Emerging Pollutants in Malaysian Rivers

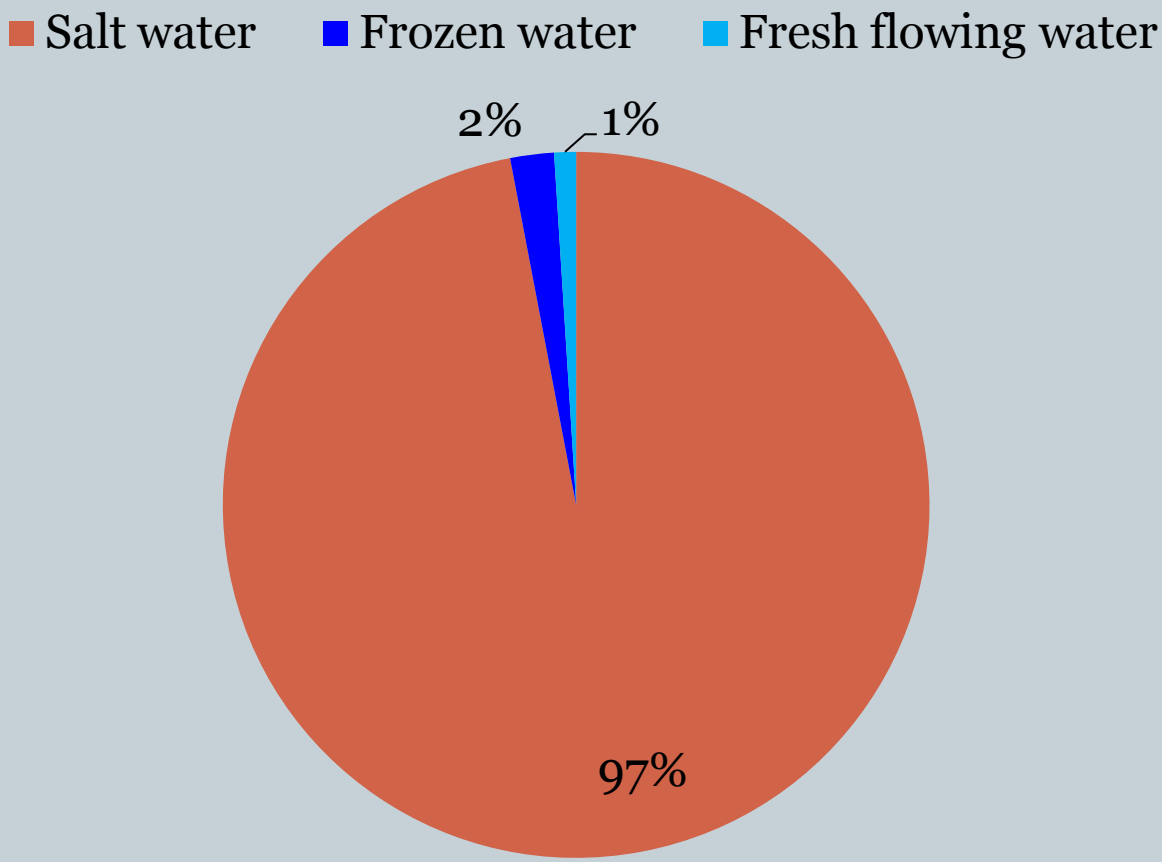
YANG FARINA FASC FMIC
MD PAUZI ABDULLAH, NURFAIZAH & WAN AFIQ
HEAD
CENTRE FOR WATER RESEARCH AND ANALYSIS (ALIR)
UNIVERSITI KEBANGSAAN MALAYSIA

- ✓Source of water and usage
- ✓Emerging Pollutants
- ✓Work in Malaysia
- ✓Conclusion

Is there enough clean and safe water for our young population?

70 % of the World's Surface is Covered with Water

97% is Salt Water



Pulau Sipadan

97 % is salt water!

2% of Our Water is Frozen

Glacier

Iceberg

Only 1% is Fresh Flowing Water

How much of this 1 % is suitable for human use?

River

Lake

Is this water safe for human consumption?

Underground water is another source of water!

