Ecology Department, Institute of Amelioration, Water Resources, and Construction
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Soil Health, Food Safety, & Health Impacts

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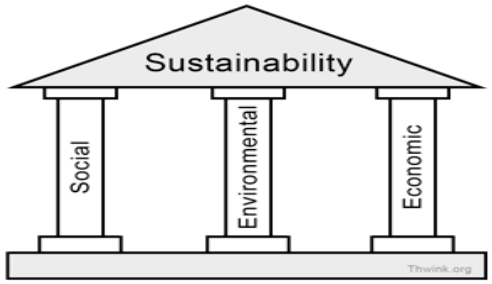


The Three Pillars of Sustainability

Social, Environmental, Economic

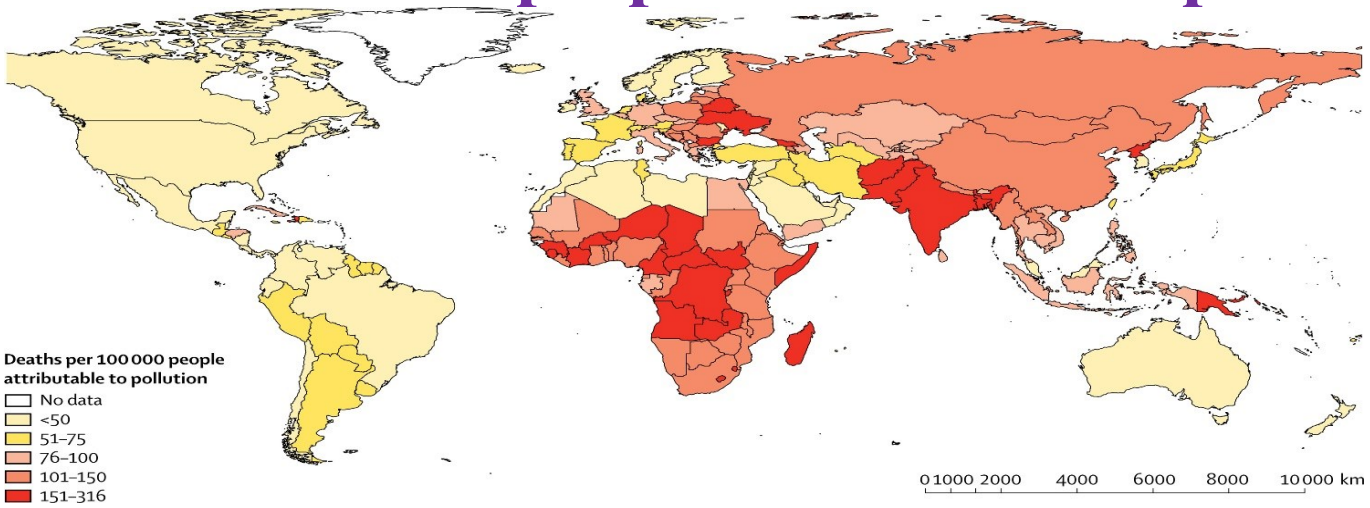
Environmental sustainability is the most important- the property of biological systems to remain diverse & productive indefinitely.

The Lancet Commission on Pollution & Health

Landrigan et al. The Lancet Commissions: Oct 19, 2017

- **Pollution is the largest environmental cause of disease & premature death in the world today**
- **Chemical pollution is a great & growing global problem**

No. of deaths/1 million people – all forms of pollution 2015



Soils are Valuable Natural Resources

USDA http://www.statlab.iastate.edu/soils/photogal/

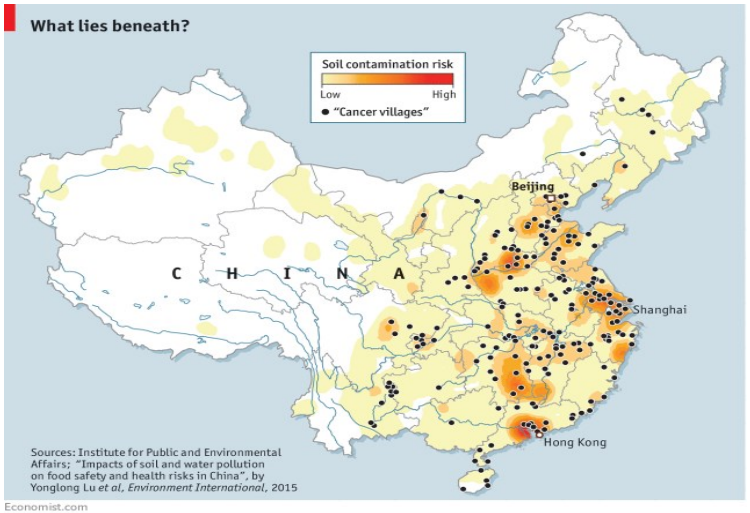
- **Soils support:**
- Production of food
- Production of fuel
- Recycling of nutrients & wastes
- Water supply & purification
- Habitat for soil organisms
  Engineering medium

Sources of Soil Pollution

Petroleum products, Industrial waste

Heavy metals, Agrochemicals

National Soil Survey, China (2014)



16.1% of soil was polluted-

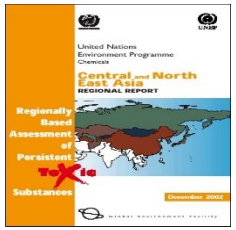
- 19.4% farmland,10.0% forest land,10.4% grassland,11.4% unused land (Zhao et al, 2015).

Of the contaminated soil samples - 6.3 million km2

- **-Cd, Hg, As, Cr, & Pb** (82%)
- **-DDT, PAHs, & HCHs**, levels are very high (samples above established safety levels account for 1.9%, 1.4%, & 0.5%)

-Persistent Toxic Substances (PTS)

(1) Persistent Organic Pollutants (POPs)
(2) Toxic Metal/Metalloids
(3) Emerging Chemicals of Concern



Regionally Based Assessment of PTS (2000-2003)

http://www.chem.unep.ch/pts

Regional Report of Central & NE Asia Wong et al
Global Report –Whylie et al, Wong

-Chemicals found in Newborn Babies

Environ Working Group (EWG) (2005): - 2 major laboratories:
Average of **200 Industrial Compounds & Pollutants** (total **287** chemicals) found in **10 Newborn Babies** (umbilical cord blood)

1. Organochlorine pesticides: DDT, dieldrin, etc.

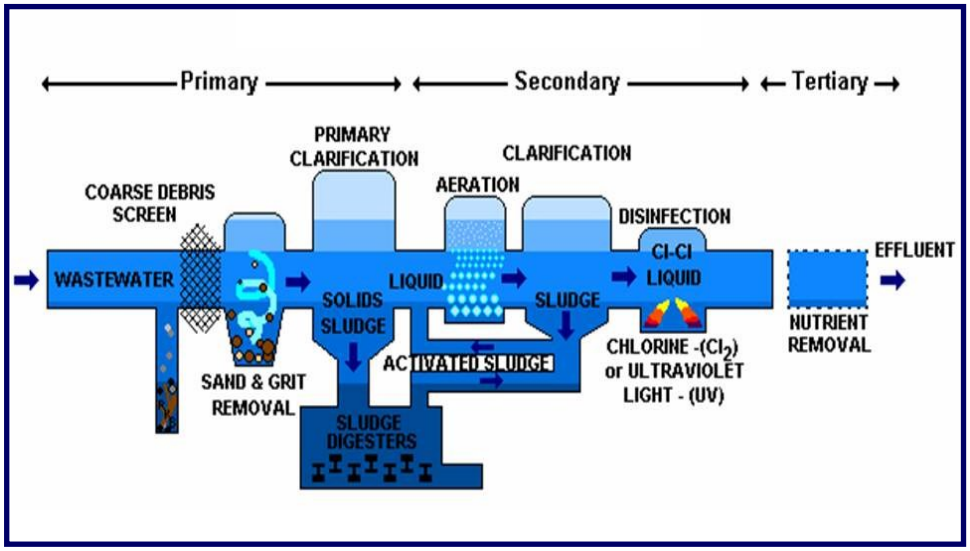
2. Chemicals used in a wide range of **consumer products** PFOA & PFOS, PBDE, PCBs

