UNIVERSITI PUTRA MALAYSIA
BERILMU BERBAKTI

NEHAP MALAYSIA
National Environmental Health Action Plan

3rd NEHAP | 25th September | Putrajaya

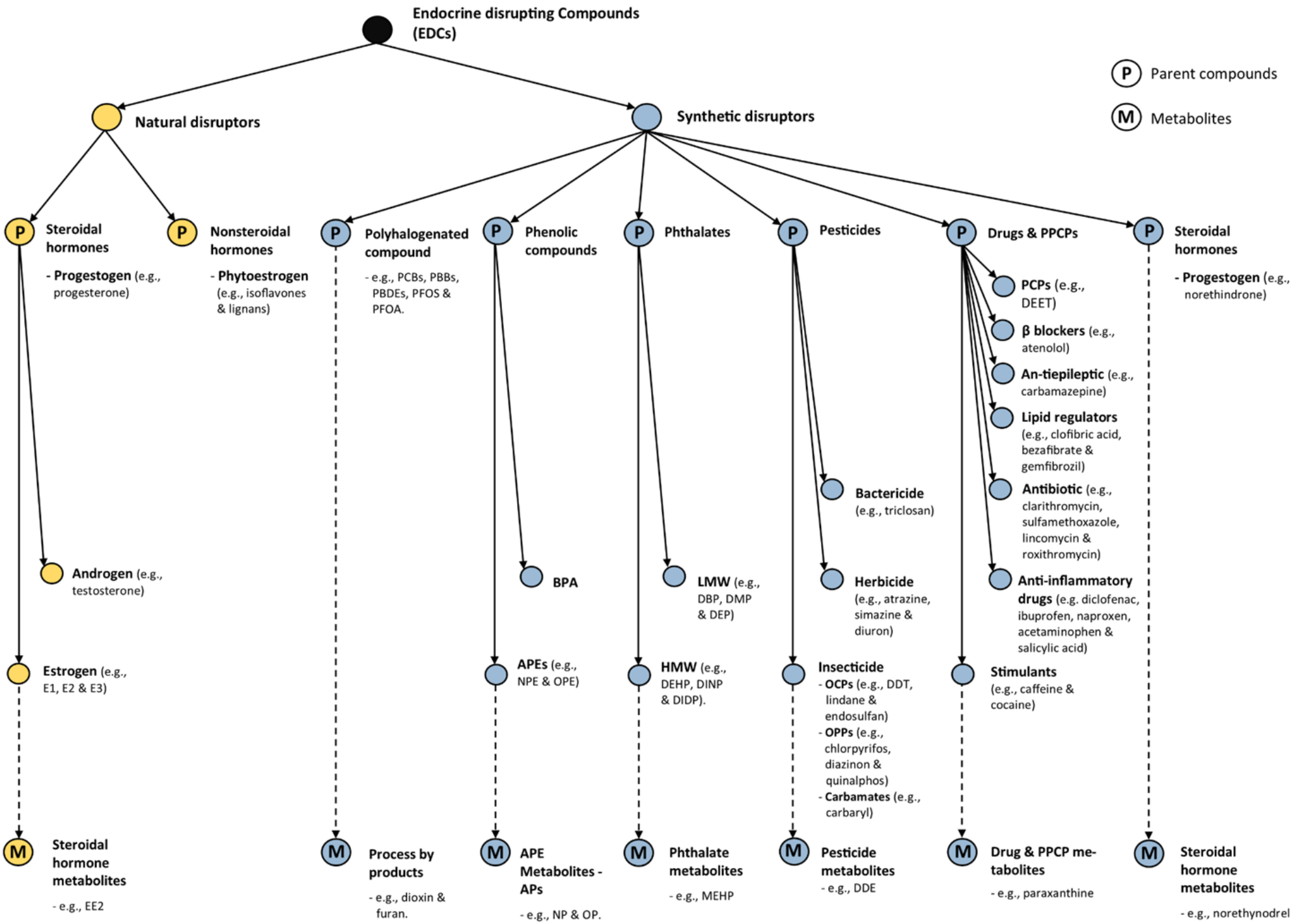
H_2O

Water Research

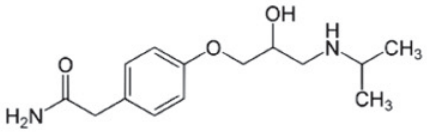
CURRENT UNDERRATED PERSPECTIVE ON ENDOCRINE DISRUPTING COMPOUNDS IN DRINKING WATER

Ahmad Zaharin Aris

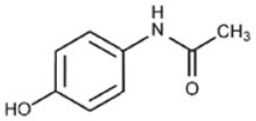
Source: Wee and Aris (2017)



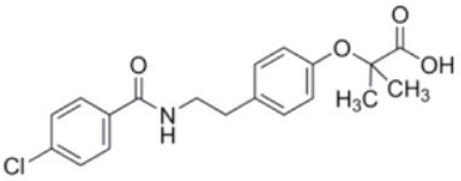
Pharmaceutical Compounds



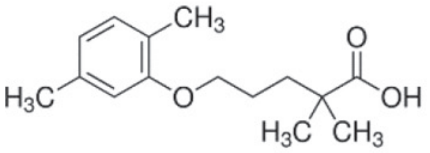
Atenolol



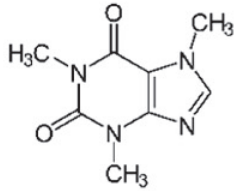
Acetaminophen



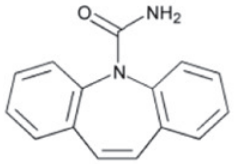
Bezafibrate



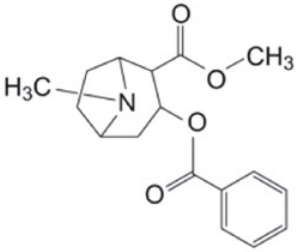
Gemfibrozil



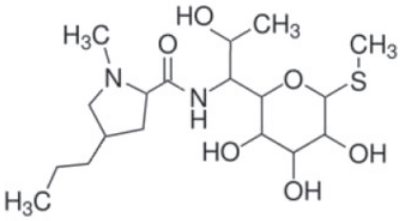
Caffeine



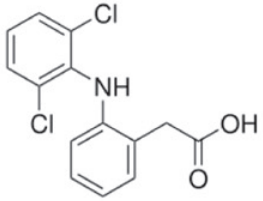
Carbamazepine



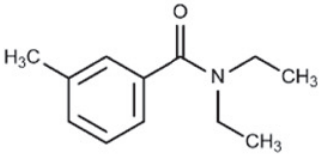
Cocaine



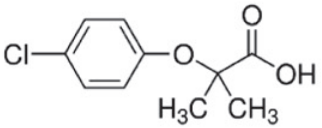
Lincomycin



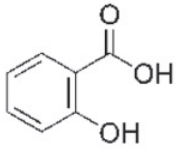
Diclofenac



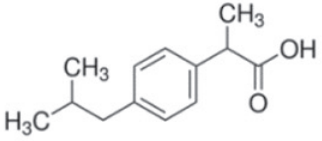
Diethyltoluamide (DEET)



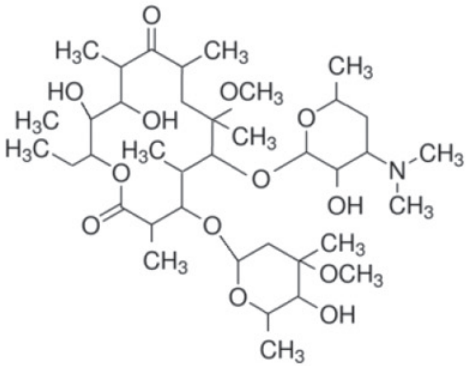
Clofibric acid



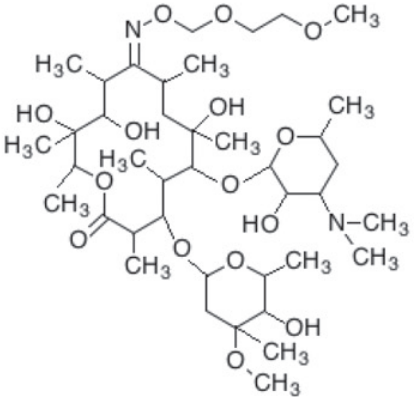
Salicylic acid



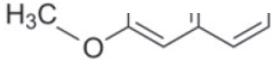
Ibuprofen



Clarithromycin



Roxithromycin



Naproxen

- Drugs were first detected in groundwater and surface water in the 1990s.
- In 1999-2000, at least one pharmaceutical was found in 80% of 139 US streams.
- Recently, trace concentrations of commonly-used drugs have been found in drinking water supplies.
- Traditional water treatment plants are not equipped to remove small, soluble pharmaceuticals.
- Although advanced water treatment could remove these contaminants from water, such technology is very expensive and it remains unclear whether these low concentrations have any effect on people.