Scale of the problem

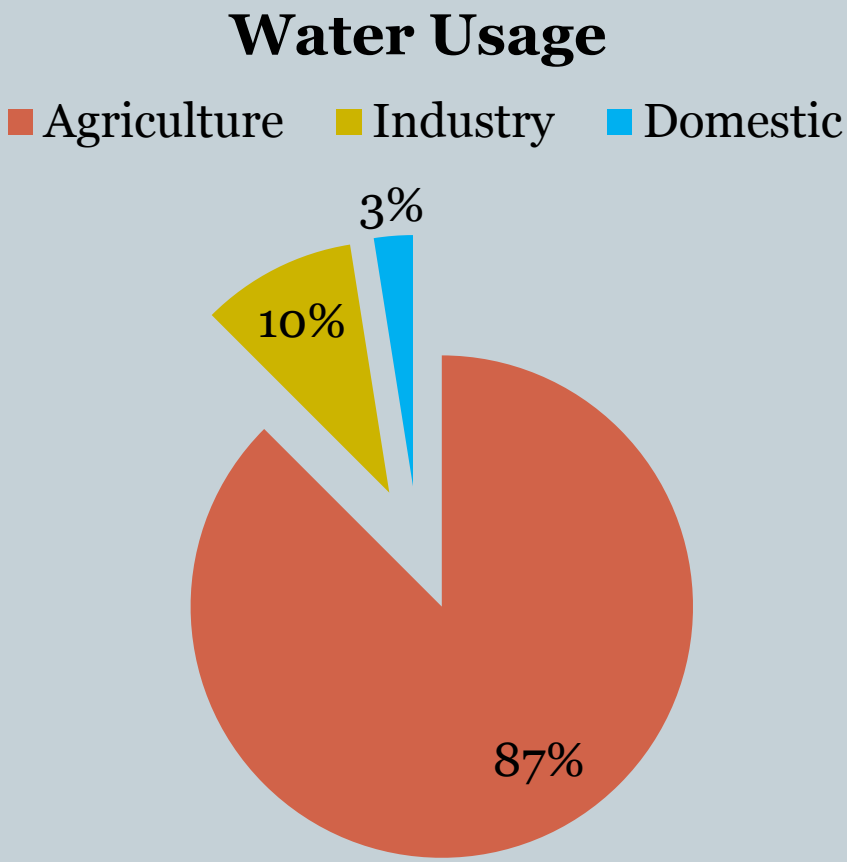
- ✓ 46% of world population has no access to potable water.

Women walk on average 6 km to find clean water!

This water tastes so good!

Water Usage

87% Fresh Water is for Agriculture



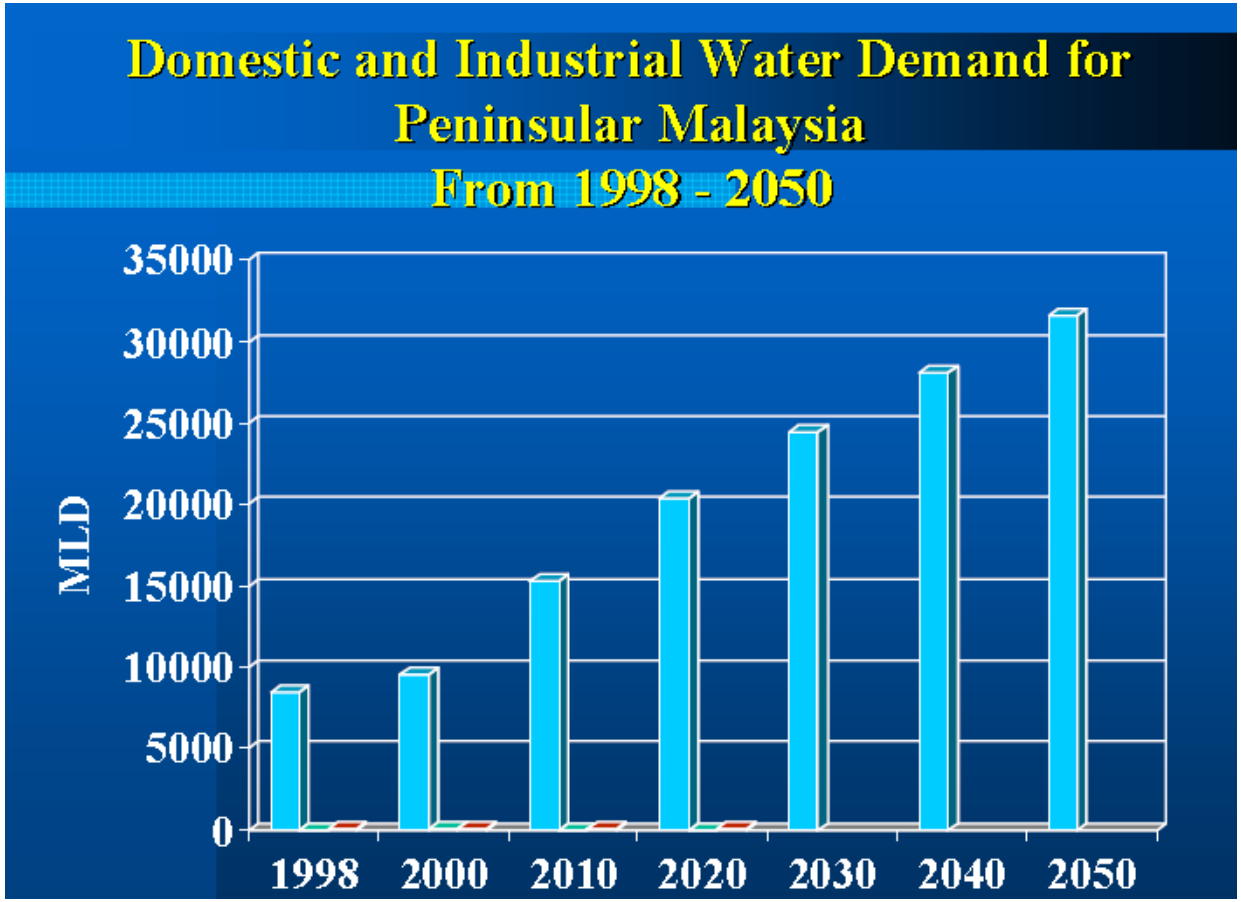
Corn planting in Tuaran.

