Emerging Issues in Three Waters: Emerging Contaminants

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NEW ZEALAND

ENGINEERING

Background

- MS/PhD in environmental engineering from Georgia Institute of Technology (Atlanta, GA) (2004-2010)

- Remediation Engineer at Geosyntec Consultants (Atlanta, GA) (2010-2013)

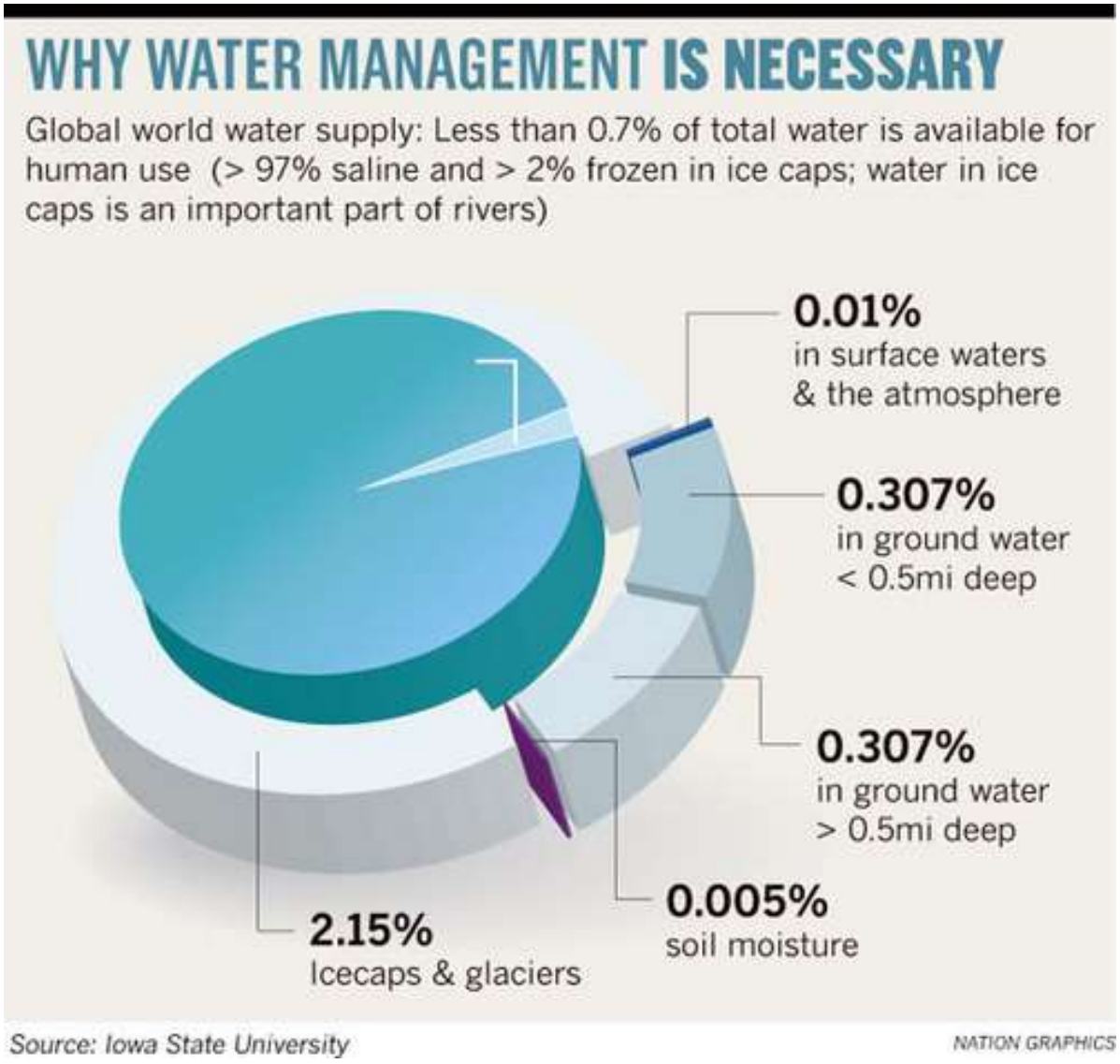
- **Assistant Professor in CESE at IIT Bombay (2013-2014)**

- Senior Lecturer and Environmental Lab Manager at the University of Auckland (2014-present)