(Kolpin et al. 2002)

Water quality

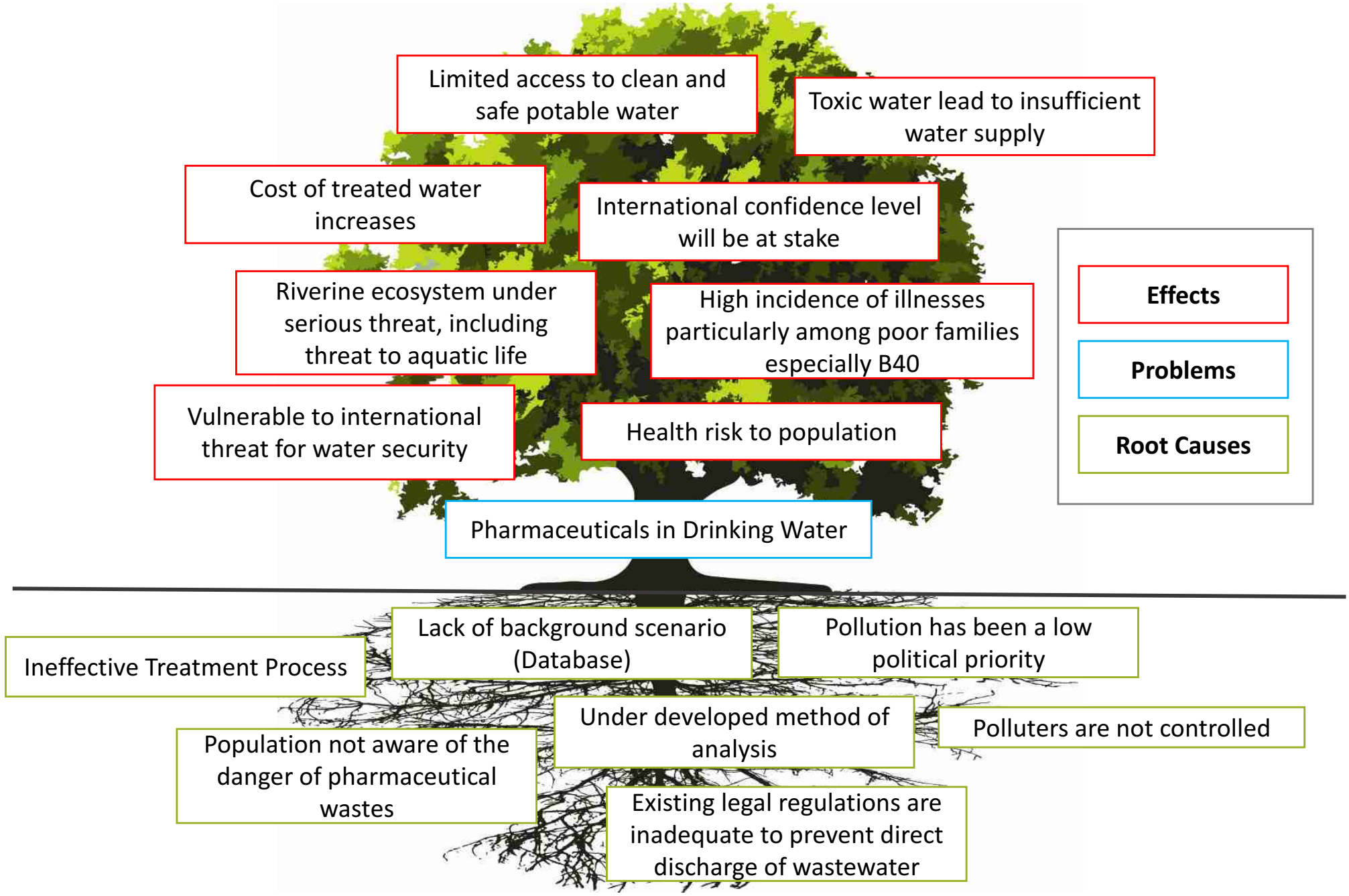
Something in the water

Drugs have been finding their way into our water supplies for as long as they have been in use, so should we worry? Maria Burke reports

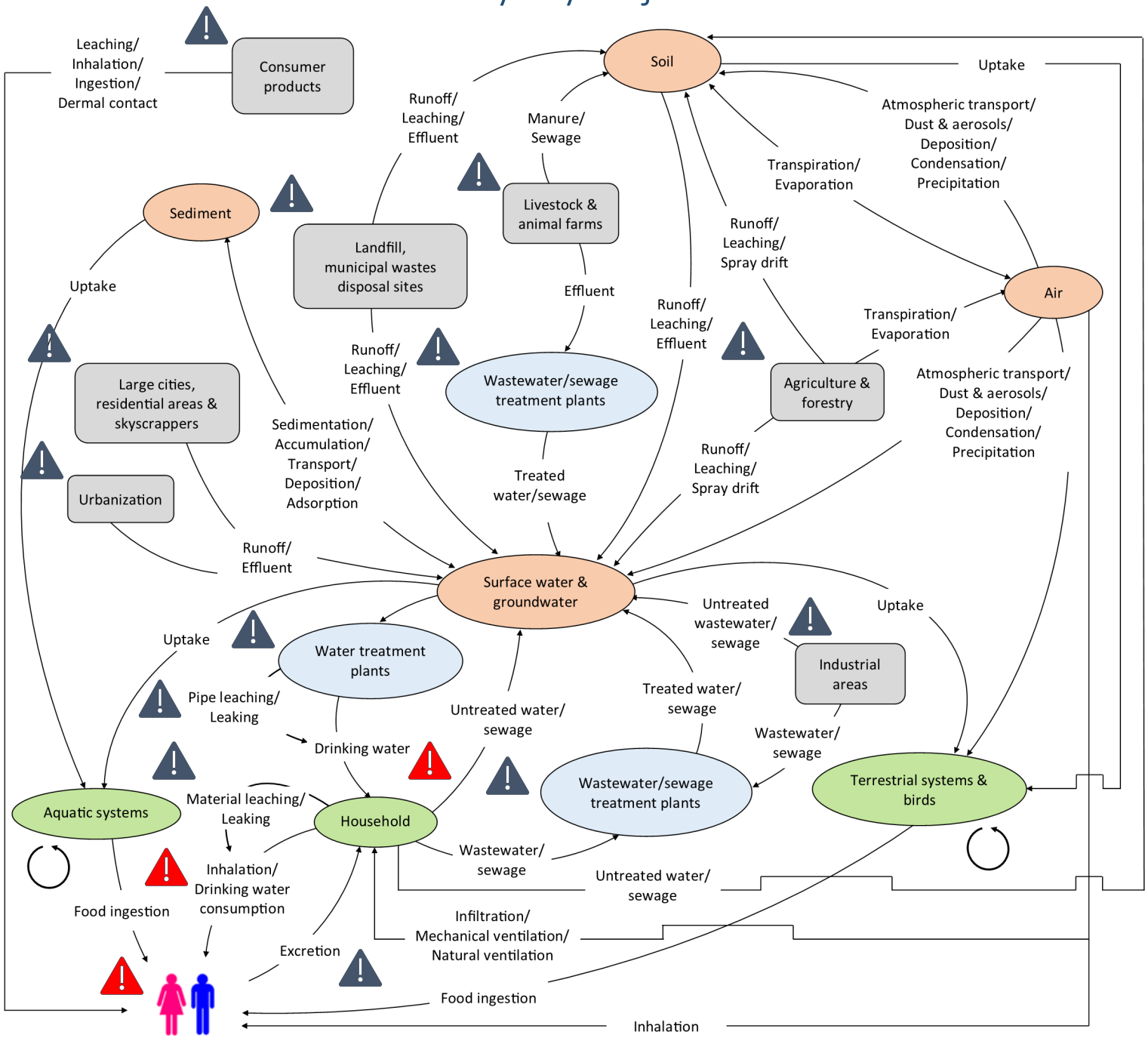
At US, Safe Drinking Water Act (SDWA) was made available after Toxic Substances Control Act (TSCA) and Food Quality Protection Act (FQPA).

Lately, Australian Drinking Water Guidelines 2011 (ADWG) have been revised and updated, incorporating guidelines for EDCs in drinking water.