Cooling towers in a nuclear plant

The demand for potable water has increased.

Ensure adequate supply.

Quality water means it is safe for consumption right from tap.



Is there enough clean and safe water for everyone?

437 rivers monitored

278 (59%) were found to be clean

161 (34%) were slightly polluted

34 (7%) were polluted.

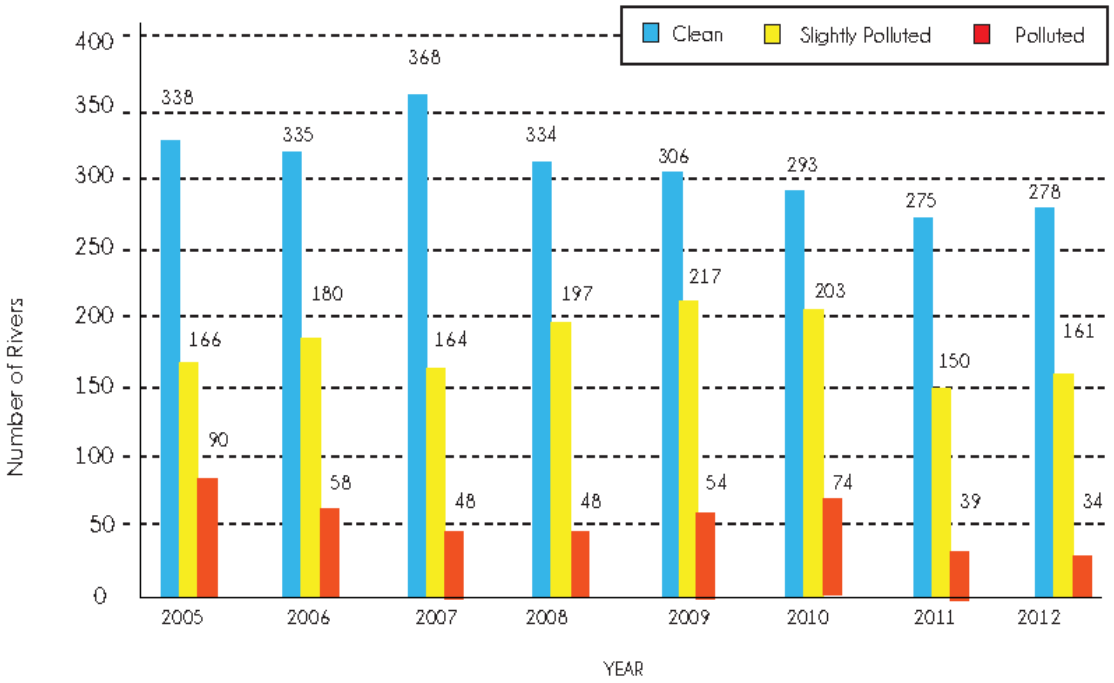


Figure 2.1 Malaysia : River Water Quality Trend (2005 - 2012)

Environmental Quality Report (DOE 2012)

