

## Znečištění chemickými látkami

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Seminář  
21.10.2020

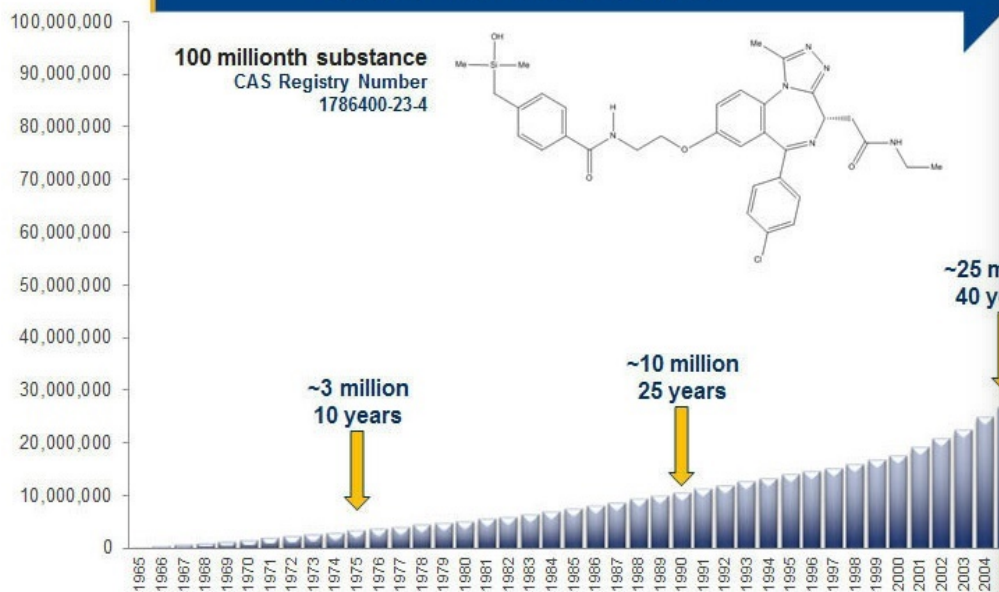


# Chemické látky

- svět kolem nás - chemie (známe > 100 mil. chemických látek)
- lidstvo v rámci svých aktivit vyrábí a používá > 100 000 látek

## CAS REGISTRY

100 millionth substance  
CAS Registry Number  
1786400-23-4



ECHA > Information on Chemicals > EC Inventory

## EC Inventory

The EC inventory published below is a copy as received from the JRC in 2008 on the founding of ECHA. It is comprised of the following:

- **EINECS** (European Inventory of Existing Commercial chemical Substances) as published in O.J. C 146A, 15.6.1990. EINECS is an inventory of substances that were deemed to be on the European Community market between 1 January 1971 and 18 September 1981. EINECS was drawn up by the European Commission in the application of Article 13 of Directive 67/548/EEC, as amended by Directive 79/831/EEC, and in accordance with the detailed provisions of Commission Decision 81/437/EEC. Substances listed in EINECS are considered phase-in substances under the REACH Regulation.
- **ELINCS** (European List of Notified Chemical Substances) in support of Directive 92/32/EEC, the 7th amendment to Directive 67/548/EEC. ELINCS lists those substances which were notified under Directive 67/548/EEC, the Dangerous Substances Directive Notification of New Substances (NONS) that became commercially available after 18 September 1981.
- **NLP** (No-Longer Polymers). The definition of polymers was changed in April 1992 by Council Directive 92/32/EEC amending Directive 67/548/EEC, with the result that substances previously considered to be polymers were no longer excluded from regulation. Thus the No-longer Polymers (NLP) list was drawn up, consisting of such substances that were commercially available between 18 September 1981 and 31 October 1993.

Last updated 11 August 2017. Database contains 106211 unique substances/entries.

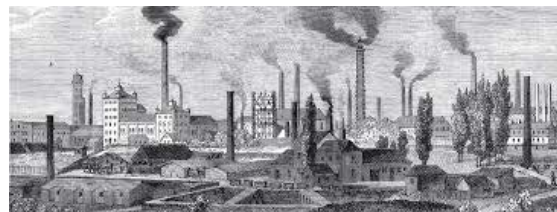
> Filter the list

Page 1 of 2,125 50 Items per Page Showing 1 - 50 of 106,211 results.

| Name                                                                                                 | EC no.    | CAS no.    | Molecular Formula | Description                 |
|------------------------------------------------------------------------------------------------------|-----------|------------|-------------------|-----------------------------|
| "mercurous oxide"                                                                                    | 239-934-0 | 15829-53-5 | Hg <sub>2</sub> O |                             |
| ((2-ethyl-1-oxohexyl)oxy)-(1-phenyl-1,3-decanedionyl)diethyl stannane<br>RHODORSIL ACCELERATEUR 2025 | 422-920-5 | -          |                   | RHODORSIL ACCELERATEUR 2025 |
| ((4-phenylbutyl)hydroxyphosphoryl)acetic acid                                                        | 412-170-7 | -          |                   | SQ 26999                    |

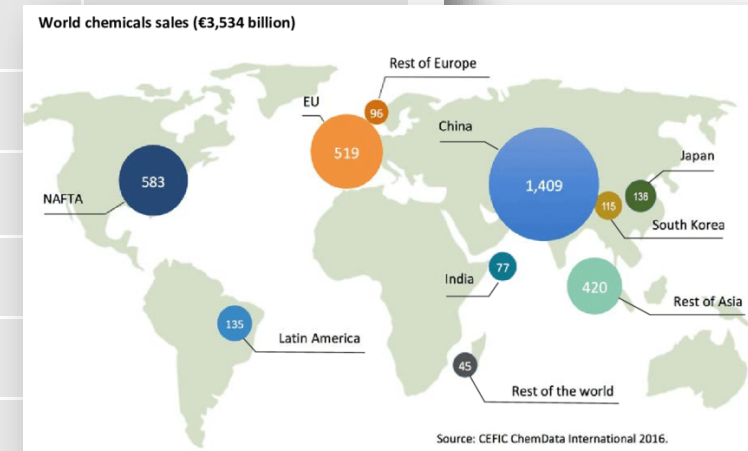
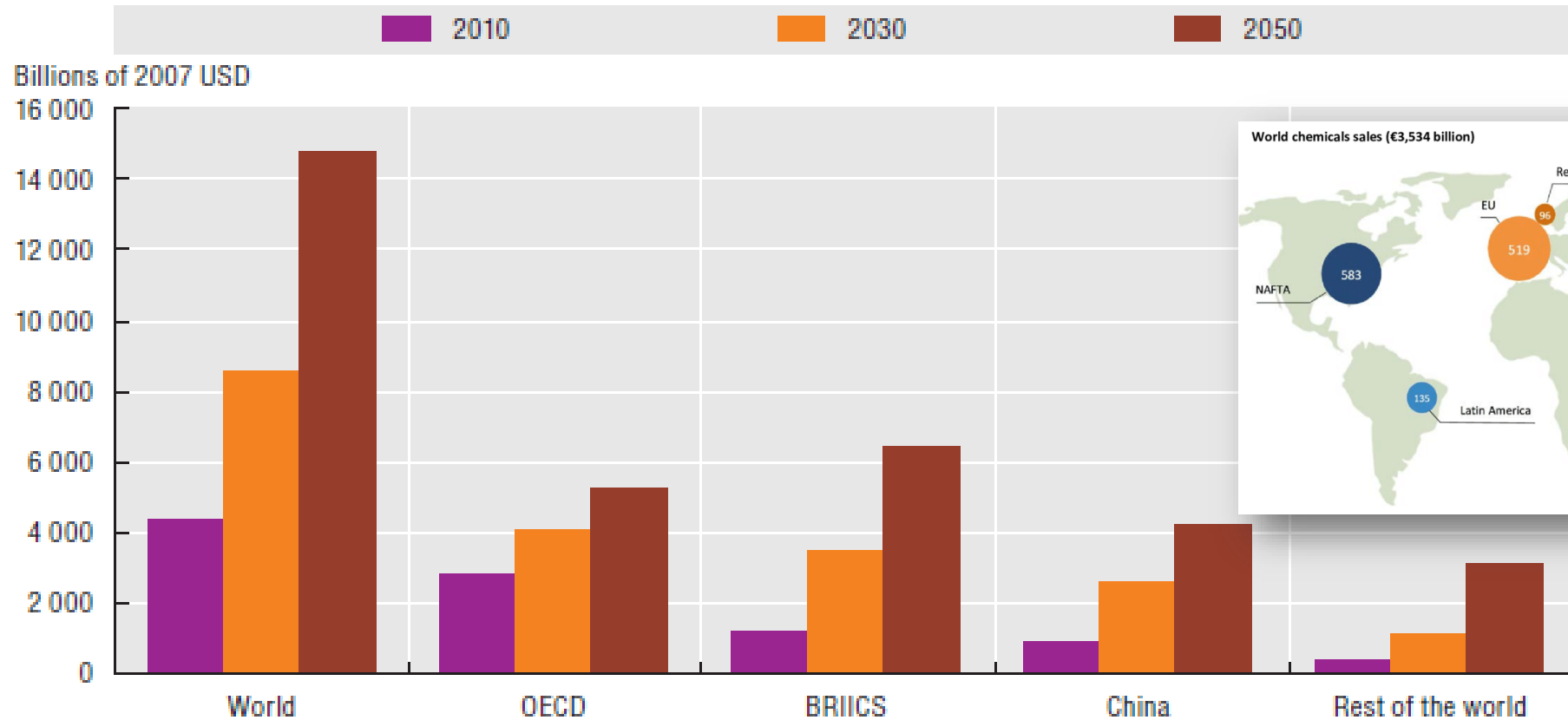
# Člověk vždy používal ChL, produkoval odpad a čelil následkům

- skládky odpadů známé již ze starověku
- olověná potrubí v římském impériu
- **průmyslová revoluce** - drastický nárůst produkce ChL a produkce odpadu
- polovina 18. století – znečištění ovzduší, londýnský smog, nemoci
- začátek 19. století – zpracování nafty, produkce organických chemikálií, umělá hnojiva, olovo do benzínu
- polovina 19. století – boom pesticidů - **green revolution**, využívání HMs
- od 60. let – zlepšení nakládání s odpady, legislativa
- od 70. a 80. let environmentální legislativa, regulace ChL
- produkce ChL a odpadu stále roste s růstem populace GDP



# Produkce chemických látek roste

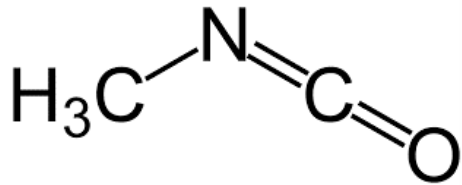
Figure 6.13. Projected chemicals production by region (in sales):  
Baseline, 2010-2050



OECD (2012)

# Bhopal

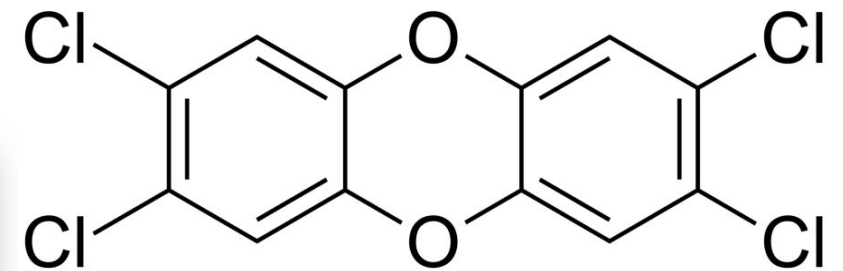
- továrna společnosti Union Carbide, výroba pesticidů pro Indii
- 2-3.12.1984 havárie zásobníku methylisokyanátu
- mrak vysoce toxického plynu těžšího než vzduch – MIC, CO, NO<sub>x</sub>, HCN, MMA, CO<sub>2</sub>, COCl<sub>2</sub> ...
- > 8000 úmrtí během týdne
- 100-200 tisíc osob s trvalými zdravotními následky



Eckerman (2005)

