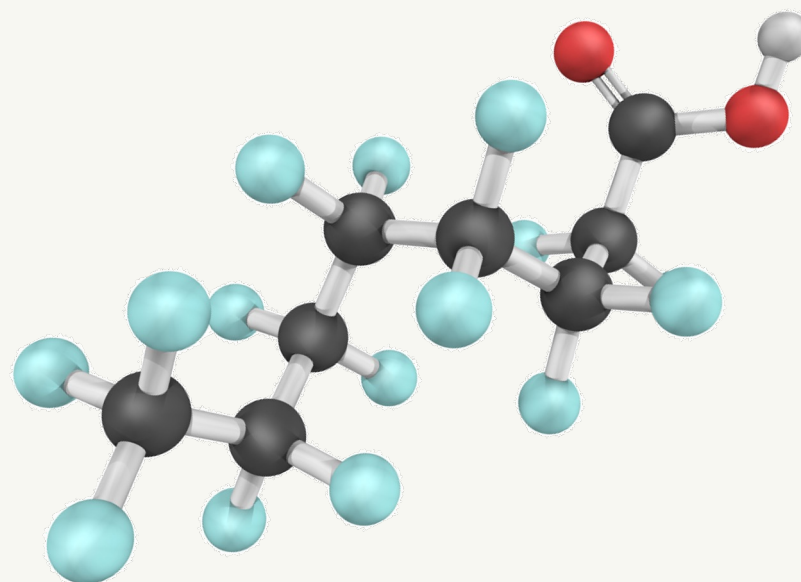


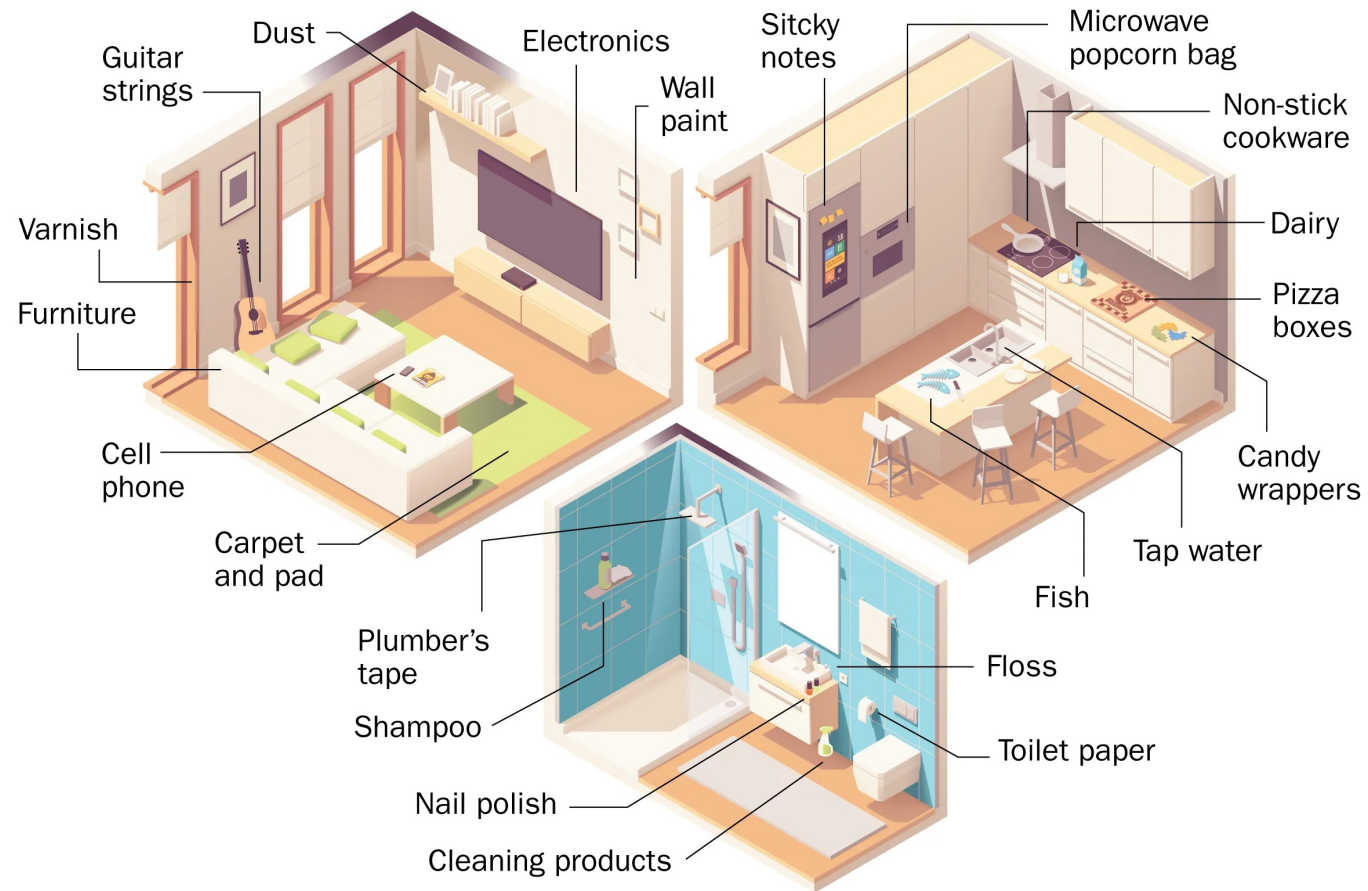
National Environmental Health Action Plan Conference | 21 September 2023

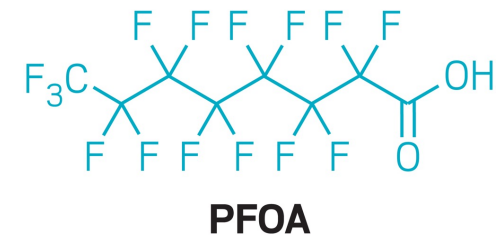
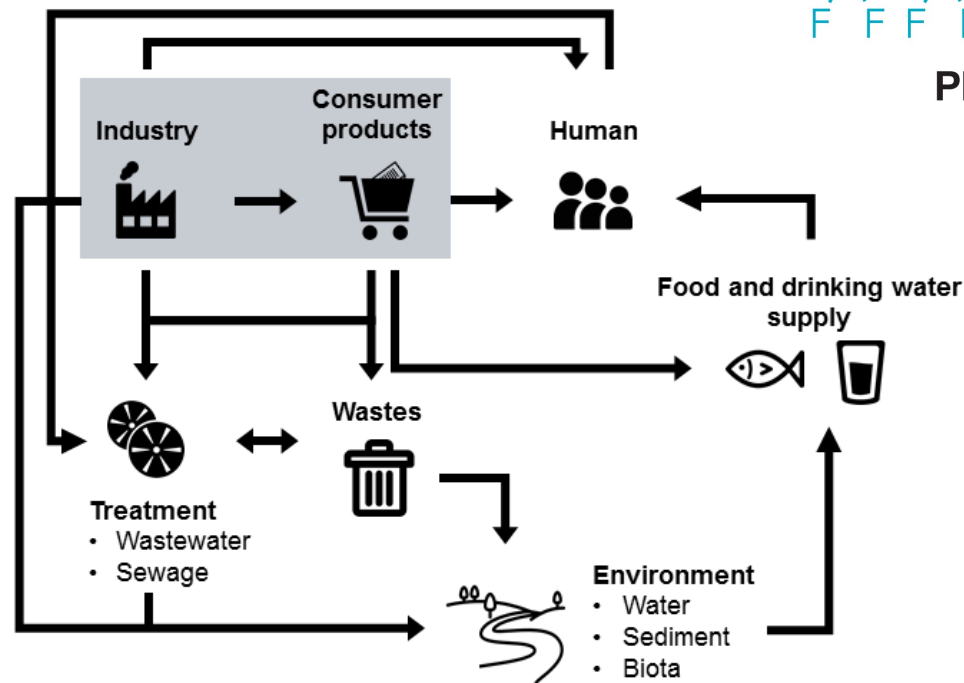
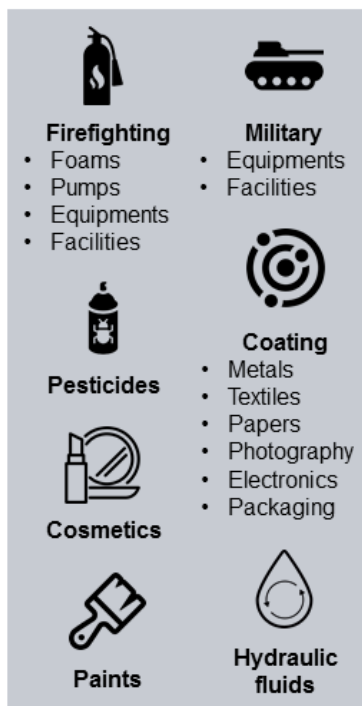
An Overview of **Per-and Polyfluoroalkyl Substances (PFAS)** in the **Environment: Source, Fate, Risk and Regulations**

