POPs in Plastic: Contamination of the terrestrial environment and the food chain

UNEP-IPCP conference on POPs

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IPEN
for a toxics-free future

About us

BALIFOKUS

Nexus for Health, Environment, and Development

CHIME

www.nexus3foundation.org

- 2000: BaliFokus Foundation
- 2019: Yayasan Fokus Nexus Tiga or Nexus for Health, Environment, and Development (Nexus3)
- Working to safeguard the vulnerable population from the impact of development to their health and environment, in collaboration with all stakeholders towards a just, toxic-free and sustainable future

Aliansi Zero Waste Indonesia

IPEN for a toxics-free future

gaia

basel action network

#break free from plastic

WECF

World Alliance for Mercury-Free Dentistry

NGO SHIPBREAKING PLATFORM

Koalisi IBUKO TA

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Acknowledgement

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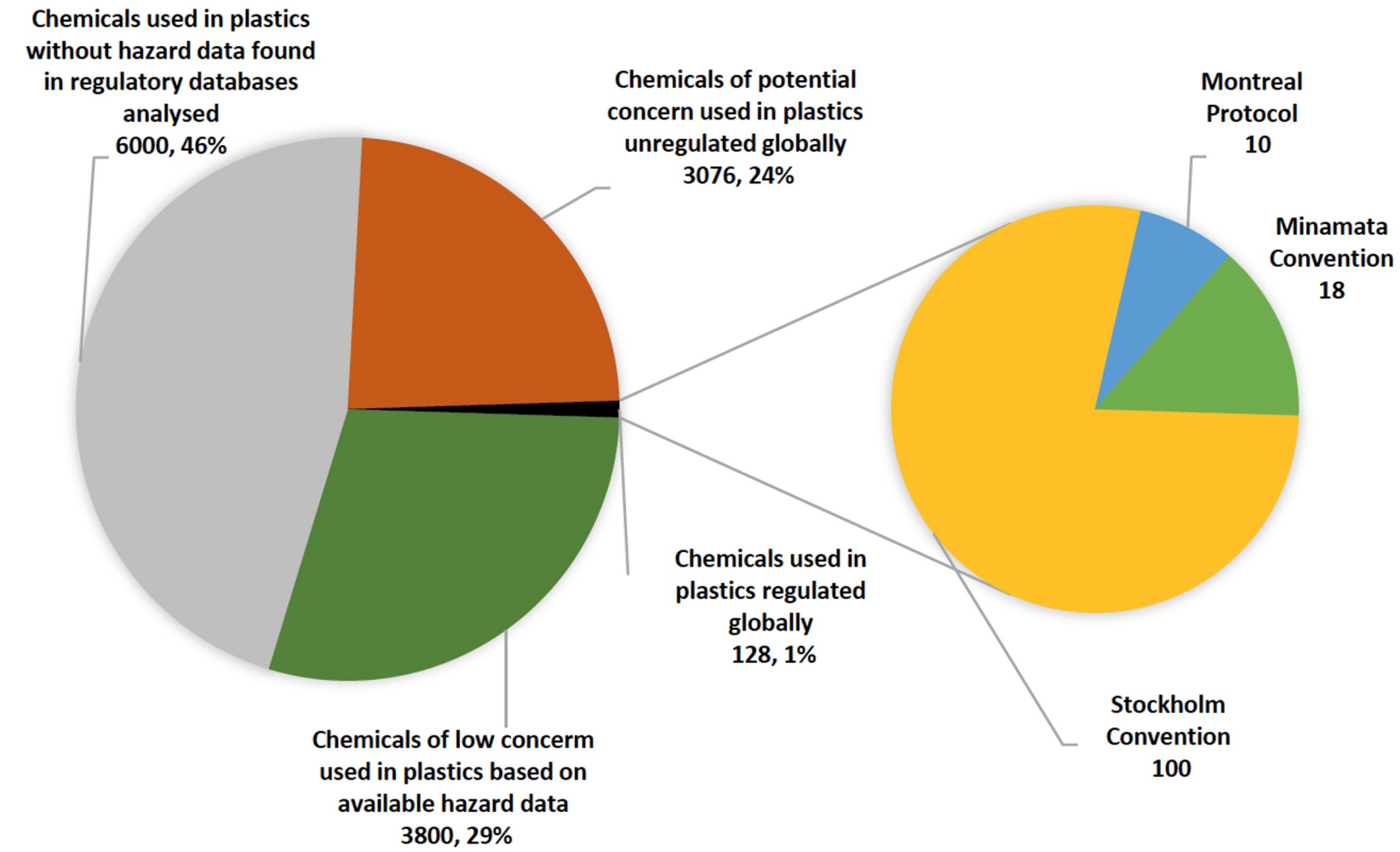
- The Sigrid Rausing Trust to Arnika
- The Swedish government to IPEN
- Arnika Association Czech
- IPEN and IPEN Participating Organisations in Europe, North America, Asia, and Africa
- Dr Peter Behnisch - Bio Detection System
- Dr Roland Weber – POPs Environmental Consulting

Chemicals of concern in plastics

Number of chemicals of concern addressed internationally.

Data extracted from supplementary material included in studies conducted by Wiesinger et al. (2021) and Aurisano et al. (2021).