3. Chemical pollutants from **waste & fossil fuel combustion** PAHs, PCDD/Fs, Hg, Pb

PTS IN DENSELY POPULATED URBAN CENTERS

Agriculture

Open burning



Flushed down to toilets

Consumer products

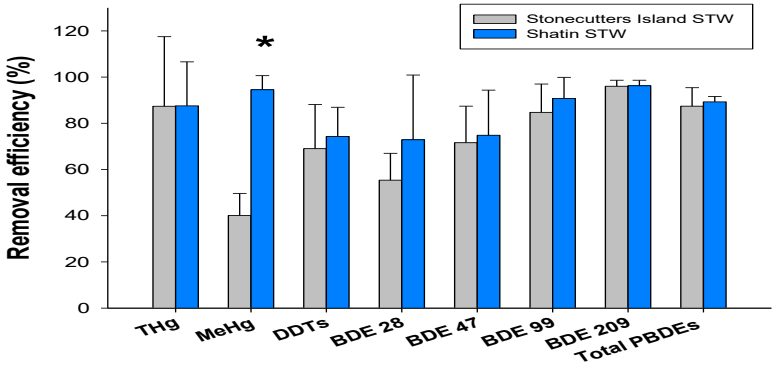
Pathways to Nature

- PTS … to STW
- They could not be removed completely
- They will enter into food chains,… use of sludge, use/discharge of effluent
- They could not be removed completely by existing drinking water treatment

-Wong, Armour, Naidu, Man (2012) **PTS: sources, fates & effects.** Rev Environ Health

Removal Efficiency of PTS by Two STWs

As, Cd, Ni, Sb, Sn, Zn, Cu, Cr, Pb, total-Hg, methyl-Hg, DDTs, PBDEs, PCBs, PAHs, bisphenol A, PFOA/PFOS, **Antibiotics:** tetracycline, ciprofloxacin, erythromycin, **Hormones:** estradiol, estriol, estrone, ethinylestradiol, testosterone



-Stonecutters Island STW: **Chemically enhanced primary treatment (CEPT)**

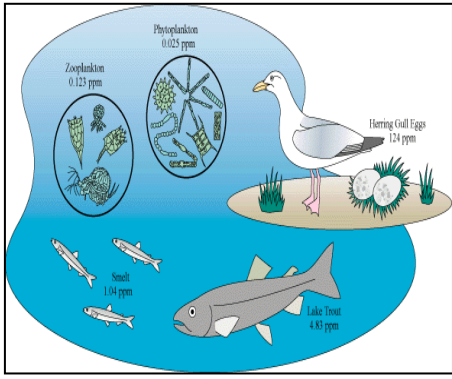
$FeCl_3$ & cationic polymer as flocculation coagulants

-Shatin STW: **Primary & secondary treatment**

Man,…Wong (2015).PBDEs.STOTEN/

Man, …Wong (2016).PAHs.JES.

PTS Enter into Food Chains



FOOD CONTAMINATION

-TOXICITY/POTENCY–

CONCENTRATIONS & TYPES OF FOOD CONTAMINANTS

-EFFECTS:

(1) SHORT-TERM:

HIGH DOSE- MAY BE FATAL;

(2) LONG-TERM:

LOW DOSE- CANCERS/HISTOLOGICAL DAMAGES

6 CASE STUDIES FOR ILLUSTRATION

Risk Assessment Via Ingestion Exposure Pathway

(US EPA, 2000).

I: Non-cancer risk

1. Mutagenicity
2. Developmental toxicity
3. Neurotoxicity
4. Reproductive toxicity

a) Estimated daily intake (mg/kg/day) / Reference Dose (mg/kg/day) = **Hazard Quotient** (HQ)

b) **EDI = (Concentration × Consumption rate)/ BW**

EDI = Estimated daily intake (mg/kg/day)
Concentration = Contaminant concentration (mg/kg)
Consumption rate = Consumption of fish per day (kg/day)
BW = Body weight (kg)

c)

HQ ≤1 = Unlikely adverse effect on human health

HQ >1 = Likely negative impacts on human health

II: Cancer risk = LTEDI X SF

LTEDI = Life-time Estimated daily intake (mg/kg/day)

SF = Slope factor $(mg/kg/day)^{-1}$

Lifetime cancer risk	
< 1/1,000,000	Very low
> 1/1,000,000 to <1/10,000	Low
1/10,000 to 1/1,000	Moderate
1/1,000 to < 1/10	High
> 1/10	Very high

(NYS DOH, 2007)

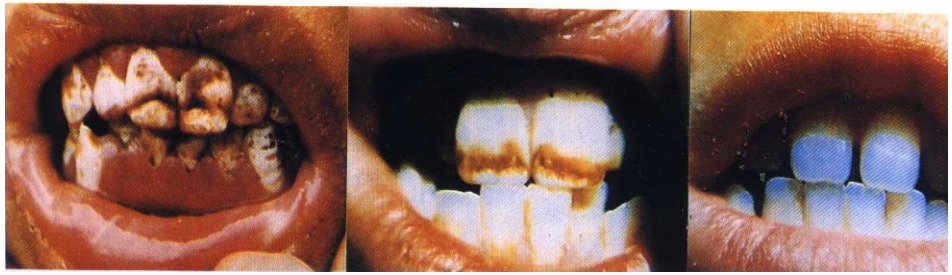
Case Study 1: RGC/HK

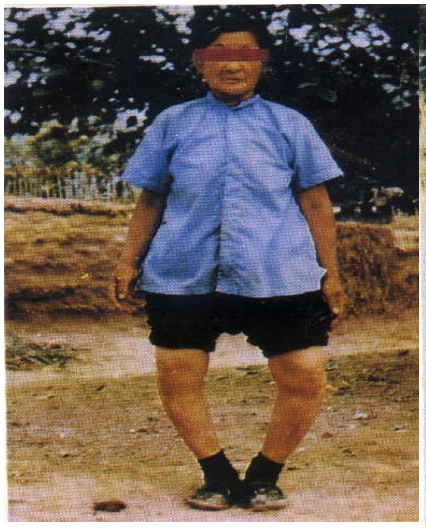
Flouride & Fluorosis

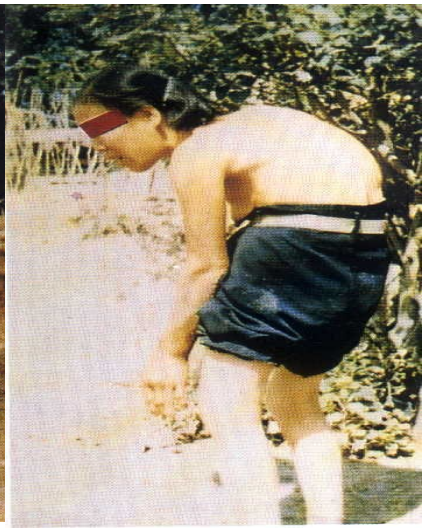
Fluorosis – due to elevated intake of F over prolonged periods:

Skeletal fluorosis & Dental fluorosis

- This disease has been found in Sichuan Province in Tibetans with a long history of drinking **brick tea** (Cao *et al*., 1997).
- Tea is a F accumulator, with a high F uptake under acid condition (<pH 5).
- F is accumulated in old leaves which are mainly used in ‘Brick Tea’ -a poor quality tea compared with the common ‘Leaf Tea’.







