Identification of Emerging Water and Health Risk Factors in a Changing Climate

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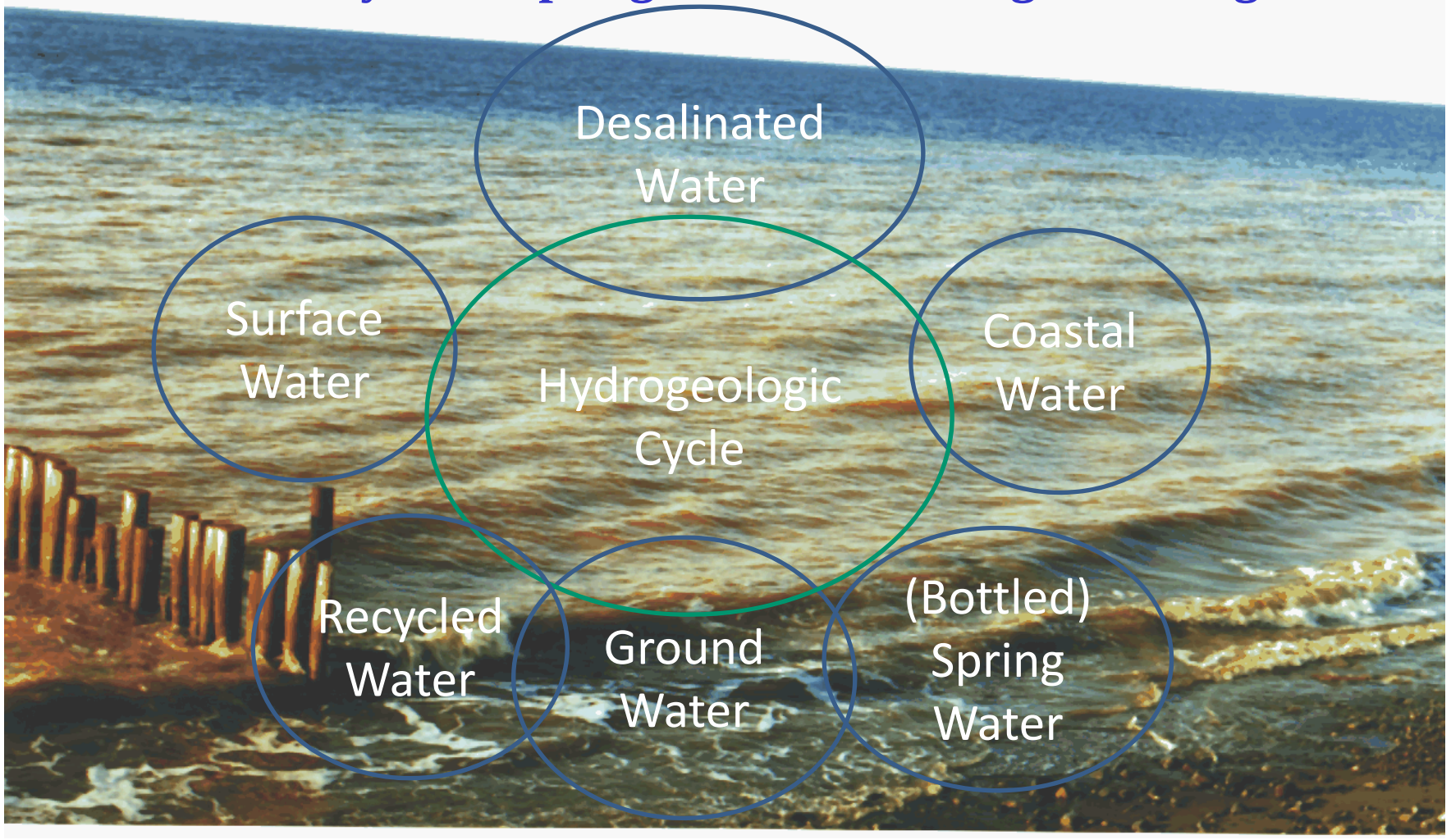
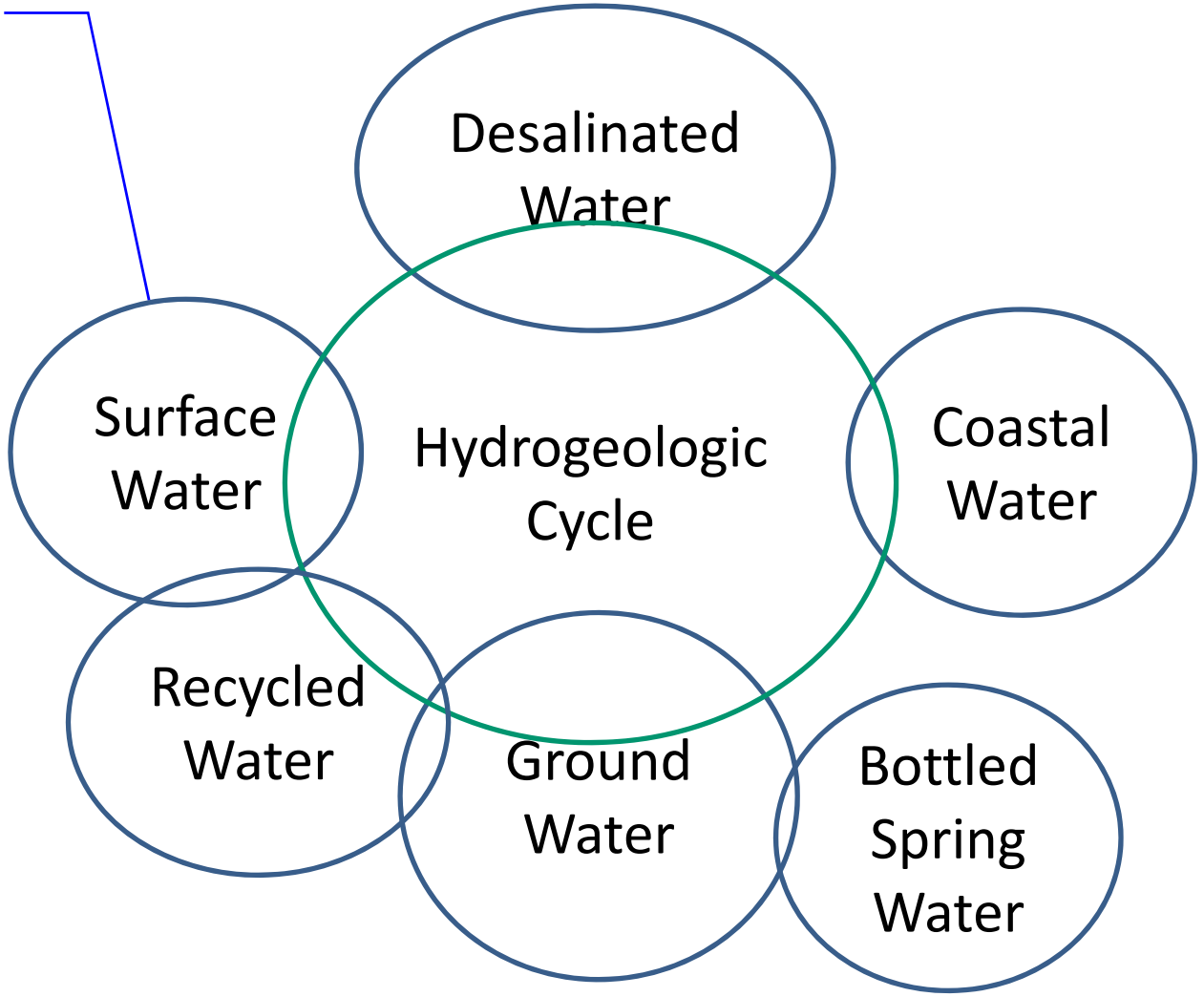
Harvard School of Public Health