Pollutants in Malaysian Rivers

- **BOD** (inadequate treatment of sewage and effluents from agro-based and manufacturing industries)
- **Ammoniacal nitrogen** (livestock farming and domestic sewage)
- **Suspended solids** (improper earthworks and land clearing activities)

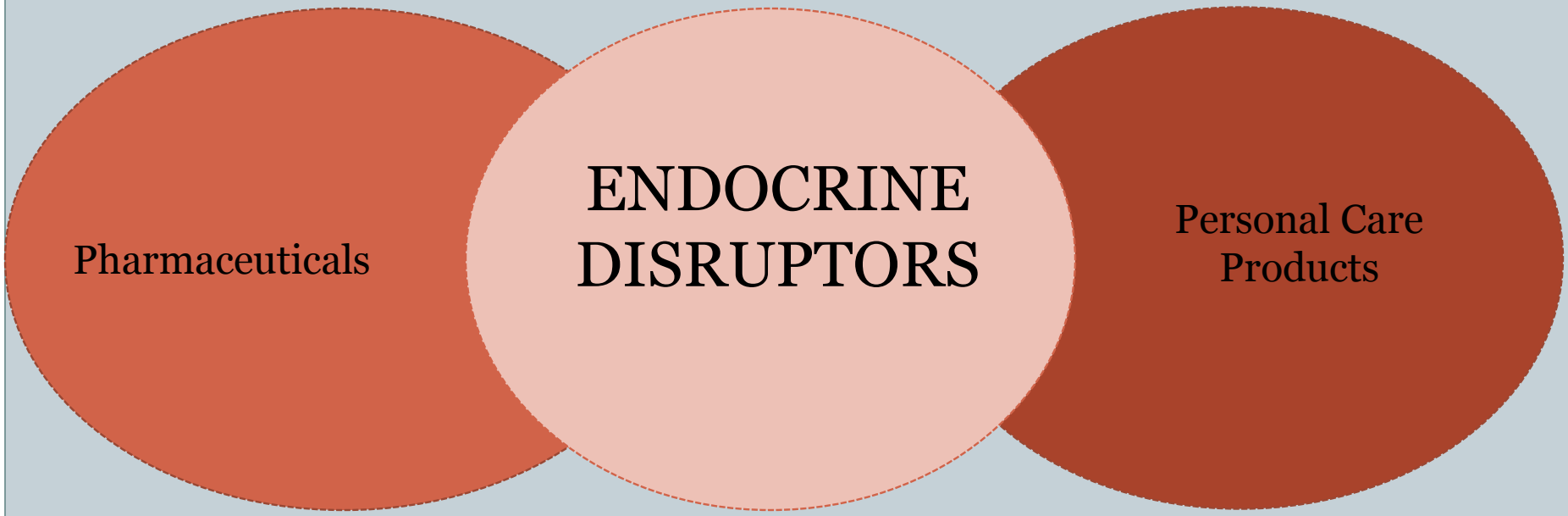
Definition of Emerging Pollutants

"ENTERING INTO OR BEING GENERATED IN THE ENVIRONMENT IN APPRECIABLE AMOUNTS" WITH A "MODICUM OF PERSISTENCE" AND "EXHIBIT DELETERIOUS EFFECTS ON ORGANISMS".