Source: BRS (2023). Global governance of plastics and associated chemicals.

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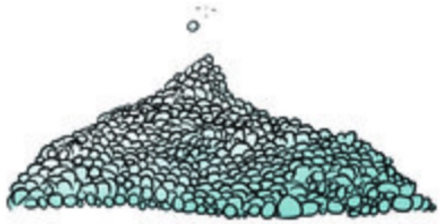
Plastic additives and its functions

Functional

Includes, for example, stabilizers, antistatic agents, flame retardants, plasticizers, lubricants, slip agents, curing agents.

Colourants

Substances such as dyes or pigments added to give colour to plastic. Some of them are added to give a bright transparent colour.



Fillers

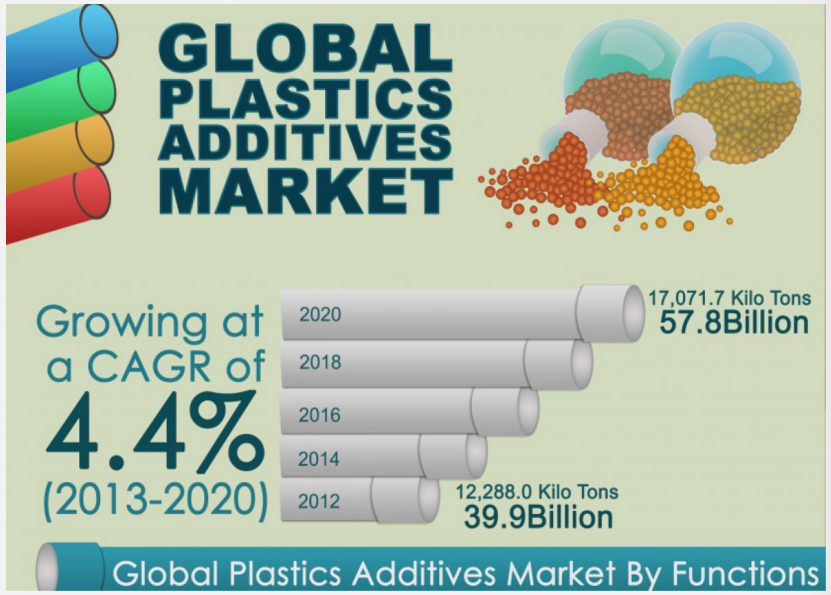
Added to change and improve physical properties of plastics. They can be minerals, metals, ceramics, bio-based, gases, liquids, or even other polymers

Reinforcement

Used to reinforce or improve tensile strength, flexural strength and stiffness of the material. For example: glass fibres, carbon fibres.

NIAS

Non-intentionally added substances. They arrive in products from processes, such as reaction by-products or breakdown products.



Credit for plastic additives graphics: UNEP (2021) in https://www.grida.no/resources/14864

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Toxic Circular Economy

Plastics = carbon + chemicals

POPs (Dioxin)
EDCs

EXTRACTION

PRODUCTION

USE

RECYCLING

INCINERATION

DUMPING & LANDFILL

TOXIC RECYCLING

GLOBAL WASTE DUMPING

POPs
EDCs

Sources:
Petrlik, J., Ismawati, Y., DiGangi, J., Arisandi, P., Bell, L., & Beeler, B. (2019). Plastic Waste Flooding Indonesia Leads To Toxic Chemical Contamination Of The Food Chain.
Petrlik, J., Bell, L., Beeler, B., Møller, M., Jopkova, M., & Brabcova, K. (2021). Plastic Waste Poisoning Food And Threatening Communities In Africa, Asia, Central & Eastern Europe And Latin America.