Case Study 2: RGC/HK; UNU-GIST (S Korea)

Arsenic (As) & Arsenicosis

Cambodia



- Arsenc (As) - major concern worldwide
- High As conc (>100 µg/L)- Mekong River

-Wang HS…Wong MH (2013) EGAH
-Phan K… Wong MH, Kim KW (2013) JHM
-Phan K…Wong MH…Kim KW (2013).EP
-Hashim JH …Wong MH.. (2013) STOTEN

As Threat in Rice FAO (2007)

FAO :: Newsroom :: News stories :: 2007 :: Arsenic threat in r...

FAONewsroom

Food and Agriculture Organization of the United Nations
helping to build a world without hunger

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Arsenic threat in rice

Reducing arsenic levels in rice through improved irrigation practices

19 December 2007, Rome – High levels of arsenic in rice could be reduced by applying improved irrigation management practices in Asia, FAO said today in a new report entitled *Remediation of Arsenic for Agriculture Sustainability, Food Security and Health in Bangladesh*.

Studies have shown that high concentrations of arsenic in soil and irrigation water often lead to high levels of arsenic in crops and are posing an increased food safety risk. At present, twelve countries in Asia have reported high arsenic levels in their groundwater resources.

"The problem of high arsenic levels in crops, particularly rice, needs to be urgently addressed by promoting better irrigation and agricultural practices that could reduce arsenic contamination significantly," said Sasha Koo-Oshima, FAO water quality and environment officer.

"Arsenic-contaminated rice could aggravate human health when consumed with arsenic-laden drinking water. The widespread addition of arsenic to soils, for example in Bangladesh, is degrading soil quality and causing toxicity to rice. Arsenic contamination is threatening food production, food security and food quality," she noted.

Entering the food chain

Arsenic enters the food chain mainly through crops absorbing contaminated irrigation water. Millions of shallow tube wells have been installed throughout Asia over the last three decades pumping water from contaminated shallow groundwater aquifers.

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(+39) 06 570 53105
(+39) 348 252 3616

Planting rice in raised beds could lower arsenic levels.

Related links
Remediation of Arsenic for Agriculture Sustainability, Food Security and Health in Bangladesh (pdf)
Arsenic contamination

Arsenic
Arsenic is an odourless and tasteless semi-metal that occurs naturally in rock and soil. The World Health Organization says consumption over long periods

Efficient As uptake by rice in contaminated area - a health concern

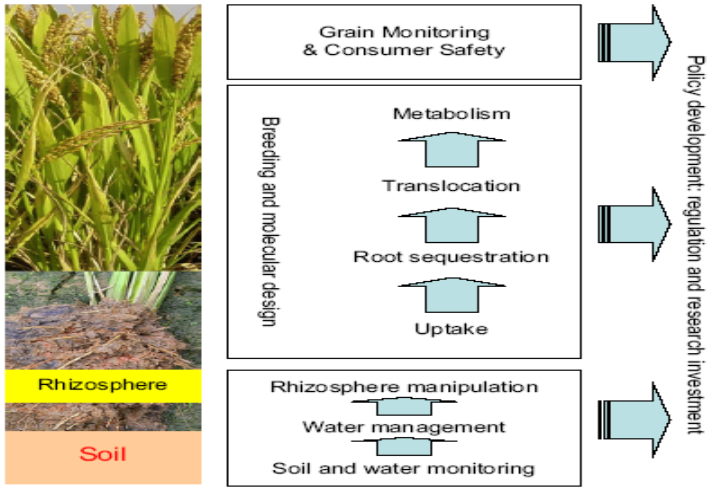
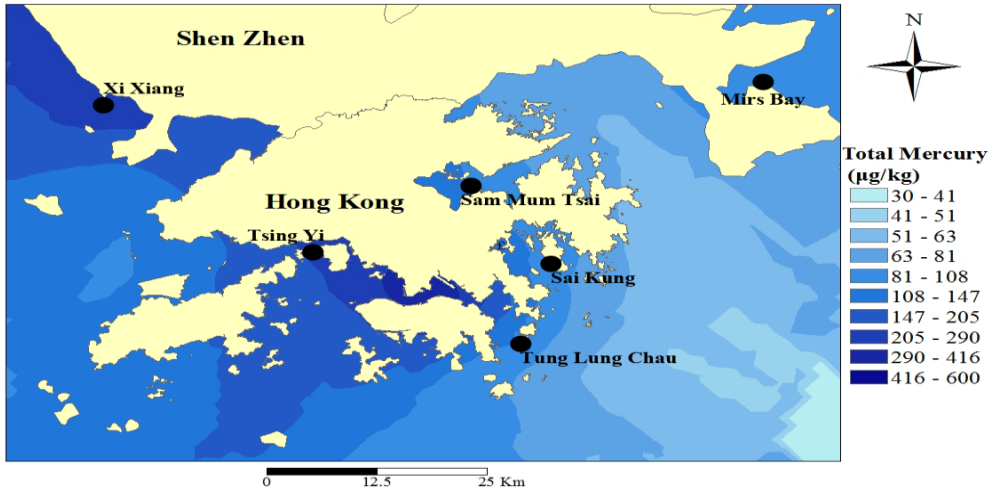


Fig. 1. Ensuring levels of As$_i$ in rice are safe for all.

Zhu YG et al (2008) EP 154

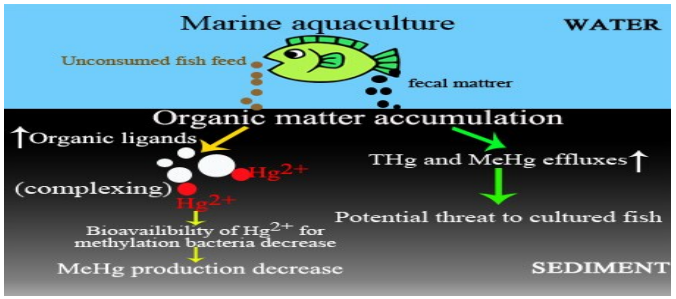
Case Study 3: RGC-CRF/RGC

Hg- Fish Contamination & Human Health



Hg speciation:

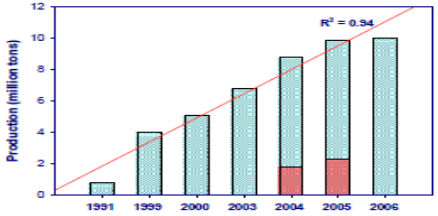
Inorganic Hg to Organic Hg (MeHg by sulfate reducing bacteria)?



Fish Feeds – Contaminated

Trash fish – small fish, low commercial value

Compound feed (fishmeal) – made from trash fish



State of World Fish & Aquac, 2006

Liang ..Wong (2016) Chemosphere 148
Shao… Wong (2012) JHM 221-222
Shao.. Wong (2013) Food Chem 136
Tao… Wong (2016) EP 219

Fish–Most Common Route of Hg Exposure

Wong, 2017, Env Tech Innov 7.