Pharmaceuticals

Personal Care Products

Endocrine Disruptors

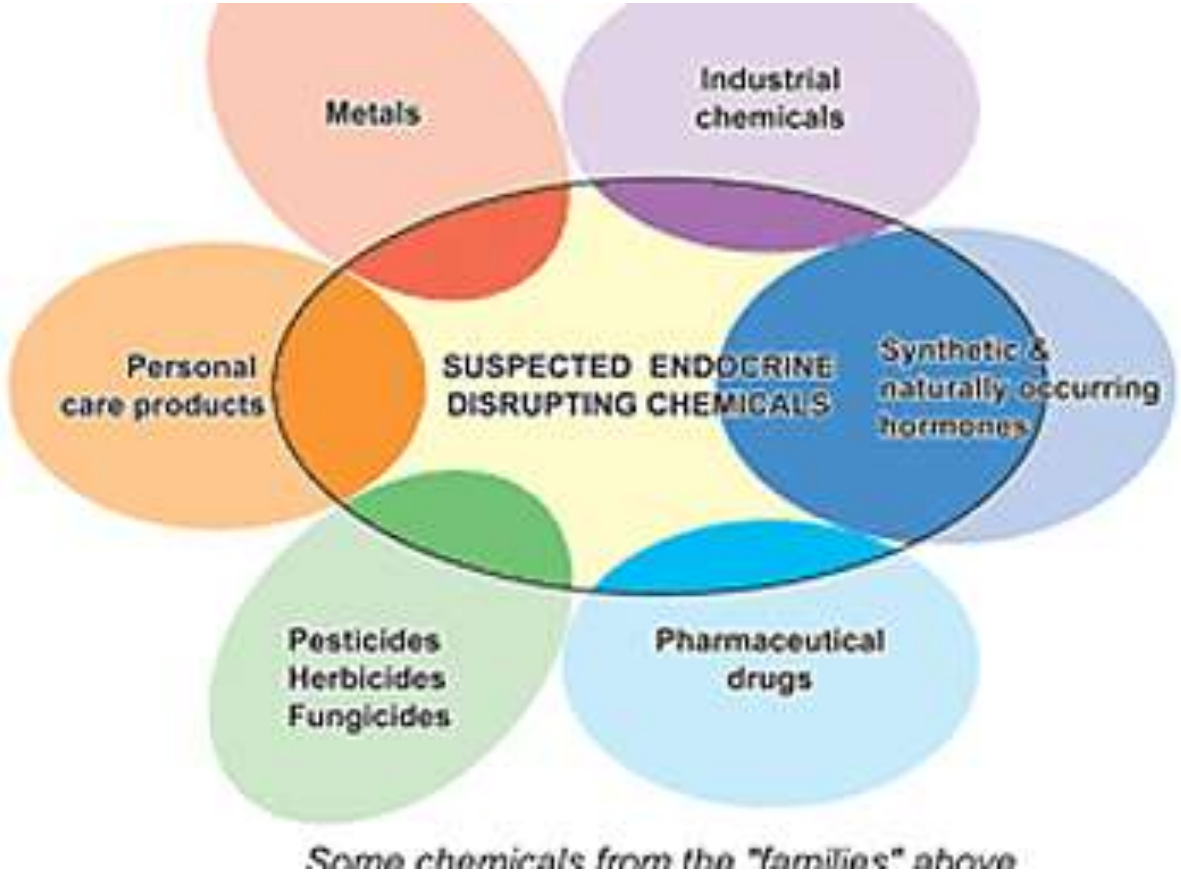


Hormones

Paraben

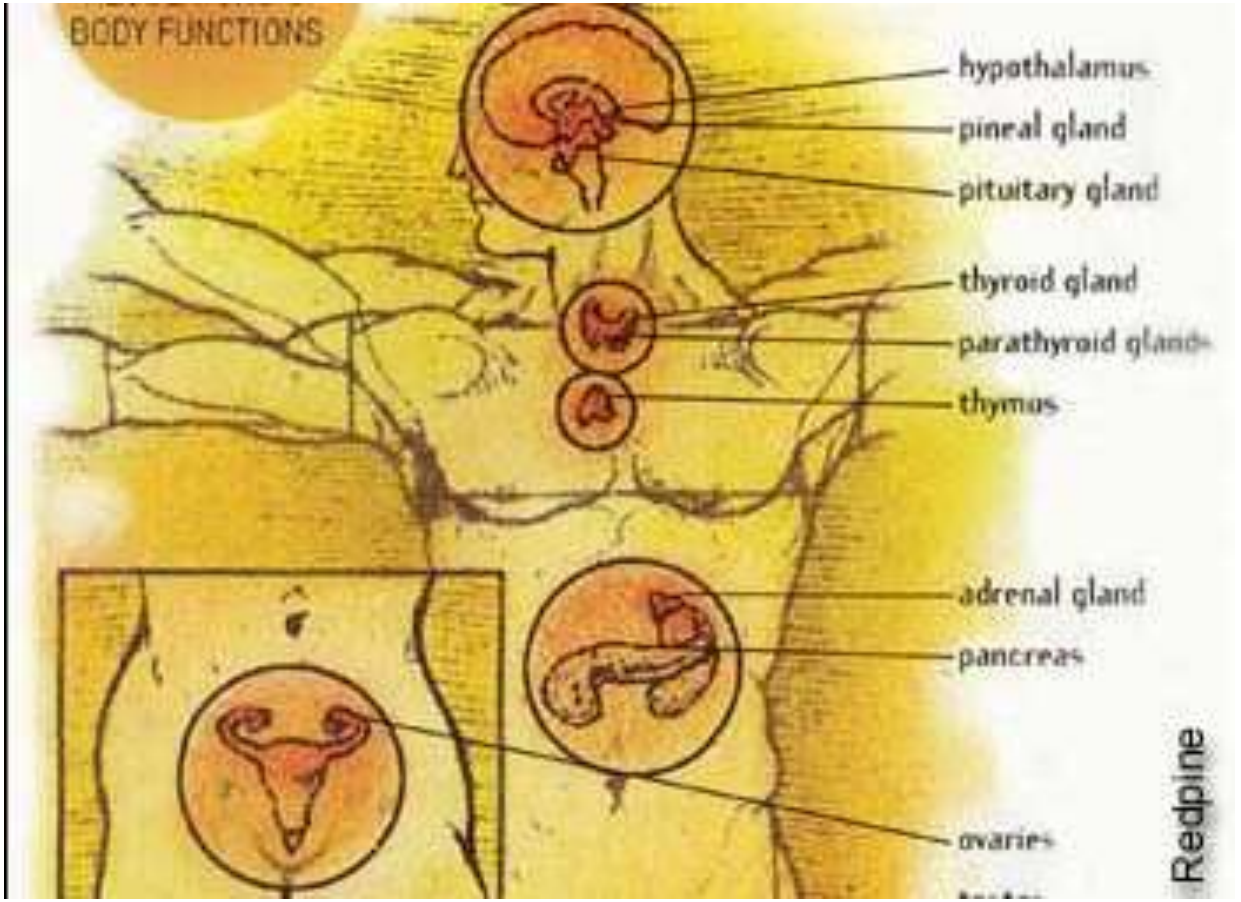