How we STORE, TREAT and USE WATER will be key in adapting to climate change challenges



How WE STORE, TREAT AND USE WATER will be key in adapting to climate change challenges

- Supply Reduction
- Algal Blooms-Toxins-Treatment costs
- Pathogen maturation rates (*Cholera*)
- Runoff discharge
- Temperature-driven volatility, solubility, biodegradation effects on POP bioavailability
- Food supply contamination from irrigation



Harmful and Nuisance Algal Blooms

Cyanobacteria (blue-green algae) produce toxins (microcystins, nodularins, saxitoxins, anatoxin-a, anatoxin-a(s) , cylindrospermopsin) whose health effects range from liver damage, including liver cancer, to neurotoxicity.

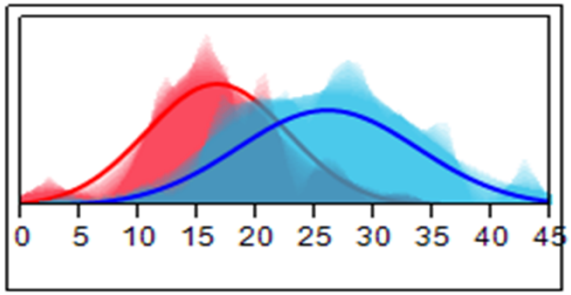
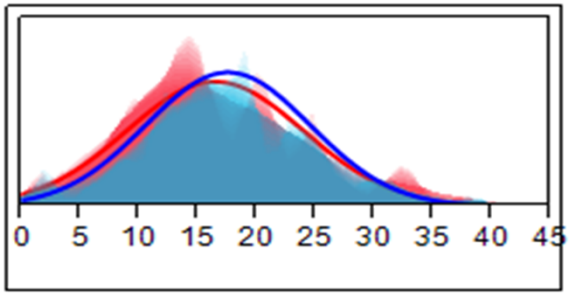
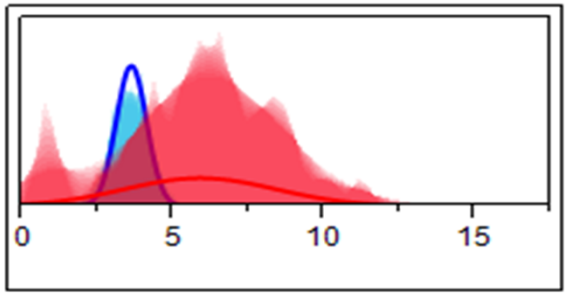
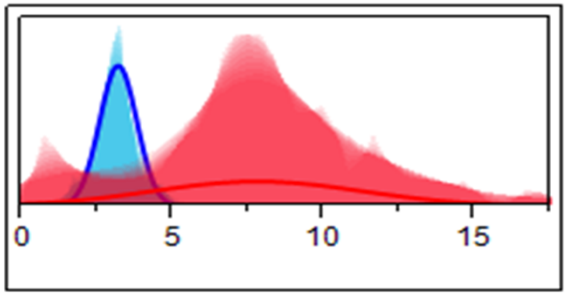
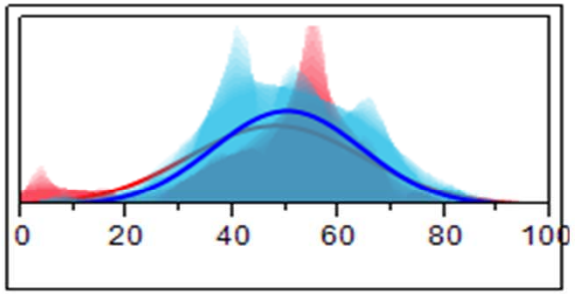
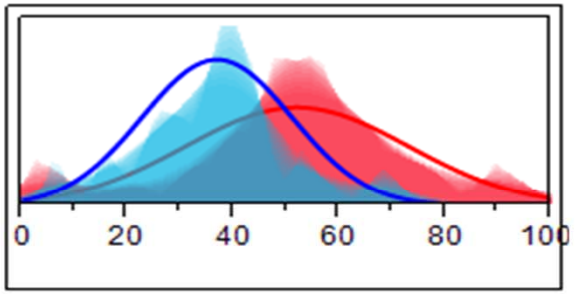
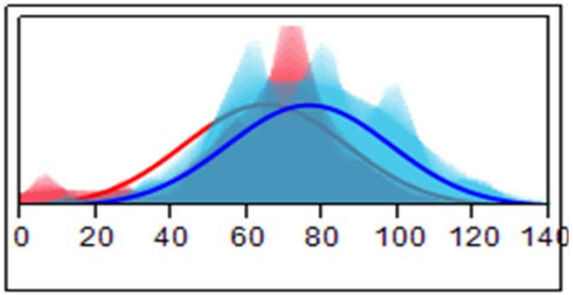
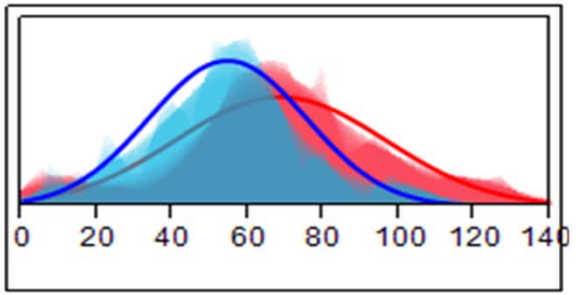
Nuisance algal blooms like those of *Cladophora spp.* are expected to grow in frequence in Cyprus coasts.