- Research group comprises 7 PhD students and 1 postdoctoral researcher (completed 5 PhDs, 10 Masters)

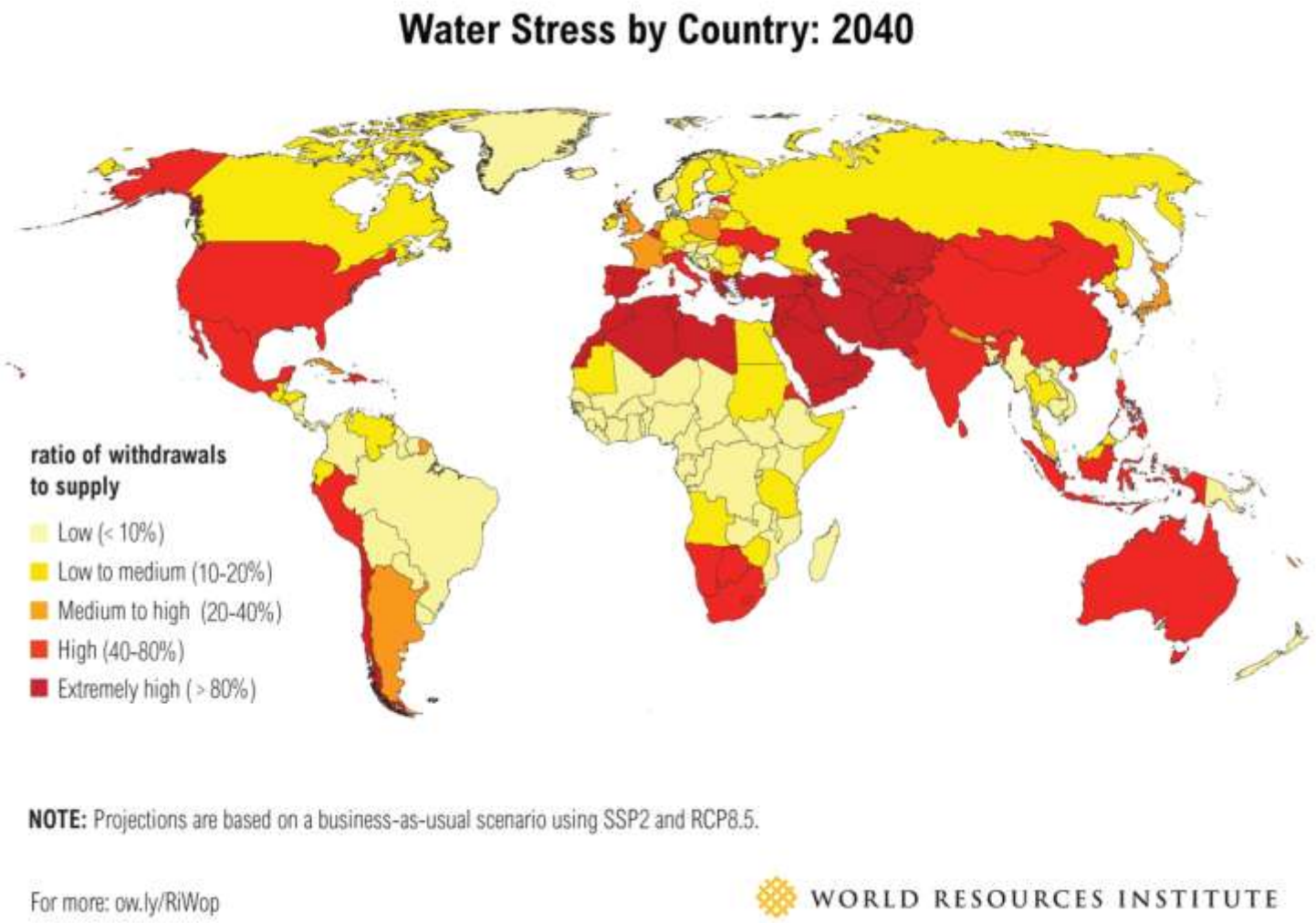
New Zealand

World's Water Portfolio



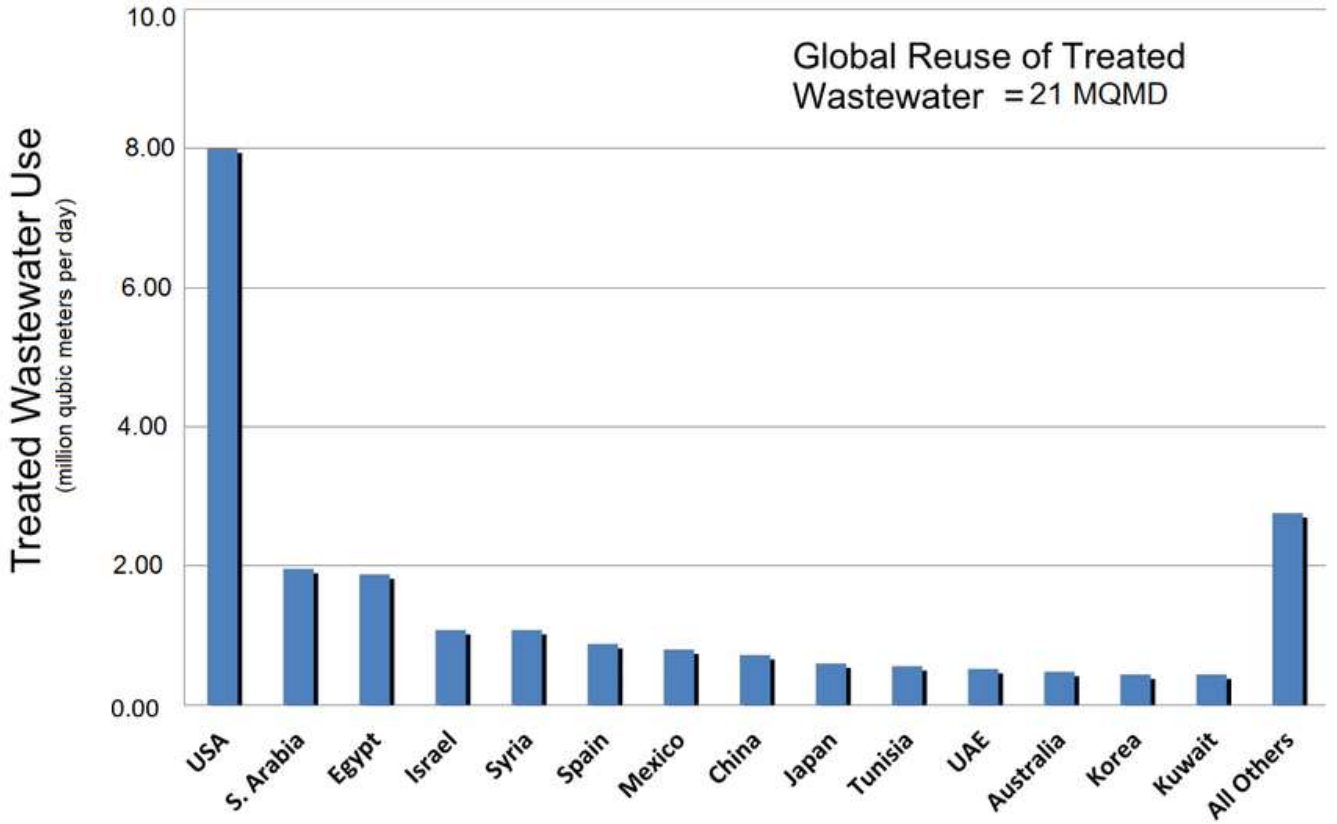
Source: www.yaleseas.com/watersymposium/powerpoints/jacangelo.ppt (Last Accessed - July 2018)

Water Stress in the World



Source: http://www.wri.org/blog/2015/08/ranking-world's-most-water-stressed-countries-2040
Last Accessed: July 16, 2018

Global Wastewater Reuse



Source: https://www.researchgate.net/publication/325701959_Reuse_of_treated_wastewater