Professor Dr. Ahmad Zaharin Aris FAPM, FASc



Places in your home





PFAS Effects on Human

(a)



Body weight, size, and growth

- Abnormal changes e.g., low birth weight, overweight/obese, and cell size.
- Altered metabolism and growth.
- Increased risk of diseases.



Nervous system and behavior

- Caused behavior deficits, neurotoxicity, and ototoxicity.
- Changes in level/expression of neurotransmitters.



Musculo-Skeletal system

- Reduced bone mineral density.
- Skeletal malformation, deposition and sequestration in bone, bone cell differentiation, and osteoporosis.



Sensory

- Caused dental carries and skin irritation or sensitization e.g., atopic dermatitis, with the potential development of allergic illnesses.



Genotoxicity

- DNA damage, mitochondrial depolarization, altered DNA methylation, and telomere shortening.
- Heritable genetic changes.



Cancers

- Altered cell proliferation, cell-cycle regulation, cell migration and invasion, gene expression, and histone modifications, with tumorigenesis.
- Affect almost any organ or tissue.



Cell toxicity/Mortality

- Induced histopathological changes, oxidative stress, cell apoptosis, necrosis, changes in ROS, DNA damage, signaling changes, and cell death.
- Impacted gene expression, metabolism, and homeostasis.
- Contribute to various diseases and biological functions.



Immune system

- Changes in inflammatory biomarkers and immune response.
- Affect immune cell production, activity, and signaling, caused cell death.
- Increased risk of allergies and infectious diseases, coupled with life-threatening illnesses.



Metabolic and digestive system

- Affect metabolite concentration and metabolism.
- Impacted gene expression, cell function, and nuclear receptor pathway (e.g., LXR, RXR, and PPAR).
- Increased risk of metabolic disorders and other chronic diseases.



Endocrine system

- Changes on the level, production, and activity of hormones and expression of hormone receptors.
- Impacts on various organs and glands with increased risk of diseases.



Respiratory system

- Altered blood oxygen level.
- Changes in cell structure and function of the lungs, airways etc.
- Changes in histology e.g., throat (larynx or pharynx).
- Increased risk of allergies and infectious diseases such as heart failure coupled with life-threatening illnesses.



Reproductive system

- Altered hormone level, germ cell production, and organ development and function.
- Failure of pubertal onset, infertility, reduced fecundity, and miscarriage.
- Changes in embryo and fetus development, and offspring birth weight.
- Increased risk of reproductive diseases.

Circulatory system

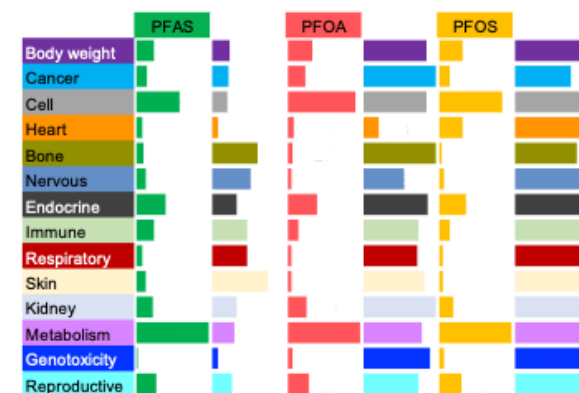
- Increased risk of heart diseases or cardiac events.
- Binding to blood proteins, interrupted hormone/protein interactions, and caused displacement of hormones.

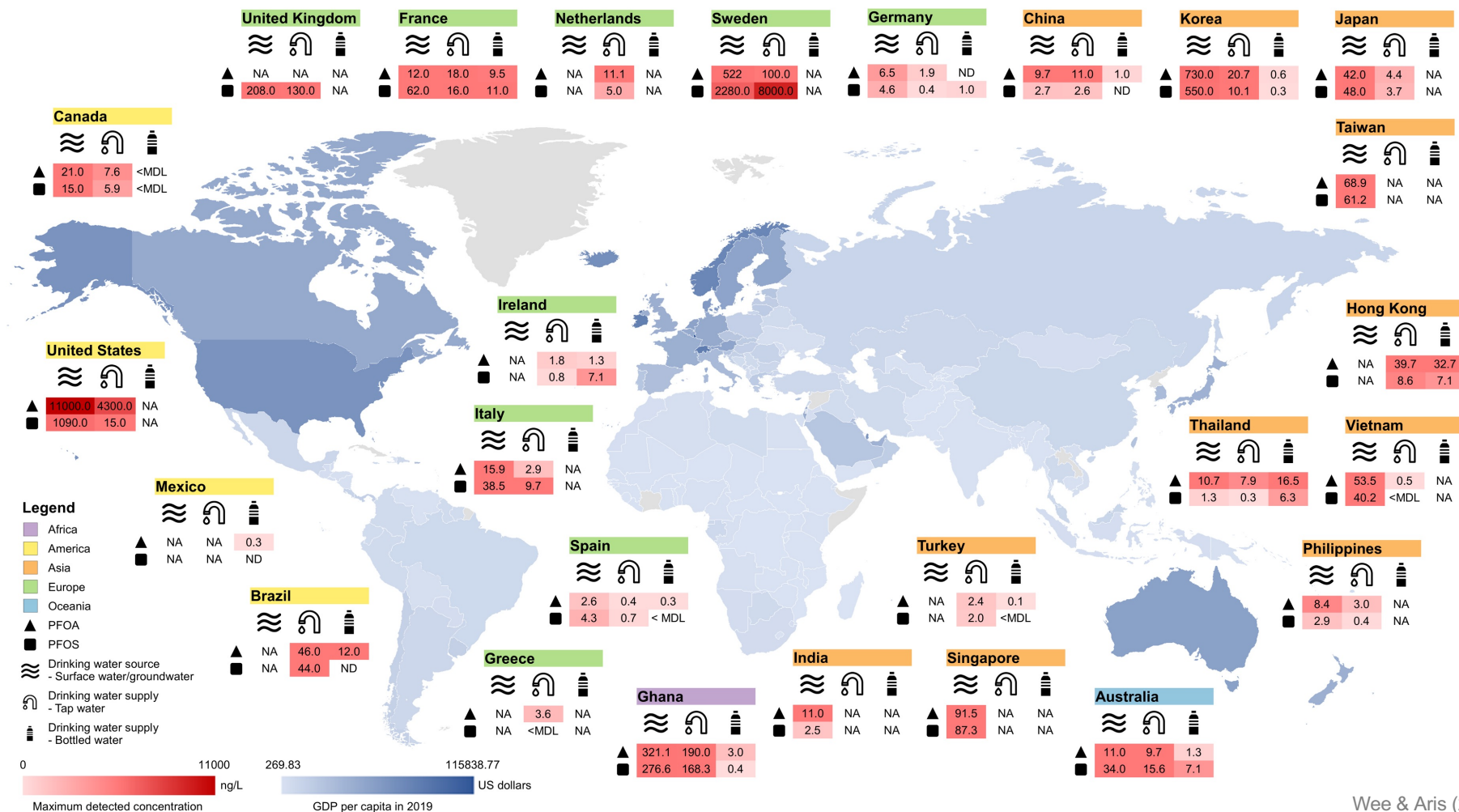


Urinary system

- Changes in organ histology.
- Altered cell and organ function.
- Changes in urinalysis, serum uric acid level, and urine albumin/creatinine ratio.
- Caused diseases e.g., cancer and diabetes.