HK, Valencia (Spain), Istanbul (Turkey), Krakow (Poland)

Hg Passing to the 2nd Generation

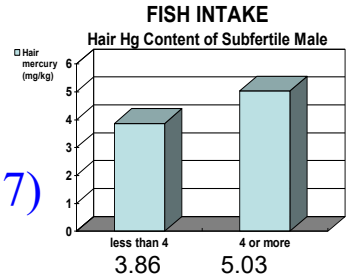
Increasing maternal **fish consumption** & maternal age – increased **cord blood Hg level** (average conc 5.8 μg/L) (Fok et al, 2006)

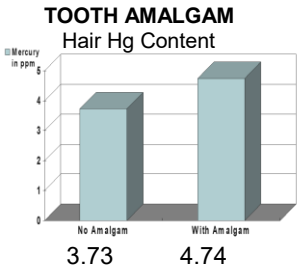
-Hg & Male Subfertility

Dr. CKM Leung, Former Director of In Vitro Fert Clinic

Subfertile men: Abnormal semen parameters (WHO, 1987)

Their hair Hg concentrations significantly correlated to (1) fish intake & (2) tooth amalgam





-Environmental Toxicants & Autism

Ye, Leung, Wong (2017). *EP* 227

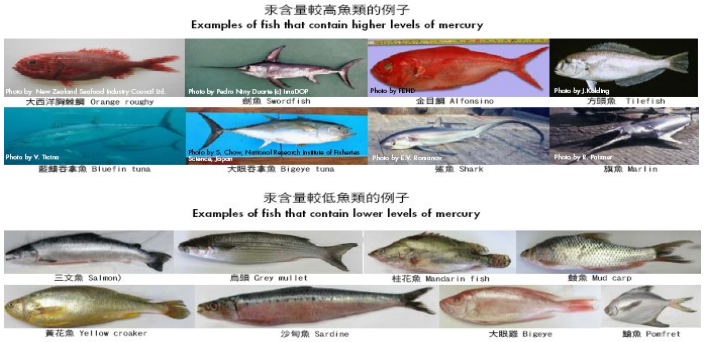
Hg, Pb, DDT, PBDEs, PCBs, Phthalates, Bisphenol A

Heavy metal overloads & autism.. -Ko, Qin, Wong (2013).

Health impacts of toxic chemicals. -Lam, Wong (2013). In: Env Contam, Ed. Wong. CRC/Lon.

-Longer-Term Effects

- **Prenatal Hg Exposure & IQ**
- **Socio-Economic Effects**



-The First HK Total Diet Study Report on MeHg (2014)

食物安全中心
Centre for Food Safety

204 composite samples,
51 food items,
6 food groups

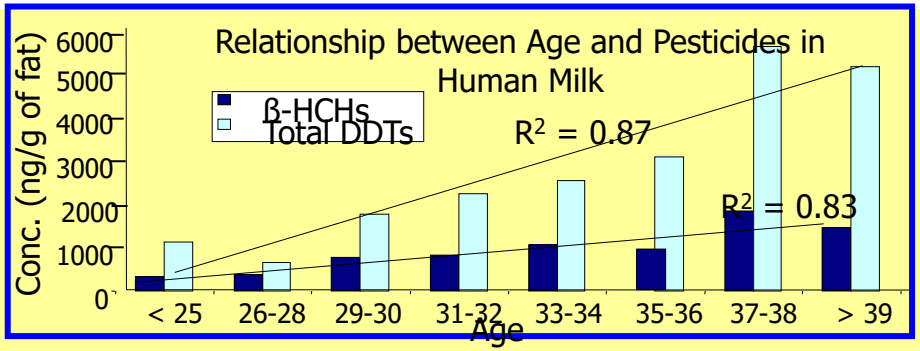
Dietary exposure to MeHg **Health concern to 11% of women aged 20-49 (childbearing age)**

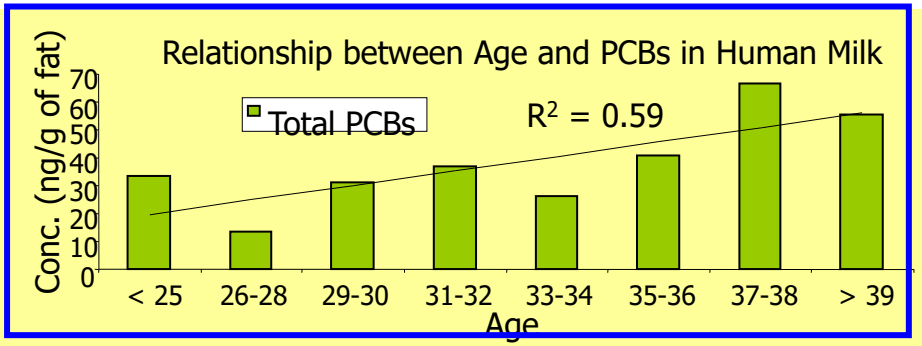
Case study 4: RGC-CRF/HK

Human Body Burdens of POPs

Wong et al. (2002). Arch Environ Contam Toxicol 43

Human Milk: Hong Kong (n=115) vs Guangzhou (n=54)





- Positive correlation between age of donors & accumulated levels of OCPs & PCBs
- Positive correlation between fish consumption & OCP/PCB levels
- OCP concentrations in HK & Guangzhou milk were 2-15x higher than in UK, Germany, Sweden, Spain, Canada; but PCBs: ~10x lower
- Lower p,p'-DDE/p,p' DDT ratio in Guangzhou indicates more recent use than HK

POPs in Adipose Tissues of Patients with Uterine Leiomyomas

-Dr CKM Leung**, Director of *In Vitro* Fertilization Clinic**

Qin YY, Leung CKM …Wong MH (2010) *ESPR* 17: 229-40

- Patients accumulated significantly *higher* ($p<0.01$ or 0.05) POPs & Hg in adipose tissues, compared with healthy females

Case Study 5: RGC-CRF/HK

E-waste is a Global Problem

Lin S, et al, Wong MH (2020). E-waste influx after China banned entry. Crit Rev EST 6

Recycling Operations

Guiyu town (Guangdong Province)


Melting a computer


Melting a circuit board over coal grills


Hammering a computer

GREENPEACE

Open Burning & Melting Electronic Boards in Strong Acids

Most destructive to the environment

Extracting Cu from cable wires

- Cu acts as catalyst for the formation of dioxins during combustion of PVC
- Burning of cable wires generates 100x more dioxins than domestic waste