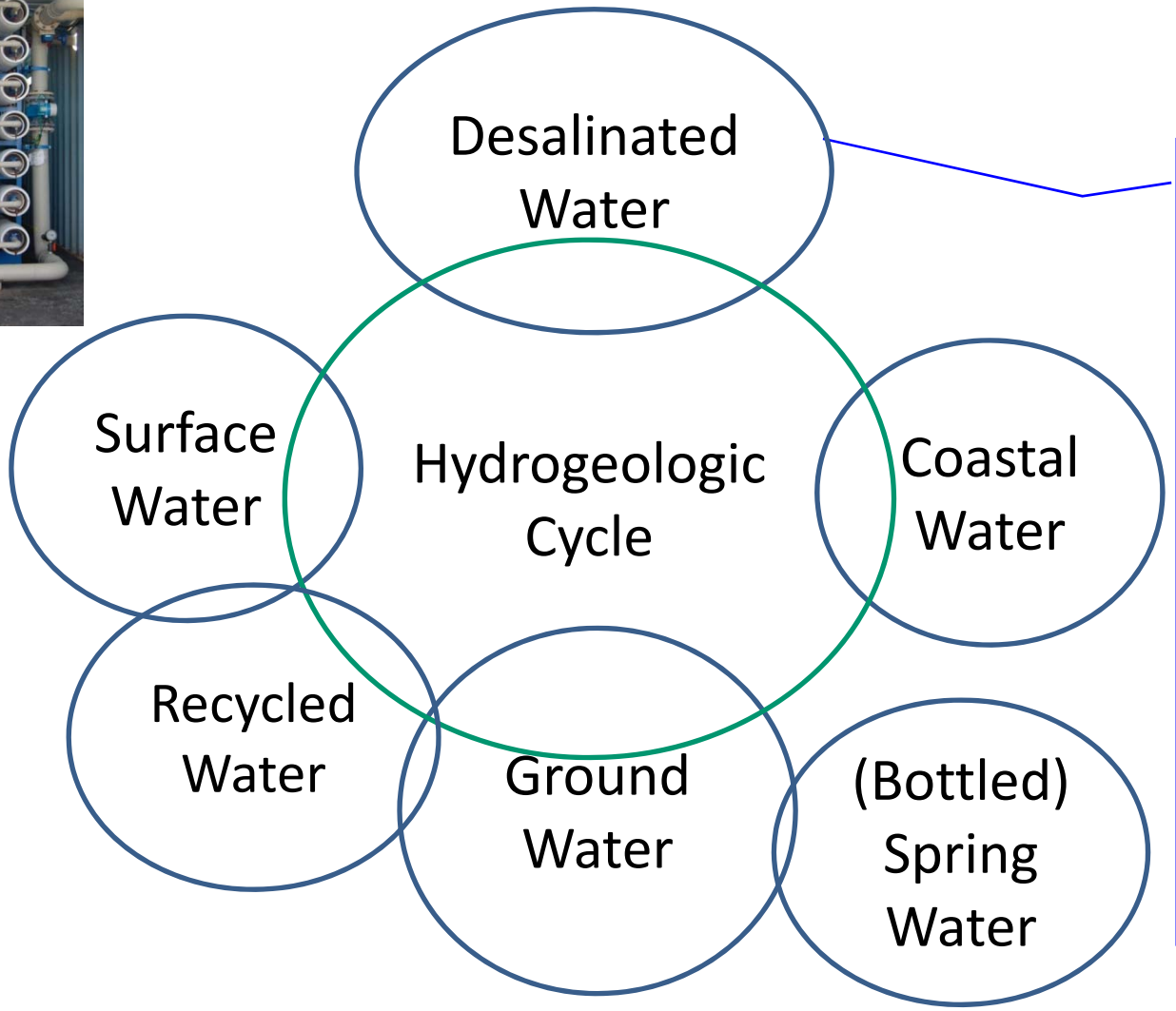
High Air and Water Temperatures

- Decrease dissolved oxygen levels
- Increase contaminant load to water bodies (both chemical and microbial)
- Reduce stream and river flows
- Foster algal blooms
- Increase the likelihood of saltwater intrusion near coastal regions
- Increase disinfection by product formation in potable water supplies
- Ozone formation
- Enhance ice/snow melt and possible release of POPs, e.g., PAH, PCB, Dioxins, EDC
- Volatility, Solubility, Biodegradation
- Increase incidence cases of *Legionella spp.* outbreaks due to prevailing of thermophila bacteria in higher ambient temperature environments

Reference by Noyes et al., 2009, Environ. International

Seasonal effect on the frequency distribution of individual and total trihalomethanes in tap water from study households located in the high (left panel) and low risk (right panel) water-district areas.