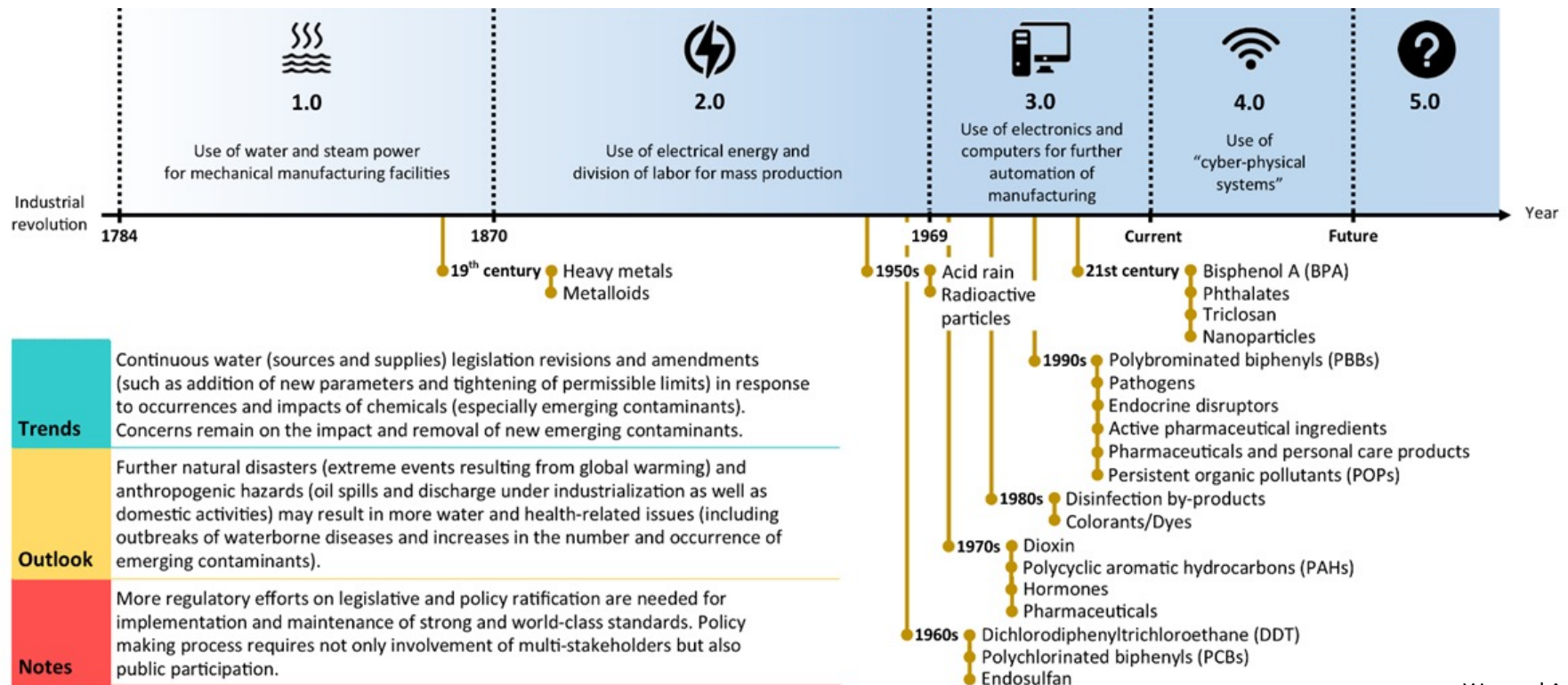
(b)





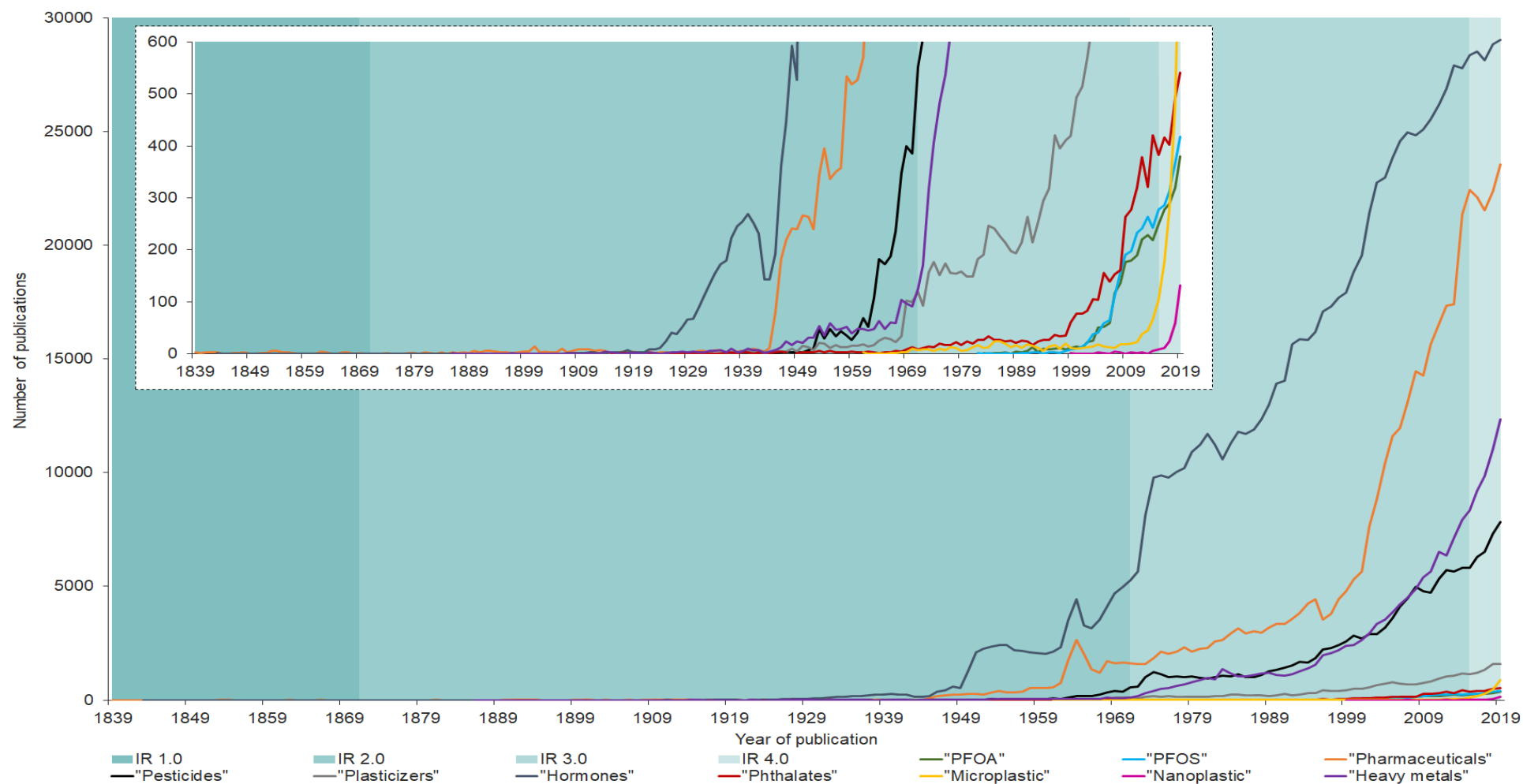
Wee & Aris (2023)

