Pharmaceuticals in Treated Wastewater Effluent and Effect on Public Health

Collaboration Project between **Sharjah Research Academy** & **University of Sharjah**

Shorjo Bhattacharjee, Post-doctoral Researcher (SRA)
Prof. Abdallah Shanableh (UoS)
Prof. Mufid Samarai (SRA)
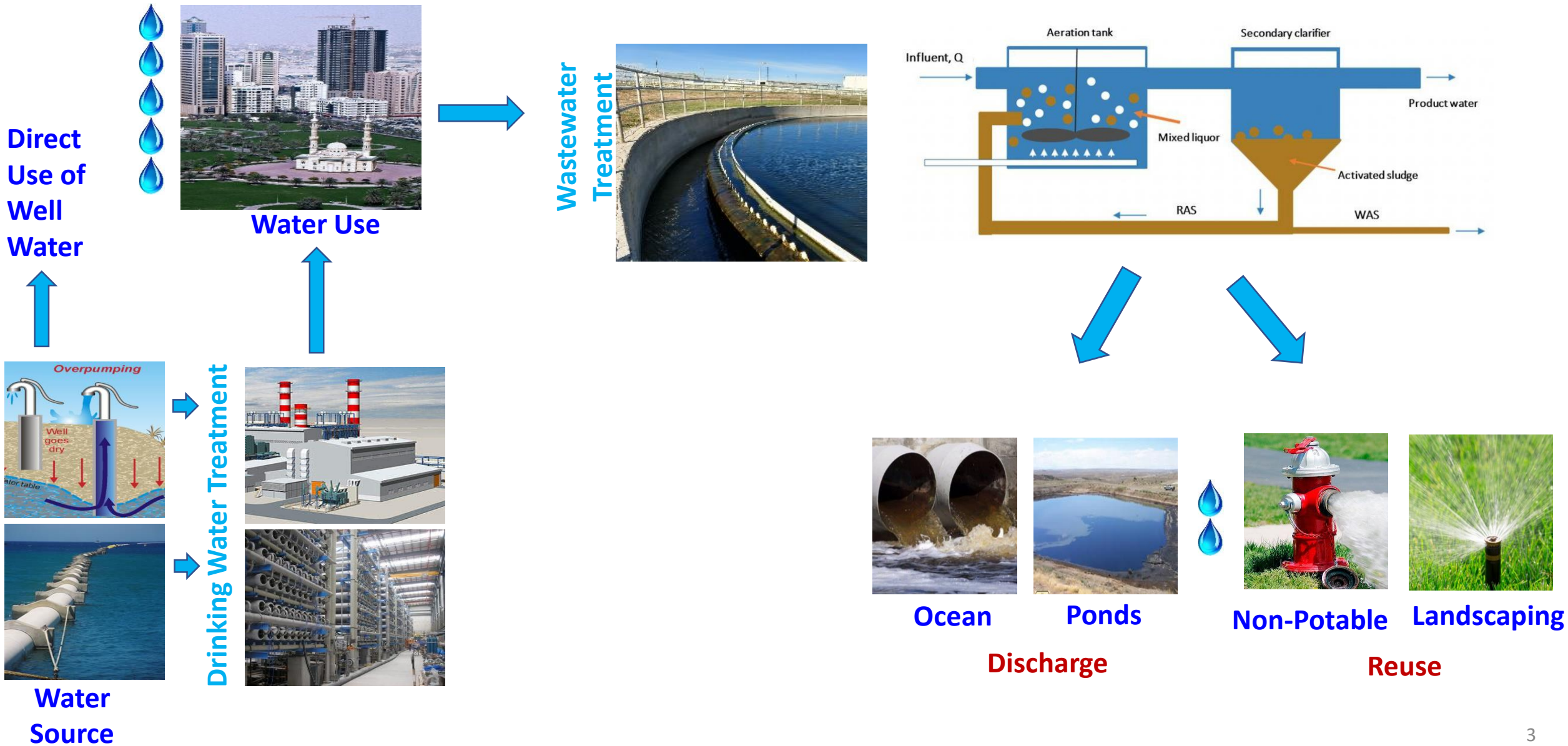Rulla Saad, Researcher (SRA)