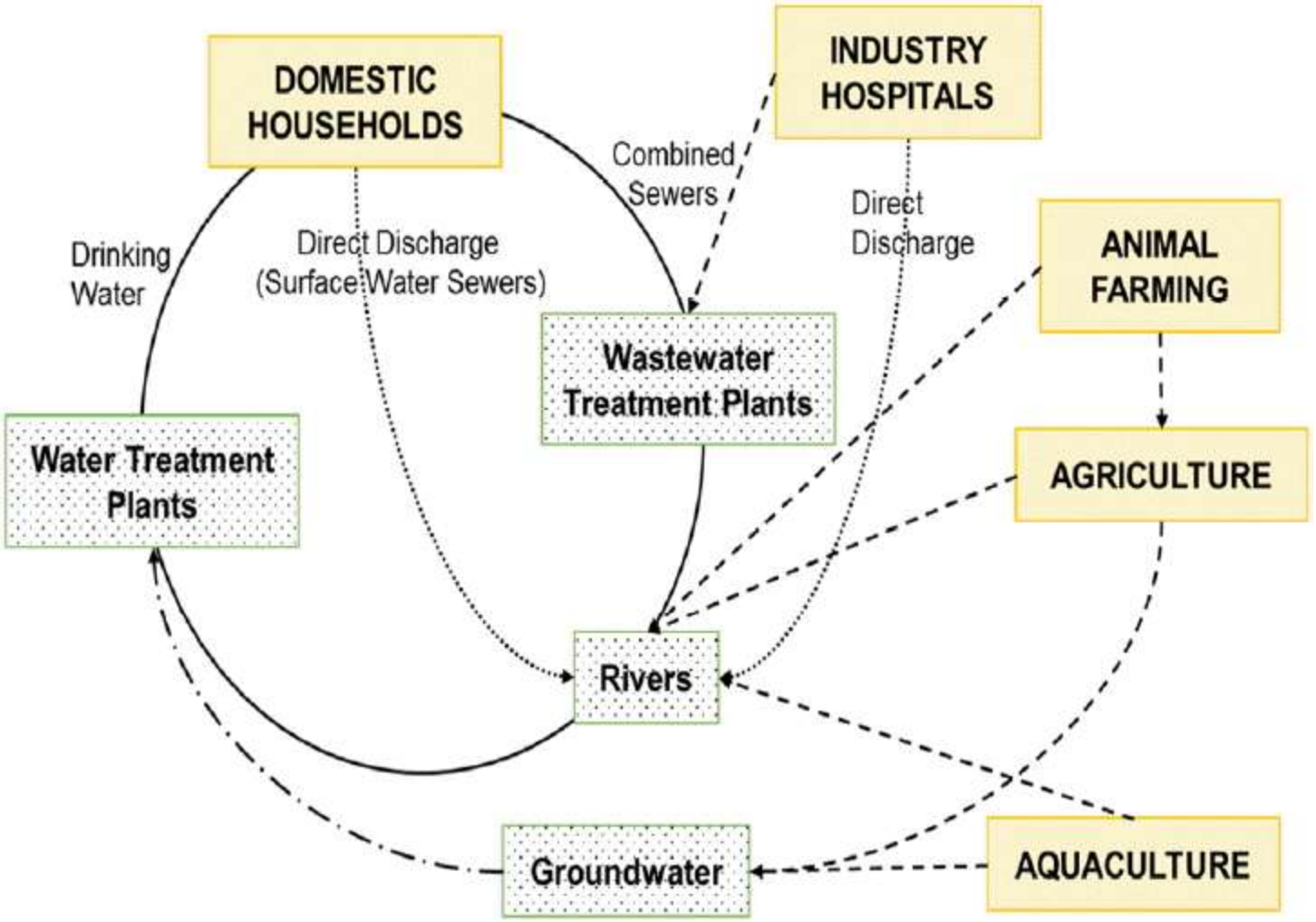
The U.S. EPA defines wastewater reuse as “using wastewater or reclaimed water from one application for another application. A common type of recycled water is water that has been reclaimed from municipal wastewater (sewage).”

Current Status of Wastewater Reuse

- More than 5,000 water reuse facilities globally (approximately 1,500 in the U.S. alone)
- Only 5-7% of wastewater is currently reused
- But also, huge **untapped potential for 'greywater' and 'stormwater runoff' reuse**