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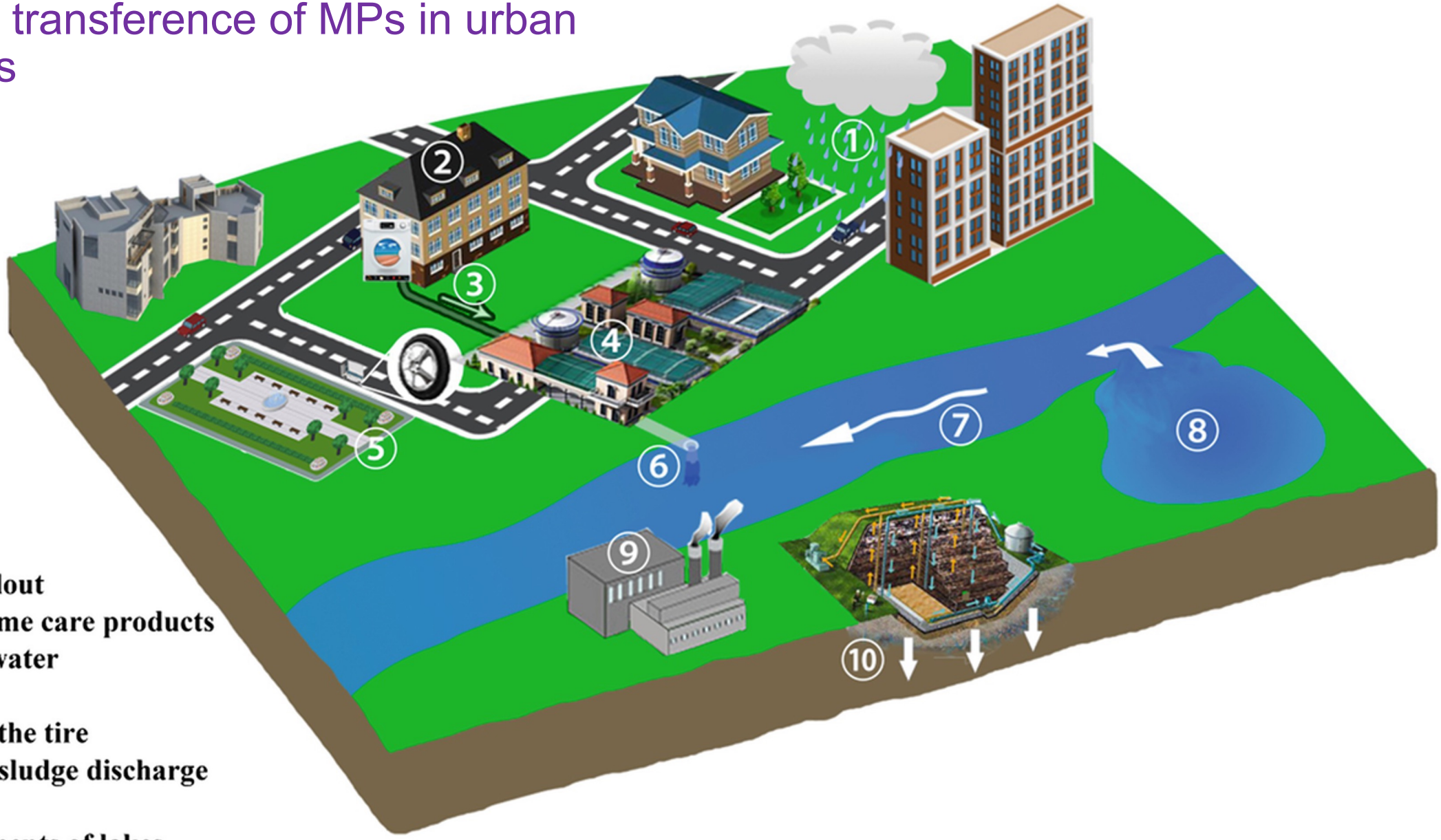
Sources and transference of MPs in urban environments