# Seveso

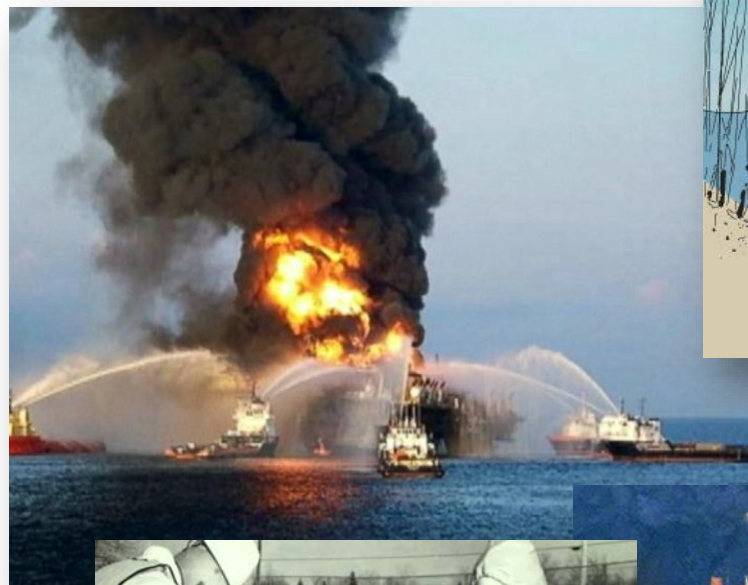
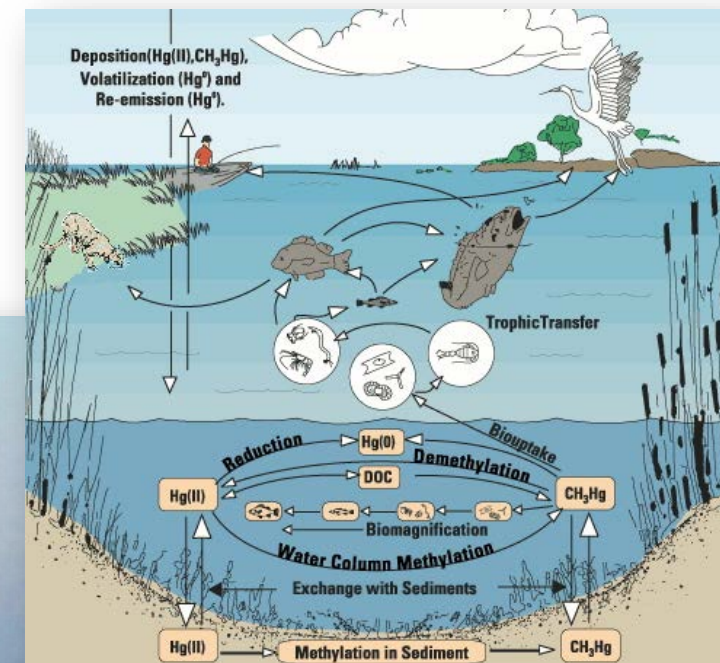
- 10.7.1976 únik chemikálií z továrny na výrobu pesticidů
- cca 6 tun chemikálií s cca 1 kg 2,3,7,8-TCDD
- zamoření oblasti cca 18 km<sup>2</sup>
- 37.000 lidí s následky otravy



# Další chemické katastrofy

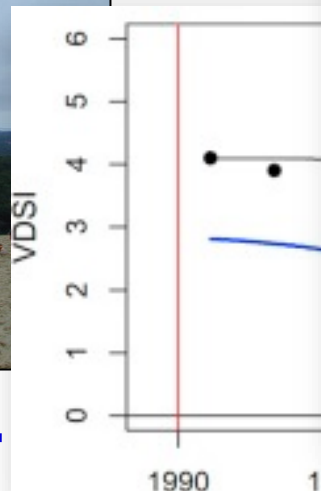
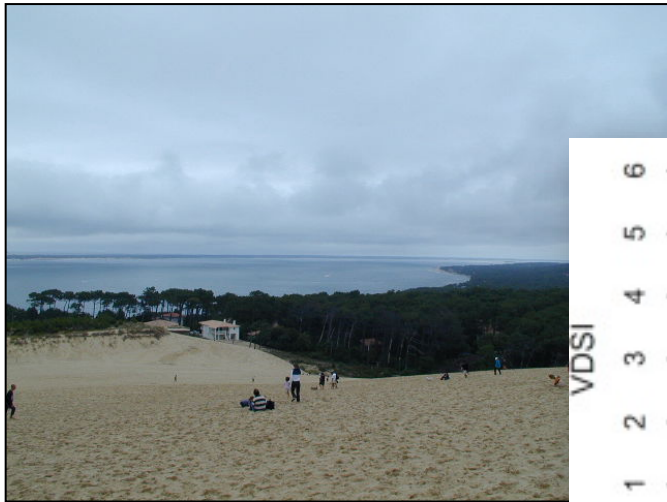
- Minamata 1950's
- Love Canal 1950's
- Agent Orange 1961-71
- Chernobyl 1986
- Exxon Valdez 1989
- Gulf war 1991
- Deepwater Horizon 2010
- Fukushima 2011
  
- desítky dalších ...

[https://en.wikipedia.org/wiki/List\\_of\\_industrial\\_disasters](https://en.wikipedia.org/wiki/List_of_industrial_disasters)



# nejen katastrofy ... Tributylcín

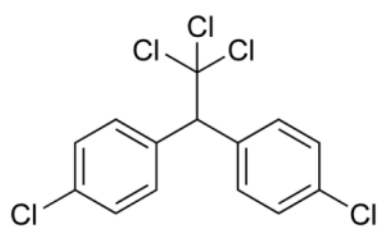
- biocid, široké využití,
- uvolnění do mořských
- bioakumulace, metab
- vliv na hormonální sys



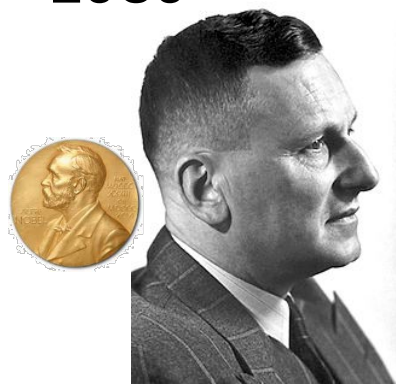
|                    |                                                                                                                                                                                                                                                                                                                                      |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Early 1970s        | Rapid increase in the use of TBT antifouling paints on vessels of all sizes and first reports of imposex in marine snails (Blaber, 1970; Smith, 1971)                                                                                                                                                                                |
| 1976–81            | Repeated failure of larval settlement leads to near collapse of oyster fishery, Arcachon Bay, France                                                                                                                                                                                                                                 |
| 1982               | France introduces legislation prohibiting the use of TBT paints on small vessels                                                                                                                                                                                                                                                     |
| 1985               | First controls introduced in United Kingdom limiting concentrations of TBT in paints                                                                                                                                                                                                                                                 |
| 1986               | Bryan <i>et al.</i> (1986) report widespread imposex in dogwhelks on southern coast of United Kingdom, linked to TBT                                                                                                                                                                                                                 |
| January 1987       | United Kingdom announces further restrictions on TBT content of applied antifouling paint                                                                                                                                                                                                                                            |
| May 1987           | United Kingdom introduces ban on retail sale of TBT paint for use on vessels < 25 m and on fish cages                                                                                                                                                                                                                                |
| June 1987          | PARCOM Recommendation 87/1 calls for similar ban over entire convention area (Northeast Atlantic)                                                                                                                                                                                                                                    |
| 1988               | United States introduces restrictions. Waldock <i>et al.</i> (1988) highlight significance of inputs from shipyards                                                                                                                                                                                                                  |
| 1989               | Restrictions introduced in Canada, Australia and New Zealand                                                                                                                                                                                                                                                                         |
| 1991               | Harmonised ban on retail sale of TBT paint introduced at European Union level                                                                                                                                                                                                                                                        |
| 1994               | Early reports of imposex in whelks from offshore areas of North Sea linked to shipping activity                                                                                                                                                                                                                                      |
| 1995               | Ministerial declaration of fourth North Sea conference (Esbjerg) commits to working for global phase-out of TBT paint within IMO                                                                                                                                                                                                     |
| 1997               | Concept of global phase out of organotin containing paints agreed at MEPC's 40th session                                                                                                                                                                                                                                             |
| 1998               | Draft mandatory regulations aimed at such a phase-out adopted. OSPAR (Convention for the Protection of the Marine Environment of the Northeast Atlantic) prioritises organotins for action to cease all releases. Cessation of all releases of organotins to marine environment, under OSPAR's hazardous substances strategy in 2020 |
| November 1999      | Deadlines for phase-out adopted under IMO Assembly Resolution A.895(21)                                                                                                                                                                                                                                                              |
| 2001<br>EEA (2001) | Text of International Convention on the Control of Harmful Anti-fouling Systems to be finalised. In 2003 worldwide prohibition on new application of organotin antifoulants to all vessels and in 2008 the existing organotin antifouling coatings will be replaced on all vessels worldwide                                         |

# nejen katastrofy ... DDT

1874



1939



**"DDT is good for me-e-e!"**

The great expectations held for DDT have been realized. During 1946, exhaustive scientific tests have shown that, when properly used, DDT kills a host of destructive insect pests, and is a benefactor of all humanity.

Pennsalt produces DDT and its products in all standard forms and is now one of the country's largest producers of this amazing insecticide. Today, everyone can enjoy added comfort, health and safety through the insect-killing powers of Pennsalt DDT products . . . and DDT is only one of Pennsalt's many chemical products which benefit industry, farm and home.

**GOOD FOR STEERS**—Heef grows meatier nowadays . . . for it's a scientific fact that—compared to untreated cattle—heef-cows gain up to 50 pounds extra when protected from horn flies and many other pests with DDT insecticides.

**GOOD FOR FRUITS**—Bigger apples, juicier fruits that are free from unsightly worms . . . all benefits resulting from DDT dusts and sprays.

**PENN SALT CHEMICALS**  
87 Years' Service to Industry • Farm • Home  
PENNSYLVANIA SALT MANUFACTURING COMPANY

1900

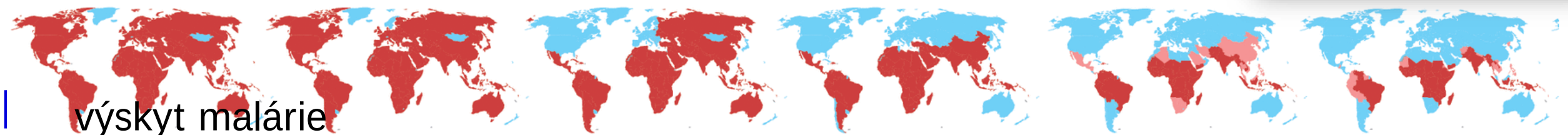
1945

1970

1990

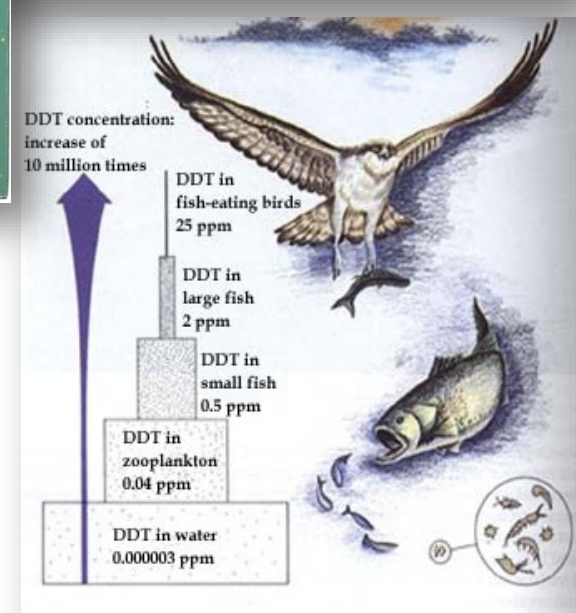
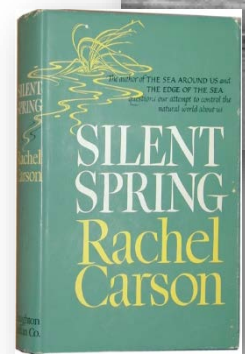
2015