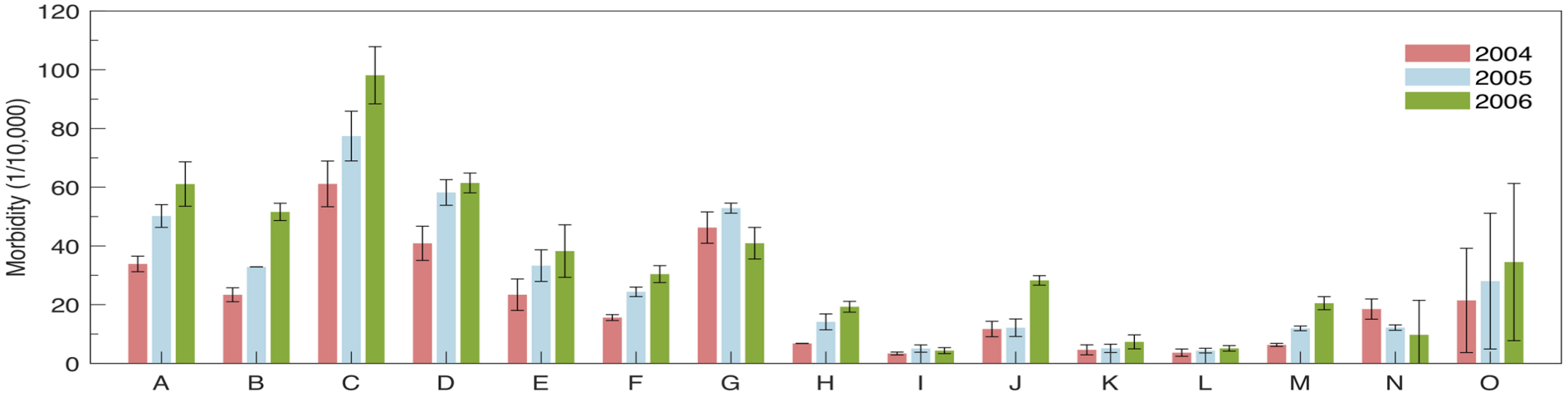
- Wong MH, et al (2007) Export of toxic chemicals – .. uncontrolled e-waste recycling. EP 149.
- Leung AOW, et al, Wong MH (2008) HMs.. Dust.. e-waste.. health implications EST 42.
- Kiddee P, Naidu R, Wong MH (2013) E-waste management... Waste Manage 33.
- Kiddee P, Naidu R, Wong MH (2013) Metals & PBDEs ... e-waste …landfills. JHM 252-253.
- Man M, Naidu R, Wong MH (2013) PTS.. from …e-waste recycling... STOTEN 463-464

Exposure, Body Burden, Health Impacts

Lin SI, et al, Wong MH (2021). Toxic chemicals from uncontrolled e-waste..... JHM 426.
Lin S, et al, Wong MH (2022). Remediation… e-waste recycling. Chem Engin J 430.

Food Consumption Survey
Food Basket Analysis (9 food groups)
-Dietary exposure is the most important exposure pathway.
-Significant correlations between exposure to e-waste & high body burdens (HMs, POPs)

Center for Disease Control & Prevention, Taizhou (2004-06)



A=Digestive system; B=Malignant tumor; C=Cardiovascular system; D=Respiratory system; E = Urinary system; F=Gynaecological disease; G=Surgical disease; H=Endocrine system; I=Infectious disease; J=Trauma; K=Blood disorder; L=Mental disorder; M=Ophthalmological & otolaryngological disorder; N = Others; O=overall results.

PLASTICS & THE CIRCULAR ECONOMY

June 2018

R Barra, SA Leonard, C Whaley, R Bierbaum

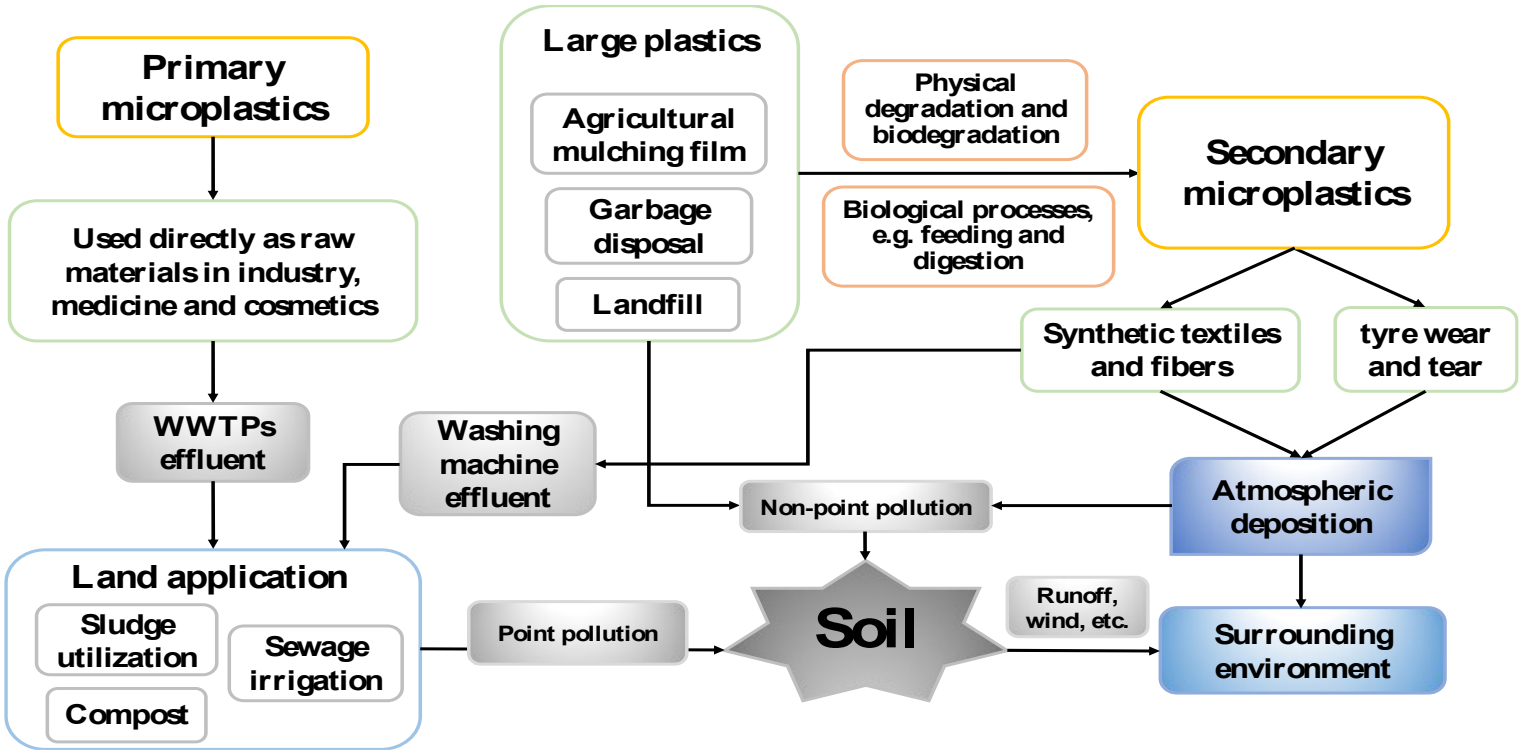
The Scientific & Technological Advisory Panel (STAP) of Global Environment Facility (GEF)

- Chemicals & waste: some POPs are used as additives in some plastics, & dioxins/furans are by products of PVC production
- Climate change: producing plastics using fossil fuels, open burning & incineration of plastic wastes – greenhouse gas emissions (390 m t of CO2 in 2012)
- International waters: widespread plastics pollution
- Biodiversity: it is the 2nd most important threat to coral reefs, after climate change – entanglements & ingestion (chemicals additives)
- Land degradation & food system: microplastics – land degradation & food contamination

Case Study 6: JU/SUST/EdU- HKRGC

Sources, migration & toxicology of MPs in soil

Guo JJ, Huang XP, Xiang L, Wang YZ, Li YW, Li H, Cai CY, Mo CH, Wong MH (2020) Environ Int

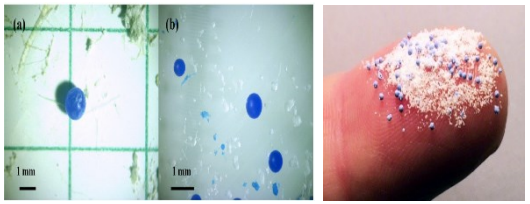


Emission, fate & transformation of MPs in biotic & abiotic compartments: Global status….