Phthalates

Steroids



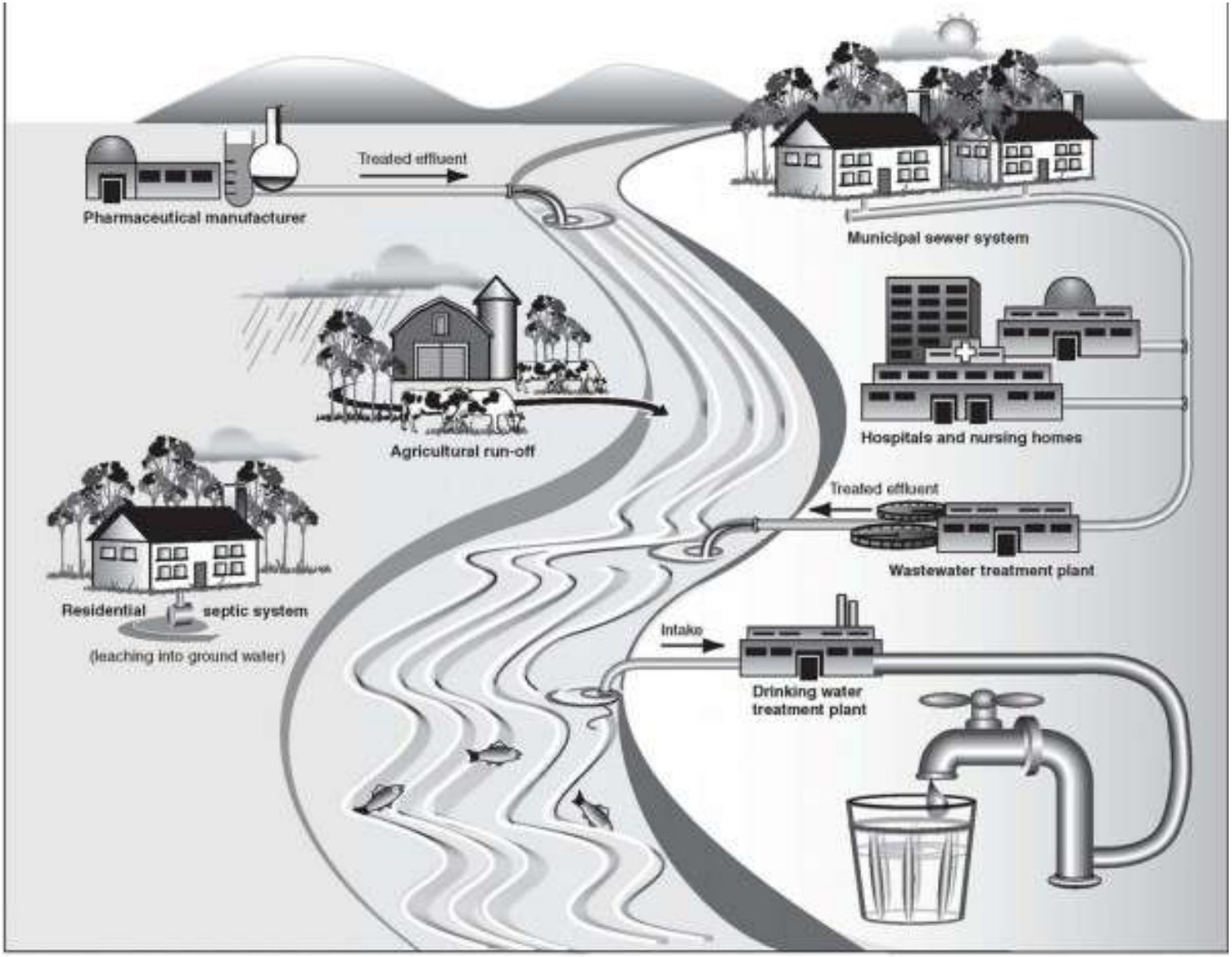
Capable of disrupting chemical signaling mechanisms controlling cellular development