2020



výskyt malárie

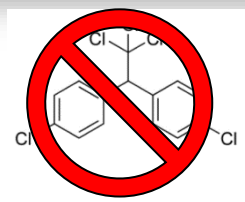
1962



1970



1972



World population: 7.2 billion  
At risk for malaria: 3.2 billion

# Ne všechny příběhy končí špatně ...

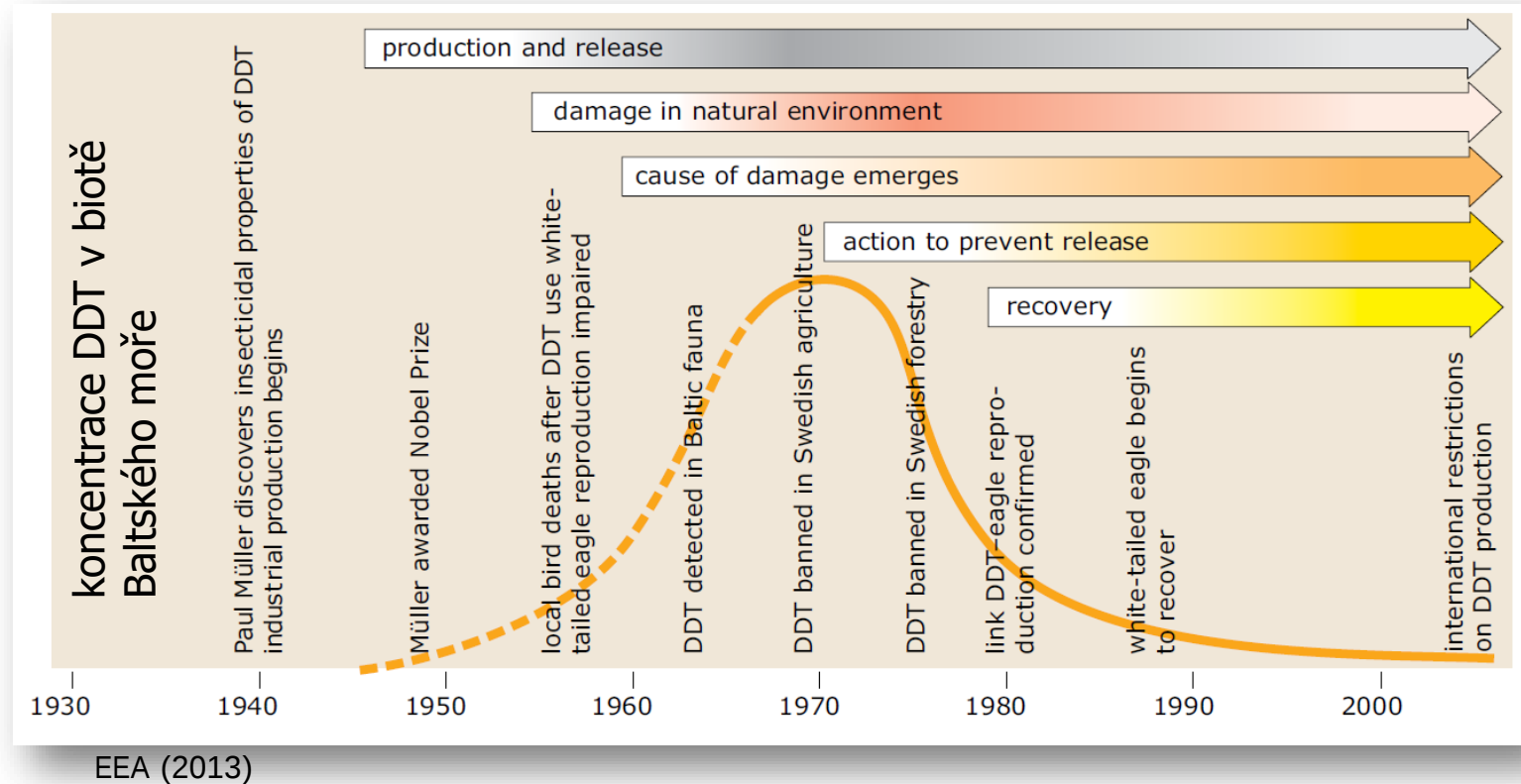
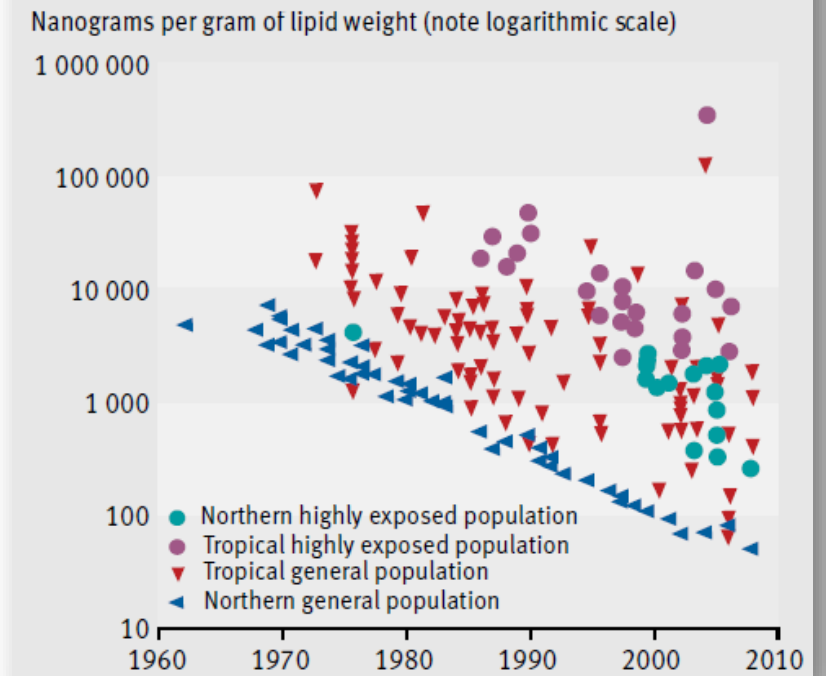
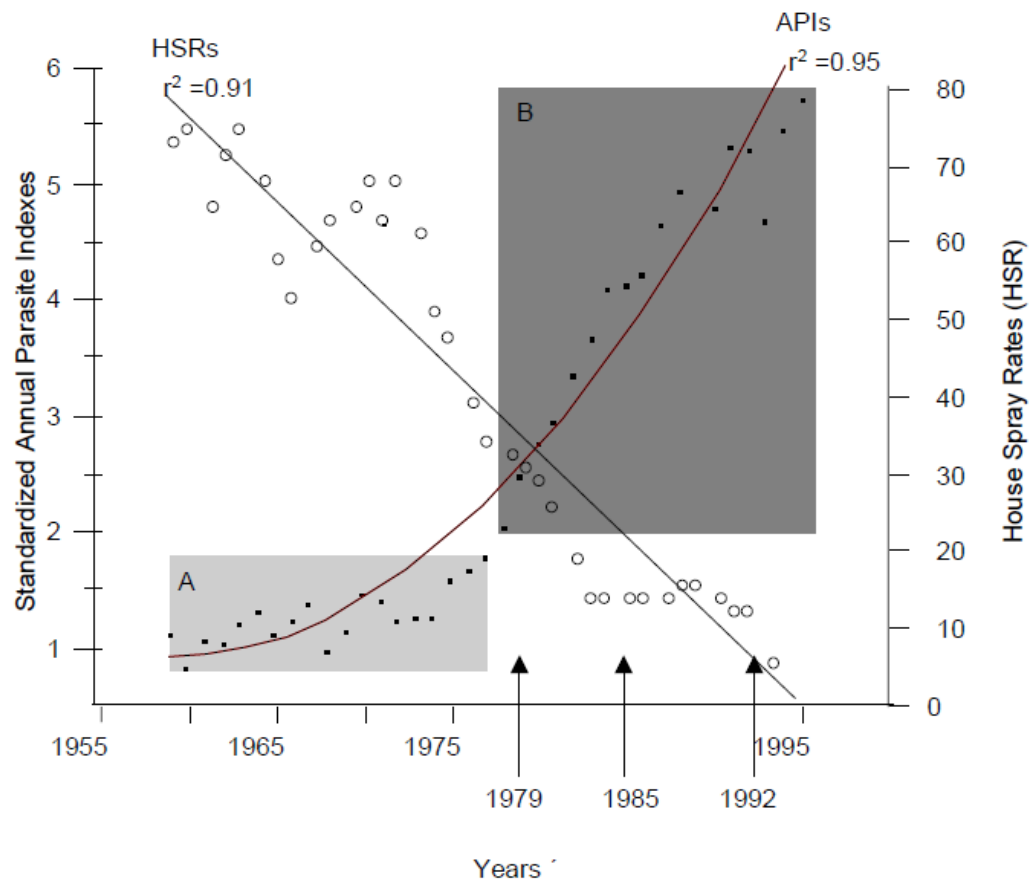


Figure 6.5 DDT levels in humans, 1960–2008



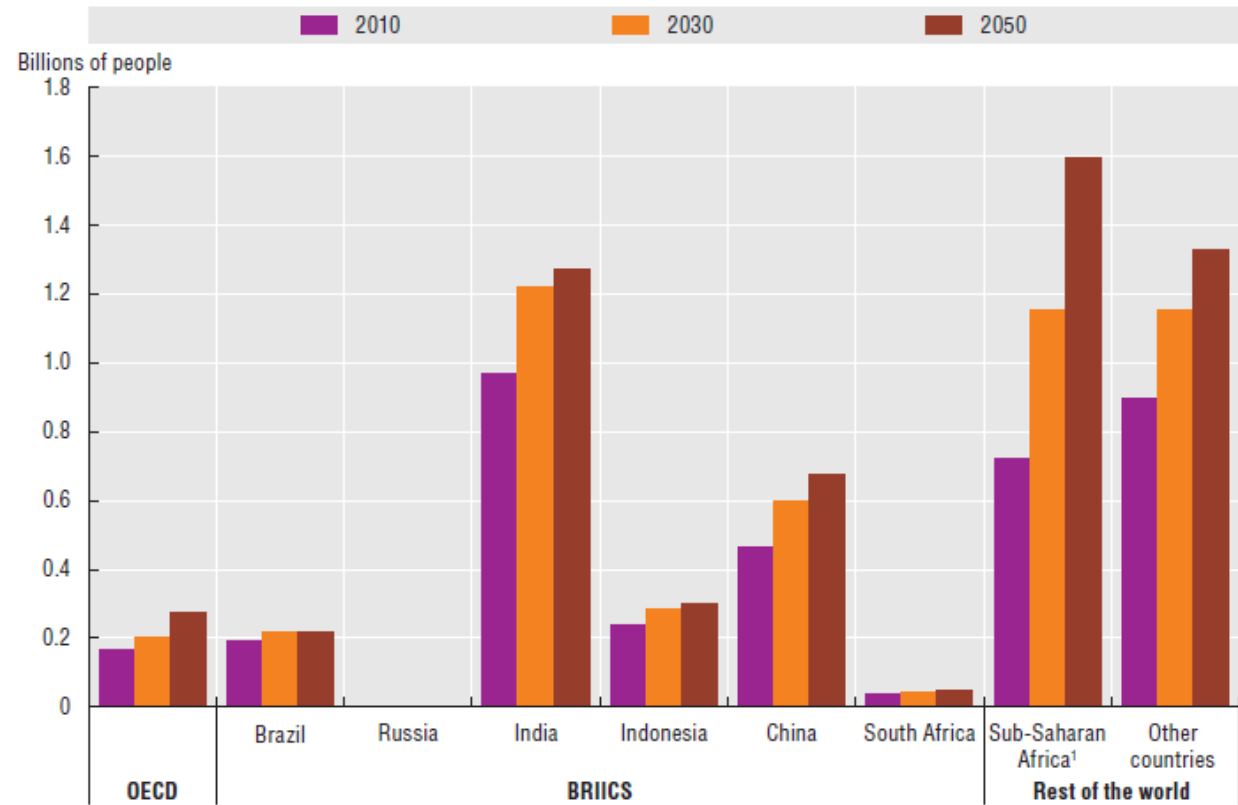
UNEP (2012)

i když ...



Roberts (1997)

Figure 6.14. Potential population at risk from malaria: Baseline, 2010-2050

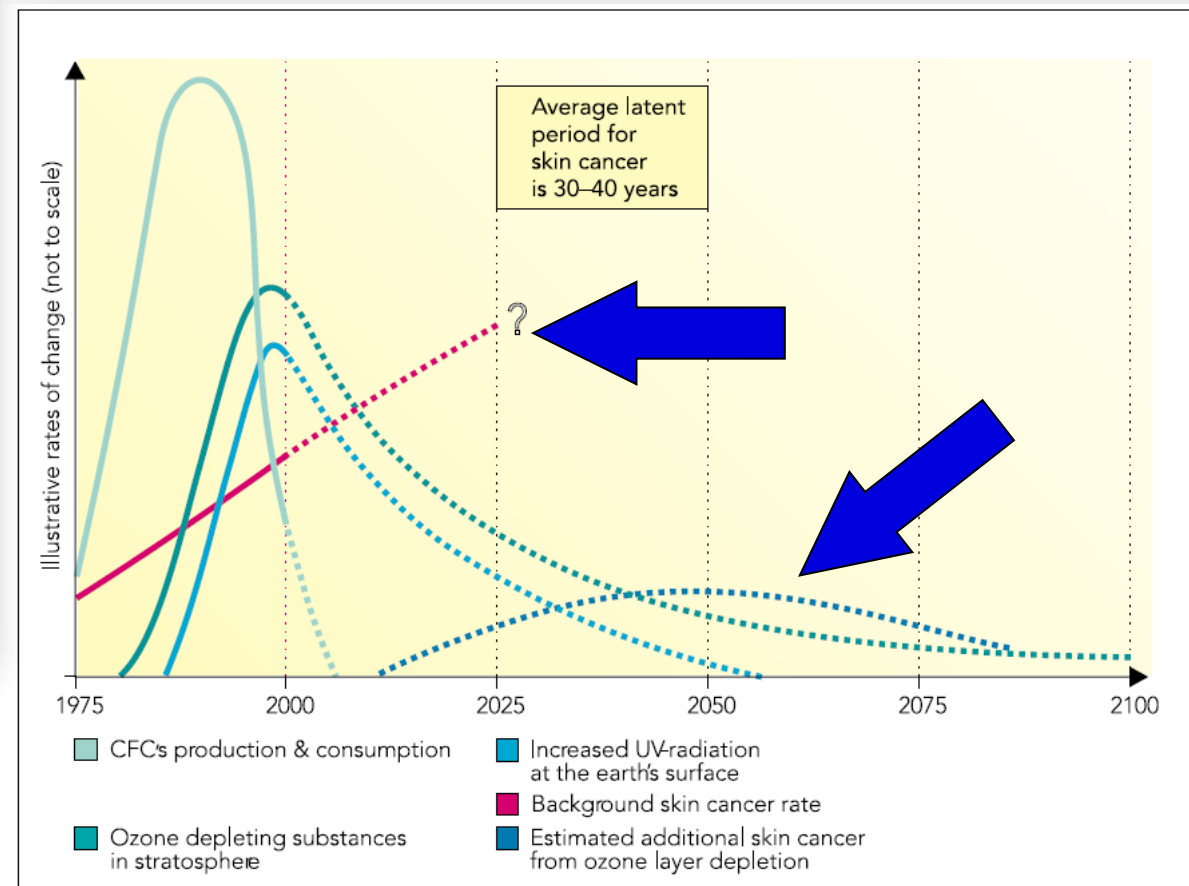


OECD (2012)