GDP and the maximum detected PFOA and PFOS in global drinking water source and supply



Wee and Aris (2019)

Contaminations have primarily arisen from industrial origin since the beginning of the Industrial Revolution in 1784



Research interests on the emerging contaminants with potential endocrine dysfunction effects over the years concerning industrial revolution between the year 1839 to 2019

Risk management

A review of the existing drinking water regulations revealed that the commonly regulated drinking water quality parameter:



Microorganisms



Physical properties



Chemical properties

- Inorganic chemicals
- Organic chemicals
- Disinfectants
- Disinfection by-products



Radioactive particles



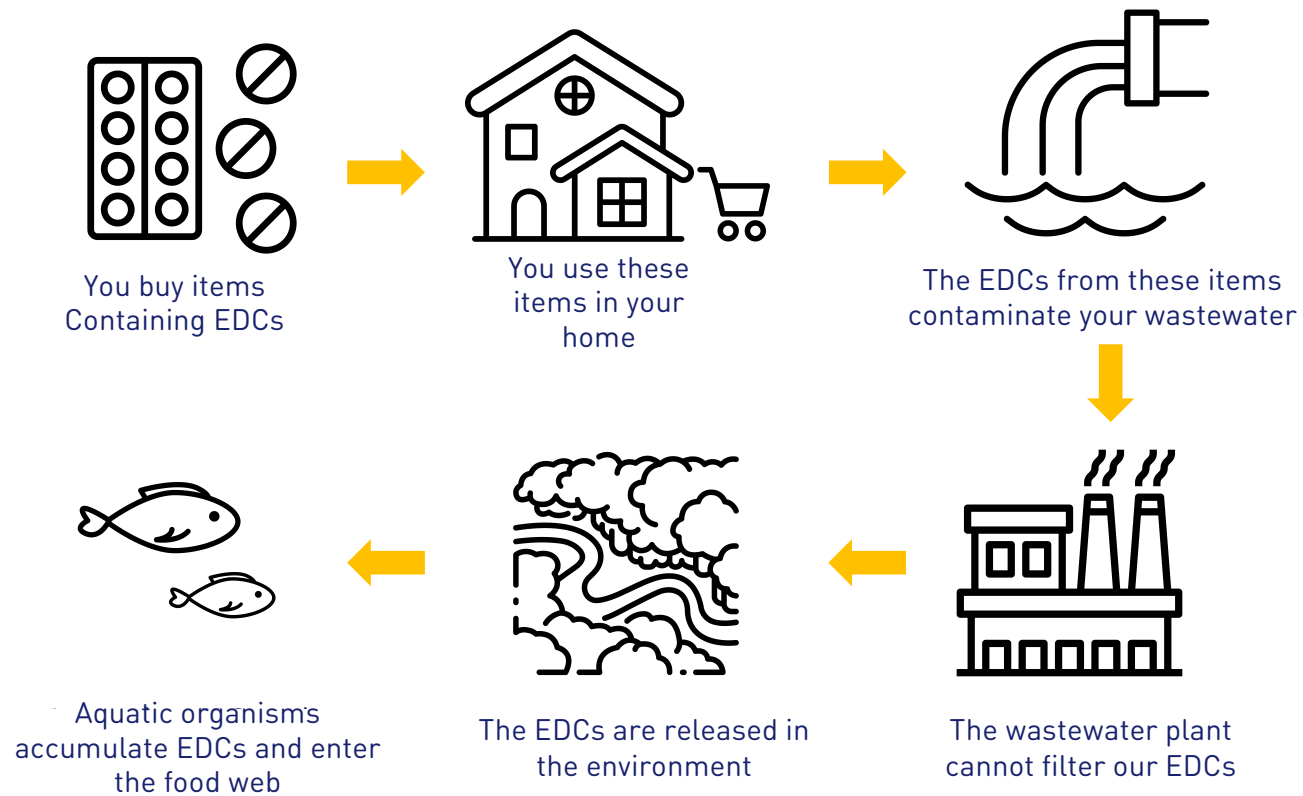
The World Health Organization (WHO) has revealed that the WHO guidelines for drinking-water quality are inadequate based on the current exposure levels to CEC in drinking water.

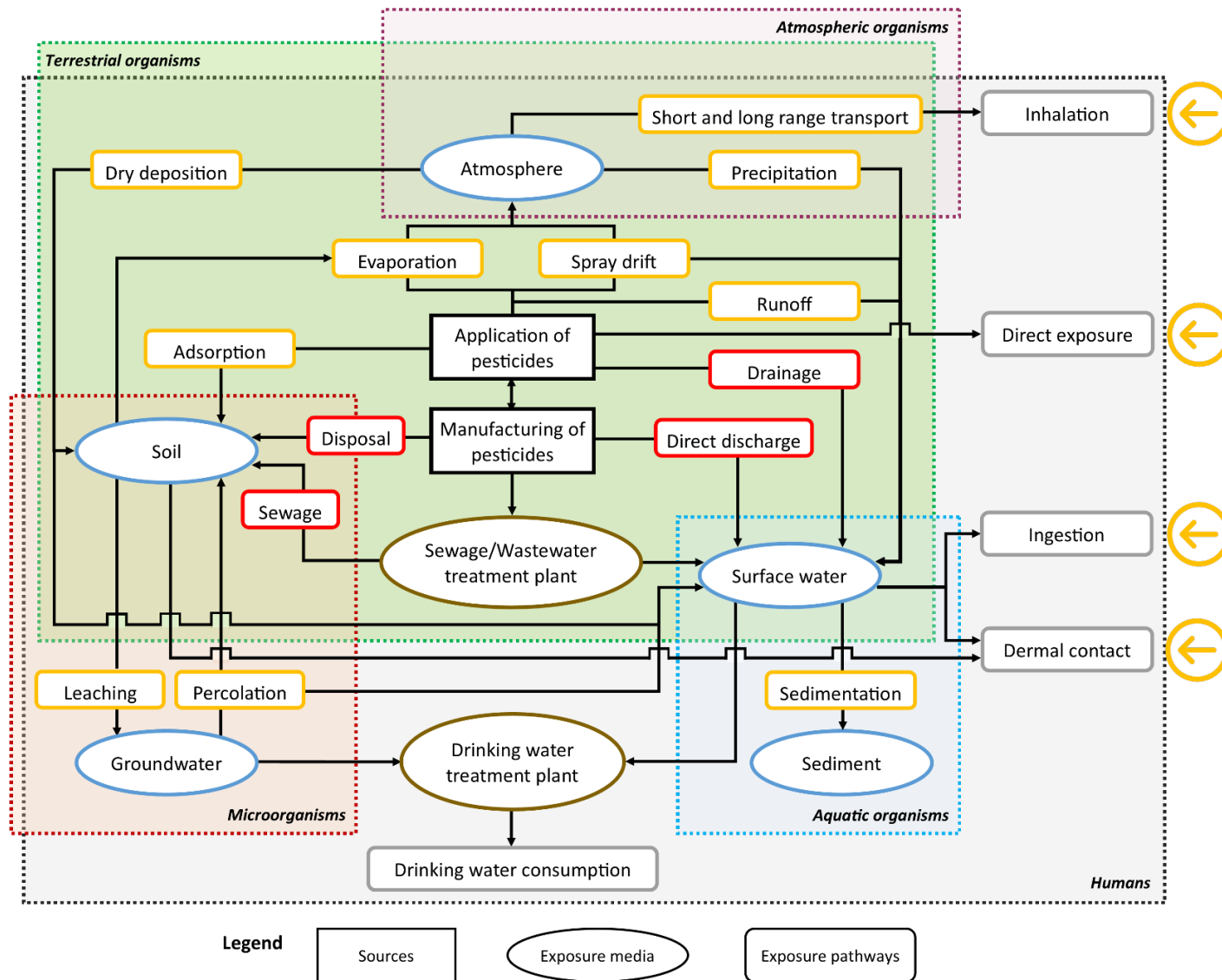
The United States Environmental Protection Agency (US EPA): Contaminant Candidate List (CCL) - A list of priority drinking water contaminants for regulatory consideration, include CECs i.e., pharmaceuticals and pesticides