- Reproduction – low sperm count
- Immune function
- Thyroid related disorder
- Bone disorder
- Neuro-development disorder in children
- Hormone related cancers
- Metabolic disorder



Affects many bodily functions and well being.

Possible modes of entry into waterways



Source: GAO.

Flushing of unused medicine is of minor importance.

What is not metabolised end up in the sewerage system.

Global Studies

- 20 years ago
  - aspirin, caffeine, and nicotine found in sewage treatment plants in U.S.
  - USDA researchers found clofibric acid (cholesterol lowering drug) in groundwater infiltration basins.

Studies which sounded the alarm:

- ~ 10 years ago, clofibric acid found beneath German treatment plant.

- mid 1990s, 30 of 60 pharmaceuticals tested for found in water samples

- Tulane University study: found low levels of drugs in Mississippi River, Lake Ponchetrain and in Tulane tape water

USGS study in 1999-2000

- Tested for 95 pharmaceuticals, hormones and other organics

- 139 streams in 30 states.
  - 82 found in one sample
  - 80% of streams had 1 or more contaminant
  - 54% of streams had > 5 contaminants
  - 13% of streams had > 20 contaminants

Work in Malaysia

30

UKM AND UPM

UKM

- Pharmaceuticals were targeted based on the top 40 drugs utilised in Malaysia.
- We have developed and validated an analytical technique based on SPE-LC/MS/TOF.

Pharmaceuticals selected

Target Compounds	Therapeutic Groups	Molecular Formula; Molecular Weight
Acetaminophen	Analgesic and anti-inflammatory	$C_8H_9NO_2$; 151.17
Caffeine	Stimulant	$C_8H_{10}N_4O_2$; 194.19
Carbamazepine	Anti-epileptic	$C_{15}H_{12}N_2O$; 236.27
Ketoprofen	Analgesic and anti-inflammatory	$C_{16}H_{14}O_3$; 254.28
Metoprolol	Anti-hypentensive	$C_{15}H_{25}NO_3$; 267.36
Norgestrel	Hormonal contraceptive	$C_{21}H_{28}O_2$; 312.45
Prednisolone	Anti-allergic	$C_{21}H_{28}O_5$; 360.44
Simvastatin	Lipid lowering agent	$C_{25}H_{38}O_5$; 418.57
Sulfamethoxazole	Antibiotic	$C_{10}H_{11}N_3O_3S$; 253.28
Theophylline	Bronchodilator	$C_7H_8N_4O_2$; 180.16

Methods

Sample Preparation
Filtration
(0.7 µm glass microfibre)

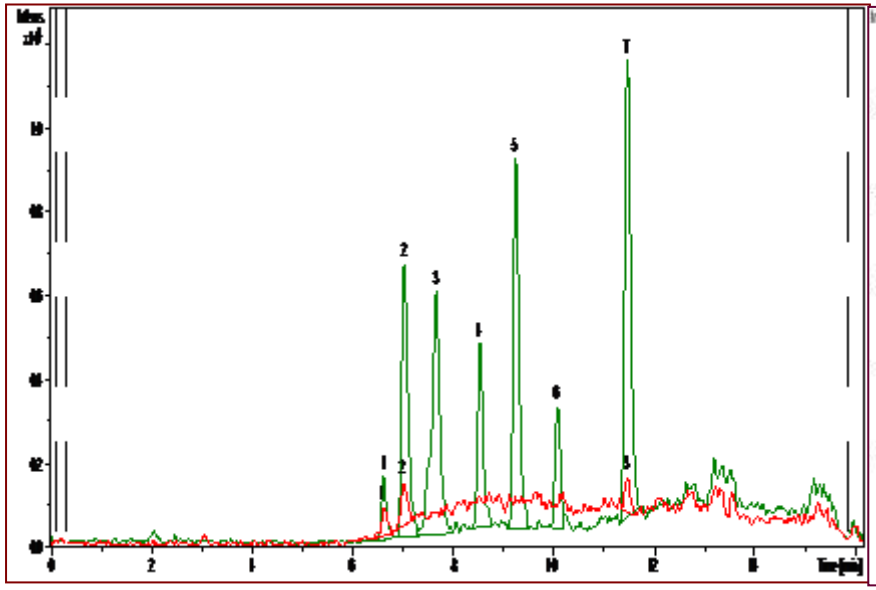
Solid Phase Extraction
Vacuum manifold
Cartridge: OASIS HLB
(3cc, 60 mg)