November 20, 2019

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Water Cycle

Direct Use of Well Water

Water Use

Wastewater Treatment

Influent, Q

Aeration tank

Secondary clarifier

Product water

Mixed liquor

Activated sludge

RAS

WAS

Drinking Water Treatment

Water Source

Ocean **Ponds** **Non-Potable** **Landscaping**

Discharge **Reuse**

Wastewater Reuse Techniques

Agricultural
Food crops; Seed crops; Aquaculture; Greenhouses

Urban
Irrigation of public parks, sporting facilities, Street cleaning; Vehicle washing

Industrial
Processing water; Cooling water; Making concrete; Soil compaction
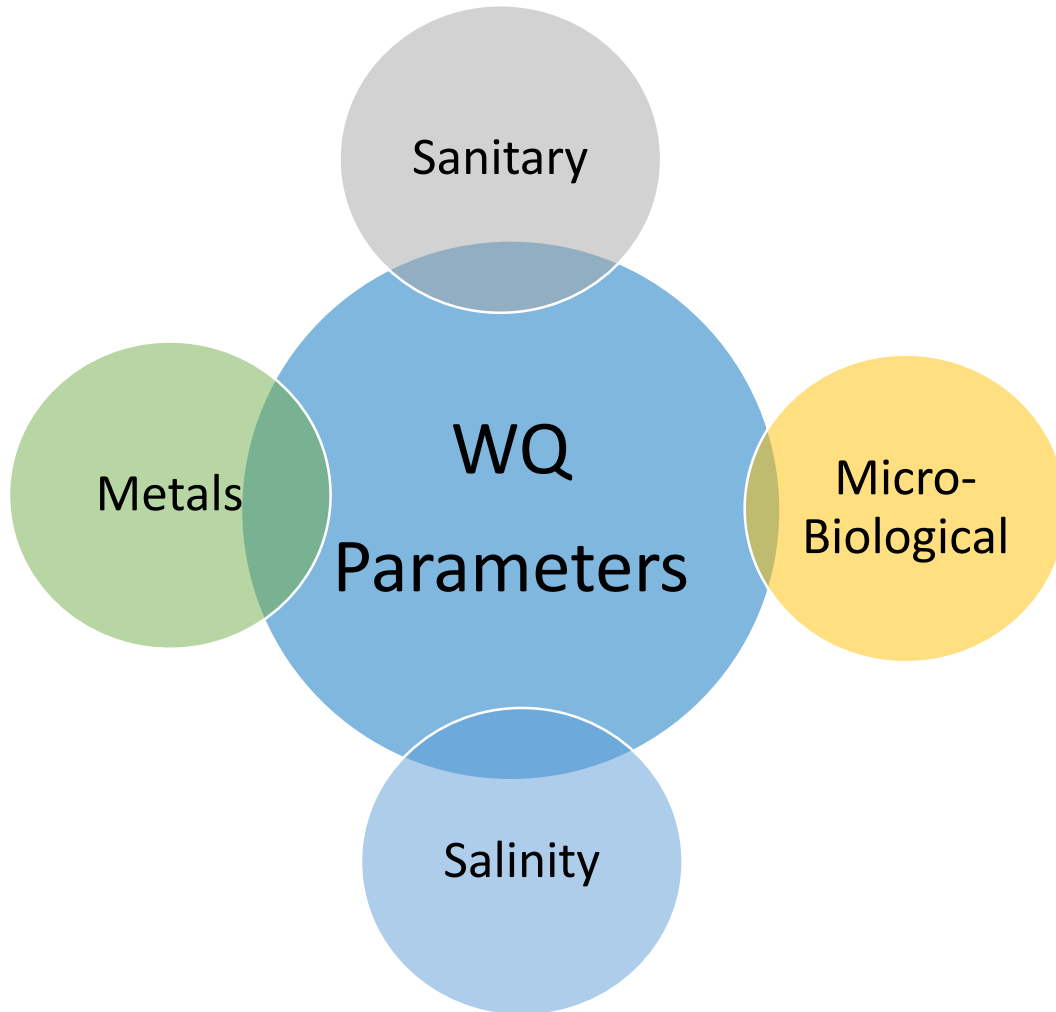