Problem Analysis

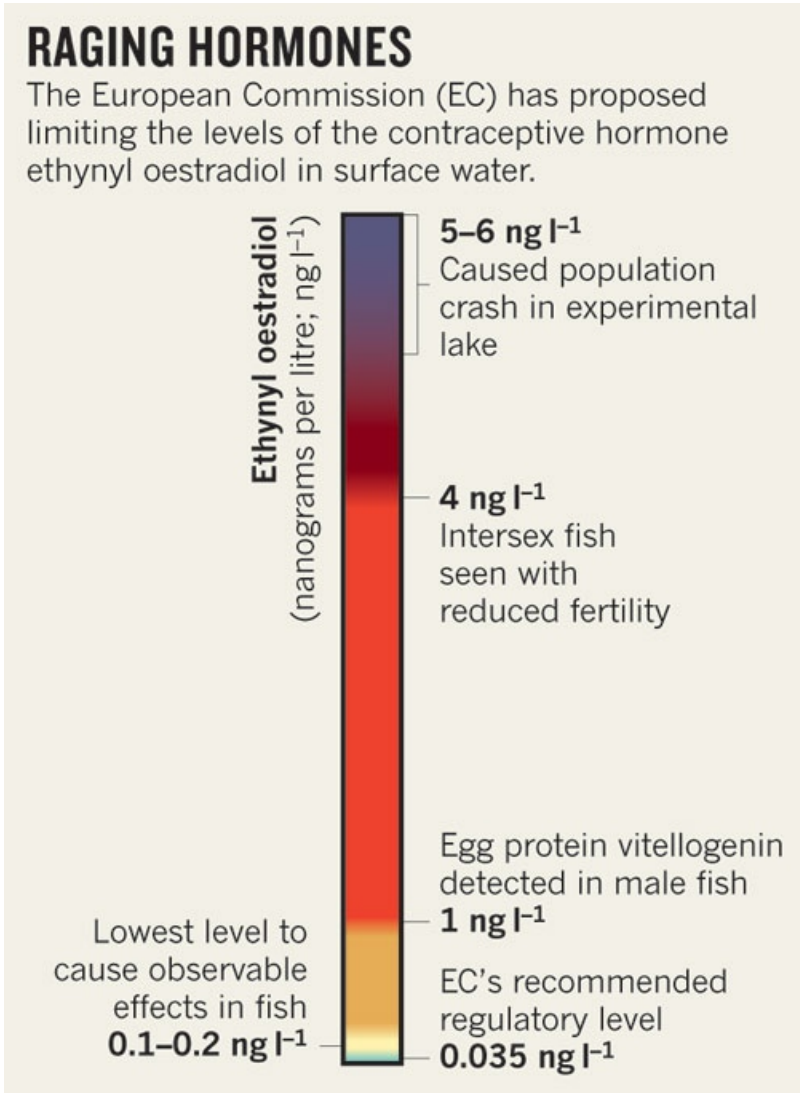


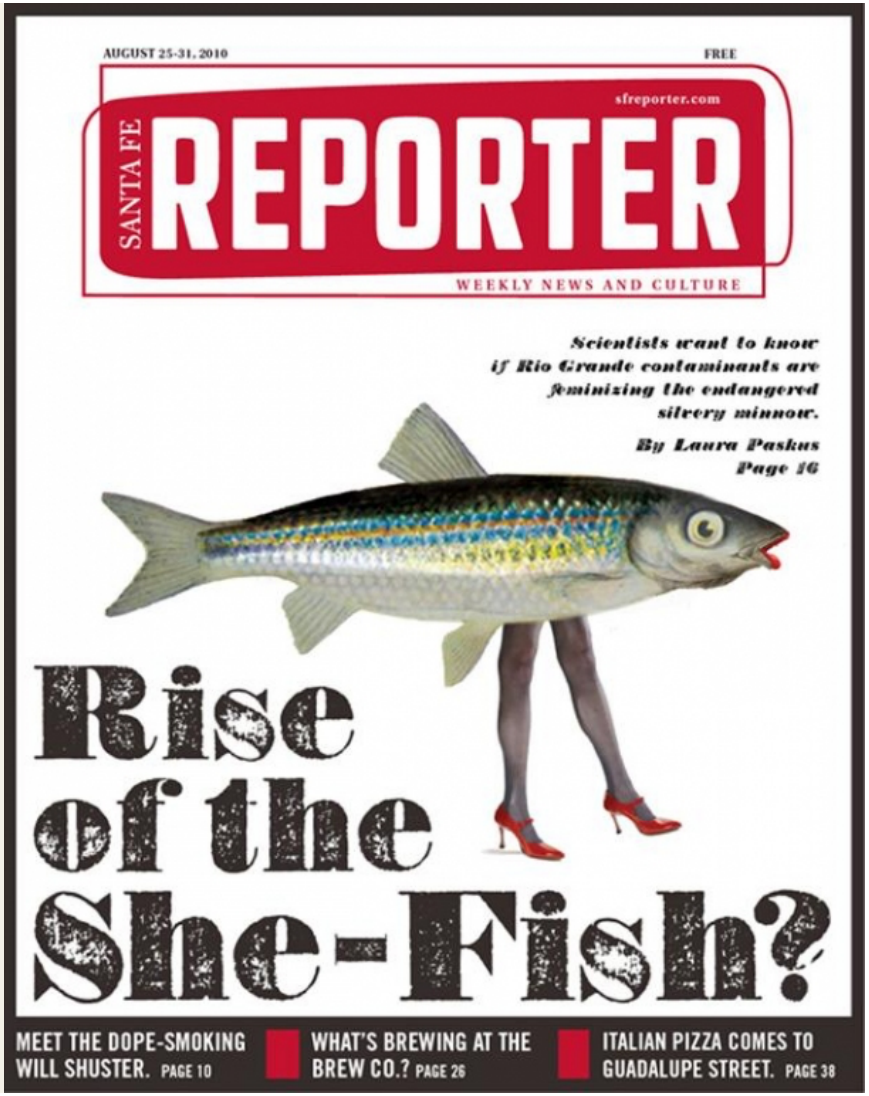
EDCs environmental pollution originated from everyday objects.



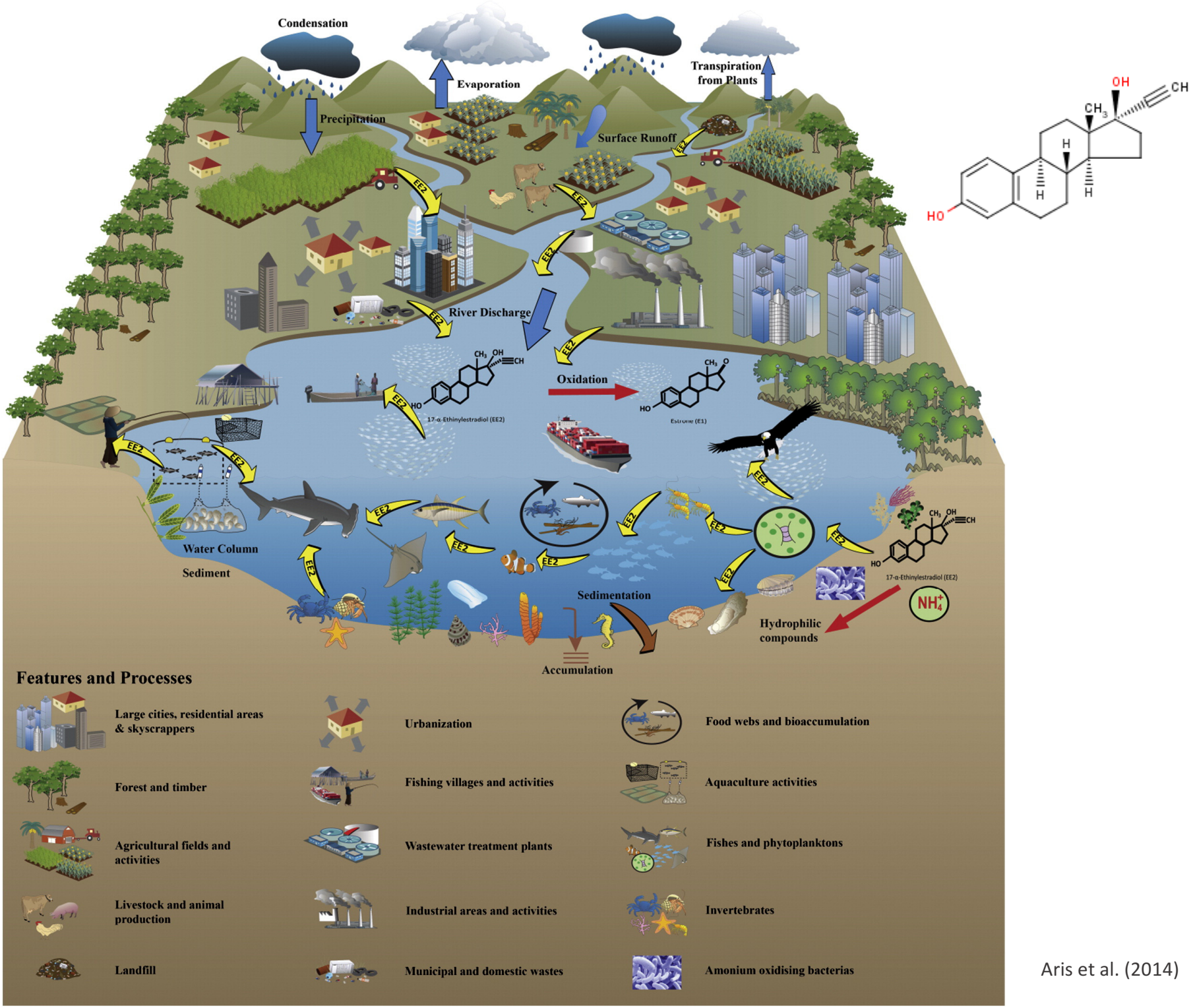

Drinking water supply, such as tap water,
is an additional and crucial route of human exposure
to the health risks associated with EDCs.