Ubaid Ali M, Lin S, Yousaf Q et al, Wong MH (2021) STOTEN

Microbeads & Microplastics in PRD

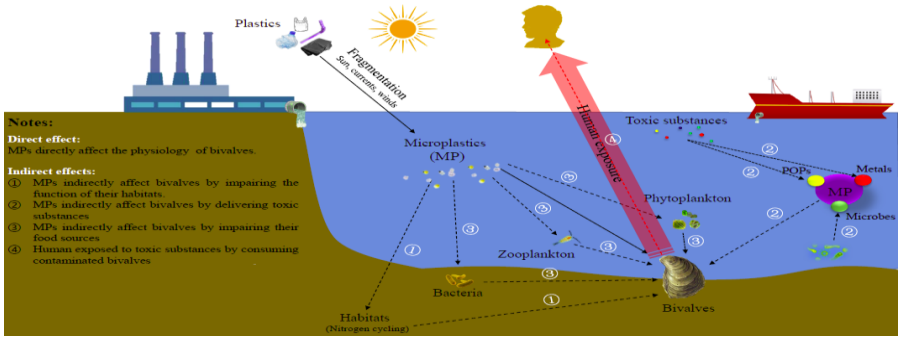
Cheung & Fok, 2016; Tsang et al, 2018



Microbeads scrubbing agents in **PCCPs** (<5 mm)
Microfibers clothes (polyester) (<2000μm)

Effects of Microplastics on Bivalves

Zhang, Man, Mo, Wong (2019) Critical Reviews EST

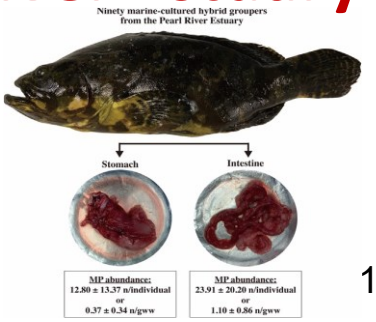


(1) Direct impact: physiology of bivalves
(2) Indirect impacts, e.g. habitat, food, etc.

Microplastics in cultured fish from the Pearl River Estuary

Lam TWW, Fok L, et al, Wong MH (2022). STOTEN 827

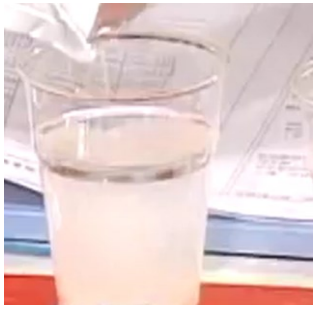
- MPs were more abundant in the intestine than in the stomach.
- Fibres accounted for 70.1% of the detected MPs.
- MPs smaller than 1 mm represented 68.6% of the total count.

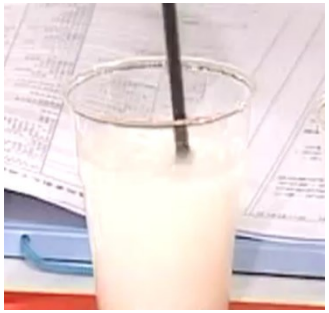


Phthalate Plasticizer (DEHP)

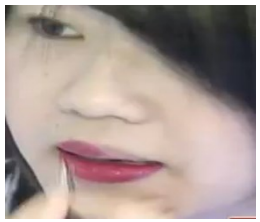
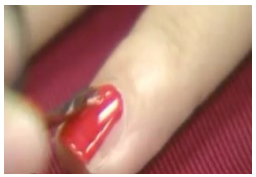
Yen et al (2011) J Formosan Med Assoc 110

- Use in foods & beverages -clouding agents (added to drinks for 60 years)
- Food safety problem in Taiwan & HK



DEHP – used in cosmetics


Baby bottles- release BPA under heat

Oral Intake of Phthalates

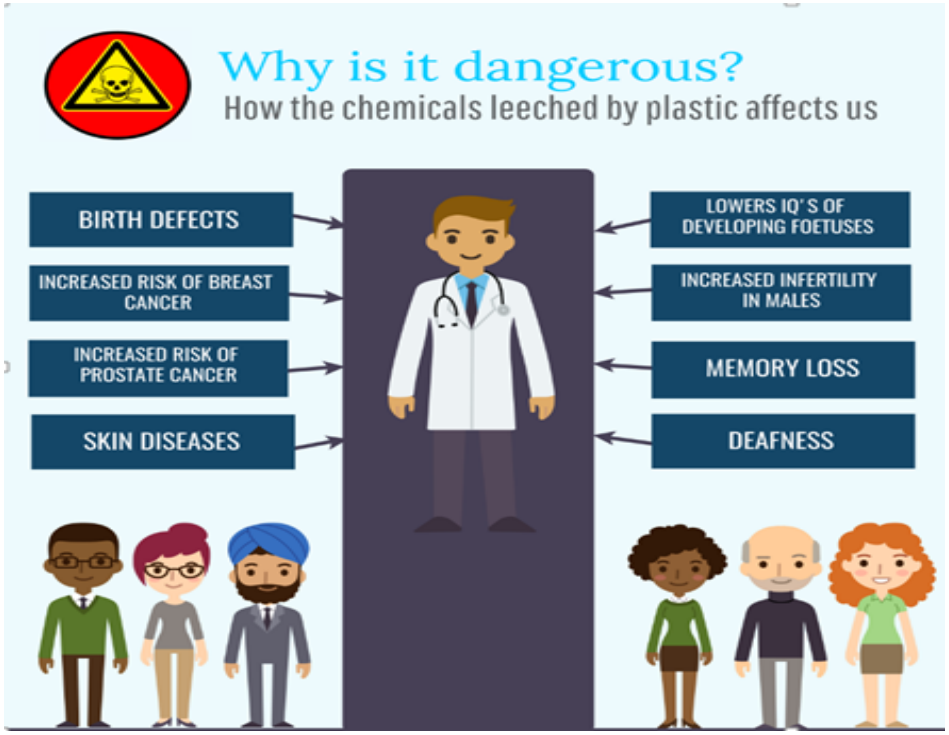
Wang W… Wong MH (2018) Environ Pollut

- Food contamination due to production, processing, & packaging

Bisphenol A (BPA)
-an organic building block
Phthalate (DEHP)
-an additive, plasticizer

Microplastics & Associated Chemicals- Health Risks

- MPs in human tissue might induce inflammation, genotoxicity, oxidative stress, apoptosis & necrosis (Wright & Kelly, 2017).
- BPA, phthalates & adsorbed POPs accumulated in bivalves - transferred to humans, cause health problems (Benjamin et al., 2017).
- MPs may cause a shift in microbial composition (e.g. lung & gastrointestinal tract) (Martínez et al., 2013).



POPS TIMELINE (1870-2013)

1850

1874 DDT first synthesized
1881 PCBs synthesized
1889 First reports of skin disease linked to POPs

1900

1929 Industrial scale production of PCBs
1948 Paul Muller receives Nobel Prize

1950

1959 Peak of DDT use in the US
1962 Rachel Carson's *Silent Spring* is published
1966 Wildlife damage reported
1972 US bans DDT
1979 US bans manufacture of PCBs
1996 Theo Colburn's *Our Stolen Future* is published
1989 Basel Convention – transboundary movement of hazardous wastes & disposal
1998 Rotterdam Convention – Prior Informed Consent (PIC) Procedure for certain hazardous chemicals & pesticides in international trade

2000

2001 Stockholm Convention on POPs
2006 Restriction of Use of Certain Hazardous Substances in EEE
2007 Waste Electrical & Electronic Equipment – design for reuse, recycle & recover
2013 Global Treaty on Mercury Pollution

Control of Existing & New Chemicals

- **Existing Chemicals**
  - **Rotterdam** obliges Parties to notify final regulatory actions for banned or severely restricted chemicals.
  - **Stockholm** Parties must eliminate certain chemicals from production and use. The Convention lays down ***POPs*** screening criteria for assessing other chemicals.
  - **Minamata** on Mercury (2013): Banning Hg mines, Hg use in products, controlling emissions, etc.