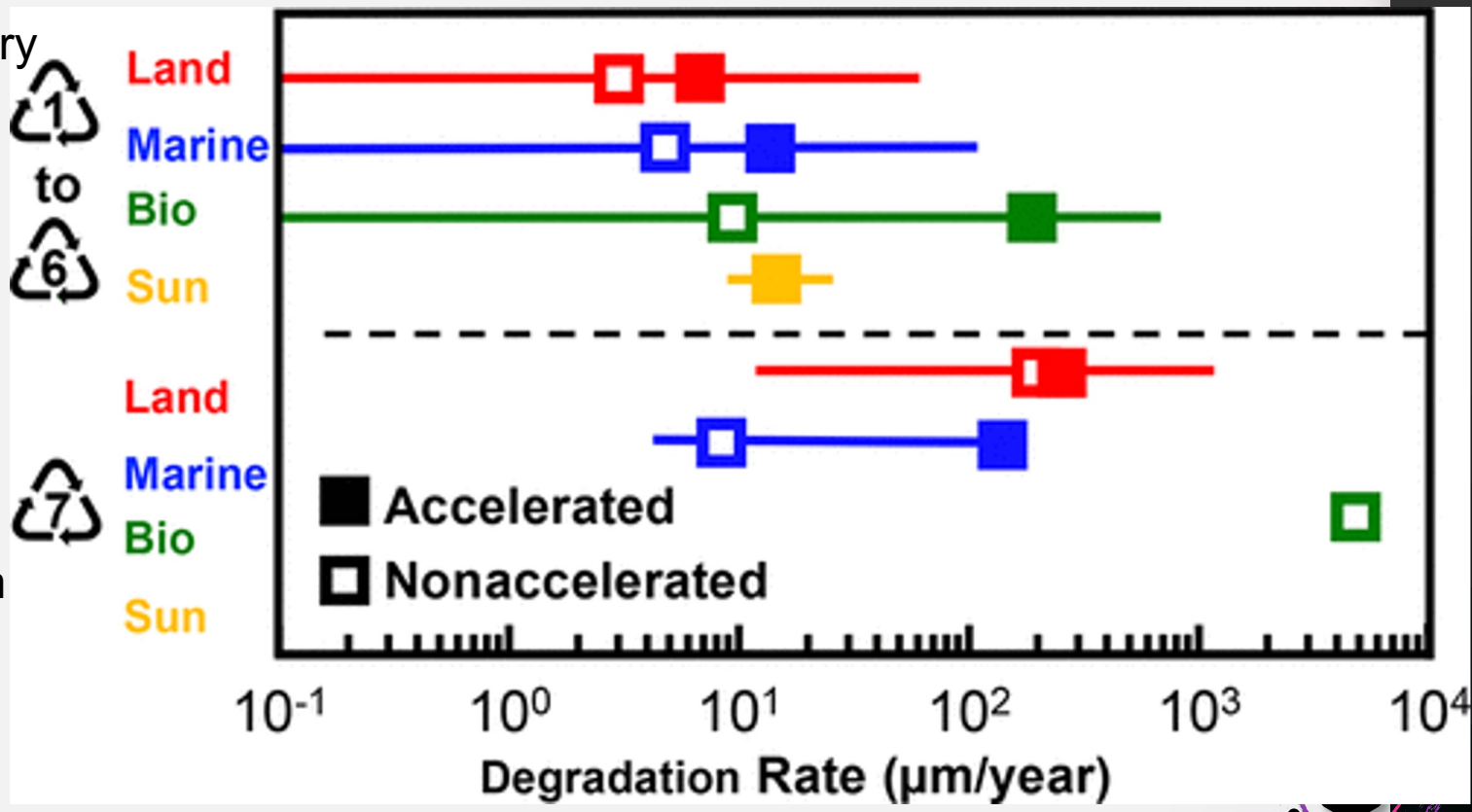


Source: Qiu, R et al. (2020). https://doi.org/10.1007/698_2020_447

Plastic‘s slow degradation, long-term humanity problem

- Plastic products and wastes are only slowly degrading in the environment and degrade to micro- & nano-plastic.
- Degradation rates depend on plastic type, thickness, temperature, biological activity and access to sun-UV.
- Using a mean Specific Surface Degradation Rate for high density polyethylene (HDPE) in marine environment, linear extrapolation leads to estimated half-lives ranging from 58 years (bottles) to 1200 years (pipes).

- The degradation of the major plastics (category 1 to 6) in soils is even slower than the degradation of plastic in marine environment.
- This results in accumulation of plastic in soils from agricultural plastic, littering or the microplastic in sewage sludge.
- POPs and other persistent chemicals can migrate over time to soil.
- Less persistent chemicals can have long term stability in plastic in soil and be transferred to grazing animals or chicken.



Source: Chamas et al. (2020) ACS Sustainable Chem. Eng. 2020, 8, 9, 3494–3511 https://doi.org/10.1021/acssuschemeng.9b06635

Plastics Dump Sites Lead to Massive Terrestrial Pollution

- The terrestrial microplastic pollution is much higher than marine microplastic pollution – estimated at four to 23 times higher, depending on the environment.
- There is a growing evidence that microplastics interact with terrestrial organisms that mediate essential ecosystem services and functions, such as invertebrates, terrestrial fungi, and plant-pollinators.

- Due to the widespread presence, environmental persistence, and various interactions with continental biota, microplastic pollution might represent a global change threat to terrestrial ecosystems. **Research need**!

OPINION https://doi.org/10.1111/gcb.14020 WILEY Global Change Biology

Microplastics as an emerging threat to terrestrial ecosystems

Anderson Abel de Souza Machado[1,2,3] | Werner Kloas[2,4] | Christiane Zarfl[5] | Stefan Hempel[1,3] | Matthias C. Rillig[1,3]

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After China Ban → Waste Moves to Southeast Asia

NGO watchdogs documented the plastic crises in other South-East Asian countries after industrial country plastic exports were shipped there.

https://www.ciel.org/project-update/plastic-climate-the-hidden-costs-of-a-plastic-planet/
https://ipen.dev.clerestory.com/site/plastic-waste-poisons-indonesias-food-chain

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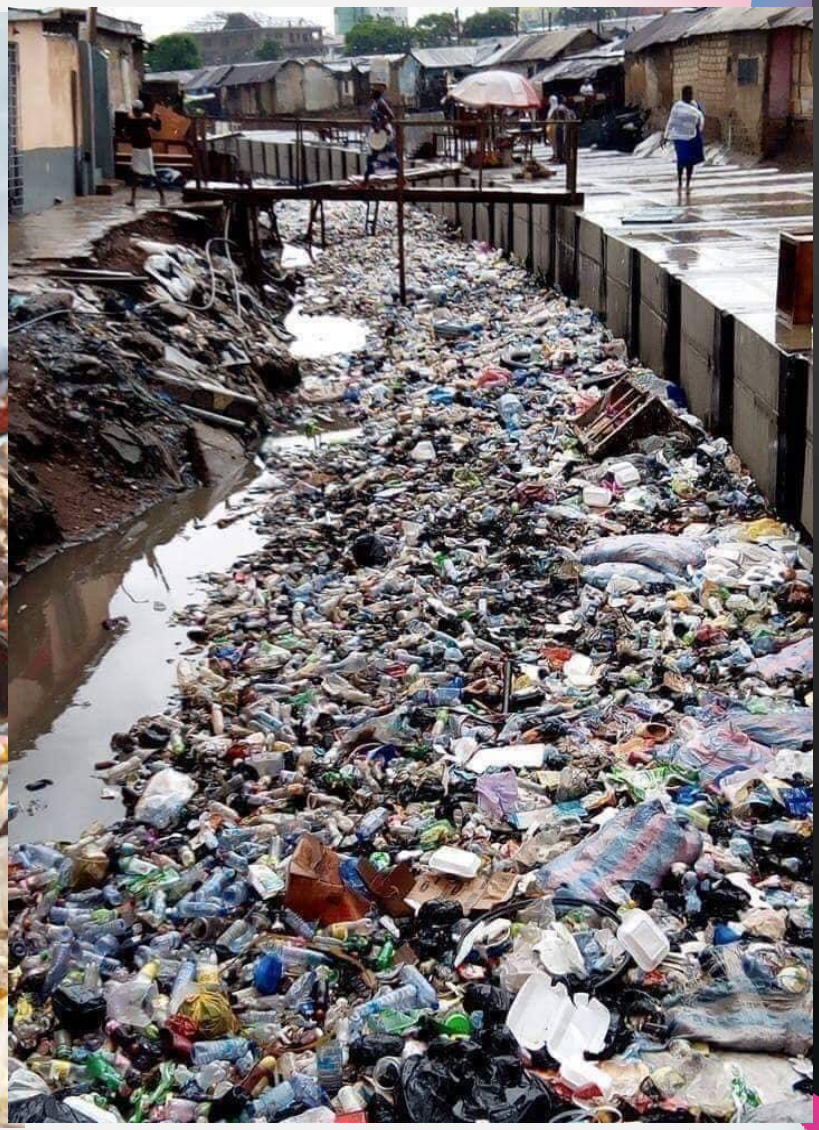
Plastic littering & dumping lead to massive land/soil pollution