Malaysia Drinking Water Quality Standard

Group 1	Group 2	Group 3	Group 4	Group 5
Total Coliform E.Coli Turbidity Color pH Free Residual Chlorine Combined Chlorine Clostridium perfringens (including spores)	Total Dissolved Solids Chloride Ammonia Nitrate Ferum/Iron Fluoride Hardness Aluminium Manganese Chemical Oxygen Demand Anionic Detergent MBAS Biological Oxygen Demand	Mercury Cadmium Arsenic Cyanide Plumbum/Lead Chromium Cuprum/Copper Zinc Natrium/Sodium Sulphate Selenium Argentum Magnesium Mineral Oil Chloroform Bromoform Dibromoklorometana Bromodiklorometana Fenol/Phenol Antimony Nickel Dibromoacetonitrile Dichloroacetic acid Dichloroacetonitrile Trichloroacetic acid Trichloroacetonitrile Trihalomethanes - Total	Aldrin / Dealdrin DDT Heptachlor & Heptachlor Epoxide Methoxychlor Lindane Chlordane Endosulfan Hexachlorobenzene 1,2-dichloroethane 2,4,5-T 2,4,6-trichlorophenol 2,4-D 2,4-DB 2,4-dichlorophenol Acrylamide Alachlor Aldicarb Benzene Carbofuran MCPA Pendimethalin Pentachlorophenol Permethrin Propanil Vinyl chloride	Gross alpha (α) Gross beta (β)

EDCs – from your home to local waterways





Routes of Exposure

Overview of contaminants of emerging concern (i.e. pesticide) exposure to terrestrial, aquatic, micro-organisms, and humans.

Why do contaminants of emerging concern matter?



CECs are
everywhere



Very low doses
can cause harm



Potential delayed
effects

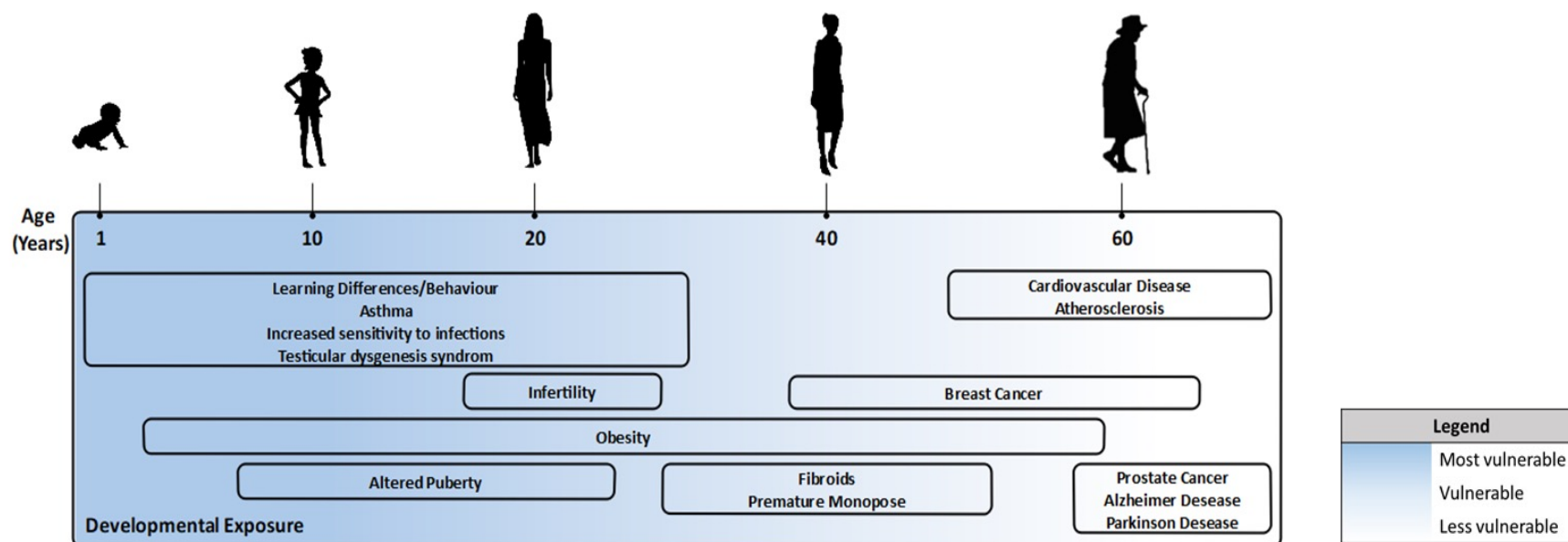


Irreversible
health damage



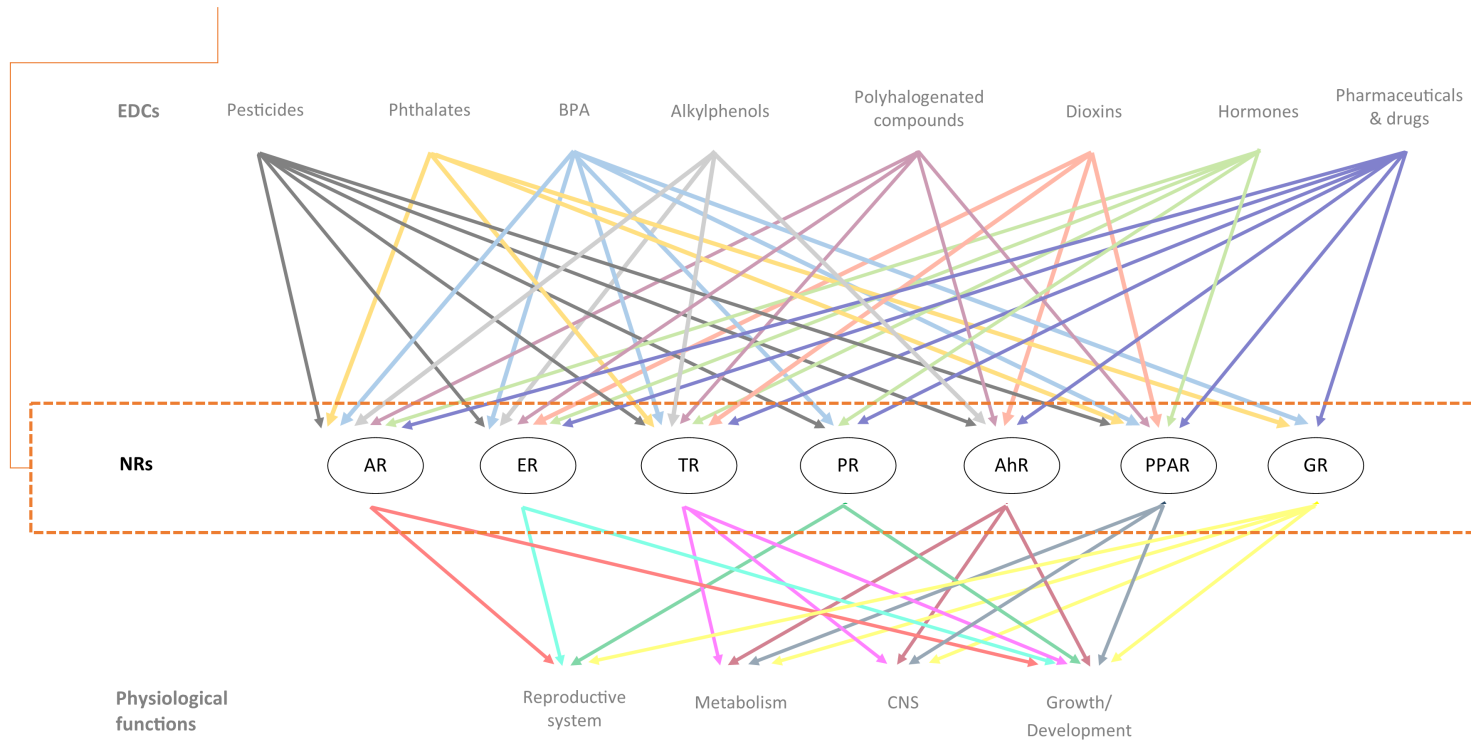
Effects largely
overlooked

Development Exposures of CECs in Human Through Age



Epidemiological studies on human uncovered associations between CECs with several age-dependent diseases

through nuclear
receptors (NRs).