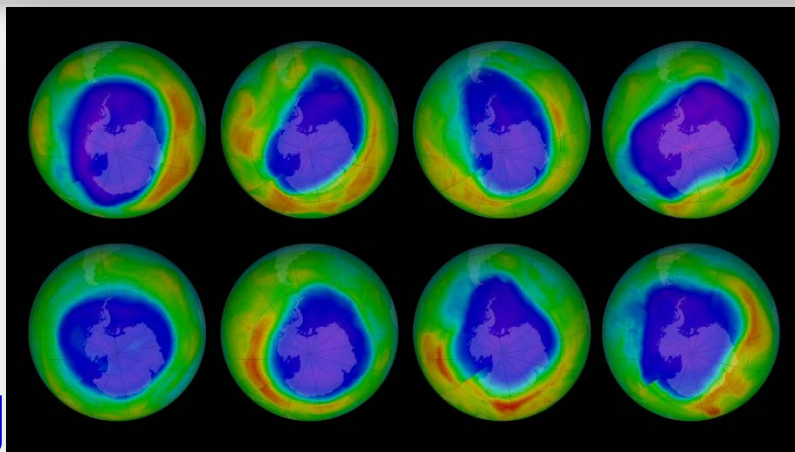
# Ne všechny příběhy končí špatně, i když ...

|       |                                                                                                                                                                                      |
|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1907  | Laboratory experiments by Weigert on the decomposition of ozone photosensitised by chlorine                                                                                          |
| 1934  | <i>Ditto</i> by Norrish and Neville                                                                                                                                                  |
| 1973  | Global survey of CFCs by Lovelock <i>et al.</i> showing their distribution in the atmosphere worldwide                                                                               |
| 1974  | Molina and Rowland publish their theoretical arguments that CFCs would be destroying the ozone layer                                                                                 |
| 1977  | United States bans CFCs in aerosols based on 'reasonable expectation' of damage, followed by Canada, Norway and Sweden.                                                              |
| 1977  | Research-oriented 'world plan of action on the ozone layer' agreed, overseen by UNEP                                                                                                 |
| 1980  | European decision restricting use of CFCs in aerosols, but rising use in refrigerators, etc. marginalises this restriction                                                           |
| 1985  | UNEP Vienna Convention for the protection of the ozone layer agrees research, monitoring, information exchange and restrictions if and when justified                                |
| 1985  | Farman, Gardiner and Shanklin publish results showing hole in ozone layer over Antarctica                                                                                            |
| 1987  | Montreal Protocol on protection of the ozone layer is signed, with phasing out of ozone depleting substances for both developed and developing countries within different timescales |
| 1990s | Increasing finance to developing countries to help them reduce their dependence on ozone depleting substances                                                                        |
| 1997  | Amendments to the Montreal Protocol in order to restore levels of chlorine by 2050–60                                                                                                |
| 1999  | Beijing Declaration calling for efforts to stop illegal trade in ozone depleting substances                                                                                          |



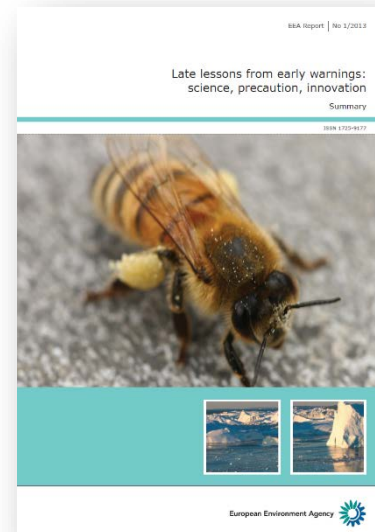
This graph illustrates the approximate time lags between CFC production, the resulting depletion of the stratospheric ozone layer and subsequent extra penetration of UV radiation and the impact this will eventually have on increasing the background rate of skin cancer, given the 30–40 year average latent period for such cancers. Reality is far more complex than this schematic illustration. For example, there are other ozone-depleting chemicals (HCFCs, HFCs and methyl bromide); the ozone hole varies with latitude, time of the year and meteorological conditions; the increased UV radiation varies between different wavelengths and with latitude and cloud cover; and the skin cancer excess comes on top of a rising background rate of skin cancer, with differential effects on the different types of skin cancer, such as malignant melanoma and non-malignant skin cancers. Human behaviour is also a determining effect in skin cancer. Health effects also include cataracts and immune response suppression. However, the figure illustrates the main relationships and time lags between CFC production and skin cancer, and the 'success' in stopping CFC production and averting much more skin cancer from ozone depletion than what is now expected. (Slaper, *et al.*, 1996).

EEA (2001)



# Příběhy - “Late Lessons from Early Warnings”

- olovo v benzínu, MTBE v benzínu
- rtuť a minamata
- azbest ve stavebnictví
- tributylcín
- PCBs v průmyslu
- freony a ozonová vrstva
- antibiotika a mikrobiální resistance
- hormony a „jako“-hormony (BPA)
- kauza dietylstilbestrol
- kouření a rakovina
- pesticidy (DDT, neonicotinoidy, )
- ...



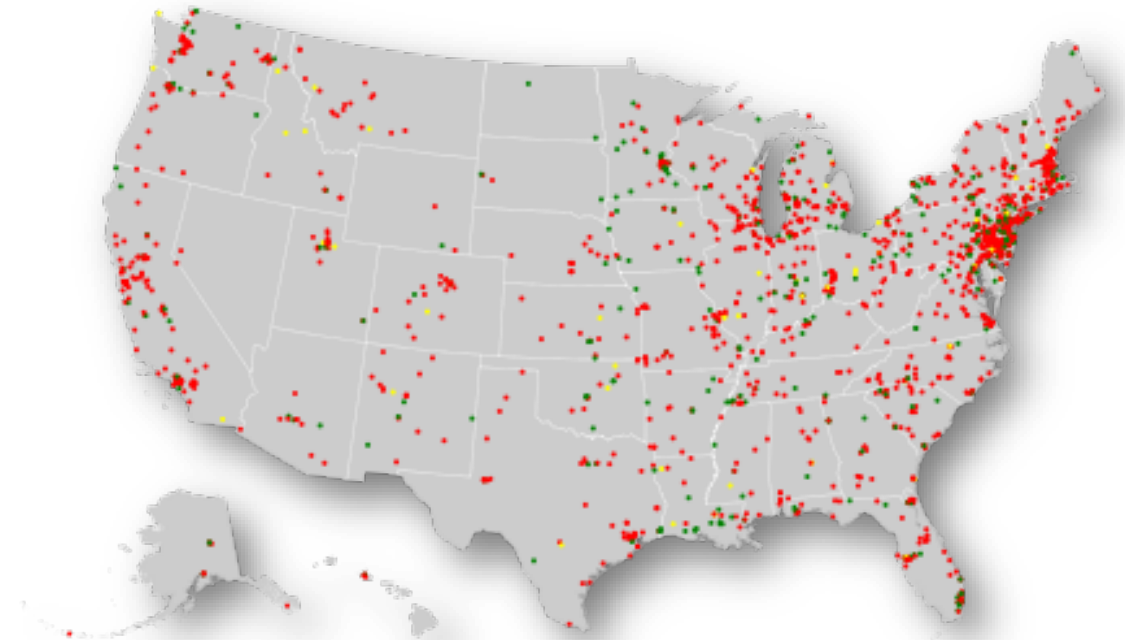
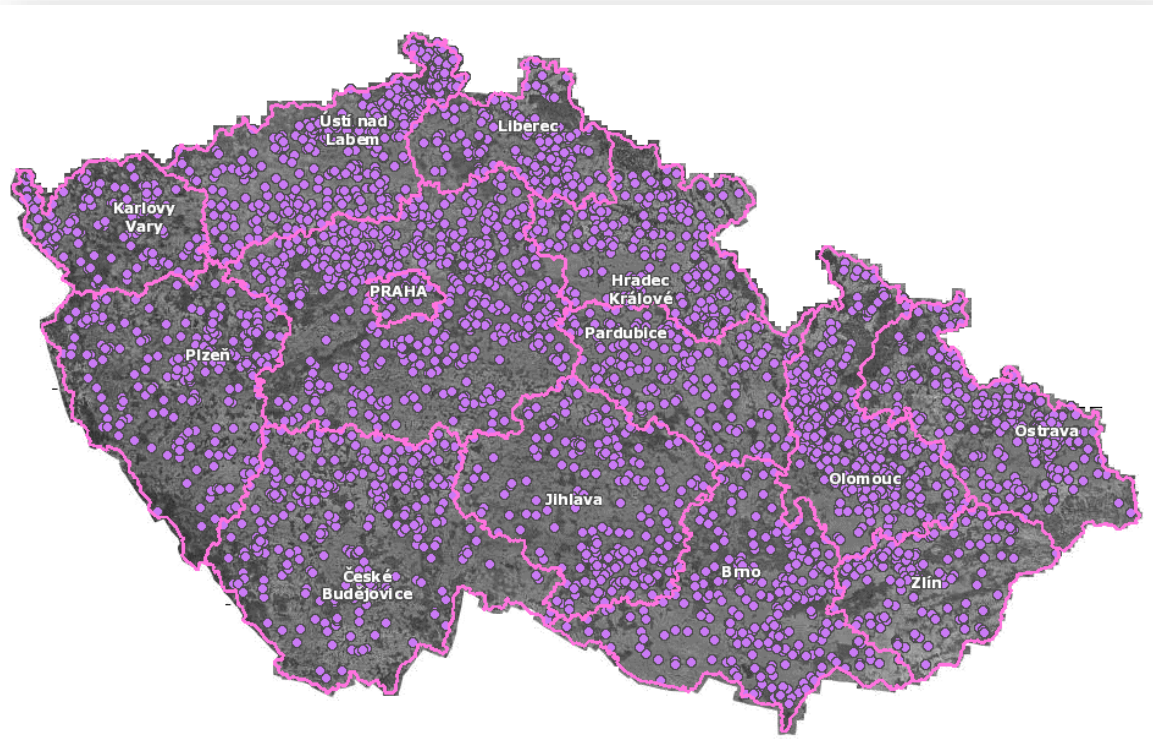
2013



2002

# Kontaminovaná místa

- v EU až 3,5 mil kontaminovaných míst, 0,5 mil vážně
- v ČR kolem 10 tisíc kontaminovaných míst <http://www.sekm.cz/>
- USA – superfund sites
- ...