https://www.ipcp.ch/activities/ipcp-webinar-series-pops-in-plastic-and-monitoring-approaches

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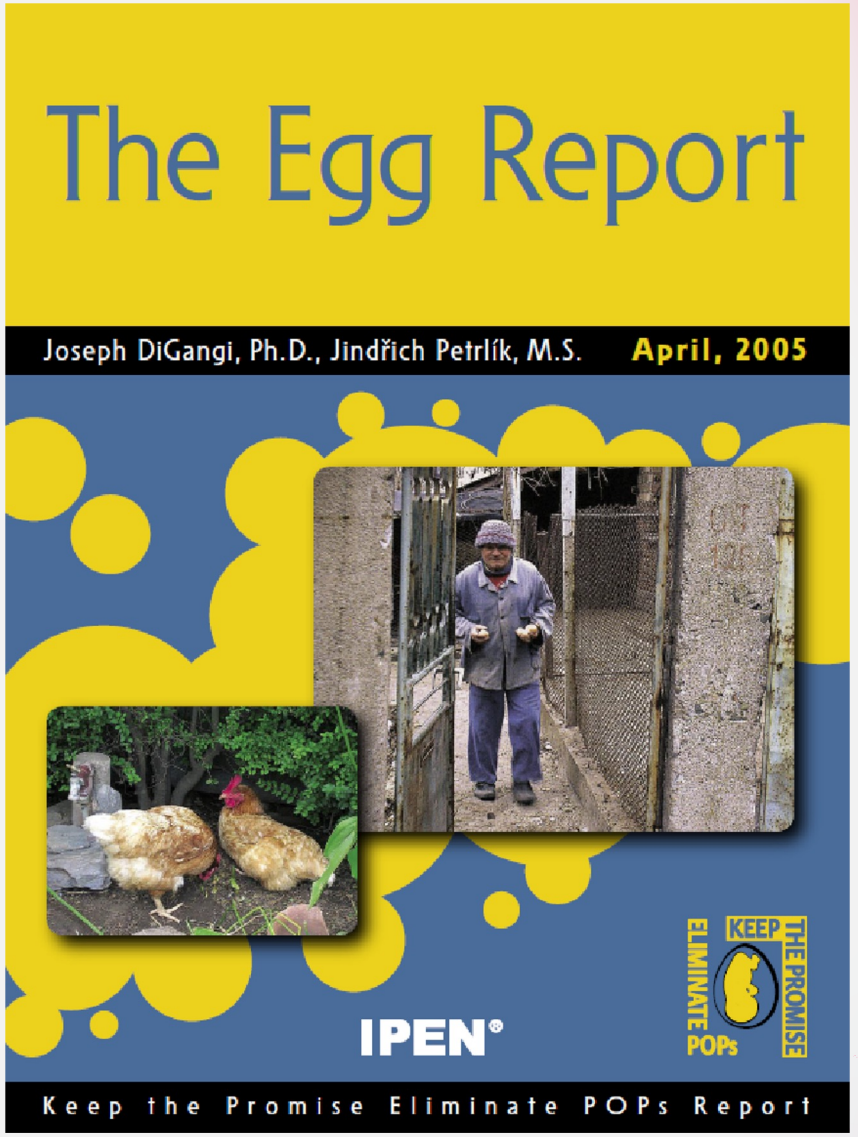
Study locations: Ghana, Indonesia, Thailand

Eggs as indicator of POPs (1/2)

- Increasing number of reports on contamination of eggs with PCDD/Fs and dl-PCBs in recent years.
- Netherlands: POPs in >50% of eggs from small scale free-range chicken holders were above EU limits (Hoogenboom, et al. (2016)).

