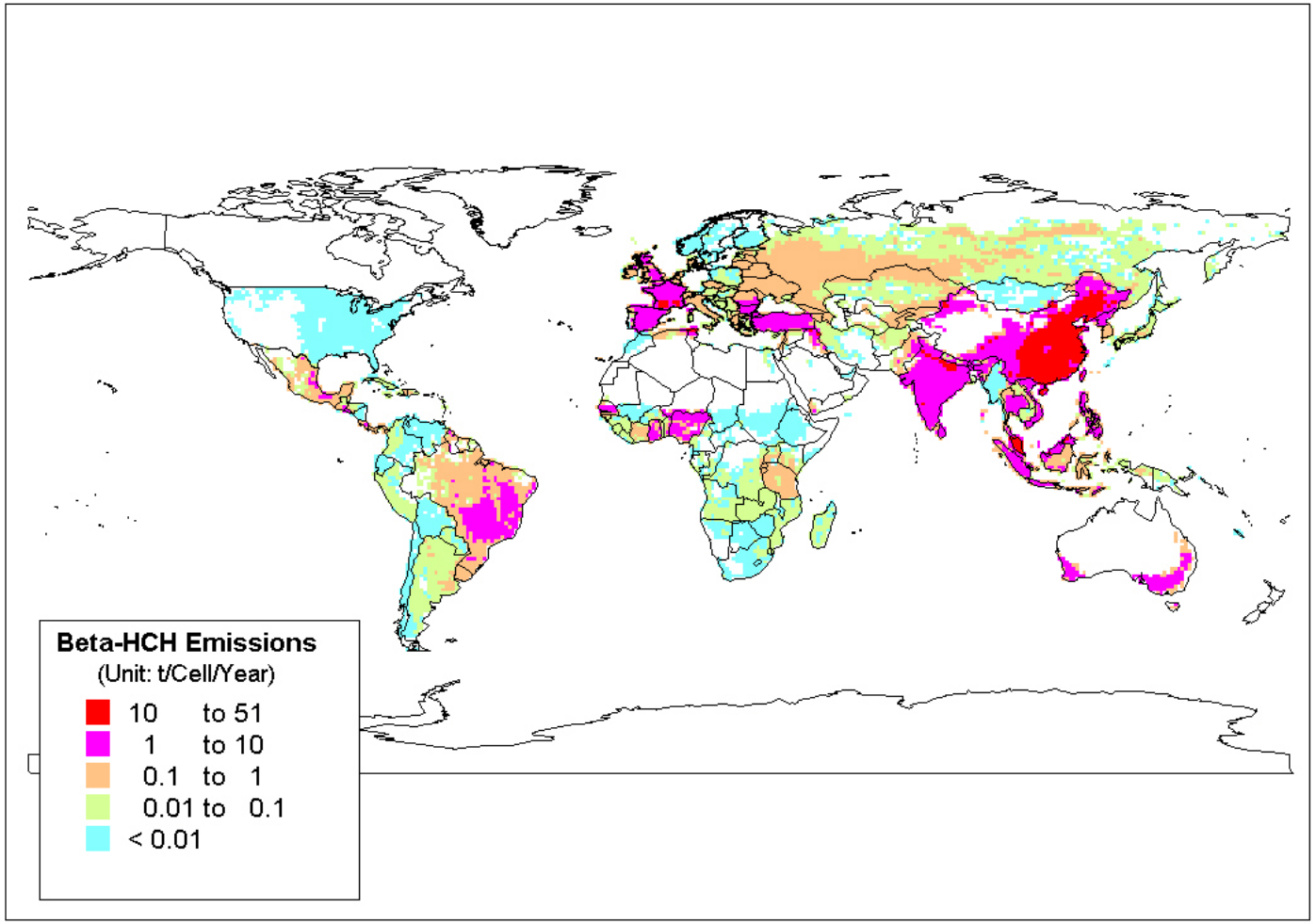
- Source: Li et al. 2000

Global α-HCH emissions in 1990 with 1° by 1° lat/long resolution



- Source: Li et al. 2000

Global β-HCH emissions in 1980 with 1° by 1° lat/long resolution



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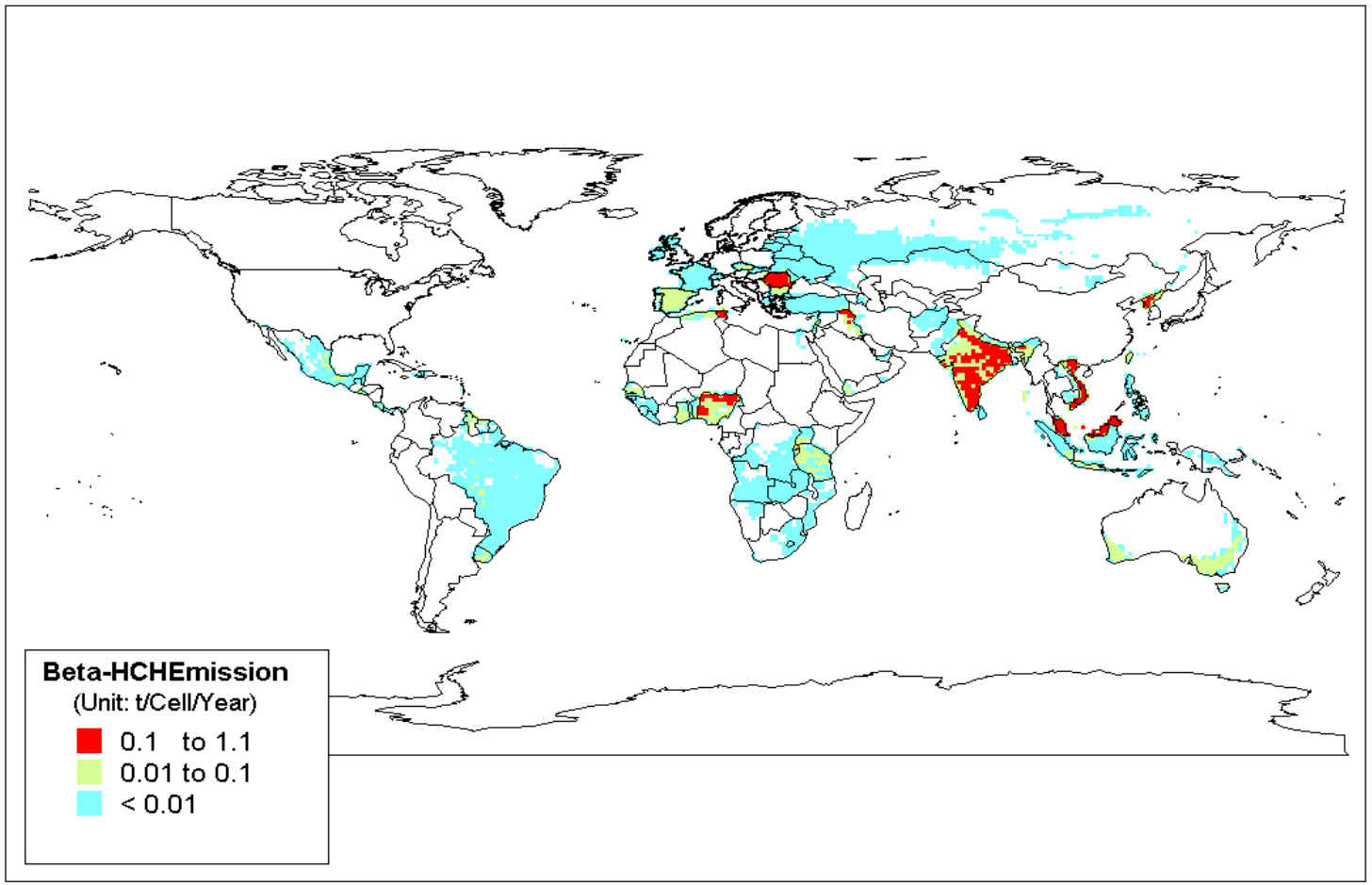

- Source: Li et al. 2003

Other cases HCH-residuals

- Poland: at least 100.000 tons
- Turkey: 3000 tons been discovered

Questions and surprises:

- Russia???
- India and China: mostly technical HCH production and later lindane
- Certainly more??

What are the lessons?

- The consequences of HCH-residuals due to lindane productions are enormous
- We just know the top of the iceberg
- The Inclusion of Lindane and HCH-residuals in the Stockholm Convention could give a start on a common way forward to solve this problem

Thank You