# Kontaminovaná místa



La Oroya, Peru



Kabwe, Zambia

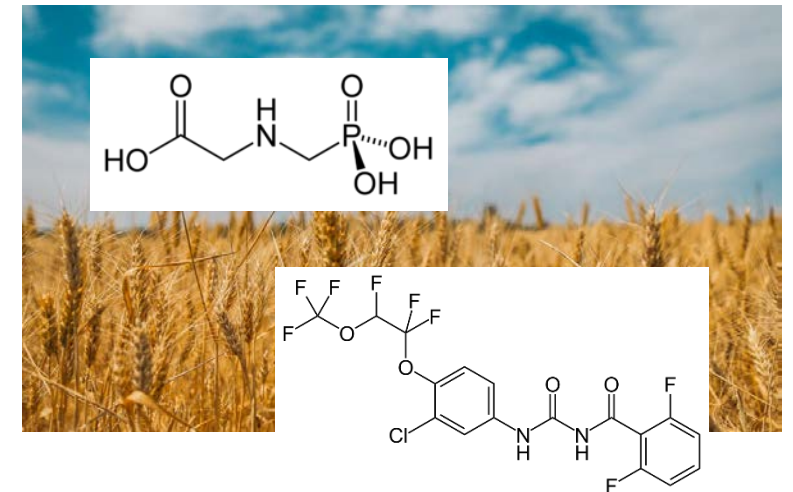
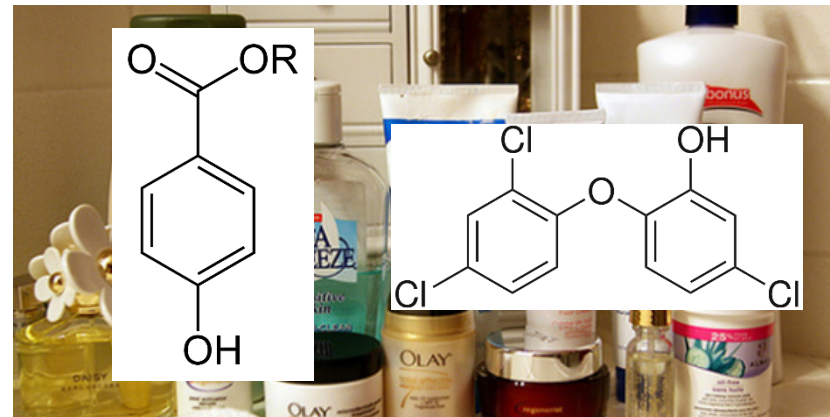
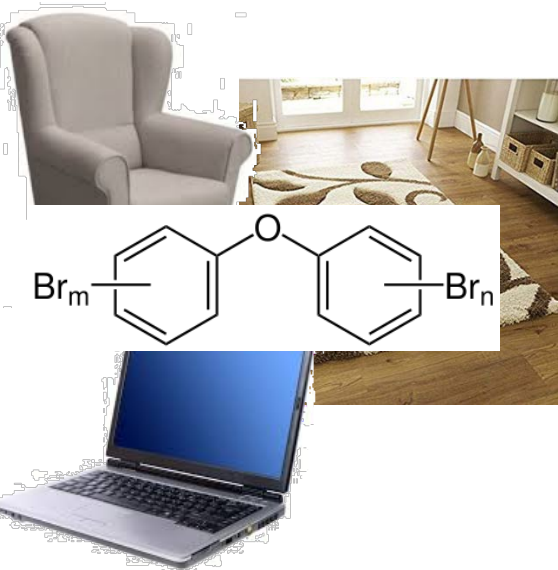
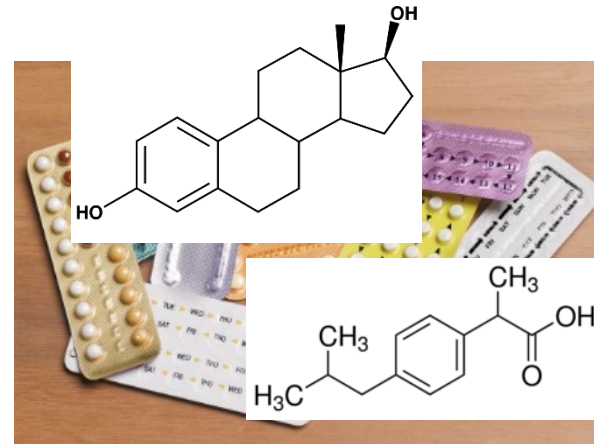
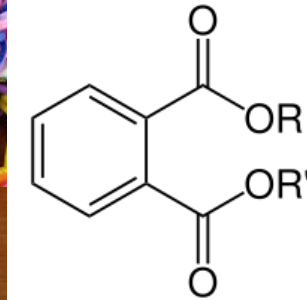
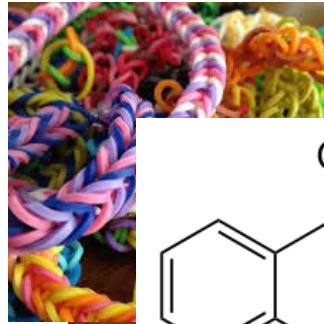
Blacksmith Institute (2006)

<https://www.thoughtco.com/worst-polluted-places-on-earth-1204101>

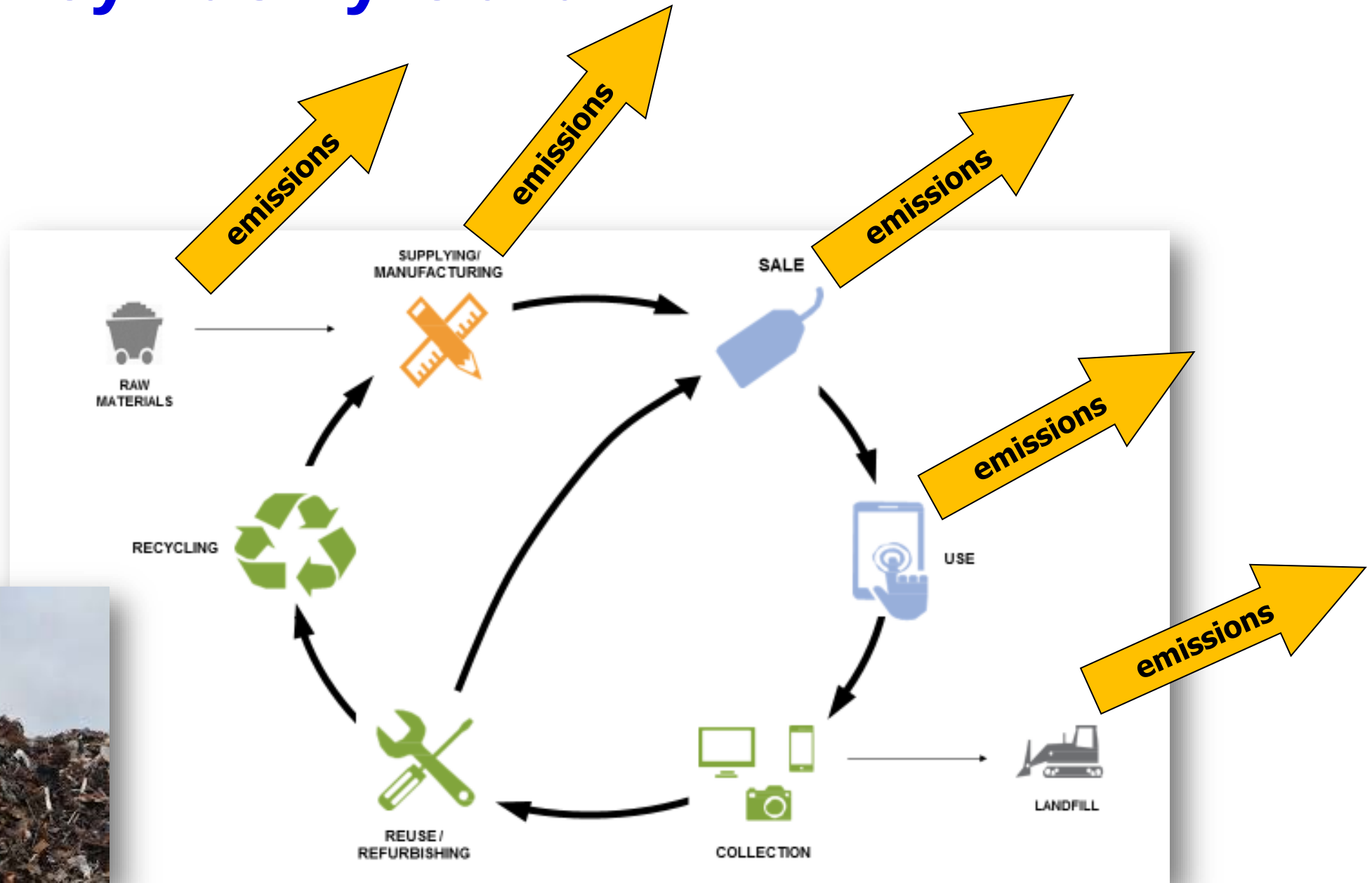
<https://www.livescience.com/30353-most-polluted-places-earth.html>

<https://www.scientificamerican.com/slideshow/10-most-polluted-places-in-the-world/>

# Pomalé uvolňování a působení ChL



# Životní cyklus výrobku



# Výsledky průzkumu půd 2015

- 
- 1 mg/kg**
- Science of the Total Environment xxx (2017) xxx-xxx
- Contents lists available at ScienceDirect
- Science of the Total Environment**
- journal homepage: [www.elsevier.com](http://www.elsevier.com)
- Currently and recently used pesticides in Central European arable soils**
- Martina Hvezdová<sup>a</sup>, Petra Koumbová<sup>a</sup>, Monika Košíková<sup>a</sup>, Kerstin E. Schen<sup>a,4</sup>, Zdeněk Šimeš<sup>a</sup>, Lukáš Brodský<sup>a</sup>, Marek Šudoma<sup>a</sup>, Lucia Škulcová<sup>a</sup>, Milan Saitka<sup>a</sup>, Markéta Svobodová<sup>a</sup>, Lucia Krkosková<sup>a</sup>, Jana Vášteková<sup>a</sup>, Natalia Neuwirthová<sup>a</sup>, Lucie Bielská<sup>a</sup>, Jakub Hofman<sup>a,\*</sup>
- <sup>a</sup> Research Centre for Toxic Compounds in the Environment (RECETOX), Faculty of Science, Masaryk University, Kamencek 753/3, Brno 602 00, Czech Republic
- <sup>b</sup> Central Institute for Supervising and Testing in Agriculture, Hrozdová 2, Brno 656 06, Czech Republic
- <sup>c</sup> AQUALTEST Inc., Geologická 4, Praha 5 152 00, Czech Republic
- <sup>d</sup> Institute for Environmental Biotechnology, Department for Agrobiotechnology (EPA-Tullu), University of Natural Resources and Life Sciences (BOKU), Konrad-Lorenz-Strasse 20, A-1430 Tulln, Austria
- <sup>e</sup> Department of Applied Geoinformatics and Cartography, Faculty of Science, Charles University in Prague, Albertov 6, Praha 2 128 43, Czech Republic