- **Eggs have been found to be sensitive indicators for PCDD/F, PCB and other POP contamination in soils** and are an important exposure pathway from soil pollution to humans (IPEN egg reports, 2005).
- Free-ranged chickens pick and ingesting food from the **soil and dust** in the local area.



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Eggs as indicator of POPs (2/2)

- Eggs have a significant lipid content and accumulate POPs.
- Chicken considered as active samplers and their eggs provide as an indicator of the POPs environmental contamination levels in that locality.
- Chicken eggs have been found to be sensitive indicators of exposure to POPs pathway from soil pollution to humans.
- Chicken eggs from contaminated areas can readily lead to exposures which exceed thresholds for the protection of human health.

Source: Van Eijkeren, Zeilmaker et al. (2006); Hoogenboom, ten Dam et al. (2014); Piskorska-Pliszczynska, Mikolajczyk et al. (2014); Petrlik, J et al (2022))

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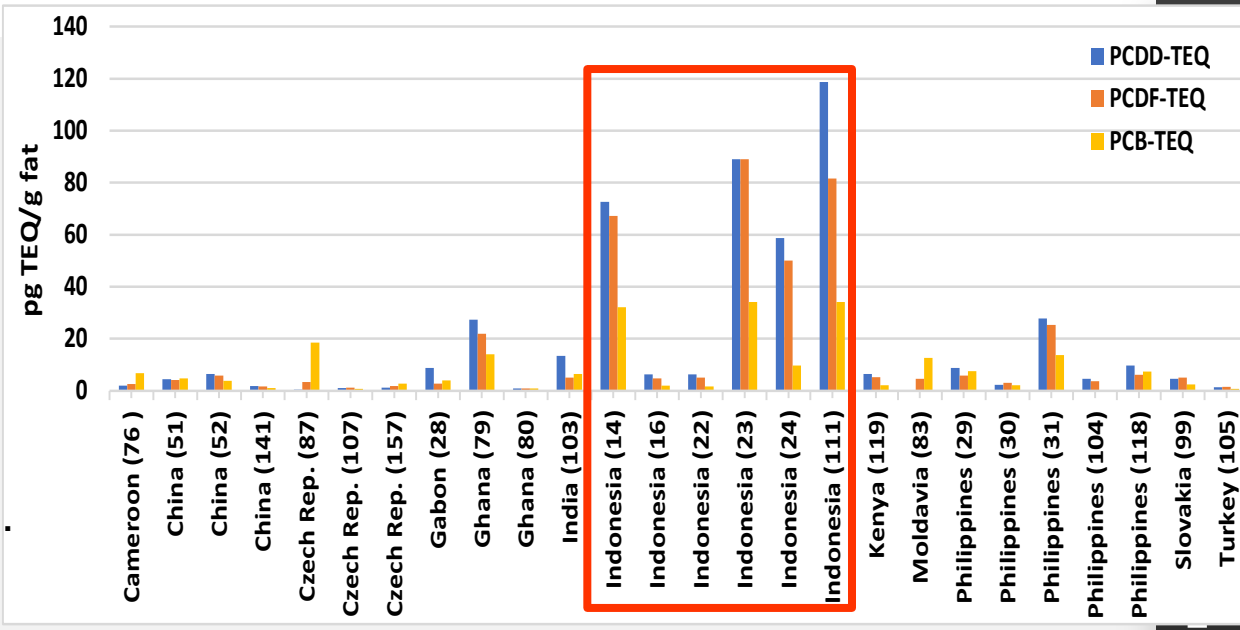
IPEN global Dioxin egg study – Plastic waste incineration sites



- Chicken eggs in Indonesia where **plastic wastes was co-incinerated** in tofu boilers or lime kiln **exceeded the EU food limits 50 to 100 times** (118.5 to 234.4 pg TEQ/g fat).
- The free-range chickens **had access to ashes stored openly or used for paving sidewalks**. These **ashes contained dioxins** at levels of 120 – 1300 ng TEQ/kg which is **60 to 600 times above 2 ng TEQ/kg in soils considered acceptable for free-range chickens**.
- **This highlights that co-incineration of plastic waste in non-BAT facilities without air pollution control and ash management, releases high levels of dioxins with associated environmental/soil contamination and human exposure** risk via chicken/eggs (and other food production).

Petrlik et al. (2022) Emer. Con. https://doi.org/10.1016/j.emcon.2022.05.001

IPEN global egg study – E-waste recycling sites

- IPEN monitored 7 pooled eggs from individual chicken flocks at e-waste sites in 5 countries (Ghana, Kenya, Indonesia, Philippines, and Thailand). The PCDD/F-PCB-TEQs were between 20.4 to 856 pg TEQ/g and therefore **all eggs exceeded the EU regulatory limit**. The **mean TEQ was 308.4 pg TEQ/kg fat** were by far the highest mean/median of all dioxin source categories.