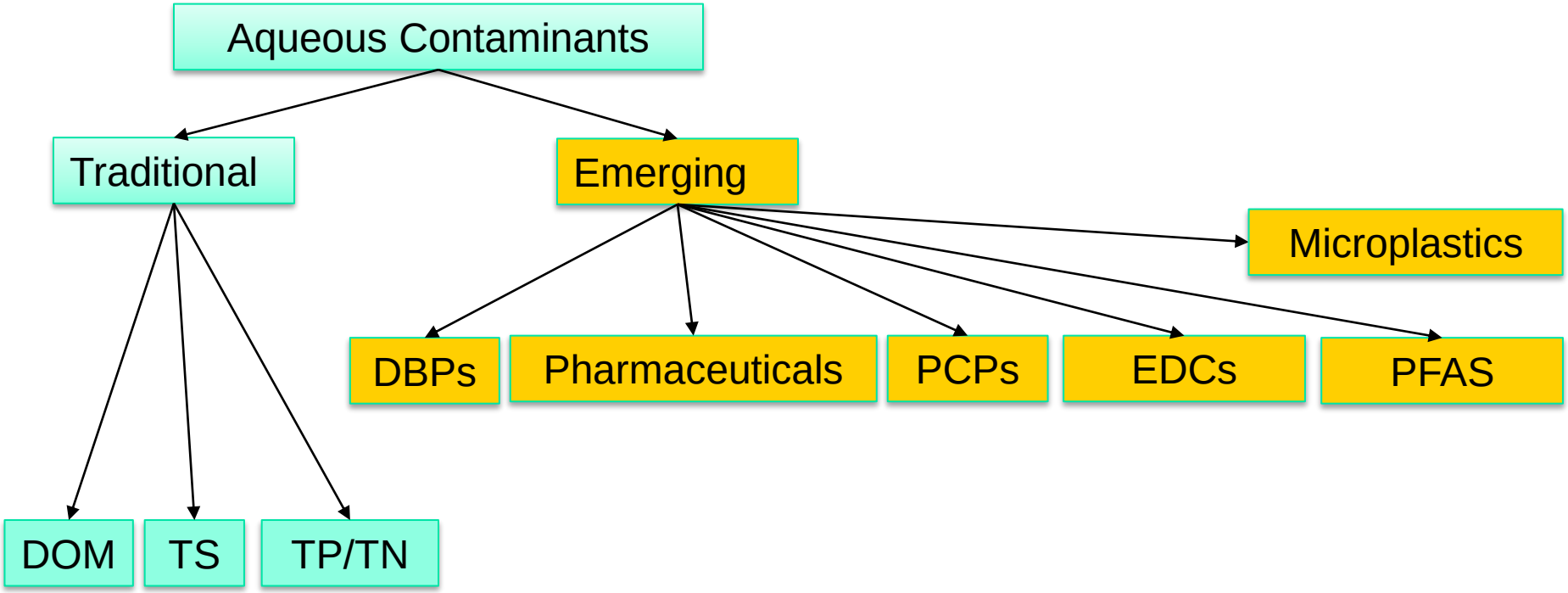
Source: www.yaleseas.com/watersymposium/powerpoints/jacangelo.ppt (Last Accessed - July 2018)

Contaminants in Water



Source: Ellis JB; Pharmaceutical and personal care products (PPCPs) in urban receiving waters. Environ Pollut. 2006;144:184–189.

Chemical Contaminants Overview



Kumar, R., Tscharke, B., O'Brien, J., Mueller, J.F., Wilkins, C. and Padhye, L.P. Assessment of drugs of abuse in a wastewater treatment plant with parallel secondary wastewater treatment train. Science of the Total Environment, **2019**, 658, 947-957.

Kumar, R., Sarmah, A.K. and Padhye, L.P. Fate of pharmaceuticals and personal care products in a wastewater treatment plant with parallel secondary wastewater treatment train. Journal of Environmental Management, **2019**, 233, 649-659.

Pharmaceuticals

- Human and veterinary substances taken in response to disease/maladies.
  - Some of these pass through our body unmetabolized
  - Unused drugs are disposed of through toilets or rubbish
  - Some of the antibiotics released can encourage antibiotic resistant genes in the environment

Personal Care Products

- Compounds used in our daily lives
  - Soaps, detergents, perfumes, aftershaves, cleaning agents, disinfectants, sprays, deodorants, bug sprays, sunscreens, personal hygiene products, etc.
  - End up in our waterways through showers, sinks, toilets

Source: https://indiebusinessnetwork.com/personal-care-products-safety-act-of-2015/ (Last Accessed – July 2018)