Pathway and Effects

Nucleus
Synthesis

Cell
Generation - Degeneration

Tissue

Organ

Organ system
Organisation - Activation - Function

Individual
Maintenance - Behavior - Growth - Reproduction

population and community matters

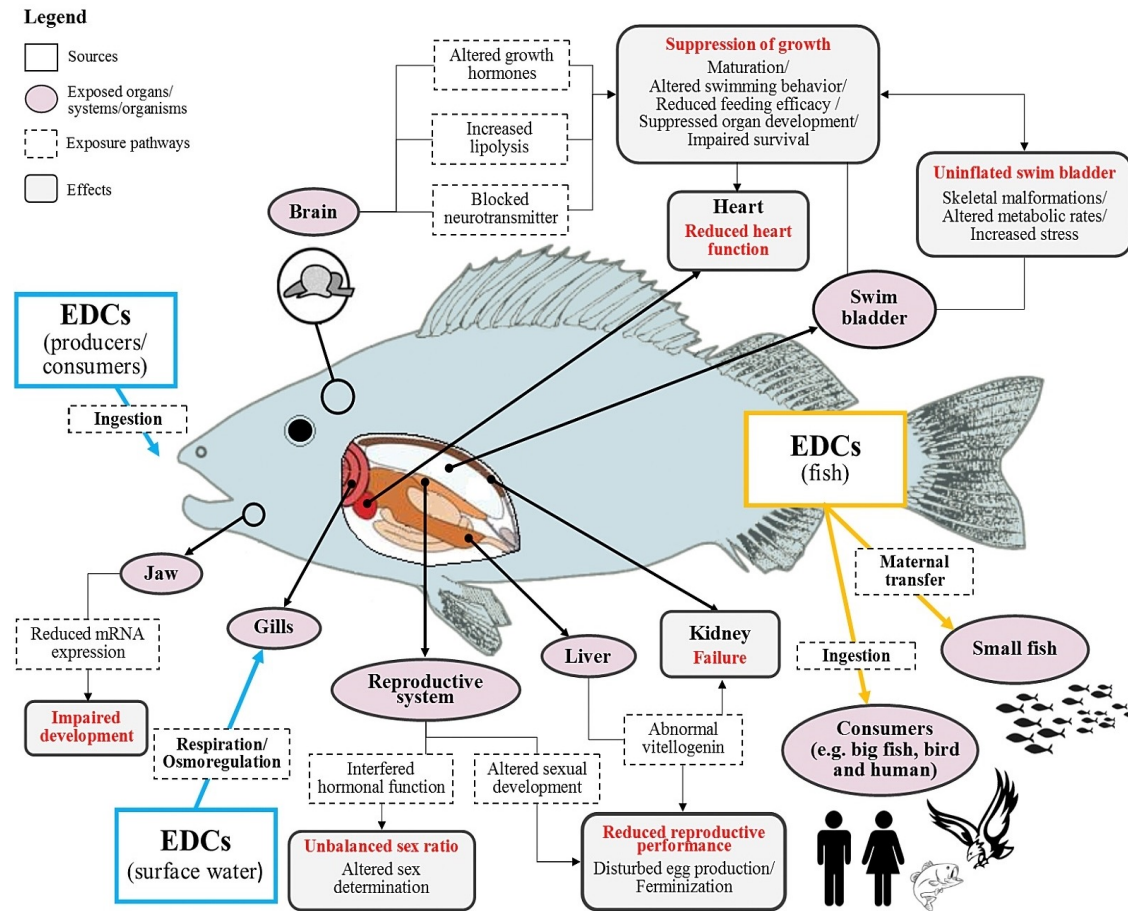
Health Effects

- Reproductive effects
- Respiratory effects
- Neurological effects
- Cancer
- Birth defects

Health Effects

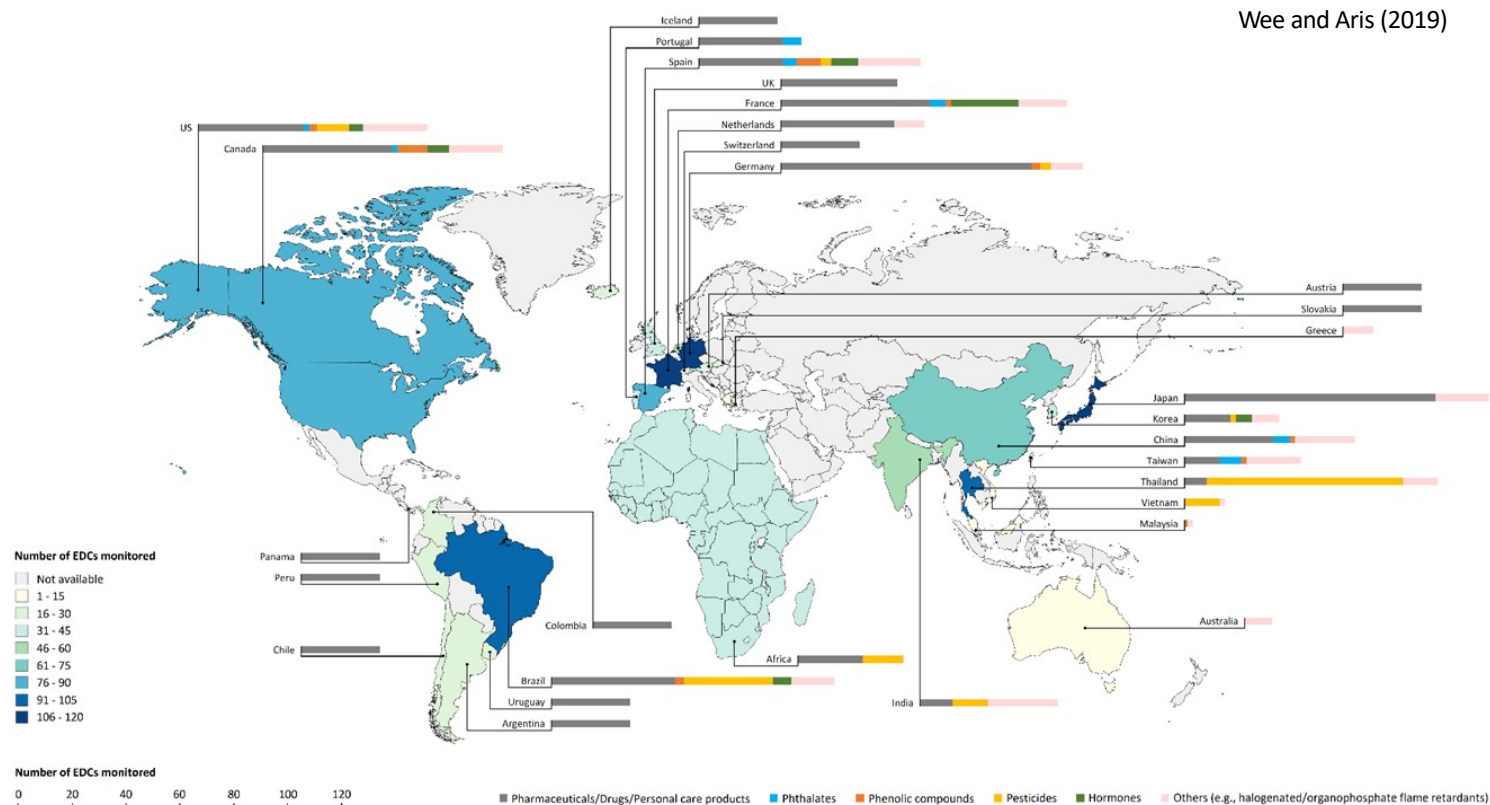
- Reproductive effects
- Respiratory effects
- Neurological effects
- Cancer
- Birth defects