- Three of the eggs from African sites had **TEQ levels above 500 pg TEQ/g fat** (more than 100 times above regulatory limits) with **856 pg TEQ/g fat** in eggs from the e-waste site in Agbogbloshie (Ghana) where e-waste, including cables, is frequently burnt. The eggs also contained brominated Dioxins from **PBDE** and **other BFRs.**

Petrlik et al. (2022) Emerging Contaminants https://doi.org/10.1016/j.emcon.2022.05.001

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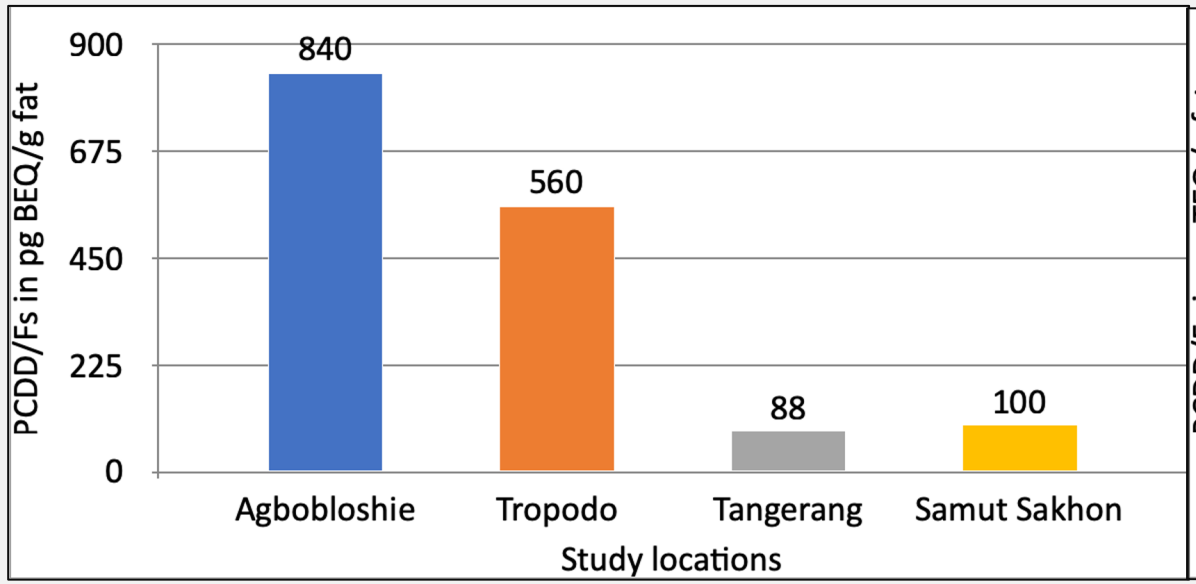
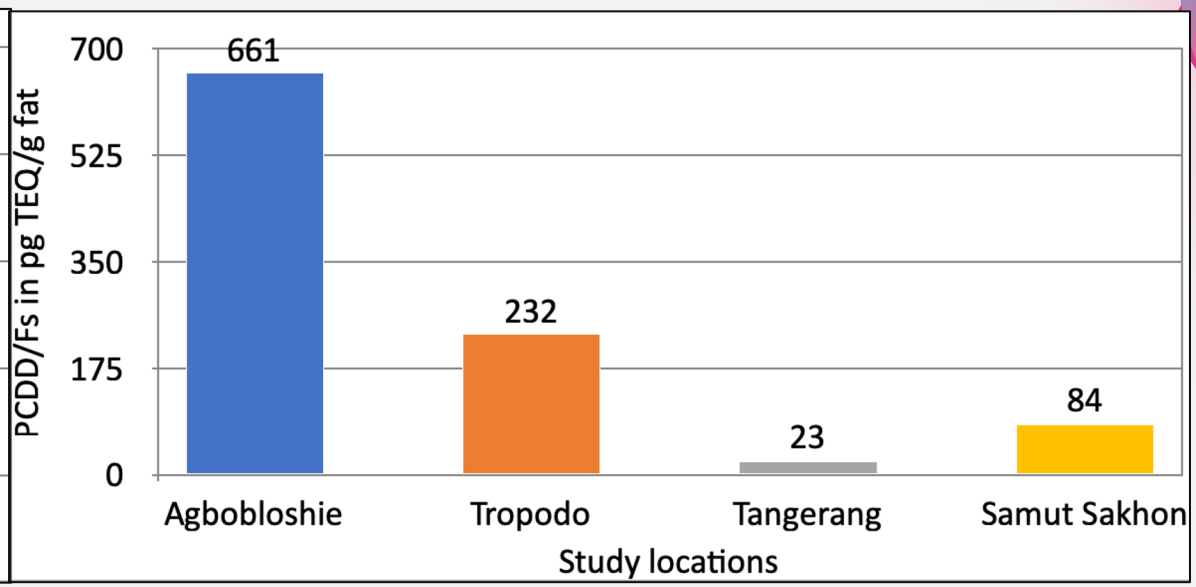
PCDD/Fs in chicken eggs from several countries





Source: Arnika-IPEN. (2019). POPs in eggs from Africa. https://ipen.org/sites/default/files/documents/a4_eggs_afrika_2019_april_web-2.pdf

- Dioxins level in:
  - Ghana's eggs: 264 times the EU food limit for dioxin (**plastic cable burning**)
  - Indonesia's eggs: 93 times the EU food limit for dioxin (**plastic burning** in boilers contaminating soils)
  - Thailand's eggs: 34 times the EU food limit for dioxin (**WEEE plastic burning**)
- The EU limit for dioxins in eggs is 2.5 pg WHO-TEQ g-1 fat and EU limit for Total PCDD/F + DL PCBs is 5.00 pg TEQ g-1 fat.
- The regulatory limit in Indonesia is 2.5 pg WHO-TEQ g-1 fat but includes both dioxins and dioxin-like PCBs.