Recreational
fishing, boating, bathing

Environmental
wetlands, aquatic habitats

Potable

Water Quality Indicators

Indicators can be categorized into:

➢ Sanitary (pH, BOD, TSS, Turbidity)

➢ Microbiological (E. Coli/Fecal Coliform)

➢ Trace Metals (Al, As, Be, Co, Cu, etc)

➢ Salinity (Conductivity, TDS, Na)

Contaminants of Emerging Concern

Contaminants of Emerging Concern (CECs)

Pharmaceuticals

Pesticides

Personal Care products

Microplastics

Prescription & over the counter drugs

Insecticides, herbicides, fungicides

Body washes, shampoos, lotions

Microbeads from cosmetics, microfibers from plastic based clothing

Pharmaceuticals in Wastewater

- **Pharmaceutical compounds in wastewater systems a global challenge**

- Inadequate treatment technologies in place at wastewater treatment plants

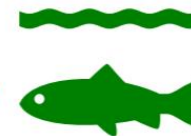- Even low levels (ng/L) of pharmaceuticals in environment are toxic

up to **>70%**
Amount of pharmaceutical dose excreted in urine
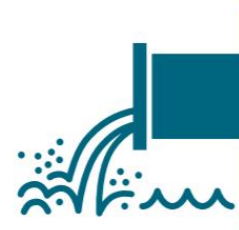
Wastewater treatment plants *are not designed to remove or degrade pharmaceuticals*
Pharmaceuticals are *released into the environment* in treated wastewater and sewage sludge

>200 Number of different pharmaceuticals detected in aquatic environments globally

antidepressants
antibiotics
Types of pharmaceuticals that have been detected in sewage sludge and treated wastewater
non-steroidal anti-inflammatory drugs
lipid regulators
anti-epileptics
beta blockers

Adapted from National Toxics Network Australia, Fact sheet, 2015

Pharmaceuticals at Sharjah Wastewater Treatment Plant

Type/ Classification	Analyte	Type/ Classification	Analyte
Antibacterial agents	Azithromycin	Central nervous system stimulants	Methamphetamine
	Erythromycin		Norbenzoylecgonine
	Lincomycin		Cotinine
	Ofloxacin		Caffeine
	Ranitidine		Nicotine
	Rifaximin	Insecticides	Imidacloprid
	Sulfameter		Acephate
	Sulfapyridine		Fenoxycarb
	Clarithromycin	Pesticides	Ethofumesate
	Erythromycin anhydrate		Hexythiazox
	sulfamethazine		Pymetrozine
	Sulfadiazine		Zoxamide
	Sulfamethoxazole	Antifungals	Azoxystrobin
	Ciprofloxacin		Thiabendazole
Hormones	Corticosterone		Imazalil
	Hydrocortisone	Nonsteroidal anti-inflammatory agents	Ketoprofen
	Estradiol		Naproxen
	17α ethinylestradiol		Paracetamol
	6a-Methylprednisolone	Cardiovascular	Digoxigenin
	Perfluorohexane sulfonate (PFHxS)	Antiprotozoal	Ternidazole
	Dosmosterol	Anticancer	Levamisole (tetramisole)
	Cholesterol	Antiepileptics	Carbamazepine
	Cholestanol	Anestitics	Benzocaine
Antihistamines	Chlorpheniramine	Contrast agents	P-aminohippuric acid
	Diphenhydramine	Personal care products	Benzyldimethyldodecylammonium chloride (BAC-C12)
	Tripolidine	Antihyper tension	Diltiazem
	Cetrizine		Metoprolol
Antipsychotic	Methylenedioxypyrovalerone (MDPV)		Atenolol
	Risperidone		

57 CECs identified
Pharmaceuticals
Pesticides
Personal care products
Sampling from January to November 2017

Shanableh, A., Semreen, M., Semerjian, L., Abdallah, M., Mousa, M., Darwish, N. and Baalbaki, Z., 2018. Contaminants of emerging concern in Sharjah waste water treatment plant, Sharjah, UAE. *Journal of Environmental Engineering and Science*, pp.1-10.