Contraceptive Hormone

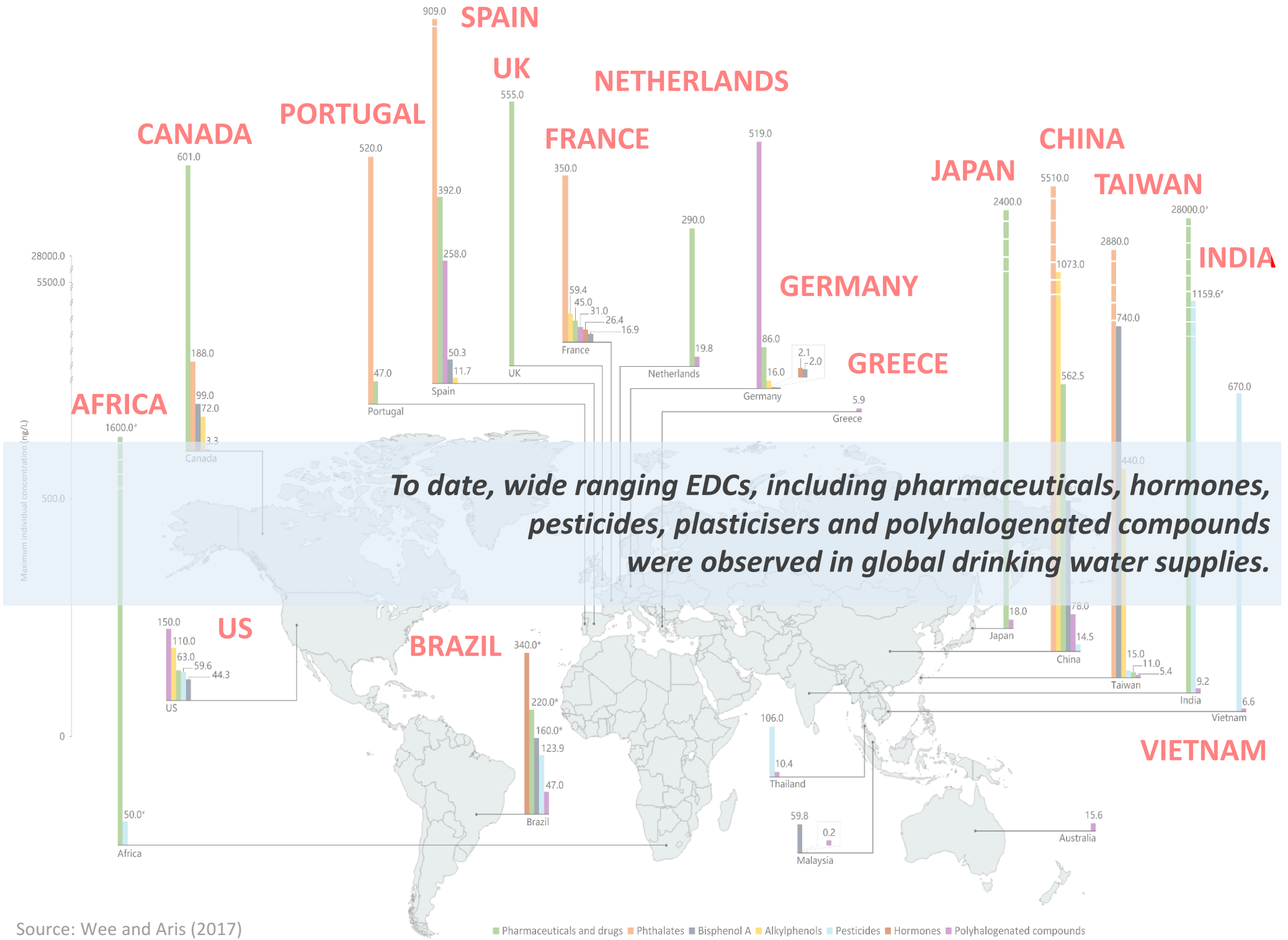




Contraceptive Hormone



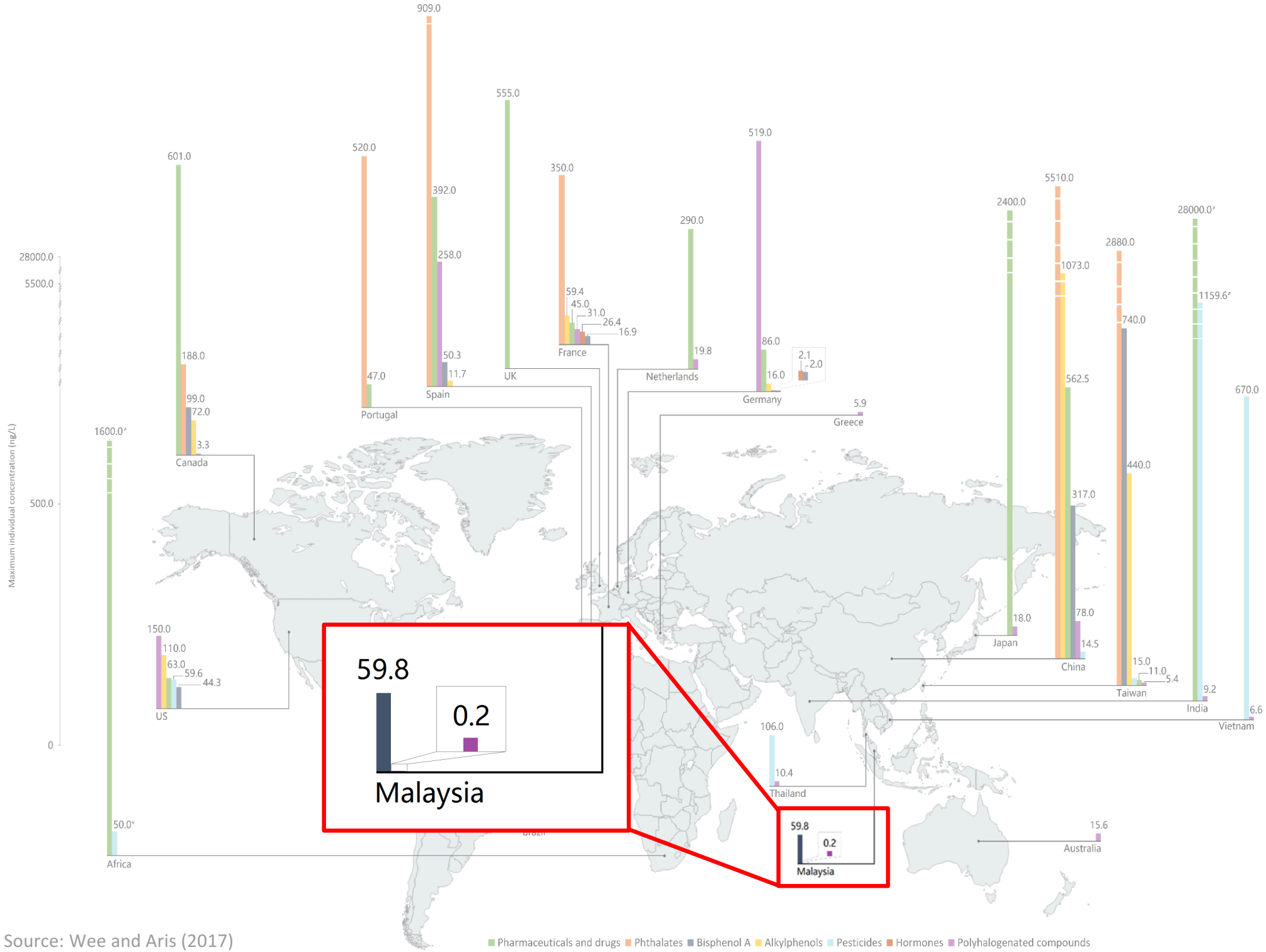
Aris et al. (2014)



To date, wide ranging EDCs, including pharmaceuticals, hormones, pesticides, plasticisers and polyhalogenated compounds were observed in global drinking water supplies.

Source: Wee and Aris (2017)

WHO has also indicated WHO Guidelines for Drinking-water Quality is unwarranted based on the current levels of exposure to EDCs in drinking water.



Source: Wee and Aris (2017)

EDCs in Malaysia environment

Selangor River

Surface water

- Phthalates
  (ND - 507.400 ng/L)
- Bisphenol A
  (0.200 - 77.500 ng/L)
- Organochlorine pesticides
  (ND - 24.600 ng/L)
- Polyhalogenated compounds
  (ND - 6.970 ng/L)

(Santhi and Mustafa, 2013)

Langat River

Surface water

- Organophosphorus pesticides
  (ND - 67.600 ng/L)
- Hormones
  (ND - 0.005 ng/L)

(Praveena et al., 2016; Wee et al., 2016)

Sediment

- Hormones
  (<MDL - 1.020 ng/g)
- Bisphenol A
  (<MDL - 1.780 ng/g)
  Pharmaceuticals
  (<MDL - 2.670 ng/g)

(Omar et al., 2017)

Peninsular Malaysia

Biota - Green Turtle (*Chelonia mydas*) Eggs

- Organochlorine pesticides
  (ND - 2.020 ng/g)
- Polyhalogenated compounds
  (ND – 3.690 ng/g)

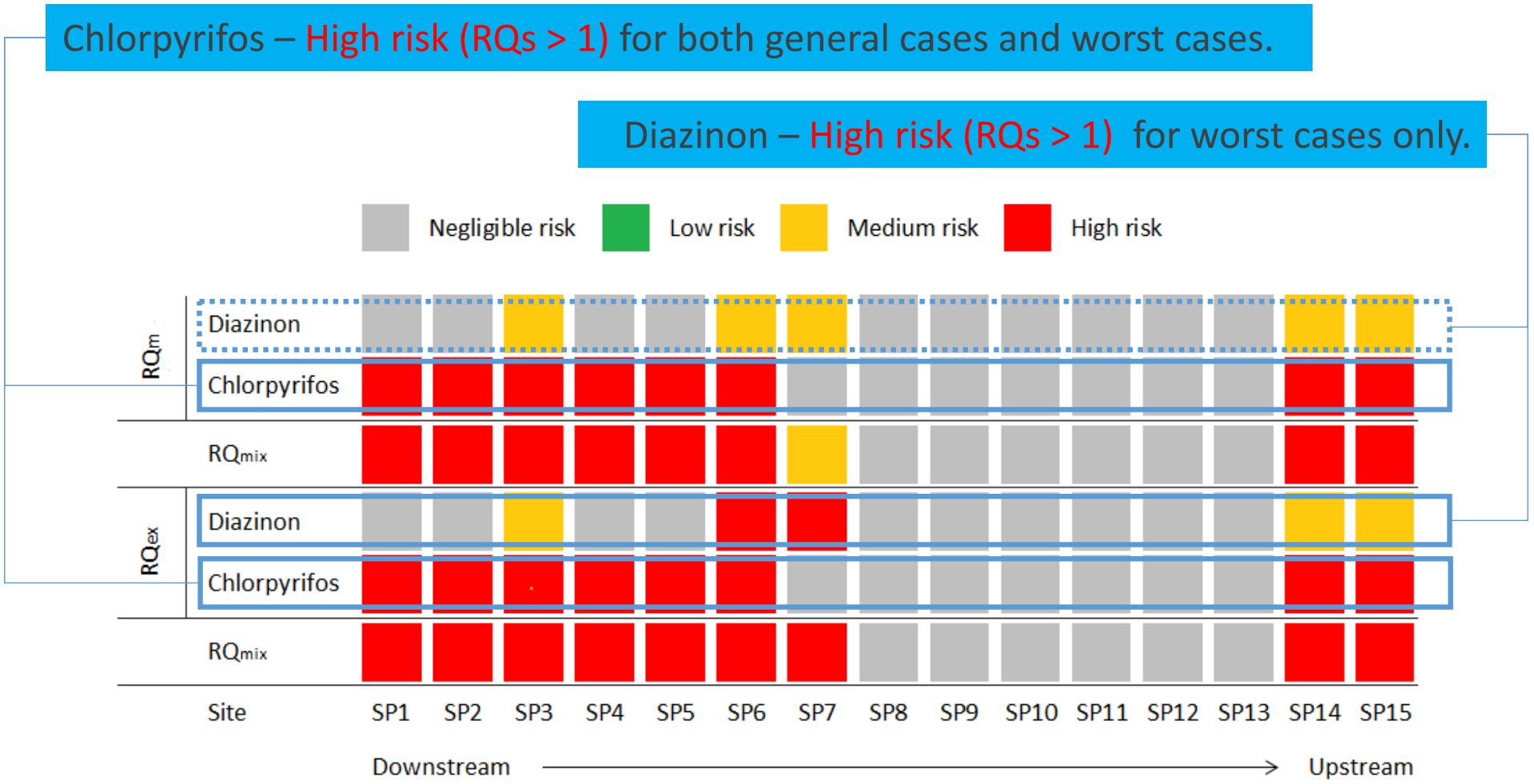
(van de Merwe et al., 2009)

Malaysia Drinking Water Quality Standard

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

Absence of most EDCs in Malaysia Drinking Water Quality Guideline

Example: Using risk quotient (RQ) method, risk assessment revealed potential risk of chlorpyrifos and diazinon in Langat River ecosystems.