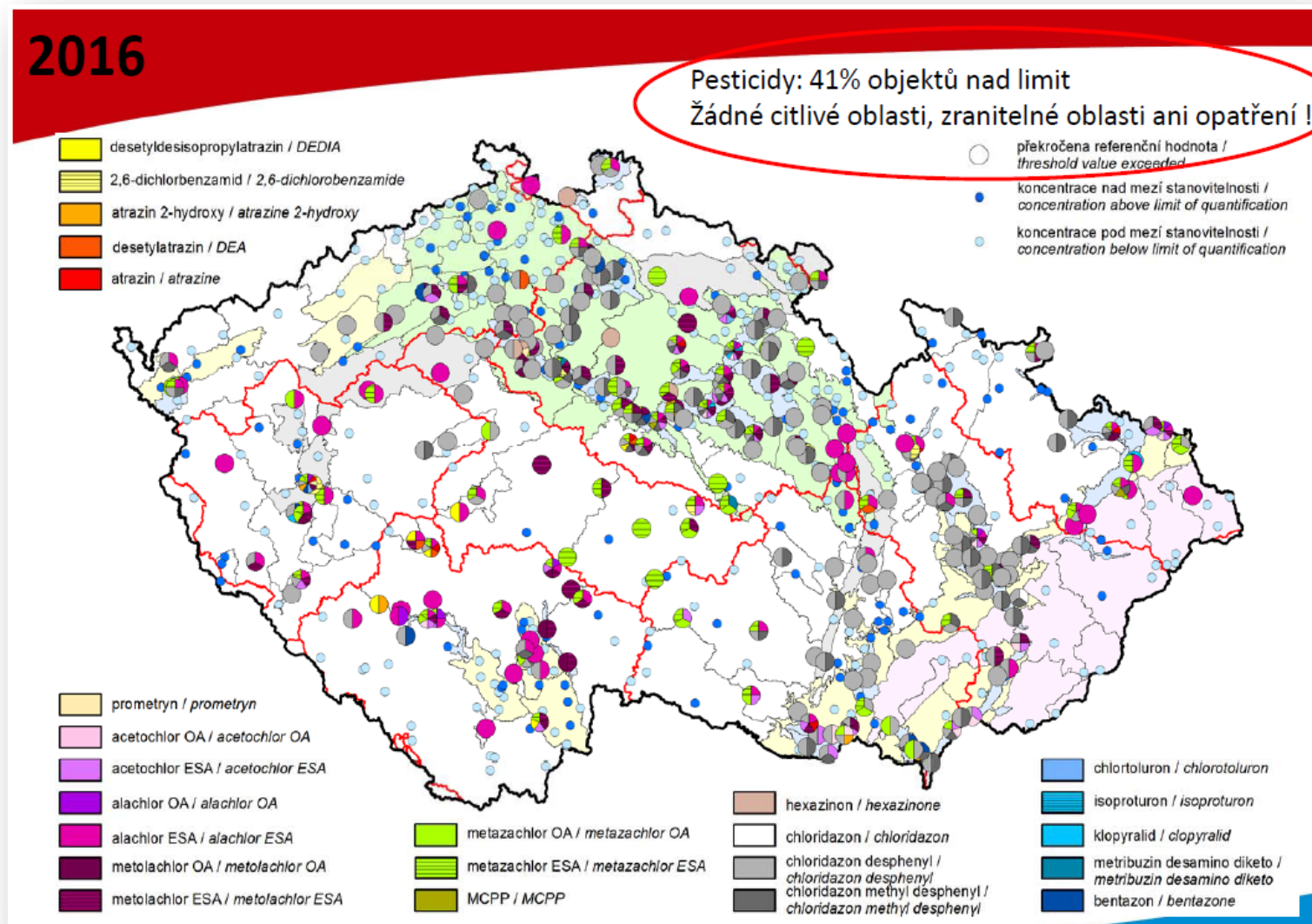


# MUNI RECETOX

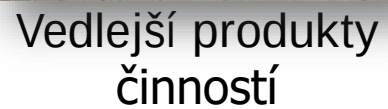
# Směsi – koktejly polutantů

## Výsledky monitoringu vod ČR 2014-2016

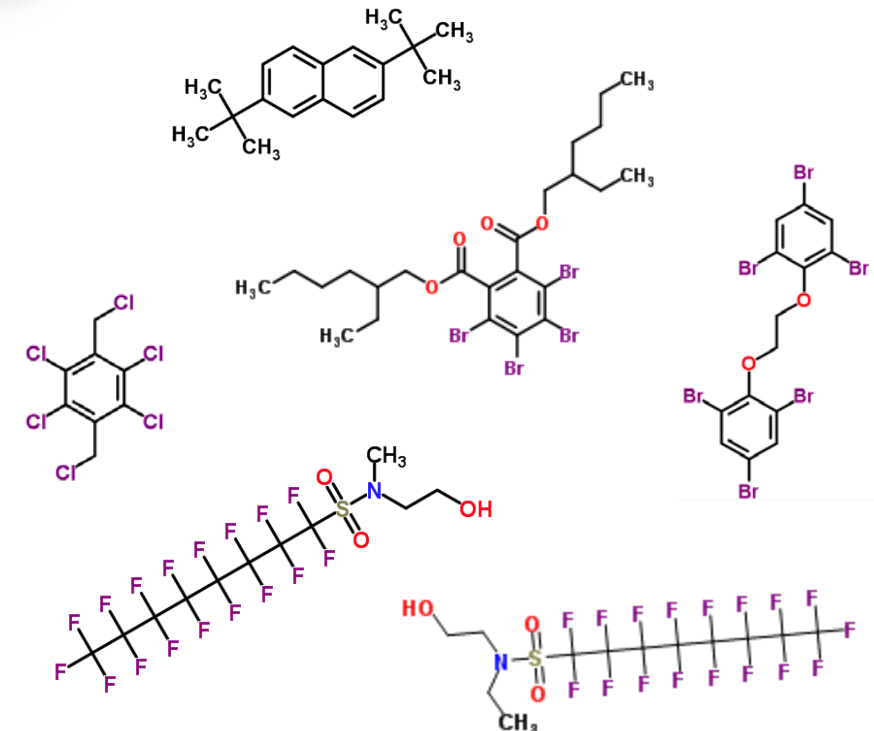
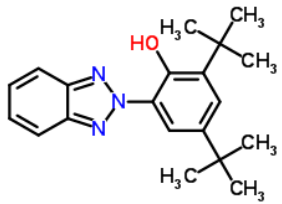
- 43% objektů nad limit 0.1 µg/L pro jednotlivý pesticid
- 31% objektů nad limit pro sumu pesticidů







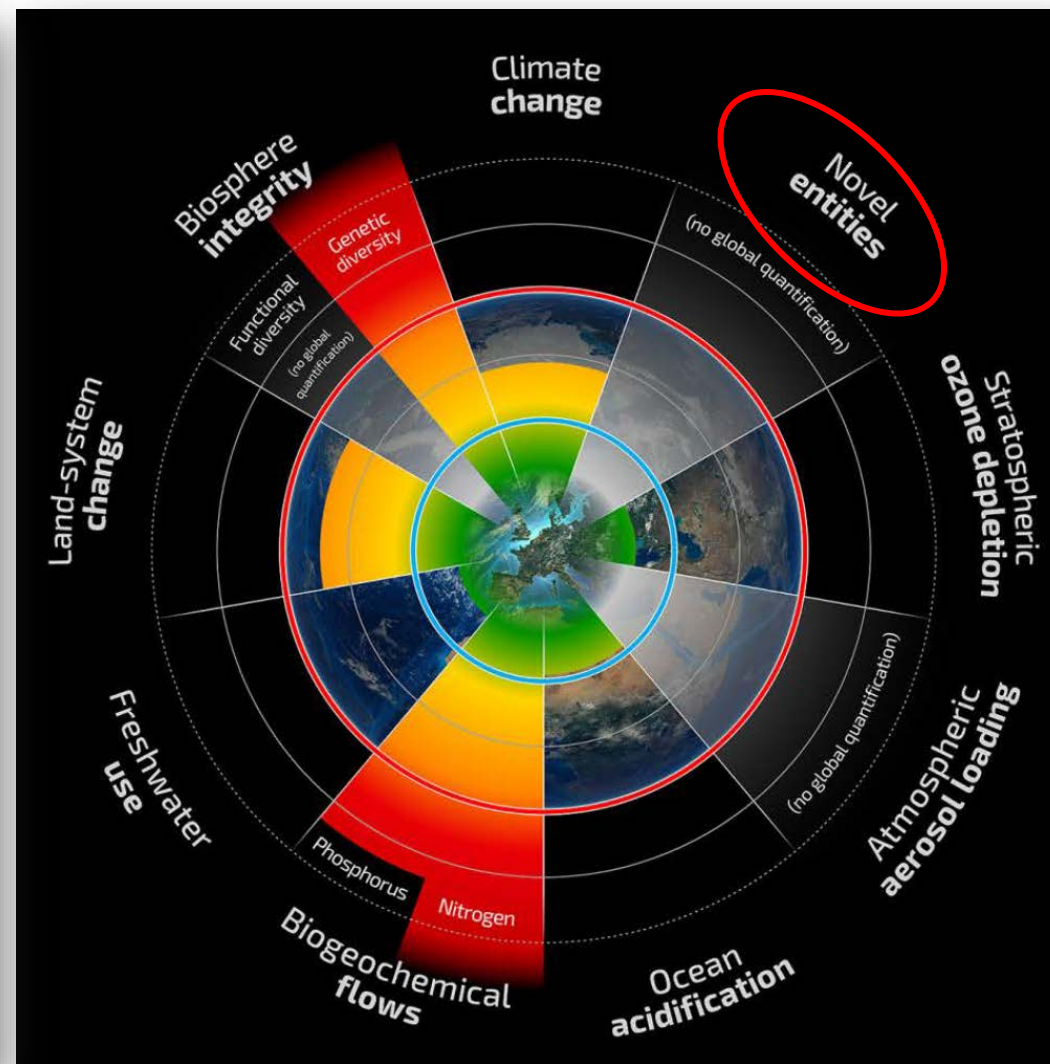
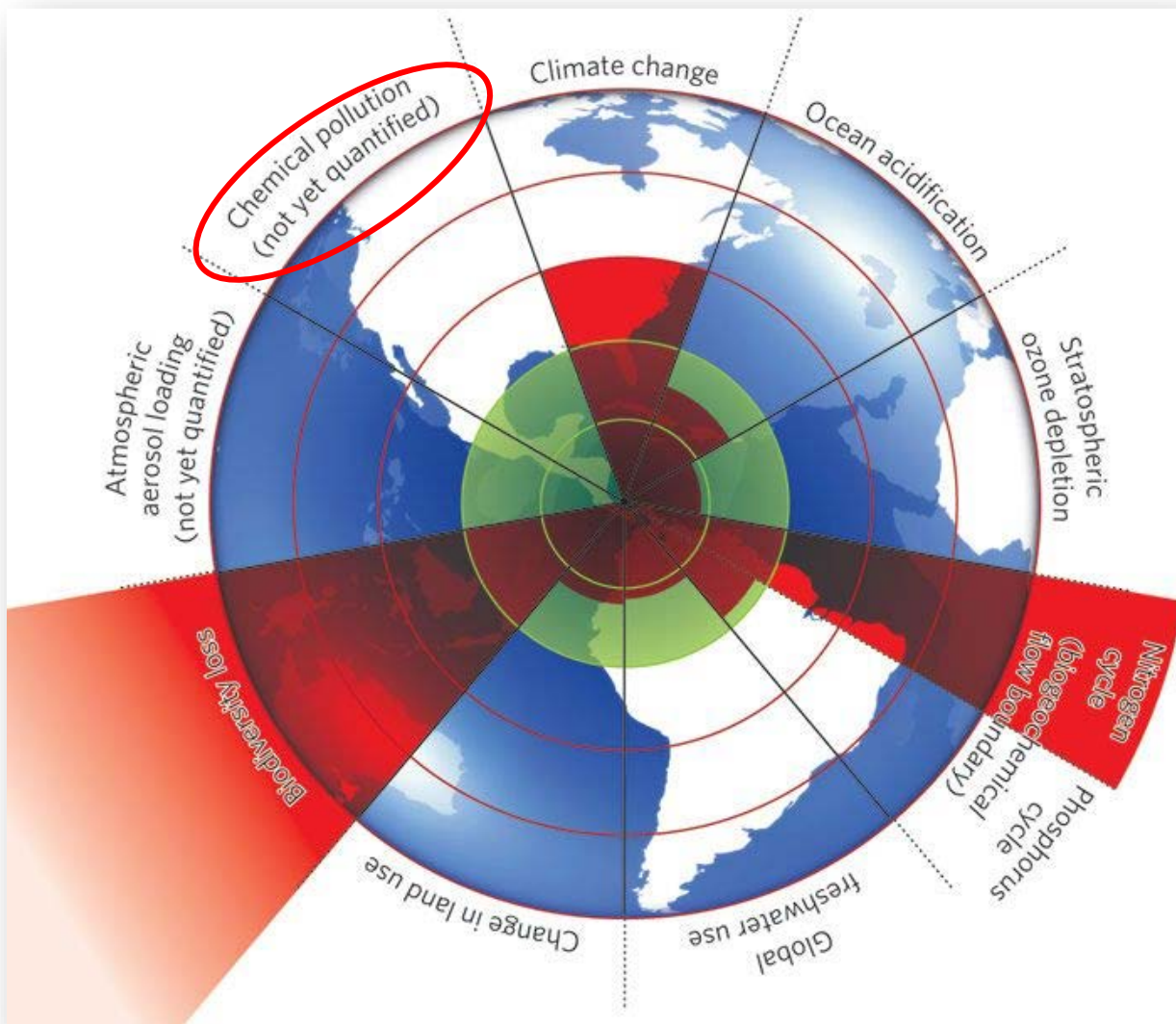
atd . . . .



# Skupiny znečišťujících látek

- anorganické plyny
- kovy
- průmyslové kyseliny
- radionuklidy
- nutrienty (živiny, anorganická hnojiva)
- organické (degradabilní, komunální, fekální) znečištění
- komunální chemie – PCPs, detergenty, mýdla, změkčovadla ...
- nehalogenovaná rozpouštědla (alkoholy, etery, BTEX ...)
- halogenované alifatické uhlovodíky (freony ...)
- látky průmyslu gumy a plastů (ftaláty, polybromované difenylethery, PFAS ...)
- persistentní organické látky (POPs), halogenované [produkty průmyslu (PCBs, PBBs) a vedlejší produkty (PCDD/Fs, PBDD/Fs)]
- pesticidy [insekticidy – nehalogenované vs. halogenované (patří mezi POPs), herbicidy]
- farmaka, léčiva
- produkty denní spotřeby (PCPs)
- PAHs – polycyklické aromatické uhlovodíky
- ...