Evaporation of solvent on
Nitrogen stream

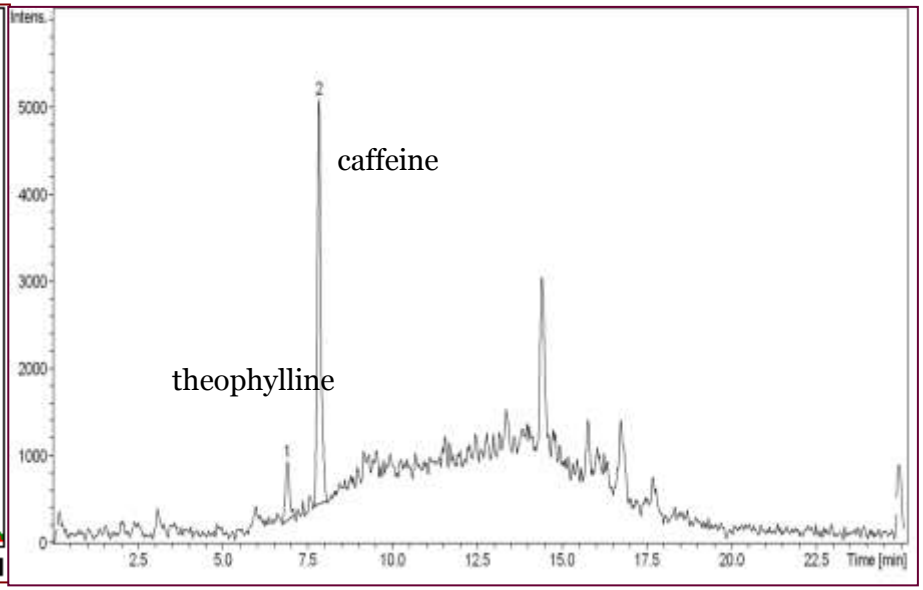
Reconstitution
1 mL final volume with 10:90 v/v MeOH-DI water

Instrumental Analysis
LC-TOF-MS
ESI +

Our recent qualitative studies of river water in Bangi area using LC-TOF-MS indicate the presence of several pharmaceuticals such as caffeine, theophylline, prazosin and simvastatin



This chromatogram indicates te presence of 1: caffeine; 2: prazosin; 3: simvastatin in Sg Tangkas, Kajang



This chromatogram indicates te presence of of theophylline and caffeine in Sg Langat

UPM

- UPM studied on the quantification of 23 targeted compounds from 7 therapeutic classes.
- Several types of targeted compounds were consistently present in surface water or wastewater namely mefenamic acid, glibenclamide and salicylic acid, acetaminophen, levonorgestrel and cyproterone.

IMPACTS?

Thus far, we found very low levels at ppt and ppb.

Chronic effects is currently being studied.

Highly effective techniques:

Advanced oxidation removes many compounds

Membrane filtration and filtration with GAC

Nano-filtration and reverse osmosis (eliminated all drugs

Our sewerage and water treatment plants are not equipped to remove these emerging pollutants.

Way Forward

- More research into developing new techniques to determine the concentrations of various pharmaceuticals.
- Need more research grant.
- Need to train more PhDs in method development.
- Include pharmaceuticals in the list of parameters to be monitored.

What goes around comes around!

The Researchers

CÁM ÓN

TERIMA KASIH

SHUKRAN

GRACIAS

ARIGATO

MERCI

THANK YOU

XIE XIE

HATURNUHUN

GRATIA

NANDRI

TASHAKKUR

DANKE SCHÖN

BEDANKT

DIOLCH

MATURNUWUN

SELAMAT

GRAZIE

KOP KUN KAH

SPASIBO

KAMSAHAMNIDA

RAKHMAT

OBRIGADA

GO RAIBH MILE MAITH AGAIBH