Exposures and Effects of CECs in Aquatic Ecosystem

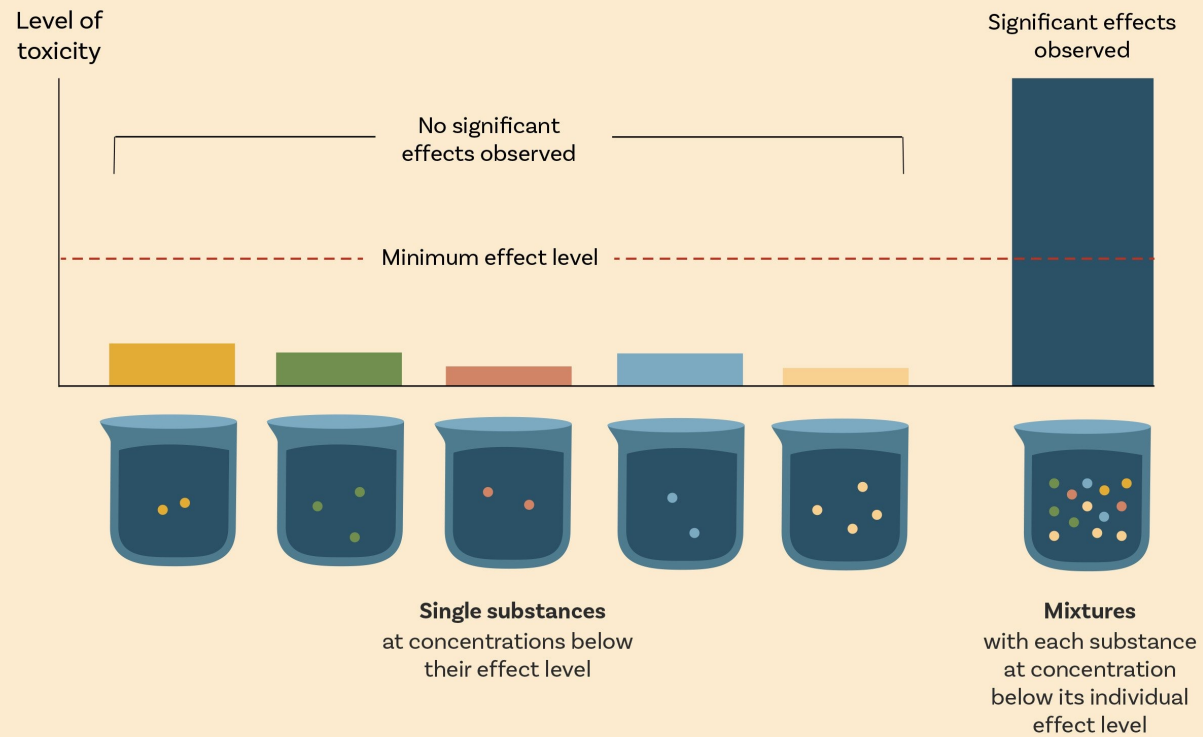


SOMETHING IN THE TAP WATER

Wee and Aris (2019)



Something from nothing - mixture toxicity matters



Risk governance and communication

npj | clean water

www.nature.com/npjcleanwater

ARTICLE OPEN



Drinking water consumption and association between actual and perceived risks of endocrine disrupting compounds

Size Yee Wee^{1,2}, Ahmad Zaharin Aris^{1,3}✉, Fatimah Md. Yusoff^{3,4}, Sarva Mangala Praveena^{3,5} and Rosta Harun¹

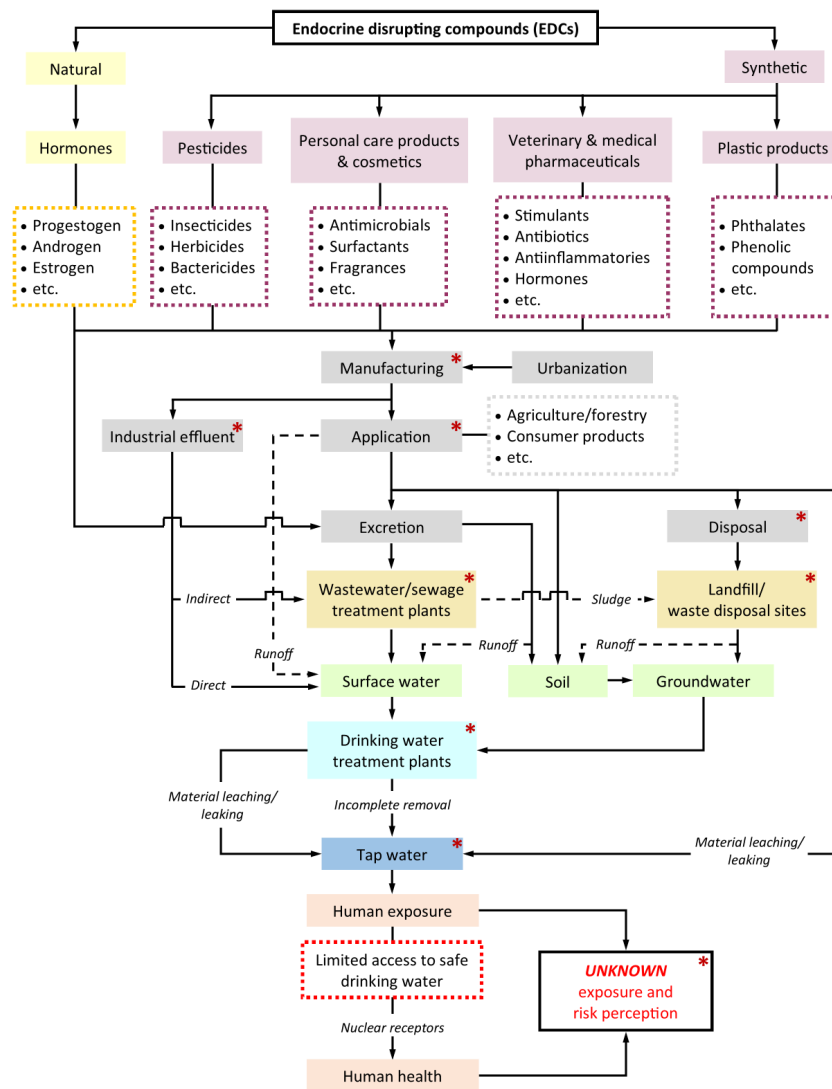
Drinking water contains emerging contaminants, i.e., endocrine disrupting compounds (EDCs). However, the extent to which it is publicly viewed as a potential risk that requires attention (public awareness, political obligation, and regulatory efforts) is substantially underrated. Thus, this study investigated drinking water consumption patterns among consumers of different life stages, evaluated household practices using tap water as daily drinking water, and examined the actual risk as well as consumers' perception of tap water quality for drinking with the potential EDCs contamination. Collectively, the present study is of great concern for regional database profiling and supporting human health risk assessment in regulating contamination and exposure of EDCs. It also provides an empirical and theoretical contribution to current public risk perception of EDCs in tap water, and promoted the formulation of risk communication and governance strategies for the development of risk behaviors in adopting public participation in the drinking water supply system monitoring and management framework.