Pharmaceuticals at Sharjah Wastewater Treatment Plant

Sulfamethazine	Antibacterial agent
Ciprofloxacin	Antibacterial agent
Ofloxacin	Antibacterial agent
Risperidone	Antipsychotic
Erythromycin	Antibacterial agent
Acetaminophen	Analgesic/antipyretic
Sulfapyridine	Antibacterial agent
Sulfadiazine	Antibacterial agent
Sulfamethoxazole	Antibacterial agent
Metoprolol	Beta blocker
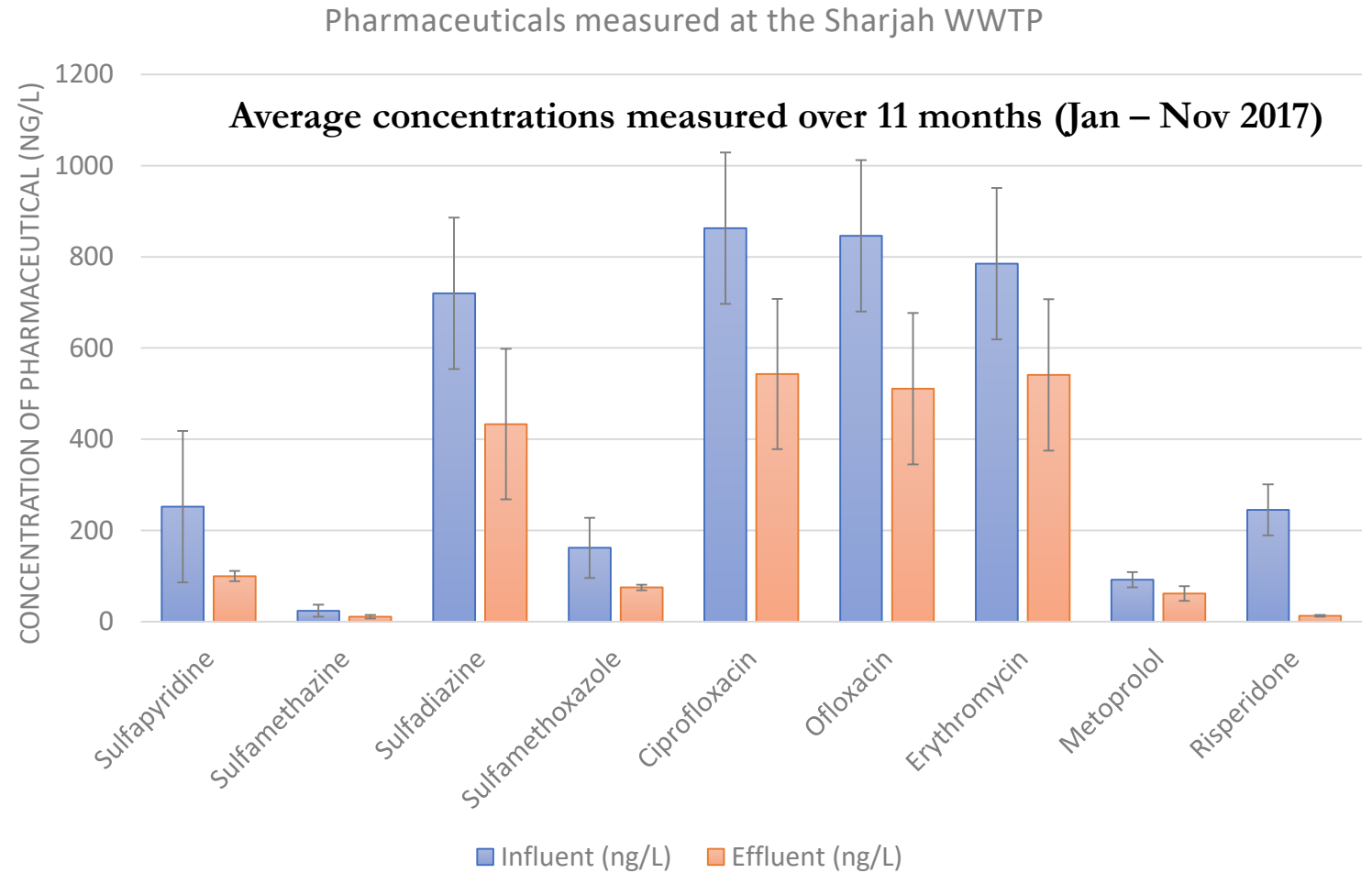
Pharmaceuticals measured at the Sharjah WWTP