# Globální chemické znečištění - dopady



# Globální chemické znečištění - dopady

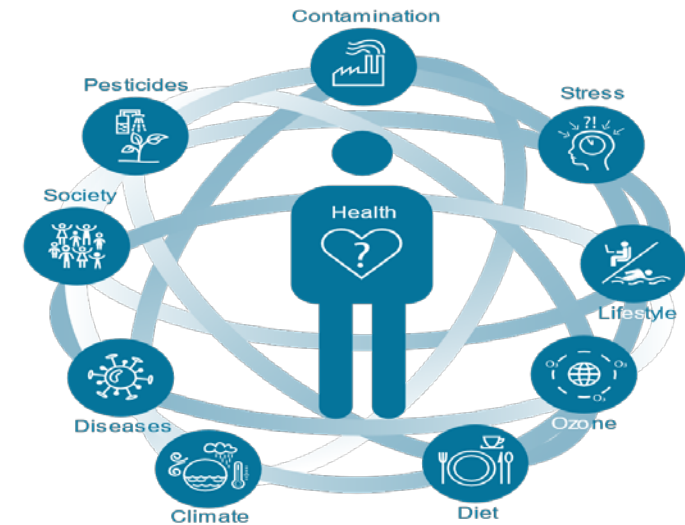
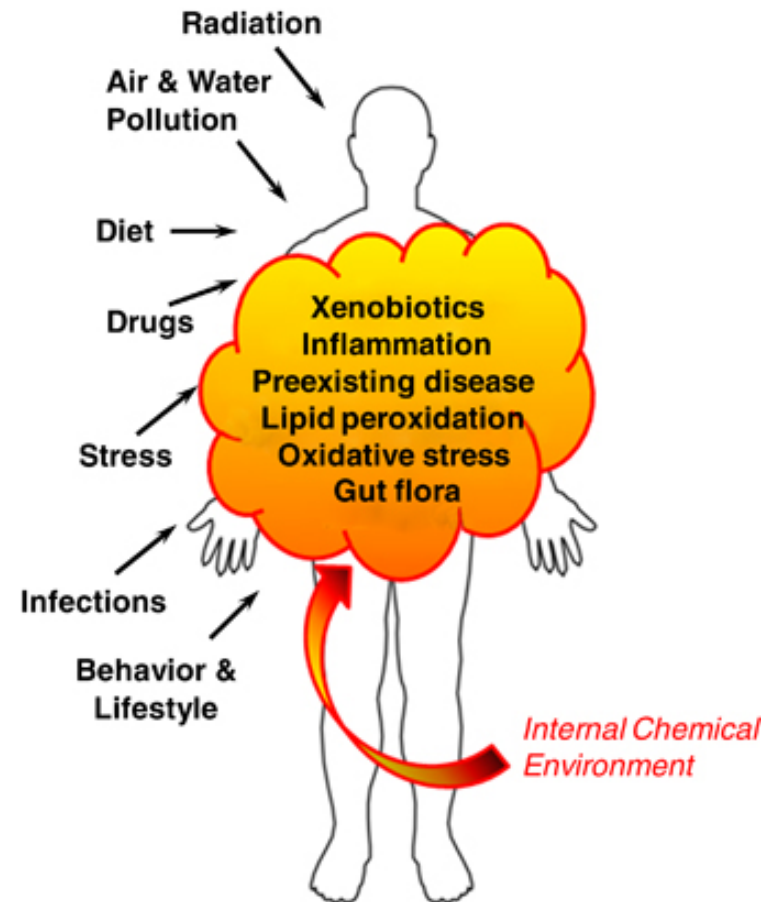


**SUSTAINABLE  
DEVELOPMENT** **GOALS**  
17 GOALS TO TRANSFORM OUR WORLD



# Expozom

SMĚSI + spolupůsobení faktorů = EXPOZOM



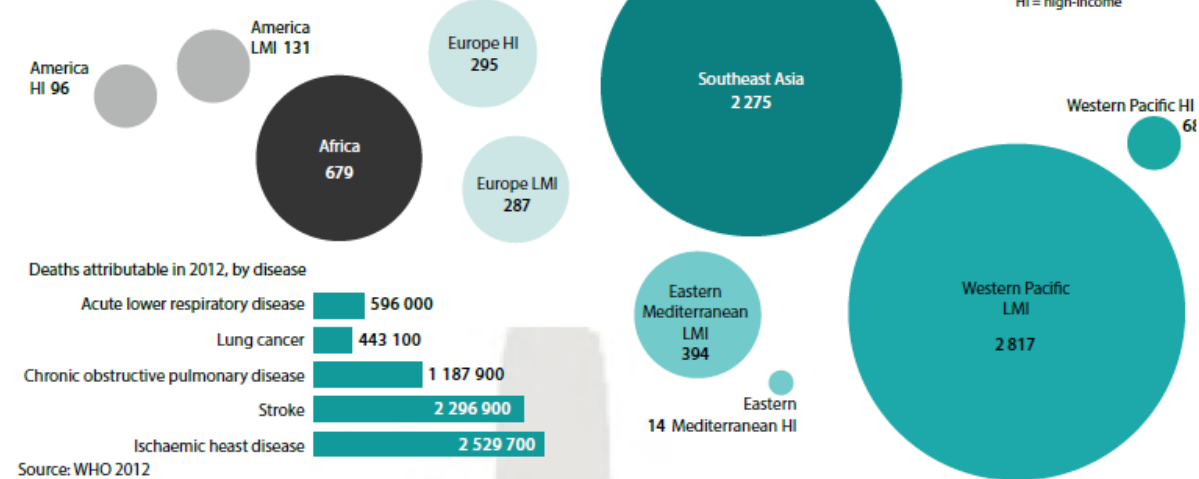
# Dopady chemického znečištění na člověka

- malárie + AIDS + tuberkulóza 3,4 mil
- 8-9 mil lidí ročně zemře na následky znečištění
  - o znečištěné venkovní ovzduší 3,7 mil
  - o znečištěné vnitřní ovzduší (pece, kamna) 4,2 mil
  - o znečištěná půda a voda 1 mil

<https://ensia.com/voices/leading-cause-death-developing-countries>

## Choking to death

Deaths attributable to the joint effects of household and ambient air pollution in 2012, by region ('000)



UNEP (2014)

## Global premature deaths from selected environmental risks: Baseline, 2010 to 2050



OECD (2012)

# Dopady chemického znečištění na člověka

**Table 1:** Some major health impacts associated with environmental exposures to chemicals and other environmental stressors. *Source: Adapted from EEA (2005)*

| Health impact           | Associations with some environmental exposures                                                                                                                                        |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Infectious diseases     | Water, air and food contamination<br>Climate change-related changes in the lifecycle of pathogens                                                                                     |
| Cancer                  | Air pollution<br>Some pesticides<br>Asbestos<br>Natural toxins (aflatoxins)<br>Polycyclic aromatic hydrocarbons<br>Some metals, e.g. arsenic, cadmium, chromium<br>Benzene<br>Dioxins |
| Cardiovascular diseases | Air pollution<br>Carbon monoxide<br>Lead                                                                                                                                              |

UNEP (2013)

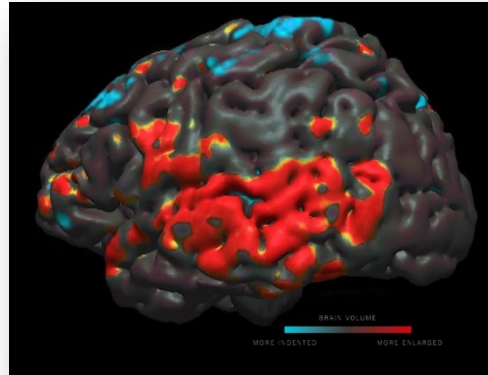
## The economic cost of air pollution

The cost of air pollution to the world's most advanced economies plus India and China is estimated to be US\$3.5 trillion per year in lives lost and ill health. In OECD countries the monetary impact of death and illness due to outdoor air pollution in 2010 is estimated to have been US\$1.7 trillion.

UNEP (2014)

|                                                |                                                                                                                           |
|------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| Respiratory diseases, including asthma         | Sulphur dioxide<br>Nitrogen dioxide<br>Inhalable particles<br>Ground-level ozone<br>Fungal spores<br>Dust mites<br>Pollen |
| Skin diseases                                  | UV radiation<br>Some metals, e.g. nickel<br>Pentachlorophenol<br>Dioxins                                                  |
| Reproductive dysfunctions                      | Polychlorinated biphenyls (PCBs)<br>DDT<br>Cadmium<br>Phthalates and other endocrine disruptors<br>Pharmaceuticals        |
| Developmental (foetal and childhood) disorders | Lead<br>Mercury<br>Cadmium<br>Some pesticides<br>Endocrine disruptors                                                     |
| Nervous system disorders                       | Lead<br>PCBs<br>Methylmercury<br>Manganese<br>Some solvents<br>Organophosphates                                           |
| Immune response                                | Some pesticides                                                                                                           |

# Dopady chemického znečištění na člověka



## Neurobehavioral Deficits, Diseases, and Associated Costs of Exposure to Endocrine-Disrupting Chemicals in the European Union

Martine Bellanger, Barbara Demeneix, Philippe Grandjean, R. Thomas Zoeller, and Leonardo Trasande

Special issue: Perspectives on the technosphere

### Toxic chemicals as enablers and poisoners of the technosphere

Miriam L Diamond

THE  
ANTHROPOCENE  
REVIEW

The Anthropocene Review  
2017, Vol. 4(2) 72–80  
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„Neurobehavioural effects caused by toxic chemical exposure have profound implications for society and its ability to self-perpetuate. Not only does society have to shoulder associated health and management costs, but a five point decrease in IQ related to neurotoxicant exposure could also decrease the number gifted individuals needed to solve complex problems in the technosphere.“

Diamond et al. (2017)

**Results:** The panel identified a 70–100% probability that polybrominated diphenyl ether and organophosphate exposures contribute to IQ loss in the European population. Polybrominated diphenyl ether exposures were associated with 873 000 (sensitivity analysis, 148 000 to 2.02 million) lost IQ points and 3290 (sensitivity analysis, 3290 to 8080) cases of intellectual disability, at costs of €9.59 billion (sensitivity analysis, €1.58 billion to €22.4 billion). Organophosphate exposures were associated with 13.0 million (sensitivity analysis, 4.24 million to 17.1 million) lost IQ points and 59 300 (sensitivity analysis, 16 500 to 84 400) cases of intellectual disability, at costs of €146 billion (sensitivity analysis, €46.8 billion to €194 billion). Autism spectrum disorder causation by multiple EDCs was assigned a 20–39% probability, with 316 (sensitivity analysis, 126–631) attributable cases at a cost of €199 million (sensitivity analysis, €79.7 million to €399 million). Attention-deficit hyperactivity disorder causation by multiple EDCs was assigned a 20–69% probability, with 19 300 to 31 200 attributable cases at a cost of €1.21 billion to €2.86 billion.

**Conclusions:** EDC exposures in Europe contribute substantially to neurobehavioral deficits and disease, with a high probability of >€150 billion costs/year. These results emphasize the advantages of controlling EDC exposure. (*J Clin Endocrinol Metab* 100: 1256–1266, 2015)

Bellanger et al. (2015)

# Přehled hlavních skupin polutantů

Holoubek (2018)

| Chemical<br>(substance<br>or<br>mixtures) | Source  |               | Context                                                                                          | Main environmental problems        | Main<br>compartment | Scale of effects |          |       |
|-------------------------------------------|---------|---------------|--------------------------------------------------------------------------------------------------|------------------------------------|---------------------|------------------|----------|-------|
|                                           | Natural | Anthropogenic |                                                                                                  |                                    |                     | Global           | Regional | Local |
| Carbon<br>dioxide<br>(CO <sub>2</sub> )   | +       | +             | Product of combustion (power generation, transport), aerobic fermentation, industrial processes. | Global warming (Greenhouse effect) | A                   | +                |          |       |

## Explanation of abbreviations

### Definition of chemicals:

The Context column gives information about the applications of chemicals and sources of release to the environment.

**Source:** ++ predominant, + source of

### Main environmental problems:

Brief overview of main problems in all parts of environment connected with this substances or mixture

### Main compartment:

Connected with this effect – can be one or one predominant or more (for example acidification affected all abiotic and biotic compartments) (A – air, W – water, S – soil, B – biota including man or can be B – wildlife, H – human)

**Scale of effects:** Main level(s) of effect(s)

# Přehled hlavních skupin polutantů

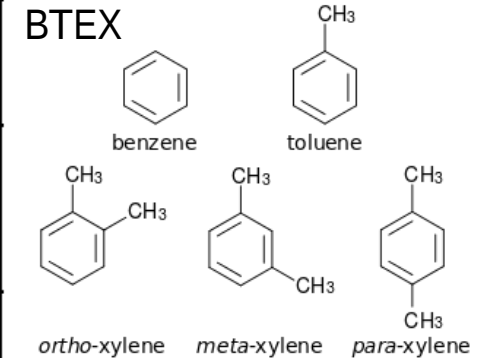
Holoubek (2018)

| Chemical<br>(substance<br>or<br>mixtures)               | Source  |               | Context                                                                                                  | Main environmental problems                                                                                                                                   | Main<br>compartment | Scale of effects |          |       |
|---------------------------------------------------------|---------|---------------|----------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------------|----------|-------|
|                                                         | Natural | Anthropogenic |                                                                                                          |                                                                                                                                                               |                     | Global           | Regional | Local |
| Carbon dioxide (CO <sub>2</sub> )                       | +       | +             | Product of combustion (power generation, transport), aerobic fermentation, industrial processes.         | Global warming (Greenhouse effect)                                                                                                                            | A                   | +                |          |       |
| Methane (CH <sub>4</sub> )                              | ++      | +             | Anaerobic fermentation, emissions of natural gas, coal-seam emissions.                                   | Global warming (Greenhouse effect)                                                                                                                            | A                   | +                |          |       |
| Carbon monoxide (CO)                                    | ++      | +             | Product of incomplete combustion, for example in transport vehicles                                      | Tropospheric ozone formation, indirect effects on CH <sub>4</sub> and O <sub>3</sub>                                                                          |                     |                  |          | +     |
| Sulfur dioxide (SO <sub>2</sub> )                       | +       | +             | Results from sulfur present in fuels.                                                                    | Acidification, aerosols formation, short term cooling (SO <sub>4</sub> <sup>2-</sup> )                                                                        | A, W, S, B, H       |                  | +        | +     |
| Nitrogen oxides NO <sub>x</sub> (NO + NO <sub>2</sub> ) | +       | +             | Produced from atmospheric nitrogen in combustion processes, and released from some industrial processes. | Acidification, eutrophication, greenhouse effects, smog, tropospheric ozone formation, short term cooling (NO <sub>3</sub> <sup>-</sup> ), aerosols formation | A, W, S, B, H       |                  | +        | +     |
| Nitrous oxide (N <sub>2</sub> O)                        | ++      | +             | Produced by soil bacteria notably from nitrogenous fertilizers.                                          | Ozone depletion, greenhouse effects, smog                                                                                                                     | A                   | +                | +        | +     |
| Ammonia (NH <sub>3</sub> )                              | ++      | +             | Produced by anaerobic respiration, for example in sewage treatment.                                      | Acidification, eutrophication, aerosols formation                                                                                                             |                     |                  | +        | +     |