npj Clean Water (2022)5:25; <https://doi.org/10.1038/s41545-022-00176-z>

presence of a low-risk perception community

a group of people who were unsure of the emerging drinking water quality issue

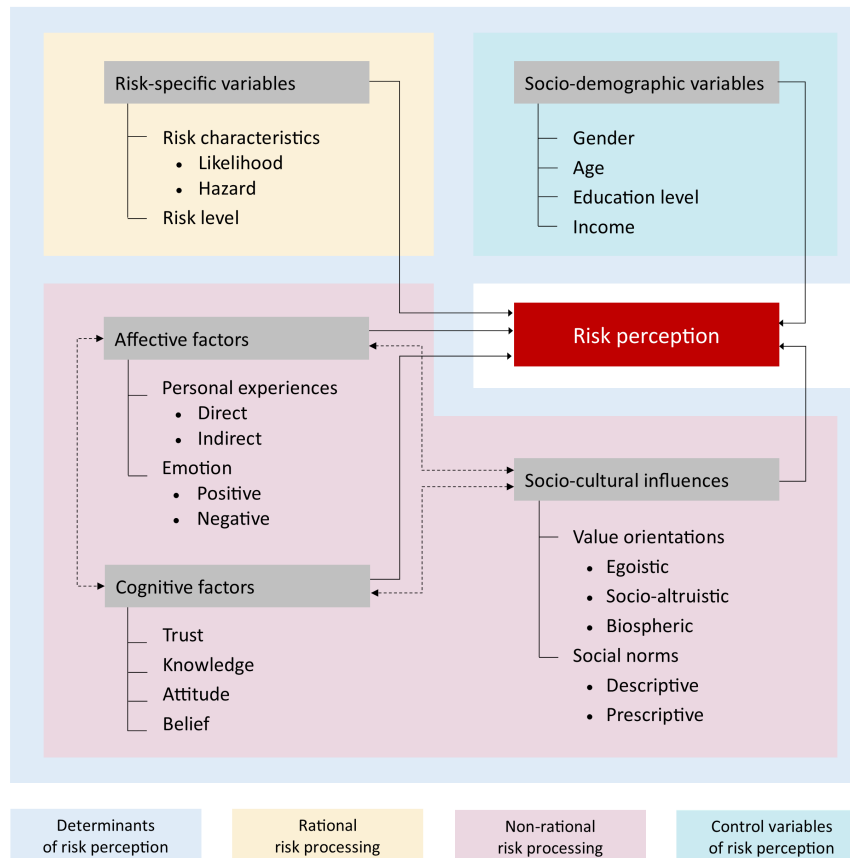
- The situation indicates the **lack of effective communication and governance** in developing countries since the broad scope of EDCs had been widely detected in global drinking water supply, particularly pharmaceuticals in Malaysian tap water
- Further, it is not a worldwide practice to **raise awareness and regulate** emerging contaminants in drinking water.
- Subsequently, **development of risk behavior** (preparedness, reduction, prevention, and mitigation) and **adoption of public participation** in a multi-barrier approach in the monitoring and management framework of the drinking water supply system **are challenging**.



Risk communication & governance

* Preventive (e.g., legislative and policy ratification) and/or intervention (e.g., risk communication and governance) measures are required.

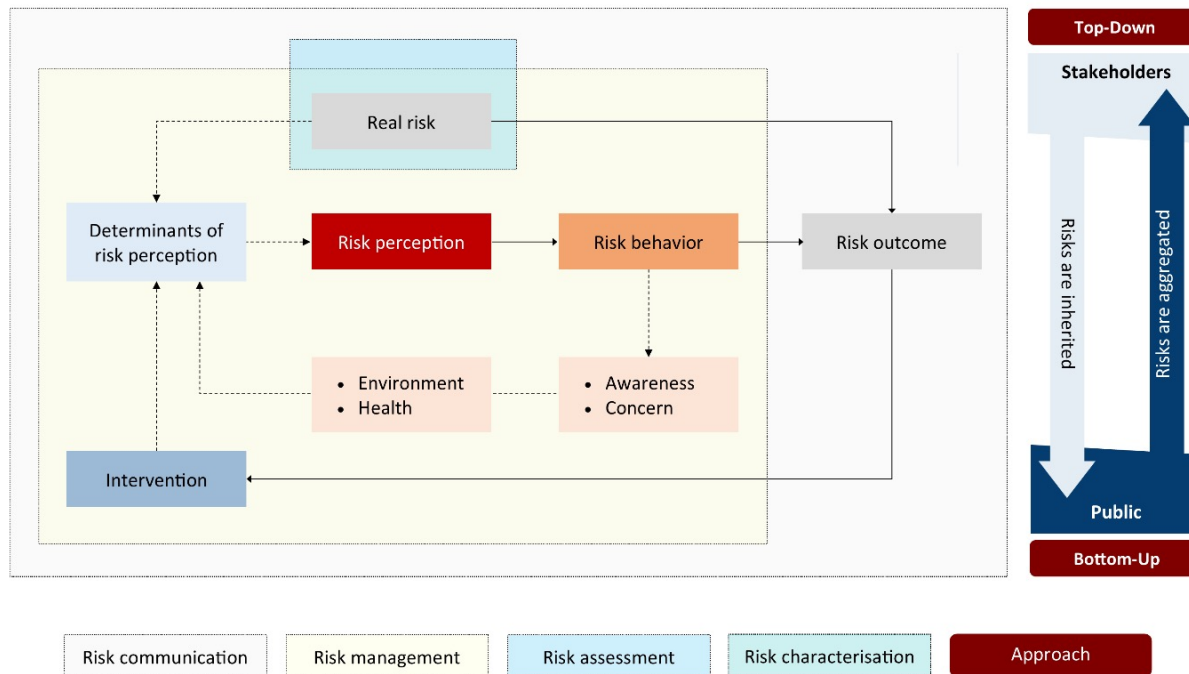
Community-based risk governance with two-way interactive communication.



Conceptual model of risk perception of environmental CEC and water security.

The interconnection among the different dimensions of risk perception depicts the importance of a theoretical understanding of how risk perceptions function in social systems for effective communication and risk management.

Top-down approach: directs attention towards or away from risk.



Bottom-up approach: creates salient values in risk processing.

What we need to understand?



- Presence of EDCs in environment was **commonly in mixture**, notably EDC **mixture is more toxic than a single compound** the combined effects of the multiresidues of EDCs.



- **Long-term exposure** (accumulation of EDCs and the combined effects of EDC mixtures) could contribute to the **significant health risks**, which will vary according to the exposure, dose and/or physiological target, although the precise mechanisms have yet to be determined.



- Analysis and occurrence of EDCs in surface water revealed the **(i) drinking water source pollution, (ii) ineffective treatment technology, and (iii) potential human exposure to EDCs via dietary intake.**



- **Adverse impacts and knowledge gaps** in EDC mixtures (i.e., parent compounds, metabolites, and other chemical pollutants such as metals) should be addressed properly for effective mitigation and prevention.



- **Regulatory efforts** are solely required for implementation and maintenance of strong and world-class standards to (i) control drinking water source pollution and (ii) improve EDC treatment efficiency, thus reducing the extent of EDC exposure and the risk to the environment and humans.



- Efficient water quality monitoring and water resources management alerts the **needs of public awareness and political obligation** in supporting preventive and intervention actions for environmental safety purposes.



- **Risk perception is the potential mediating** influence on the development of risk behavior, where risk perception potentially affects the adoption of risk prevention and intervention in safeguarding environment quality.



- The presence of EDCs in surface water concerns not only ecological risks but also the **security and sustainability of water resources**.



- **Drinking Water Treatment Plant is the last security step** to protect human from exposure to chemicals in drinking water source via drinking water intake, adverse impacts and knowledge gaps remain when the environmental EDC concentration is increasing and the efficiency of drinking water treatment plant is relatively incapable in removing EDCs in raw water for safe drinking water supply.



THANK YOU

H₂O

Hydrochemistry

"We have made clear to you the signs;
perhaps you will understand."
(57:17)

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