Negligible risk RQ < 0.01; *Low risk* 0.01 ≤ RQ < 0.1; *Medium risk* 0.1 ≤ RQ < 1; *High risk* RQ ≥ 1

Figure RQs (RQ_m, RQ_{ex}, and RQ_{mix}) for diazinon and chlorpyrifos in surface water along Langat river.

Wee and Aris (2017)

- Overall diazinon - medium risk (RQ_m = 0.17 and RQ_{ex} = 0.66; 0.1 ≤ RQ < 1). **Medium risk**
- Overall chlorpyrifos - high risk (RQ_m = 1.44 and RQ_{ex} = 4.83; RQ ≥ 1). **High risk**
- Potential high risk of the mixture (RQ_{mix} > 1). **High risk**

Table 4 Ecotoxicity endpoints for fish, aquatic invertebrates and algae and RQ for diazinon and chlorpyrifos evaluated in surface water of the Langat River.

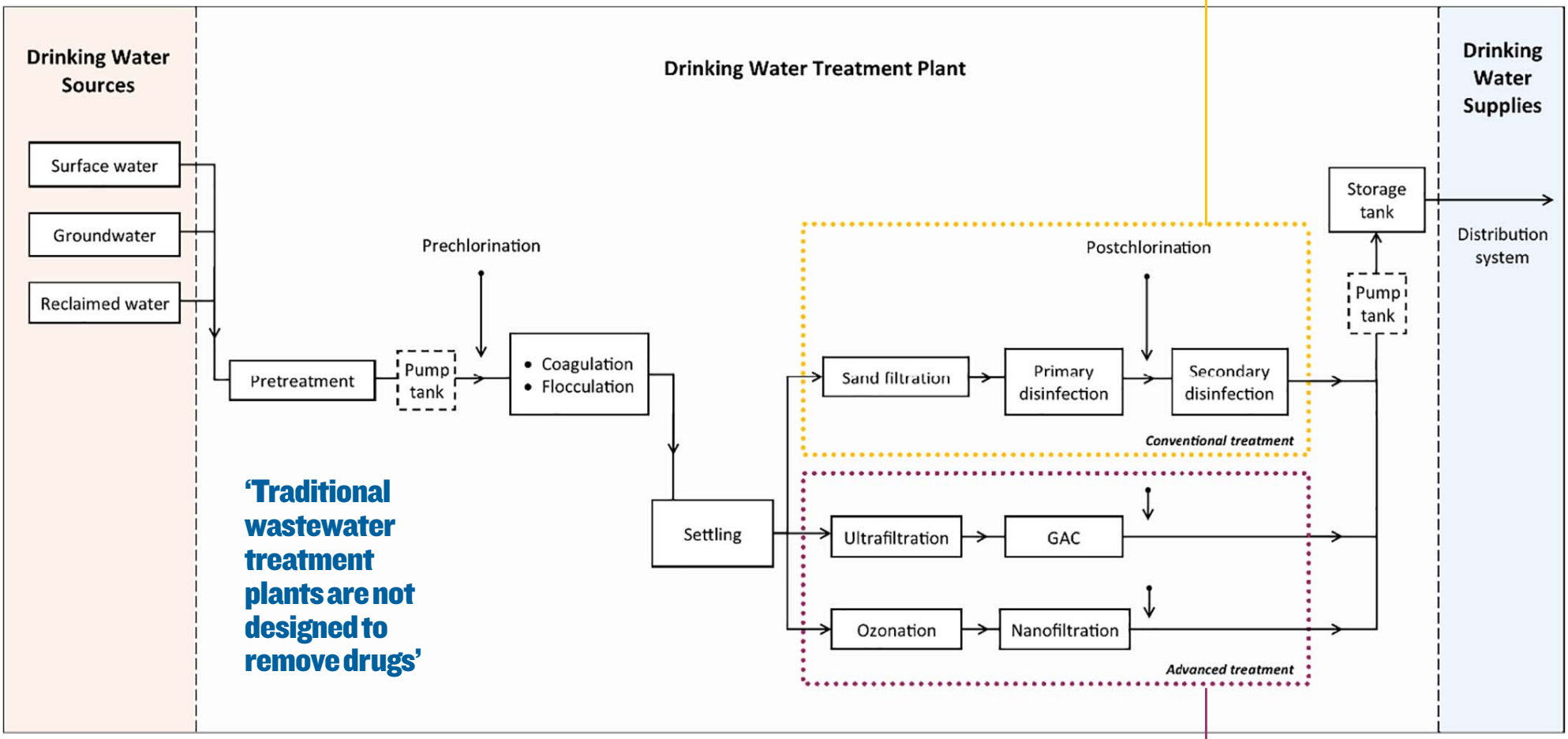
Compound	NOEC (µg/L)				Assessment factor	PNEC (µg/L)	Concentration (µg/L)		RQ_m	RQ_{ex}
	Fish	Aquatic invertebrates	Algae	Critical concentration			Mean	Maximum		
Diazinon	700.00	0.56	10000	0.56	10	0.056	0.0094	0.0372	0.17	0.66
Chlorpyrifos	0.14	4.60	43	0.14	10	0.014	0.0202	0.0676	1.44	4.83
								RQ_{mix}	1.61	5.49

NOEC No-observed effect concentration; *PNEC* Predicted no-effect concentration; RQ_m Risk quotient based on mean value; RQ_{ex} Risk quotient based on maximum value; RQ_{mix} Risk quotient of the mixture

Source: Lewis et al. (2016) and Wee et al. (2016).

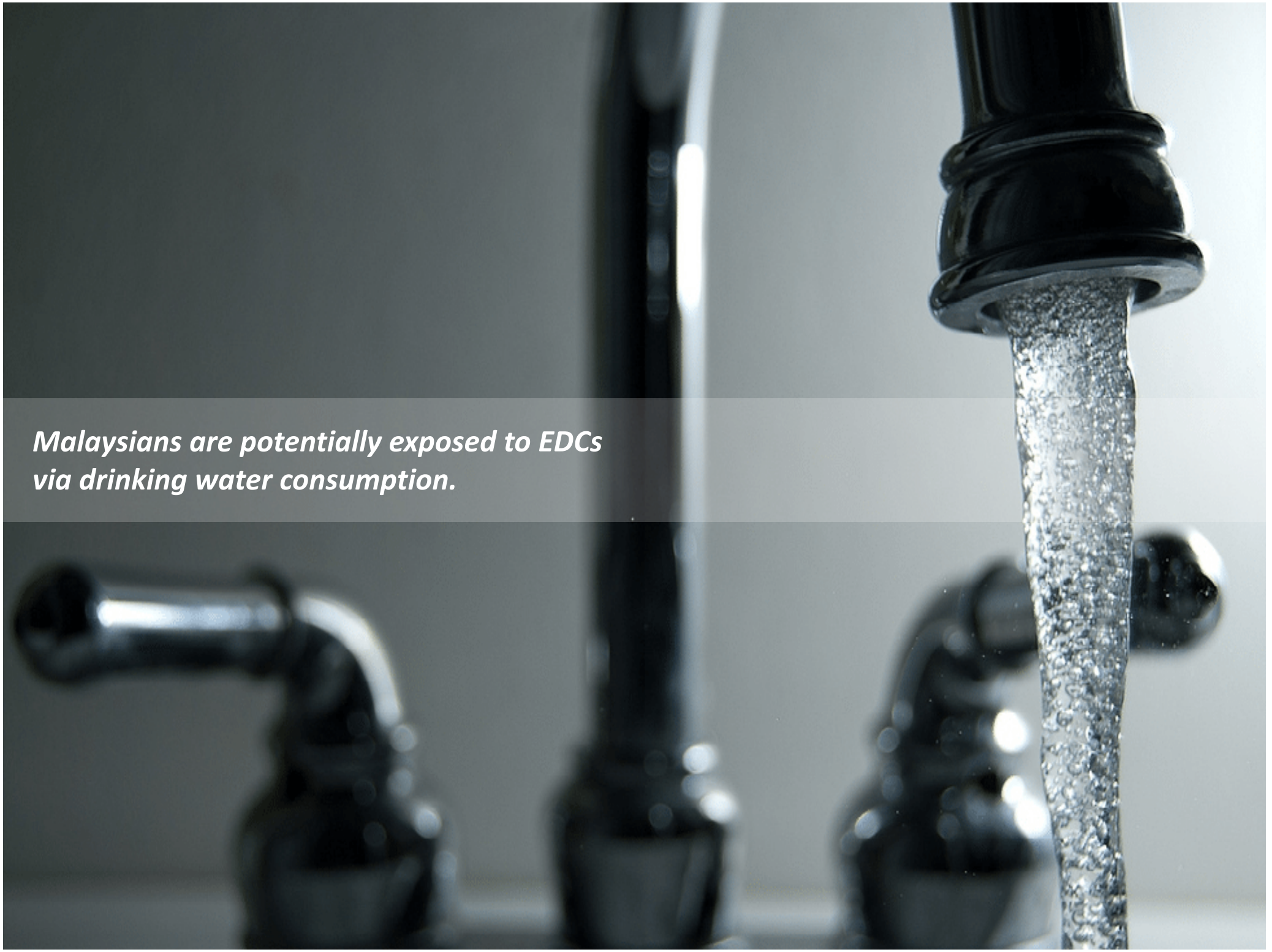
Other than that, disinfectant by-products are of great concern as they might be associated with even higher risks than the parent compounds and metabolites (Cai et al., 2015; Postigo and Richardson, 2014; Huerta-Fontela et al., 2011).