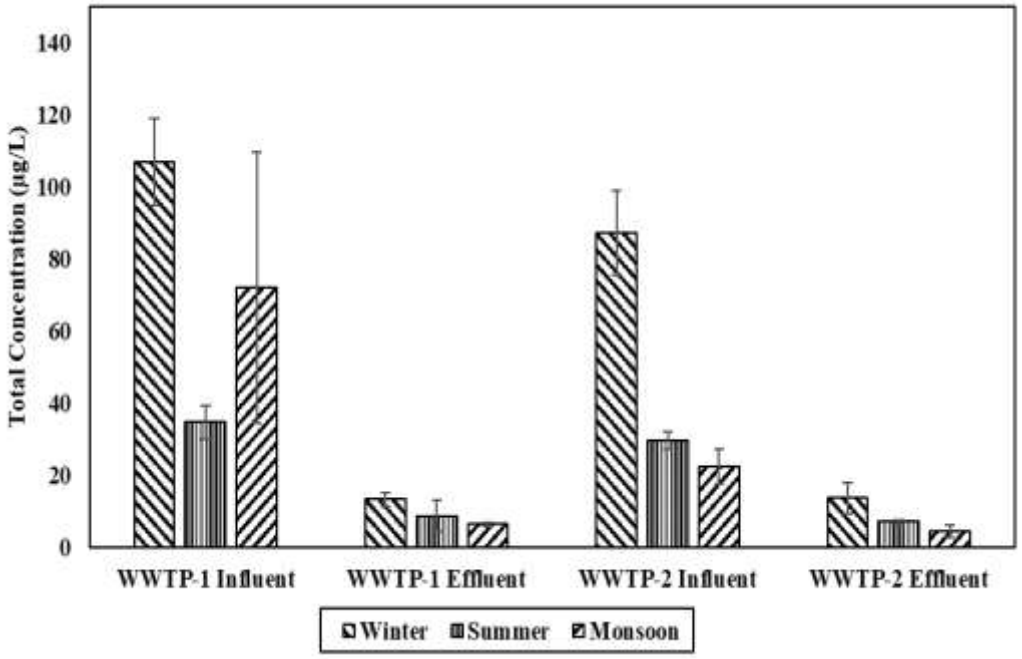
Endocrine Disruptors

- ‘Endocrine Disrupting Compounds/Chemicals’ (EDCs) are substances that mimic a hormone in the endocrine system and disrupt the function of the hormone.
  - Bisphenol A (BPA) – plastic water bottles, white vegetable can liners
  - Estrogenic substances - birth control pills
  - Pthalates - in toys and air fresheners
  - Fire retardants

Source: https://desdaughter.com/2016/12/02/endocrine-disruptors-the-manufacture-of-a-lie/ (Last Accessed – July 2018)

PPCPs and EDCs (2013-2021)

Findings: Found on all three continents with similar patterns and removals. Wastewater effluent concentrations are typically in µg/L range



Seasonal variation in total concentrations of monitored pharmaceuticals in the influents of two Indian WWTPs.

Mohapatra, S., Sharma, N., Mohapatra, G., Padhye, L. P., & Mukherji, S., Seasonal variation in Fluorescence Characteristics of Dissolved Organic Matter in Wastewater and Identification of Proteins through HRLC-MS/MS, Journal of Hazardous Materials, 2021, 413, 125453.

Padhye LP, Yao H, Kung'u FT, Huang CH. Year-long evaluation on the occurrence and fate of pharmaceuticals, personal care products, and endocrine disrupting chemicals in an urban drinking water treatment plant. Water Res. 2014 Mar 15;51:266-76.

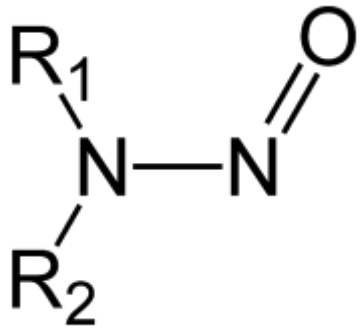
Kumar R, Sarmah AK, Padhye LP. Fate of pharmaceuticals and personal care products in a wastewater treatment plant with parallel secondary wastewater treatment train. J Environ Manage. **2019** Mar 1;233:649-659.