**Average concentrations measured over 11 months (Jan – Nov 2017)**

Shanableh, A., Semreen, M., Semerjian, L., Abdallah, M., Mousa, M., Darwish, N. and Baalbaki, Z., 2018. Contaminants of emerging concern in Sharjah waste water treatment plant, Sharjah, UAE. *Journal of Environmental Engineering and Science*, pp.1-10.

Pharmaceuticals in WW & health effects

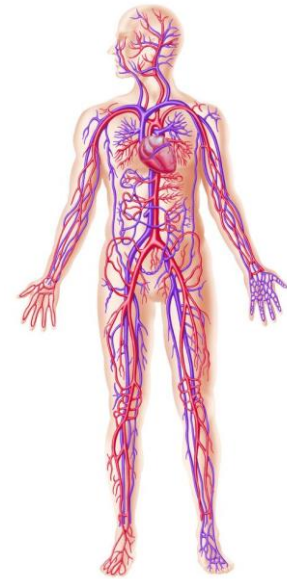- Acute toxicity to aquatic organisms
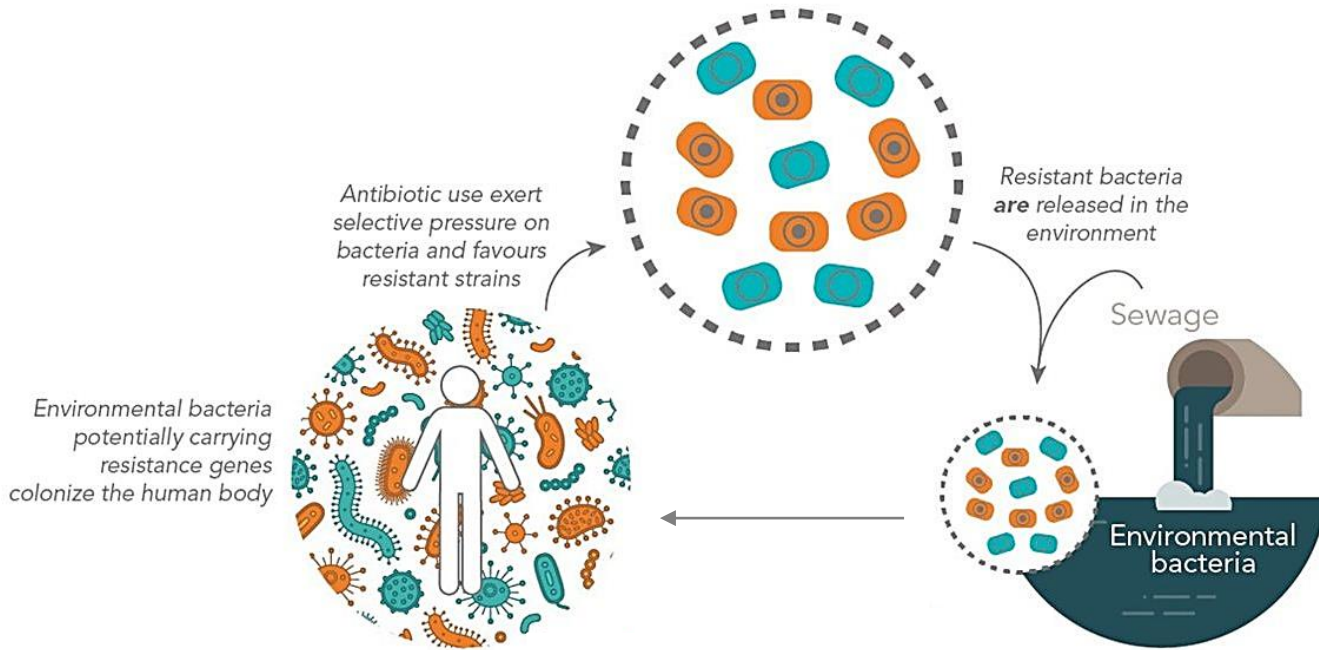- Feminization of male fish
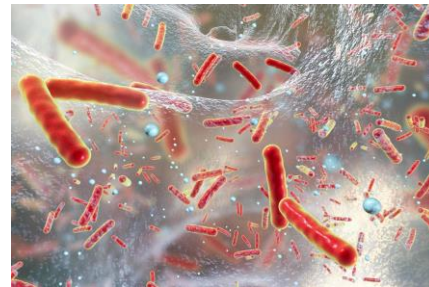
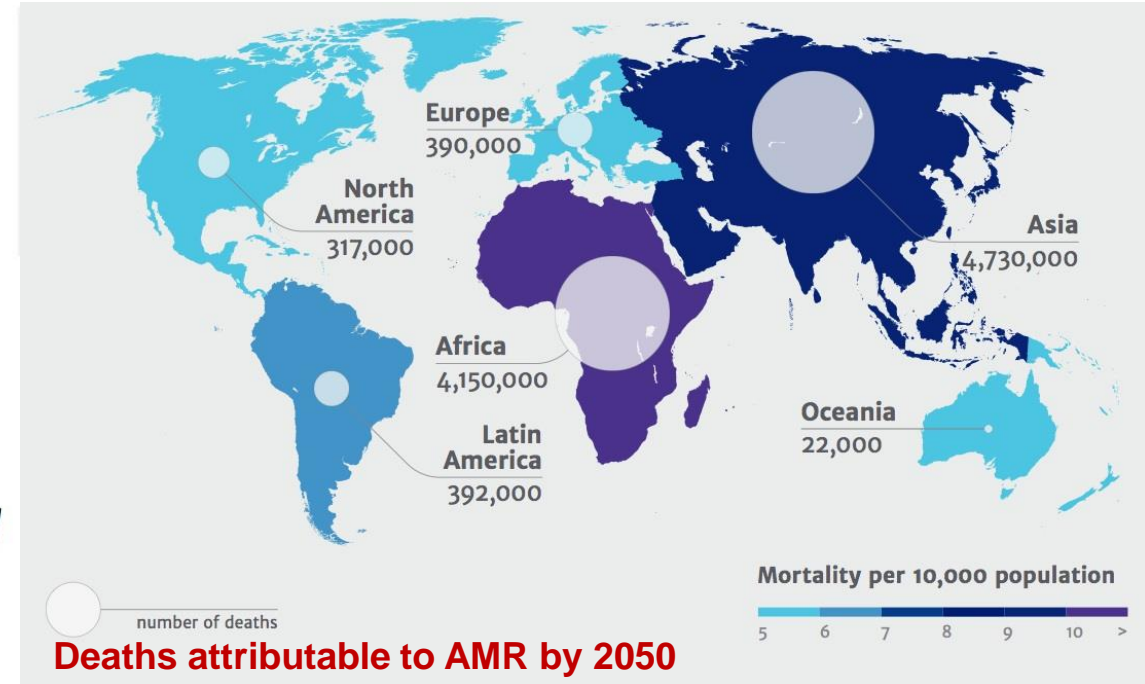Antibiotic resistance genes

Wastewater reuse

Human health impacts?