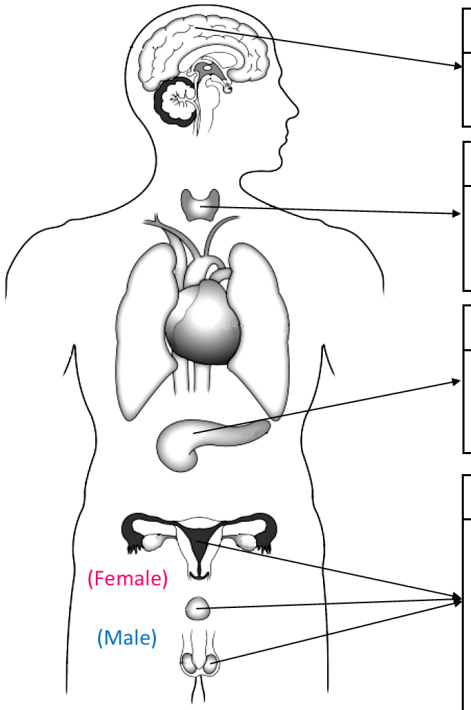
as inefficient



Nevertheless, the toxicological relevance of EDCs should be prioritized before additional advanced treatment technologies are regulated for the complete removal of EDCs from drinking water supplies.

tain
ydrophilicity


Malaysians are potentially exposed to EDCs via drinking water consumption.



Central nervous system (CNS)

- Neurological & behavioral changes
- Reduced stress handling ability

Thyroid

- Hypothyroidism
- Retarded development, metabolism & adult physiology

Pancreas

- Hyperinsulinemia
- Provoked insulin resistance
- Impaired glucagon secretion

Reproductive system

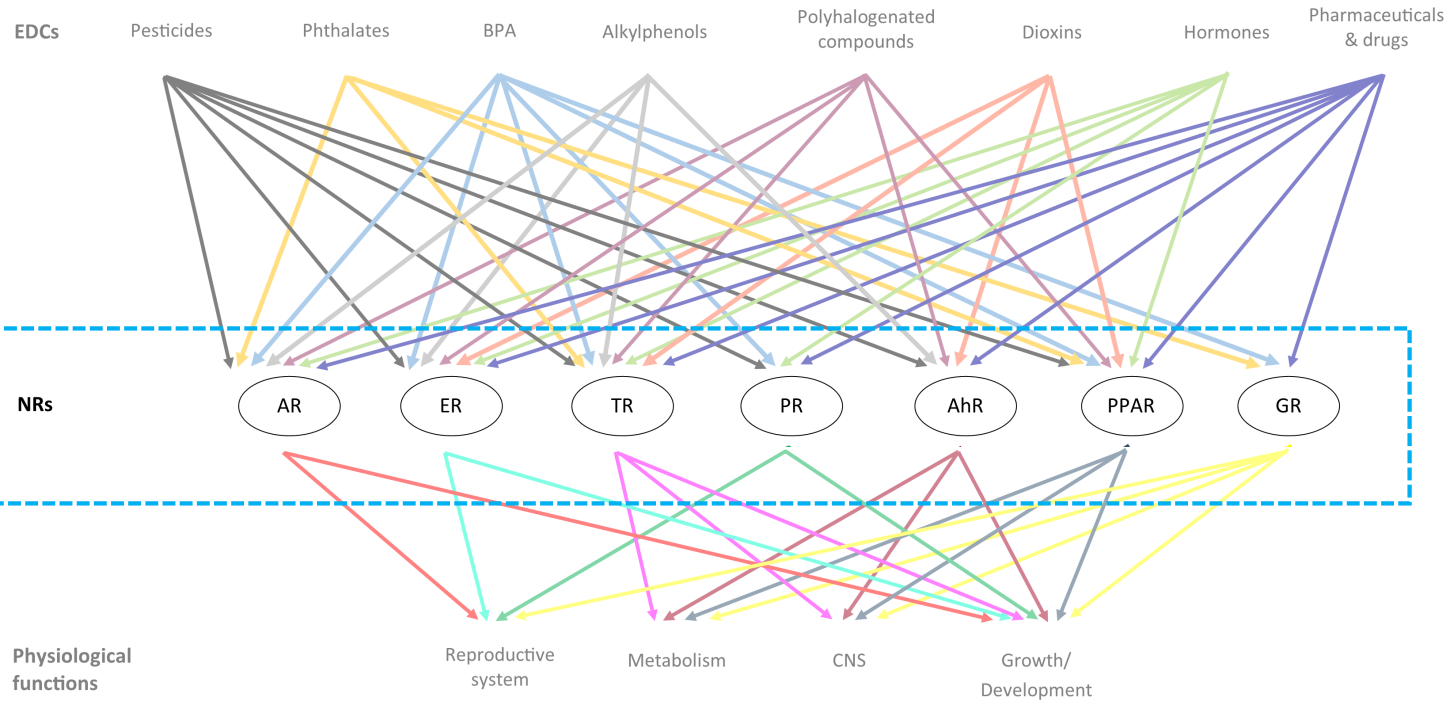
- Intrauterine growth retardation (IUGR)
- Reduced fertility & reproductive health
- Ovulatory & lactation disorders
- Cancer & interfered development (e.g., breast & prostate)
- Testicular dysgenesis syndrome (TDS)
- Early puberty

Metabolic syndromes

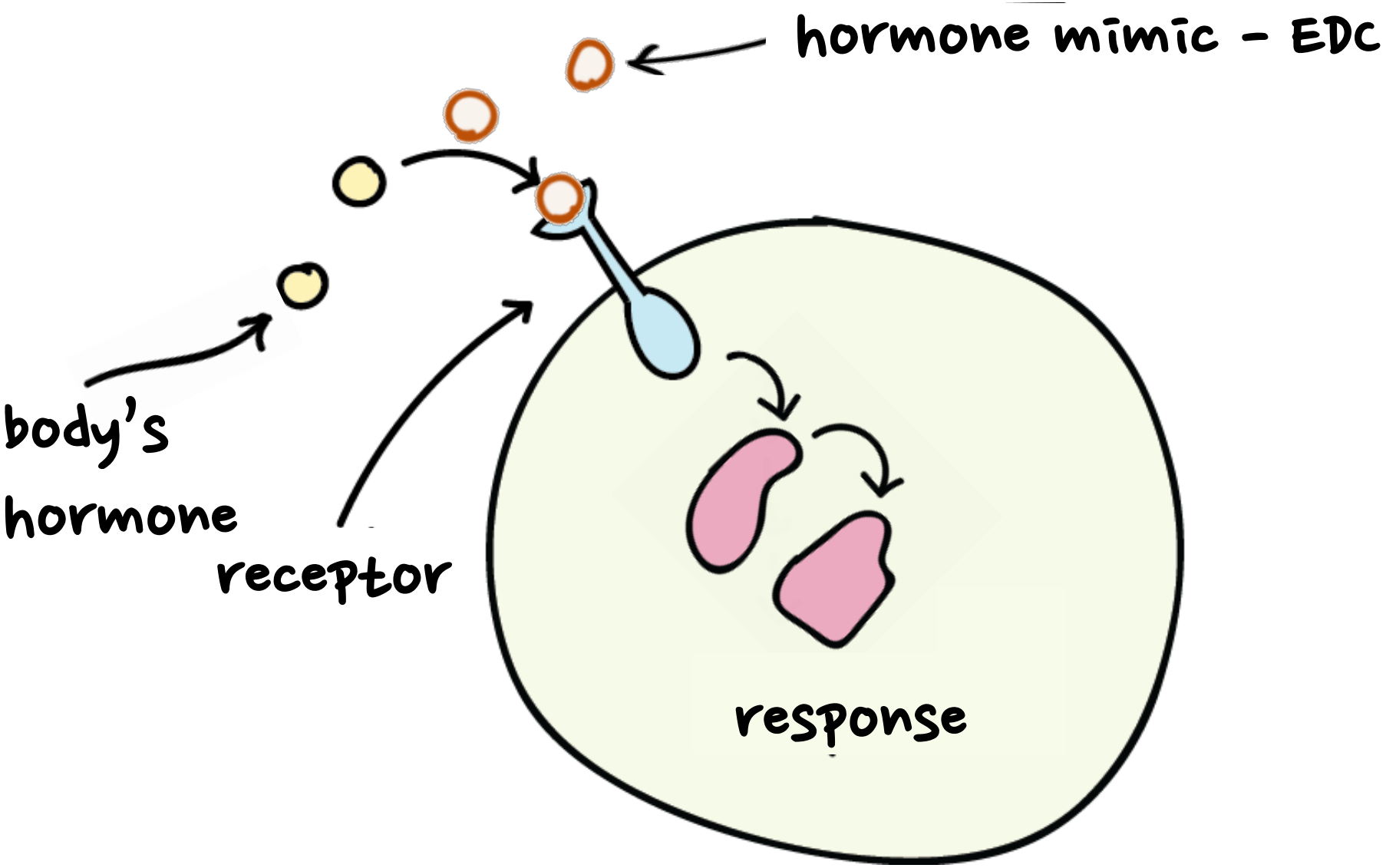
- Obesity
- Type 2 diabetes mellitus
- Hepatic injury
- Autoimmune diseases
- Susceptibility to diseases
- Cardiovascular diseases (e.g., atherosclerosis & coronary heart disease)
- Fetal origins of adult disease (FOAD)