Disinfection By-Products (DBPs)

- DBPs are formed when water/wastewater disinfectants react with organics present in the matrix to form more toxic compounds
  - Suspected Carcinogens
  - Suspected to affect reproduction
  - Large population exposure to DBPs
  - Traditional DBPs include: trihalomethanes, haloacetic acids
  - Emerging DBPs include:

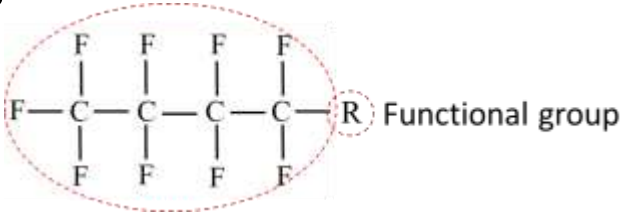
    Nitrogenous DBPs like nitrosamines

    <u>Cancer-causing at ng/L</u>

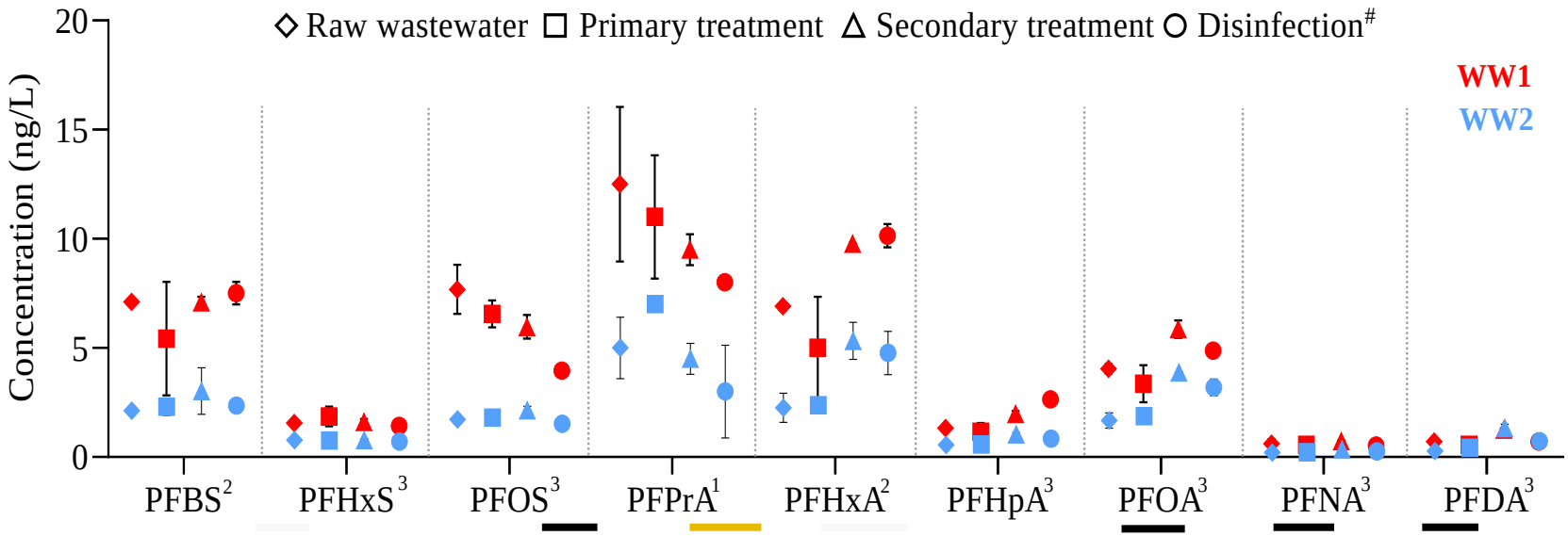


Per-and Polyfluoroalkyl Substances (PFAS)

- Termed as ‘Forever Chemicals’ due to C-F bond
  - Present everywhere in our daily lives
  - Toxic at ng/L



PFAS (2020-present)