Pharmaceuticals in WW & health effects

Antibiotic use exert selective pressure on bacteria and favours resistant strains

Resistant bacteria **are** released in the environment

Sewage

Environmental bacteria potentially carrying resistance genes colonize the human body

Environmental bacteria

Adapted from - Mahfouz, N., Caucci, S., Achatz, E., Semmler, T., Guenther, S., Berendonk, T.U. and Schroeder, M., 2018. High genomic diversity of multi-drug resistant wastewater Escherichia coli. *Scientific reports*, *8*(1), p.8928.

Europe 390,000

North America 317,000

Africa 4,150,000

Latin America 392,000

Asia 4,730,000

Oceania 22,000

number of deaths

Mortality per 10,000 population

5 6 7 8 9 10 >

Deaths attributable to AMR by 2050

O'neill, J. I. M. "Antimicrobial resistance: tackling a crisis for the health and wealth of nations." *Rev. Antimicrob. Resist* 20 (2014): 1-16.

Risk assessed based on toxicological data

Landscape workers

Children

Adult facility users

Exposure through dermal routes and ingestion assessed Overall risk low (RQ <1)

Semerjian, L., Shanableh, A., Semreen, M.H. and Samarai, M., 2018. Human health risk assessment of pharmaceuticals in treated wastewater reused for non-potable applications in Sharjah, United Arab Emirates. *Environment international*, *121*, pp.325-331.

- **Effects of exposure of pharmaceutical cocktails?**

- **Environmental risks from accumulation in biota/aquatic food webs?**

- **Limited understanding of risks, lack of regulations**

- **Challenges with detection of CECs**

- **Better WW treatment techniques needed**

Overview of different treatment technologies for pollutant removal from wastewater

Performance of the technologies is represented by L –Low, M- Medium, H- High

Pollutant	BOD, COD	TSS	N	P	Alkalinity	Total Coliform	Viruses	TDS	TOC	Turbidity	Color	Emerging Micro-Pollutants (e.g., Pharmaceuticals, Pesticides, EDCs, etc.)
Conventional primary settling system	L	M	L	L					L	L	L	L
Conventional activated sludge system	H	H	L	L	M	L			H	H	L	L
Biological nutrient removal	H	H	H	H		L			H	H	L	L
MBR	H	H	H	H		M			H	H	H	M
Activated carbon	H	H	M	H		L	L	H	H	H	H	H
Tertiary filtration												
MF		H	L		M	M	L	L	M	H	M	L
UF		H	L		M	H	H	L	H	H	H	L
NF					H	H	H	H			H	H
Reverse osmosis			H		H	H	H	H	H		H	H
Chlorination						H		L				L
Ozonation						H	H					H
UV						H	M					
Constructed wetlands	H	M	H	M	H	M	M	L	M	M	M	M

Stefanakis, A.I., 2016. Modern Water Reuse Technologists: Tertiary Membrane and Activated Carbon Filtration. In *Urban Water Reuse Handbook*

Big data & contaminants in wastewater

Monitors and sensors to assess water quality -

- **Continuous addition of new chemicals**

- **Risks unknown**

- **Challenges with detections limits**

Big data can help with –

➢ **Understanding points of origin of contaminants**
     - Information of medicine use among population, polluting industries

➢ **Predicting treatment efficiency and additional treatment techniques required**

➢ **evidence-based decision making and investment planning**

Summary

- CECs such as pharmaceuticals in WW a critical issue

- Conventional treatment plants have limited capacity to treat CECs

- Significant knowledge gaps in health and environmental risks

- Opportunities for big data to aid with decision making related to emerging contaminants

Thankyou!