Endocrine system disruption on exposed organism, particularly humans,

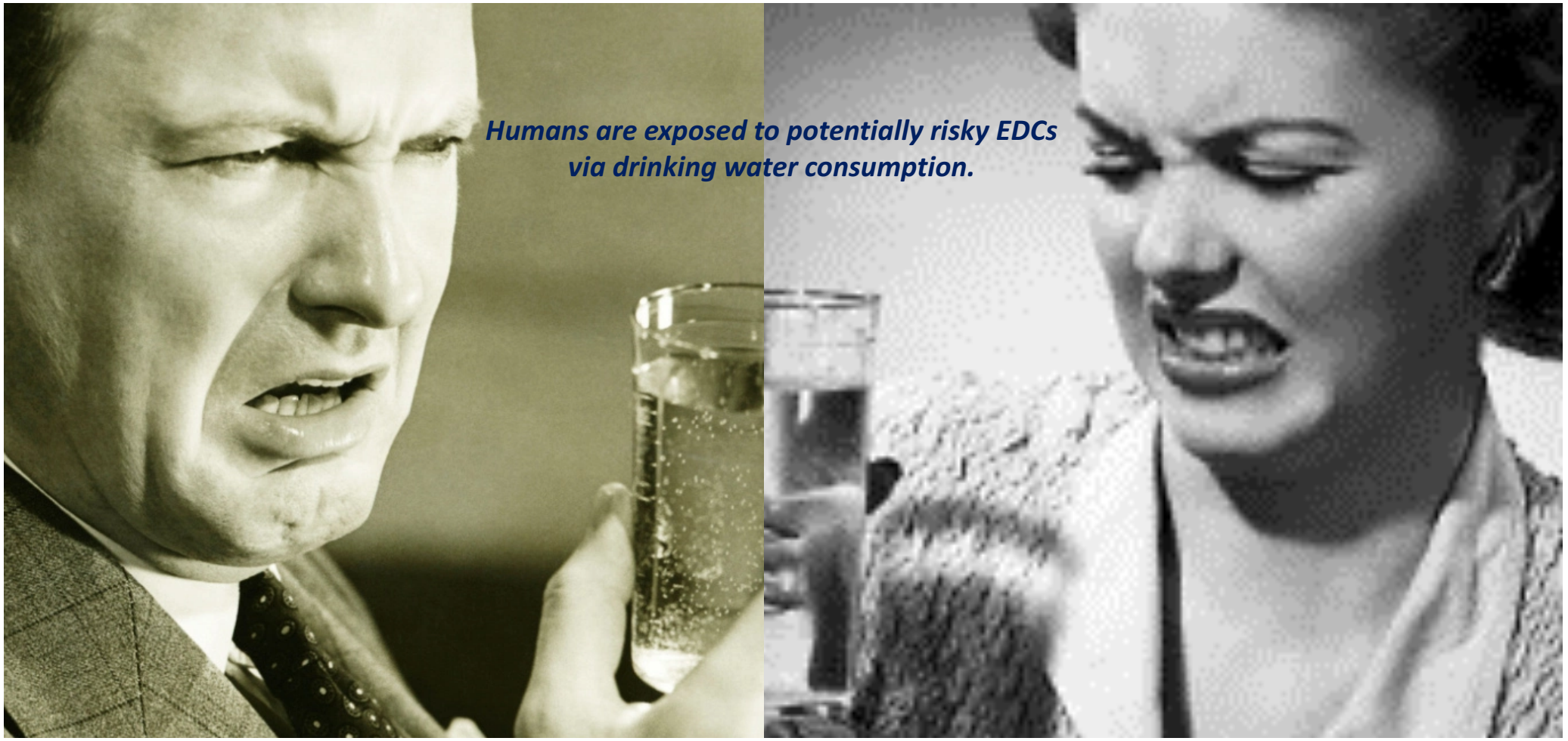
through nuclear receptors (NRs).



What happen?



Although current risk assessments indicate that the trace concentrations of EDCs in drinking water are very unlikely to pose any risks to human health, there are knowledge gaps in terms of assessing the risks associated with long-term, low-level exposures and possible combined effects of chemical mixtures.



The unknown possible combined effects (additive, synergistic, potentiation or antagonistic) of EDC mixtures are of great concern for an accurate exposure assessment to determine whether there are any potential risks to human health, taking into account sensitive subpopulations such as pregnant women and infants.

Challenges in regulating EDCs in drinking water

CHALLENGES

Unwarranted control of drinking water source quality & treatment efficiency in DWSSs.

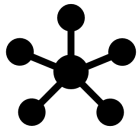
Existing legal regulations are incompetent to regulate the occurrence & distribution of EDCs.

Politically unprioritized and/or unregulated EDC usage & discharge lead to continuous EDC contamination.

Lack of willingness, inclusive political obligation, & public awareness in regulating EDC contamination.

Trace level contamination of the wide diversity of complex EDCs has high cost for:

- Detection & quantification of the broad scope of EDCs in the interference-rich environmental matrices.
- High sensitivity instruments for EDC detection & characterization.
- Simultaneous development and optimization of analytical methods, followed by method validation & sensitivity improvement.