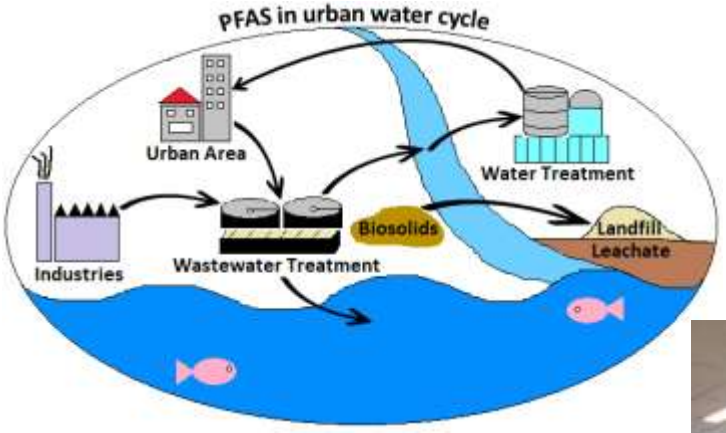
- More than 9,000 chemicals and only less than 1% could be quantified with the current analytical techniques
- Present even in a country like New Zealand which has no PFAS manufacturing industry
- In India, PFAS are unregulated while the developed world is moving towards regulations at ng/L

Lenka, S., Kah, M., **& Padhye, L. P.,** Occurrence and fate of poly- and perfluoroalkyl substances (PFAS) in urban waters of New Zealand, Journal of Hazardous Materials, 2022, 428, 128257.. https://10.1016/j.jhazmat.2022.128257

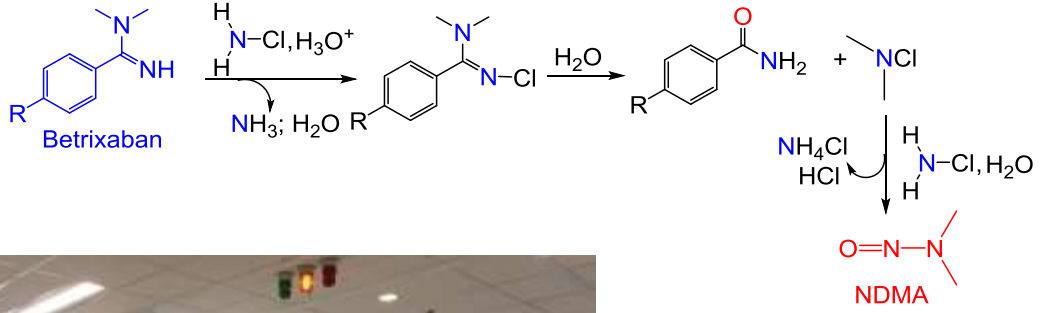
Plastic (Microplastics)

- Microplastics (<5 mm) are everywhere
  - Direct ingestion by organisms
  - Accumulation in the food chain
  - Vectors for other pollutants

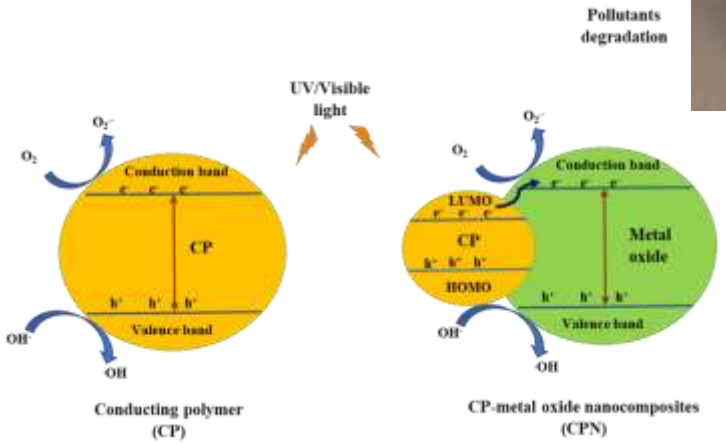
Emerging Contaminants Laboratory



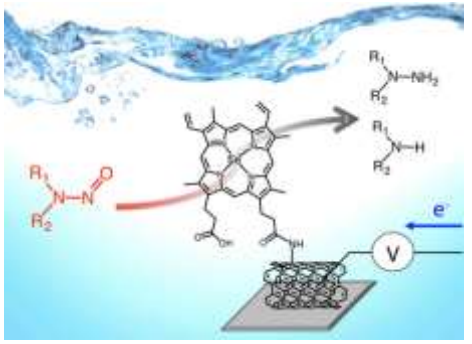
Occurrence and Fate



Transformation



Innovative Treatments



Key Messages

- Contaminants documented in water for >50 years
- More and more ‘emerging contaminants’
- If we look hard enough, we will find contaminants
- No treatment process is “perfect”
- Pollutant reduction vs. pollution relocation
- Cleaner water vs. carbon footprint

Acknowledgements

- **Collaborators:**



- **Funding Sources:**