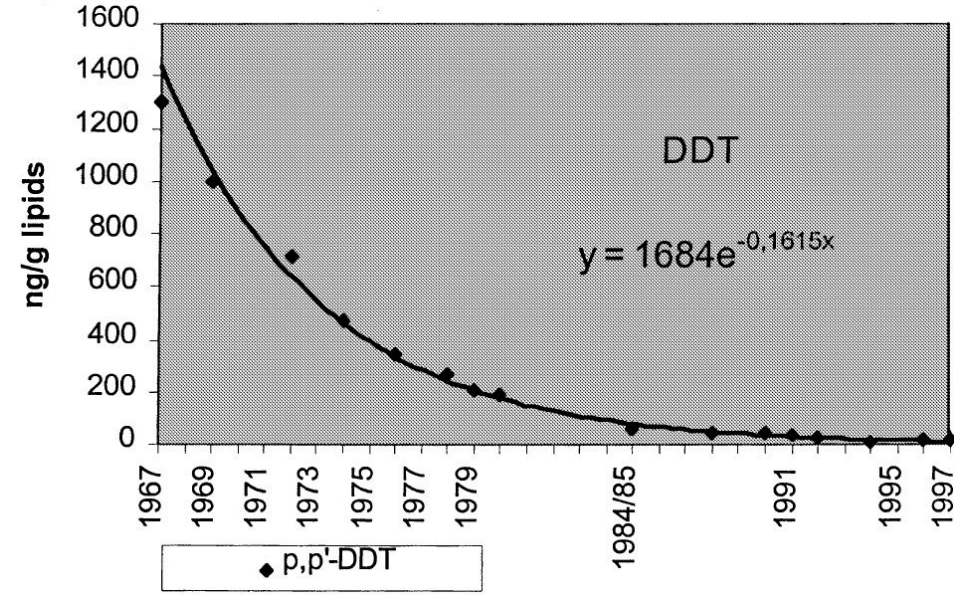
(Geneva, 30 September 2009)

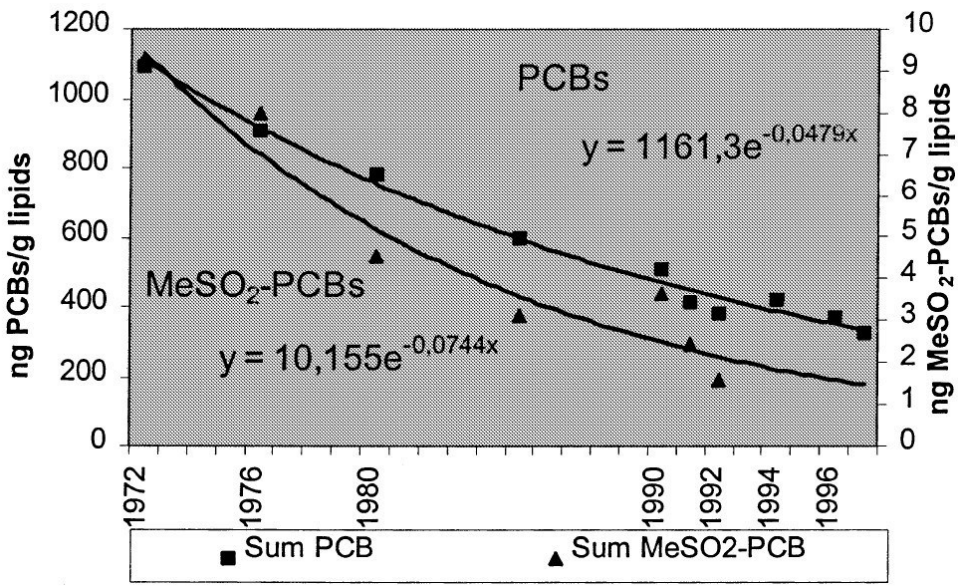
New Chemicals

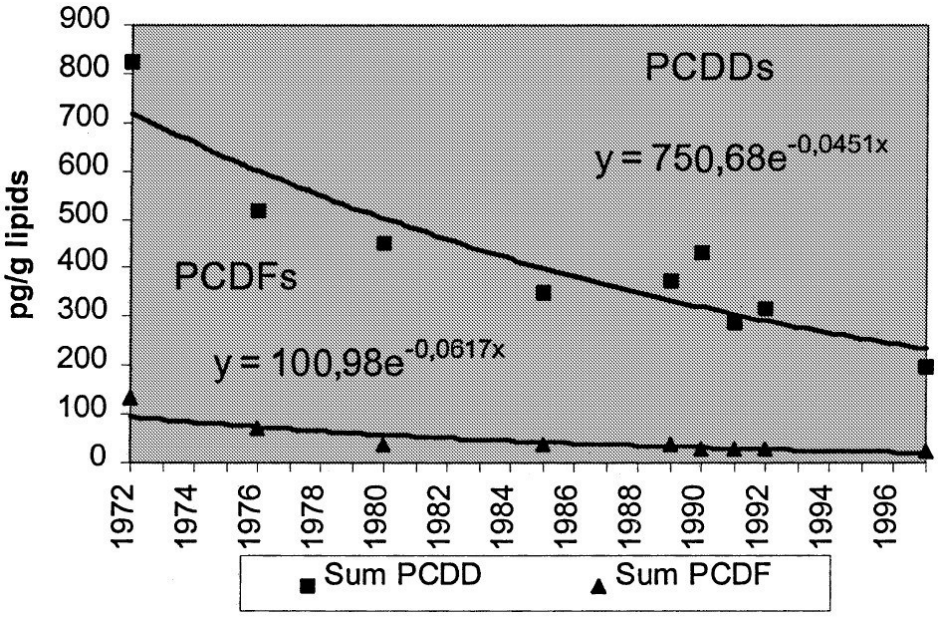
Stockholm requires Parties with regulatory & assessment schemes to prevent production and use of new pesticides or new industrial chemicals that exhibit POPs characteristics.