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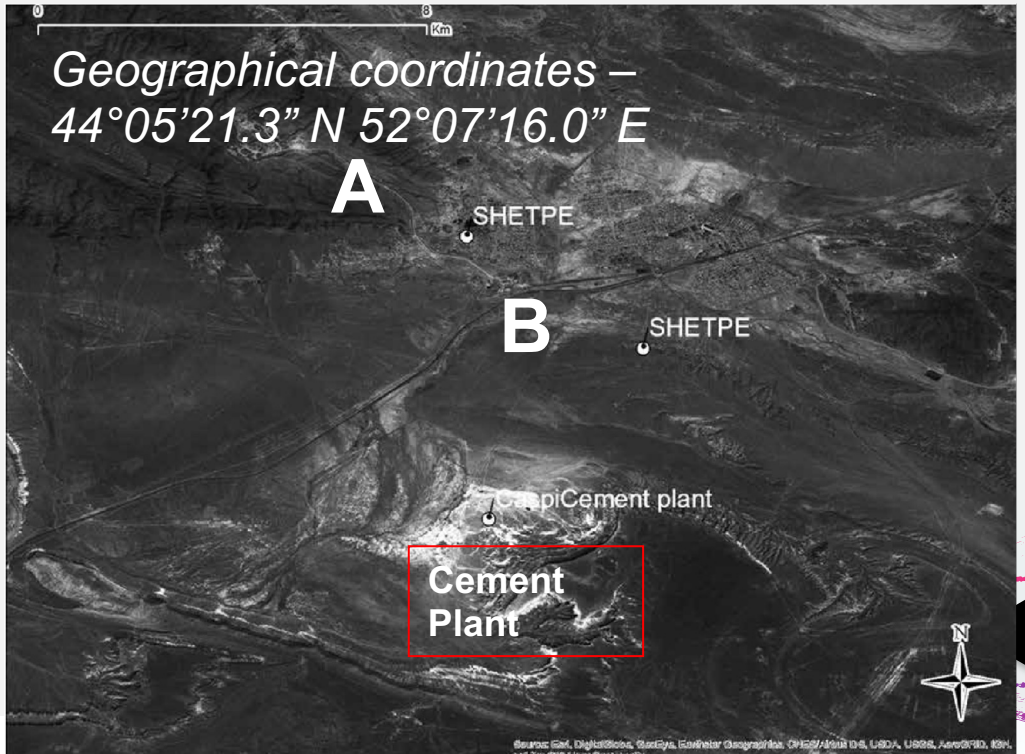
BFR egg-monitoring in Kazakhstan - HBCDD

- The highly impacted pooled egg (18320 ng/g fat) was collected from the free-ranged chicken eggs sampled in Shetpe in 2016.
- In Shetpe, car wrecks were located with chickens feeding around them and this could have served as potential source of contamination.
- Hexabromocyclododecane (HBCDD) was partly used in cars as flame retardants for mats, textiles, and expanded polystyrene (EPS). Exposure from EPS/XPS insulation cannot be ruled out.

- Kazakhstan as a country with a cold winter is increasingly using insulation in buildings and has an EPS/XPS factory.



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BFR egg-monitoring in Kazakhstan/Thailand - HBCDD

- For HBCDD one highly impacted sample was detected with **18320 ng/g fat** in free range chicken eggs (4 pooled eggs).
- The second egg from Kazakhstan supermarket had **1036 ng/g** fat.
- Only 2 from 8 pooled eggs from Kazakhstan were below detection limit.
- In Thailand 2 from 4 pooled eggs were below detection limit.

Location	Balkhash-south-west A	Balkhash-south-west B	Balkhash-Rembaza	Balkhash-Rembaza	Karagandasupem.	Baskuduk	Shetpe	Tauchik	Map Tha Put (Thailand)	Koh Samui (Thailand)	Bangkok-supermarket (Thail.)	Qihua
Sum HBCD	<2.1*	197	<2.6*	225	1036	187	18321	430	144	165	<2.8*	<3.3*

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Conclusions

- Large pollution of the terrestrial environment with plastic and microplastic pollution much higher than marine microplastic pollution (**four to 23 times higher**)
- Open burning of WEEE plastic results in high Dioxin pollution in soils and can contaminate chicken and eggs with extreme high Dioxin levels and related exposure
- **Using plastic as fuel** in non-BAT incinerators like tofu boilers or lime kilns contaminate the environment with high levels of dioxins, in particular mismanagement of dioxin-containing ash (PVC is likely a driver).
- Plastic and polymer foams containing **POPs additives** like **HBCD and PBDE** result in the contamination of chicken/eggs from directly picking EPS/XPS or PUR foam.
- With the increased threats of plastic pollution in the environment and related food contamination with Dioxins and POPs, capacity building for local researchers and laboratories are needed to support evidence-based policy and the control of human contamination from POPs contaminated food.

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Thank you

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