# Přehled hlavních skupin polutantů

Holoubek (2018)

| Chemical<br>(substance<br>or<br>mixtures)  | Source  |               | Context                                                                                                                                                                   | Main environmental problems                                                       | Main<br>compartment | Scale of effects |          |       |
|--------------------------------------------|---------|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|---------------------|------------------|----------|-------|
|                                            | Natural | Anthropogenic |                                                                                                                                                                           |                                                                                   |                     | Global           | Regional | Local |
| Ozone (O <sub>3</sub> )                    | ++      | +             | Produced from nitrogen oxides and volatile organic compounds in the troposphere.                                                                                          | Smogs, tropospheric formation                                                     | A, B, H             | +                | +        | +     |
| Particulate matter                         | ++      | +             | Industrial processes and transport emissions.                                                                                                                             | Short-term cooling, aerosols formation, health effects, long-range transport      | A, H                |                  | +        | +     |
| Volatile Organic Compounds (VOC)           | ++      | +             | Solvent emissions, products on incomplete combustion, vegetation emissions                                                                                                | Smogs, aerosols formation, indirect effects on CH <sub>4</sub> and O <sub>3</sub> | A, H                | +                | +        | +     |
| Chlorofluorocarbons (CFCs)                 | (+)     | ++            | Formerly in wide use as refrigerants, foaming agents and aerosols, now largely phased out and replaced by hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs). | Ozone depletion, long-range transport, global warming                             | A, B, H             | +                | +        |       |
| Nitrate (NO <sub>3</sub> <sup>-</sup> )    | +       | ++            | Sourced from nitrate fertilizers and released into the environment.                                                                                                       | Acidification, eutrophication                                                     | W, H                |                  | +        | +     |
| Phosphate (PO <sub>4</sub> <sup>3-</sup> ) | +       | ++            | Sourced from phosphate fertilizers and released into the environment.                                                                                                     | Eutrophication                                                                    | W, H                |                  | +        | +     |



# Přehled hlavních skupin polutantů

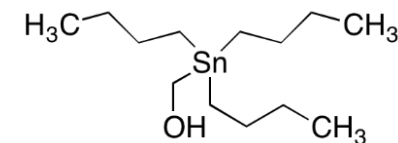
Holoubek (2018)

| Chemical<br>(substance<br>or<br>mixtures) | Source  |               | Context                                                                                                                                                        | Main environmental problems                       | Main<br>compartment | Scale of effects |          |       |
|-------------------------------------------|---------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|---------------------|------------------|----------|-------|
|                                           | Natural | Anthropogenic |                                                                                                                                                                |                                                   |                     | Global           | Regional | Local |
| Heavy metals                              | ++      | +             | Released from industrial processes including mining and processing of metal ores.                                                                              | Health and wildlife effects, long-range transport | A, W, S, B, H       | +                | +        | +     |
| Mercury                                   | +       | ++            | Mercury metal released during coal combustion, also artisanal mining, and converted to fat-soluble methyl and dimethyl mercury in the environment.             | Health and wildlife effects, long-range transport | A, W, S, B, H       | +                | +        | +     |
| Cadmium                                   | +       | ++            | See heavy metals (above). Also present in some phosphate fertilizers, and taken up by crops such as potatoes.                                                  | Health and wildlife effects                       | W, S, B, H          |                  | +        | +     |
| Lead                                      | +       | ++            | Leaded fuels phased out, and 85% of lead-acid batteries are recycled, but some uses persist. Contaminated sites remain. Lead paints still used in some places. | Health and wildlife effects                       | (A), W, S, B, H     |                  | +        | +     |
| Arsenic                                   | +       | ++            | Formerly widely used as pesticides, resulting in contaminated legacy sites. Released in mining and smelting operations.                                        | Health and wildlife effects                       | W, S, B, H          |                  | +        | +     |

# Přehled hlavních skupin polutantů

Holoubek (2018)

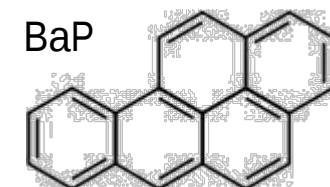
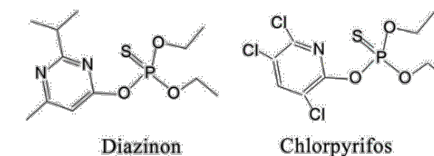
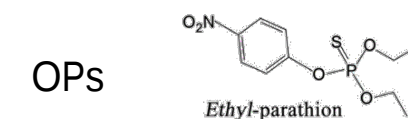
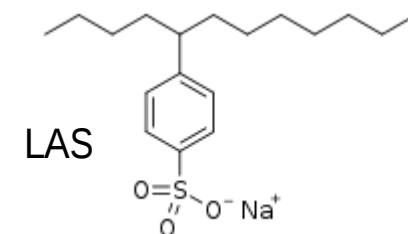
| Chemical<br>(substance<br>or<br>mixtures) | Source  |               | Context                                                                                                                                                                                      | Main environmental problems                                          | Main<br>compartment | Scale of effects |          |       |
|-------------------------------------------|---------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|---------------------|------------------|----------|-------|
|                                           | Natural | Anthropogenic |                                                                                                                                                                                              |                                                                      |                     | Global           | Regional | Local |
| Radionuclides                             | +       | ++            | Released in mining and processing of uranium ores, nuclear power station operation and disestablishment. Some medical uses.                                                                  | Health and wildlife effects                                          | W, S, B, H          | +                | +        | +     |
| Organometallic compounds                  | +       | ++            | The most common examples are butyl tin compounds used as marine anti-foulants.                                                                                                               | Health and wildlife effects                                          | W, S, B, H          |                  | +        | +     |
| Nutrients                                 | +       | +             | Commonly released from food processing operations and poorly-managed food wastes leading to landfill leachates.                                                                              | Eutrophication                                                       | W, S, B, H          | +                | +        | +     |
| Biologically easy degradable chemicals    | +       | +             | Detergents and other surfactants, for example.                                                                                                                                               | Eutrophication                                                       | W, S, B, H          |                  | +        | +     |
| Oil pollution                             | +       | ++            | While major spills draw attention, there is ongoing leakage of petroleum hydrocarbons into the environment from oil-recovery operations, and uses such as lubrication of transport vehicles. | Health, wildlife, ecosystems effects, exchange of surface properties | W, S, B, H          | +                | +        | +     |



# Přehled hlavních skupin polutantů

Holoubek (2018)

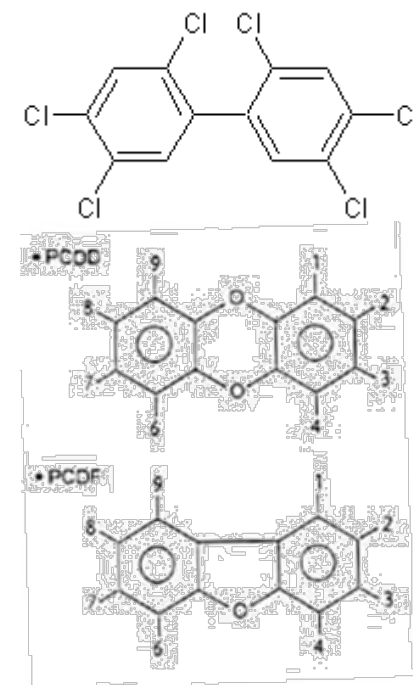
| Chemical<br>(substance<br>or<br>mixtures) | Source  |               | Context                                                                                                                                                                                                                    | Main environmental problems                                   | Main<br>compartment | Scale of effects |          |       |
|-------------------------------------------|---------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|---------------------|------------------|----------|-------|
|                                           | Natural | Anthropogenic |                                                                                                                                                                                                                            |                                                               |                     | Global           | Regional | Local |
| Surfactants                               |         | ++            | Resistant ("hard") detergents and other surfactants.                                                                                                                                                                       | Health and wildlife effects, alteration of surface properties | W, B, H             |                  | +        | +     |
| Pesticides                                |         | ++            | Agricultural uses release pesticides into the environment, and domestic use can also expose people to hazardous material.                                                                                                  | Health, wildlife and ecosystems effects                       | A, W, S, B, H       | +                | +        | +     |
| Persistent Organic Pollutant pesticides   |         | ++            | Chemicals such as dieldrin, heptachlor, hexachlorocyclohexane (HCH) and other organochlorines have been banned under the Stockholm Convention but legacy quantities remain. Use of DDT is restricted under the Convention. | Health, wildlife and ecosystems effects, long-range transport | A, W, S, B, H       | +                | +        | +     |
| Polycyclic aromatic hydrocarbons (PAH)    | +       | +             | These substances are components of natural petroleum but are also produced from other hydrocarbons during combustion processes. Many are carcinogenic.                                                                     | Health, wildlife and ecosystems effects, long-range transport | A, W, S, B, H       |                  | +        | +     |



# Přehled hlavních skupin polutantů

Holoubek (2018)

| Chemical<br>(substance<br>or<br>mixtures)                         | Source  |               | Context                                                                                                                                                                                          | Main environmental problems                                   | Main<br>compartment | Scale of effects |          |       |
|-------------------------------------------------------------------|---------|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|---------------------|------------------|----------|-------|
|                                                                   | Natural | Anthropogenic |                                                                                                                                                                                                  |                                                               |                     | Global           | Regional | Local |
| Polychloro-<br>-biphenyls<br>(PCBs)                               |         | ++            | Used as insulating and heat transfer fluids and plasticizers, now being phased out under the Stockholm Convention on Persistent Organic Pollutants.                                              | Health, wildlife and ecosystems effects, long-range transport | A, W, S, B, H       | +                | +        | +     |
| Polychloro<br>dibenzodi<br>oxins and<br>-furans<br>(PCDDs/<br>Fs) | +       | ++            | Produced during many combustion processes, released to the environment and bioaccumulated mainly from foods. Steps taken under the Stockholm Convention have seen great reductions in emissions. | Health, wildlife and ecosystems effects, long-range transport | A, W, S, B, H       | +                | +        | +     |
| Brominate<br>d flame<br>retardants<br>(BFRs)                      |         | ++            | Many such compounds in use. Some are problematic because of transport, bioaccumulation and toxicity and have been banned under the Stockholm Convention.                                         | Health, wildlife and ecosystems effects, long-range transport | A, W, S, B, H       | +                | +        | +     |
| Perfluoro-<br>octane<br>sulfonic<br>acid<br>(PFOS)                |         | ++            | Major use in electroplating of metals but also released during environmental degradation of other industrial products such as surface active agents.                                             | Health, wildlife and ecosystems effects, long-range transport | A, W, S, B, H       | +                | +        | +     |



# Přehled hlavních skupin polutantů

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| Chemical<br>(substance<br>or<br>mixtures) | Source  |               | Context                                                                                                                                                                                | Main environmental problems             | Main<br>compartment | Scale of effects |          |       |
|-------------------------------------------|---------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|---------------------|------------------|----------|-------|
|                                           | Natural | Anthropogenic |                                                                                                                                                                                        |                                         |                     | Global           | Regional | Local |
| Pharmaceuticals                           |         | ++            | Many pharmaceuticals are discharged with human wastes into sewage systems and have been detected in water ways and water treated for drinking.                                         | Health, wildlife and ecosystems effects | W, S, B, H          |                  | +        | +     |
| Veterinary drugs                          |         | ++            | Veterinary drugs are released to the environment in the same ways as pharmaceuticals.                                                                                                  | Health, wildlife and ecosystems effects | W, S, B, H          |                  | +        | +     |
| Personal care products                    |         | ++            | Chemicals in personal care products, like pharmaceuticals, are discharged to wastewater and sewage systems.                                                                            | Health, wildlife and ecosystems effects | W, S, B, H          |                  | +        | +     |
| Endocrine disrupting agents               |         | ++            | Chemicals such as phthalate plasticizers, bisphenol A (plastic component) and alkylphenols (in detergents) have been shown in laboratory studies to disrupt endocrine hormone systems. | Health, wildlife and ecosystems effects | W, S, B, H          | +                | +        | +     |

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