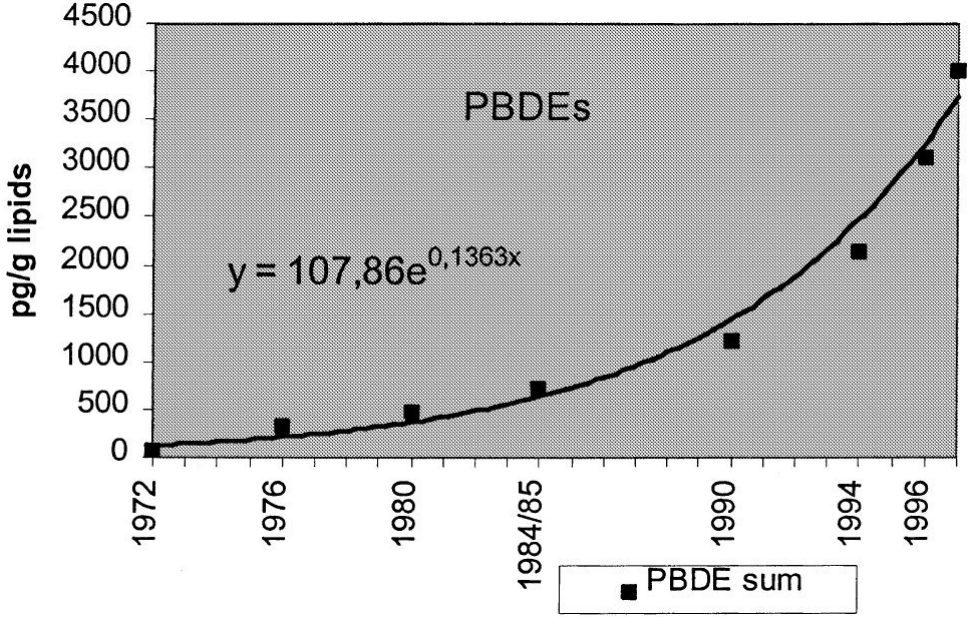
POPs in Human Milk – Stockholm Region

Noren & Meironyte (2000) Chemosphere 40: 1111-23









Emerging Chemicals Management Issues

-To support the **sound management of chemicals** throughout their life-cycle to **minimize significant adverse effects on human health & the global environment-** Global Environment Facility (GEF)

H Bouwman, MH Wong, R Barra (2012)

http://stapgef.org/pops-and-ozone

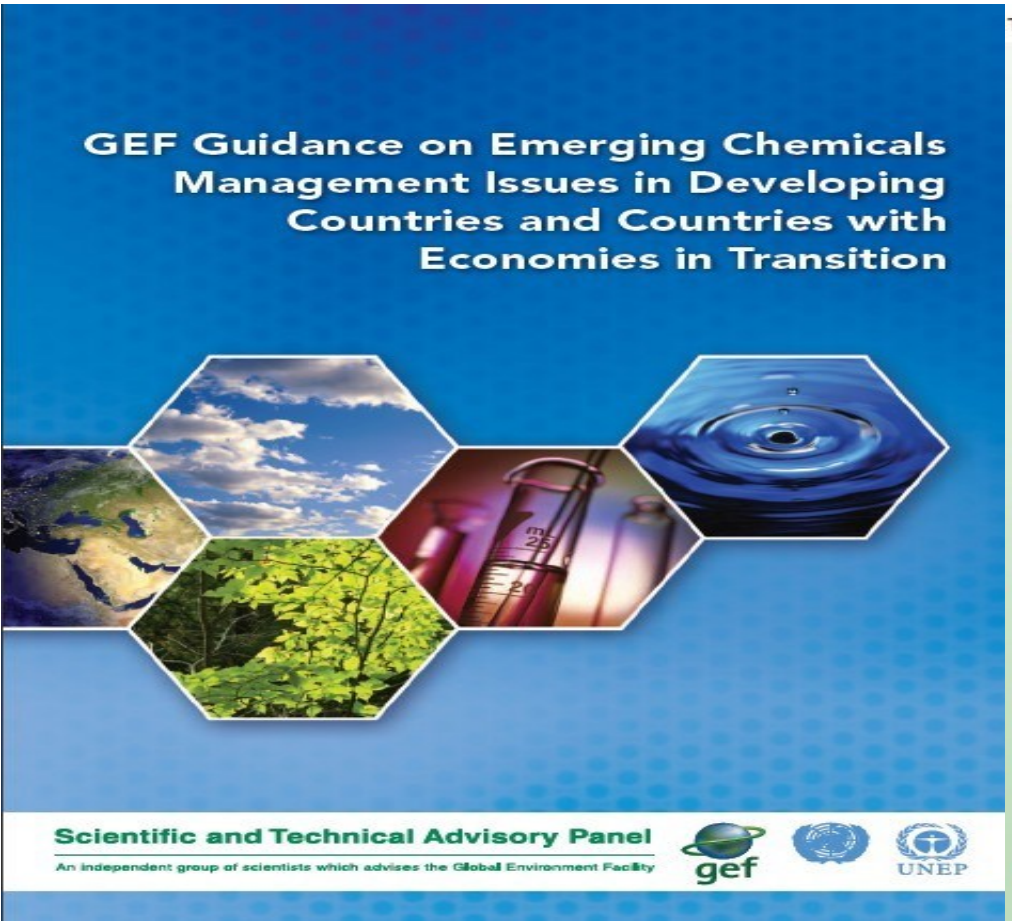


Table 1: Regional and all-regional ECMIs ranked on Aggregate concern

ECMI	Central & South America	Africa	Asia	Eastern Europe	Oceania	All regions - Oceania	All regions + Oceania
Heavy metals	1	1	1	1	3	1	1
PAHs	3	2	2	4	2	2	2
Mixture effects	2	7	6	2	15	3	4
Open burning	5	5	3	3	1	4	3
Endocrine disruption	4	12	4	7	12	5	6
Sewage	6	10	12	6	5	6	5
Inorganic fertilizer	8	9	13	5	7	7	7
Arsenic	10	11	5	10	9	8	9
E-waste	13	3	7	14	7	9	8
PPCPs*	7	8	15	11	14	10	11
Mine waste	11	14	11	8	10	11	10
Lead in paints	17	4	8	15	16	12	13
Illicit drugs	9	6	18	19	17	13	14
Cadmium in fertilizer	12	15	10	16	10	14	12
Food additives	15	13	14	13	21	15	16
Phthalates	16	17	16	9	20	16	17
Bisphenol A	19	20	9	20	18	17	19
Organotins	18	21	17	12	12	18	18
Marine debris	14	19	19	21	4	19	15
Alkylphenols	20	18	20	21	18	20	21
Ammunition/conflict	22	16	22	18	6	21	20
Nanoparticle/material	21	22	21	17	22	22	22

*Pharmaceuticals and personal care products

Eleven Chemicals or Groups of Chemicals – Emerging Evidence Indicates a Risk

Identified by Global Chemicals Outlook II (GCO-II)

http://stapgef.org/pops-and-ozone

(1) Arsenic (As) -Highly toxic to human health (e.g., carcinogenic).
(2) Bisphenol A -Used in producing plastics- high reproductive toxicity.
(3) Cadmium (Cd) -Group 1 carcinogens (to humans) causing lung cancers.
(4) Glyphosate -The most widely used herbicide- health concern.
(5) Lead (Pb) -A multi-system toxicant - cause chronic & debilitating health impacts.
(6) Intentionally added microplastics in products -<5 mm added to PCPP & cosmetics intentionally.
(7) Neonicotinoids -Insecticides may be a threat to bees & other pollinators
(8) Organotins (TBT) -Banned in anti-fouling systems (2008), but used as biocides –environmental & health risks
(9) Phthalates produced in high volumes- Plasticizers- extensive environmental & human exposures
(10) Polycyclic Aromatic Hydrocarbons (PAHs) –100 organic compounds with high persistence, bioaccumulation, toxicity & long-range transport potentials.
(11) Triclosan -an antibacterial chemical used in consumer & medical products

General Recommendations

1. Manage soils sustainably as they are our valuable and Yet vulnerable resources
2. Guard them against from human activities where toxic chemicals are emitted.
3. Control/manage toxic chemicals, especially their emissions & usages. International cooperation is essential.
4. Understand geochemical cycles of food contaminants
5. Cleanup contaminated sites for crop & fish production
6. Ensure toxic chemicals are not used during food production/food processing/preparation. .
7. Reactive local agriculture & aquaculture -for safe/quality food production, & cut down foot print & C emission

The End

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