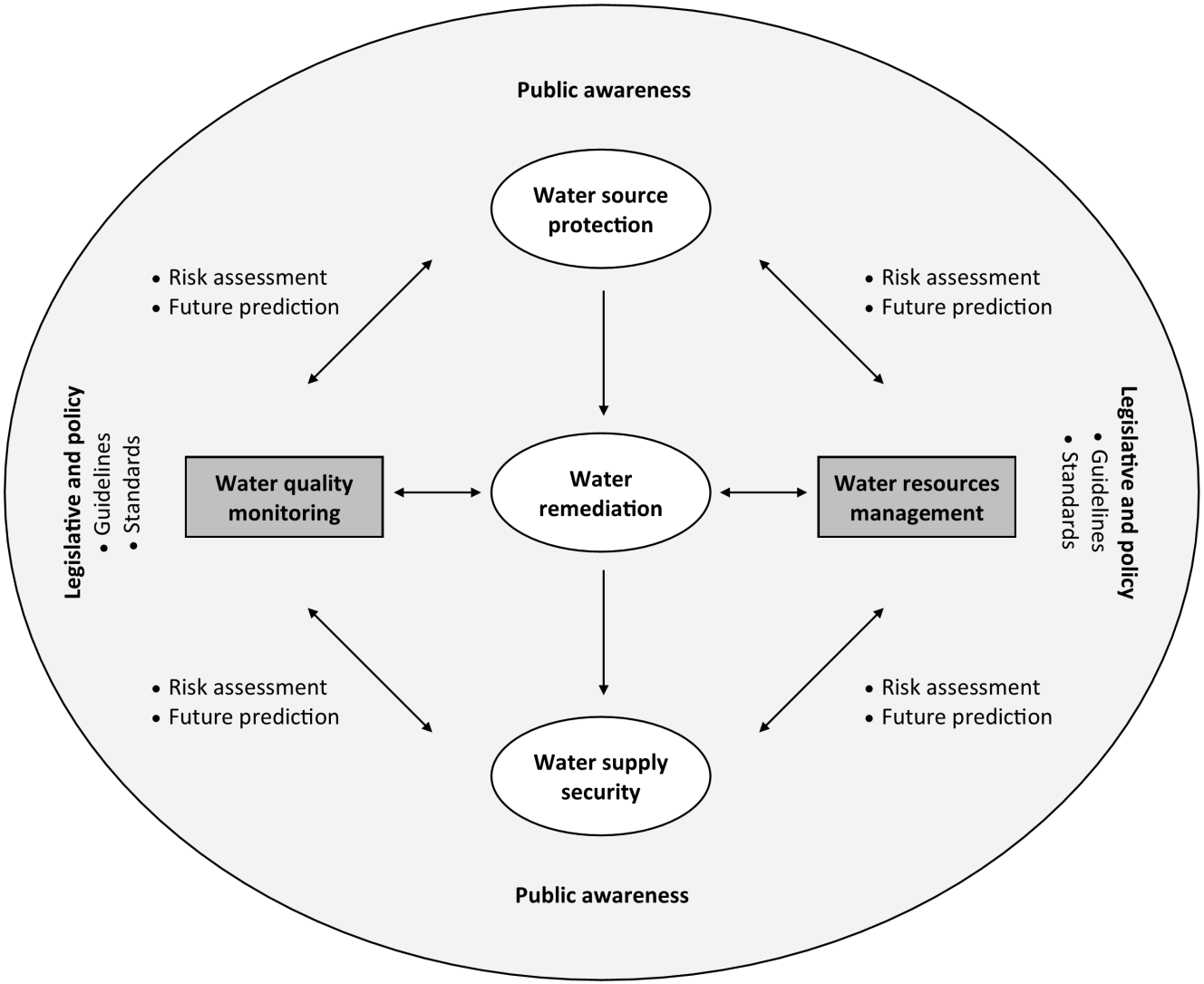


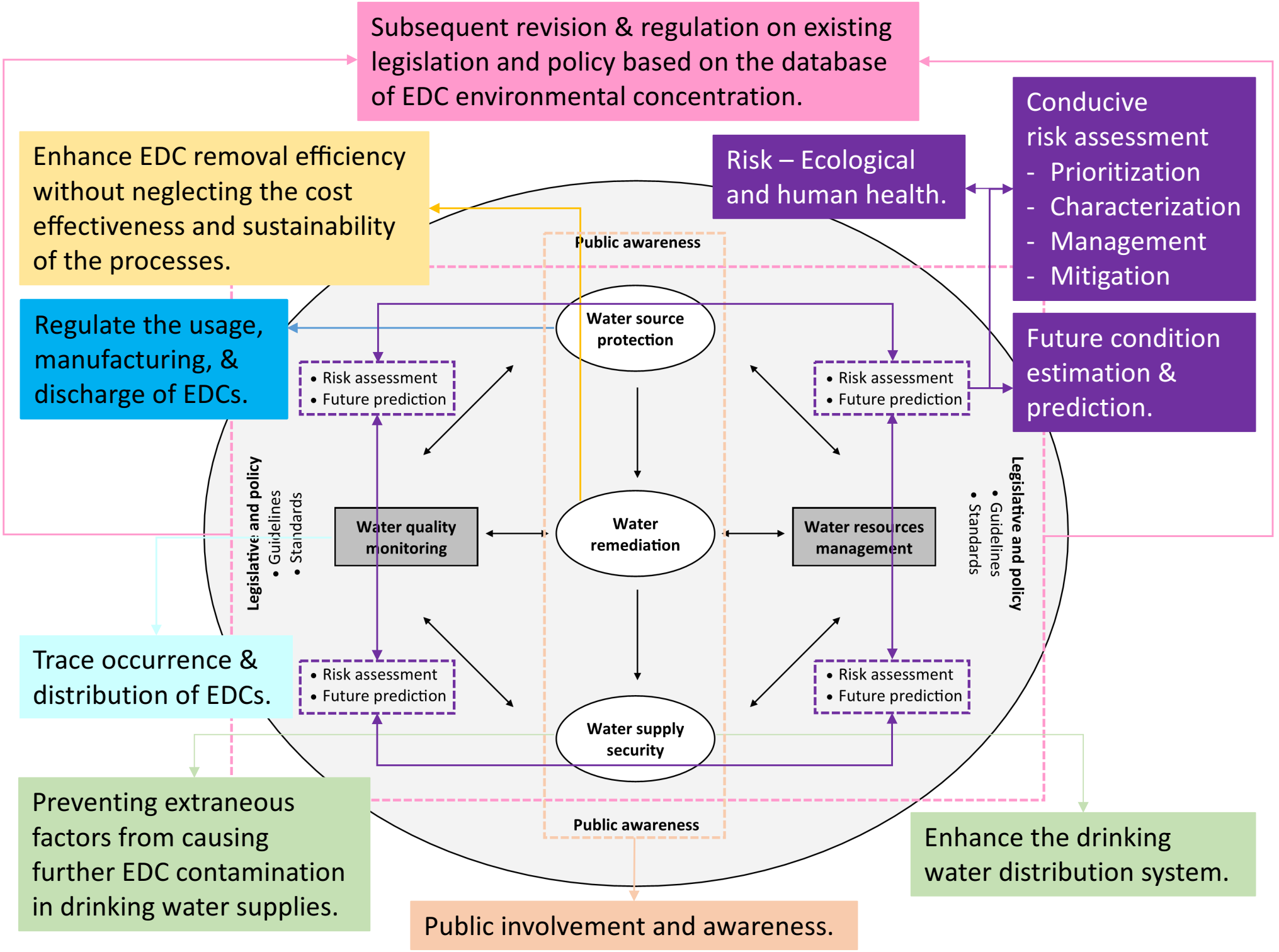
Interruption of human health risk assessment for risk mitigation because of inadequate databases, for example:

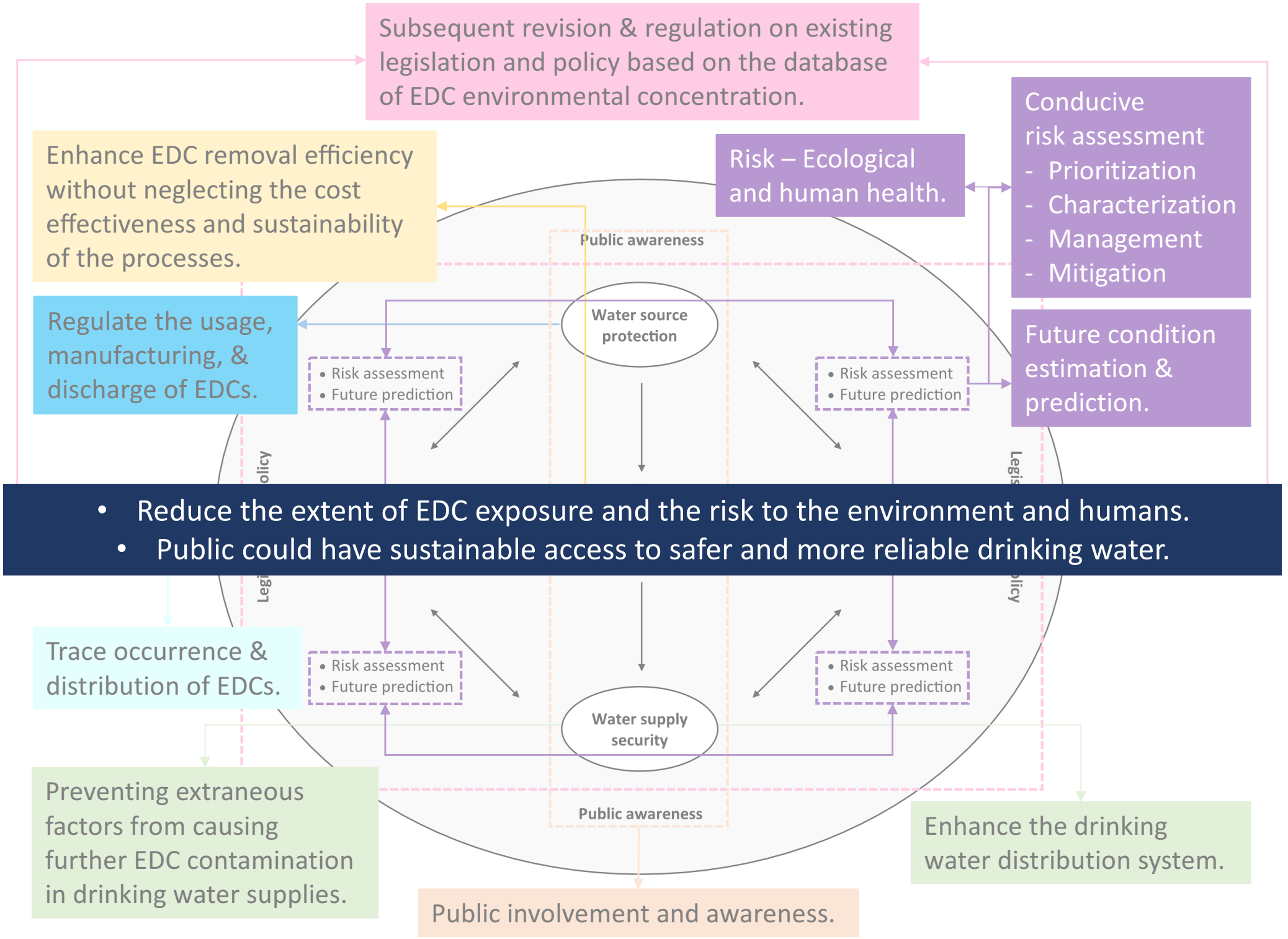
- Degradation & transformation of the complex EDCs during treatment processes.
- Potential risks derived from the EDC mixtures, metabolites, and by-products.

Recommendation

A holistic system - An integrated solution using a multi-barrier approach in DWSS monitoring & management for safe drinking water.




Subsequent revision & regulation on existing legislation and policy based on the database of EDC environmental concentration.
Enhance EDC removal efficiency without neglecting the cost effectiveness and sustainability of the processes.
Regulate the usage, manufacturing, & discharge of EDCs.
Trace occurrence & distribution of EDCs.
Preventing extraneous factors from causing further EDC contamination in drinking water supplies.
Public involvement and awareness.
Enhance the drinking water distribution system.
Risk – Ecological and human health.
Conducive risk assessment
- Prioritization
- Characterization
- Management
- Mitigation
Future condition estimation & prediction.
Public awareness
Water source protection
Water quality monitoring
Water remediation
Water resources management
Water supply security
• Risk assessment
• Future prediction
Legislative and policy
• Guidelines
• Standards
Public awareness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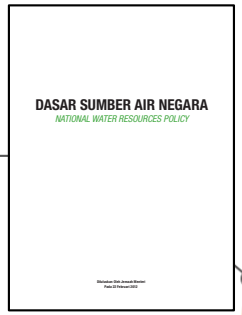
Public awareness
Water source protection
• Risk assessment
• Future prediction
• Risk assessment
• Future prediction
Legislation & policy
Legislation & policy
• Reduce the extent of EDC exposure and the risk to the environment and humans.
• Public could have sustainable access to safer and more reliable drinking water.
Trace occurrence & distribution of EDCs.
• Risk assessment
• Future prediction
• Risk assessment
• Future prediction
Water supply security
Public awareness
Preventing extraneous factors from causing further EDC contamination in drinking water supplies.
Enhance the drinking water distribution system.
Public involvement and awareness.

Sustainability Spoke

National Water Resources Policy

"To provide clear directions and strategies for water resources management, including collaborative governance to ensure water security and continued sustainability"



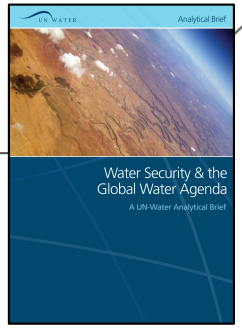
RMK 11 - Eleventh Malaysia Plan

"This transformation will ensure sustainability of the nation's natural resources, minimise pollution, and strengthen energy, food and water security. "

Water Security

United Nations - Water Security

"Access to safe and sufficient drinking water at an affordable cost in order to meet basic needs, which includes sanitation and hygiene (cf. United Nations General Assembly, 2010), and the safeguarding of health and well-being"



SUSTAINABLE DEVELOPMENT GOALS

6 CLEAN WATER AND SANITATION

National Key Results Area (NKRA)

"To push for improving basic infrastructure, which include ensuring public access to clean and treated water."

THANK YOU

"We have made clear to you the signs;

perhaps you will understand."

(57:17)

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