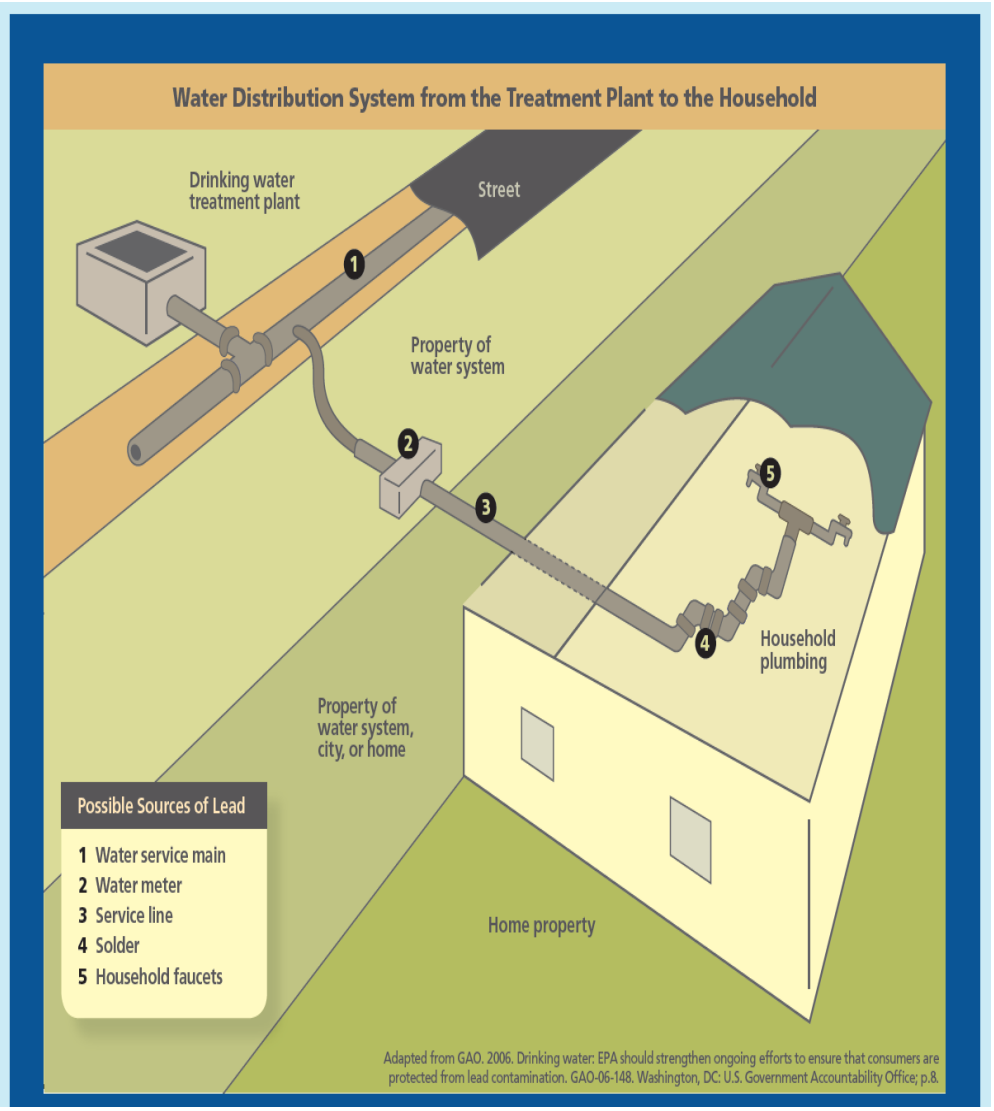
	HIGH RISK AREA (Red: summer; Blue: winter)	LOW RISK AREA (Red: summer; Blue: winter)
Cl_3		
Br_3		
Br-THM		
Total THM		



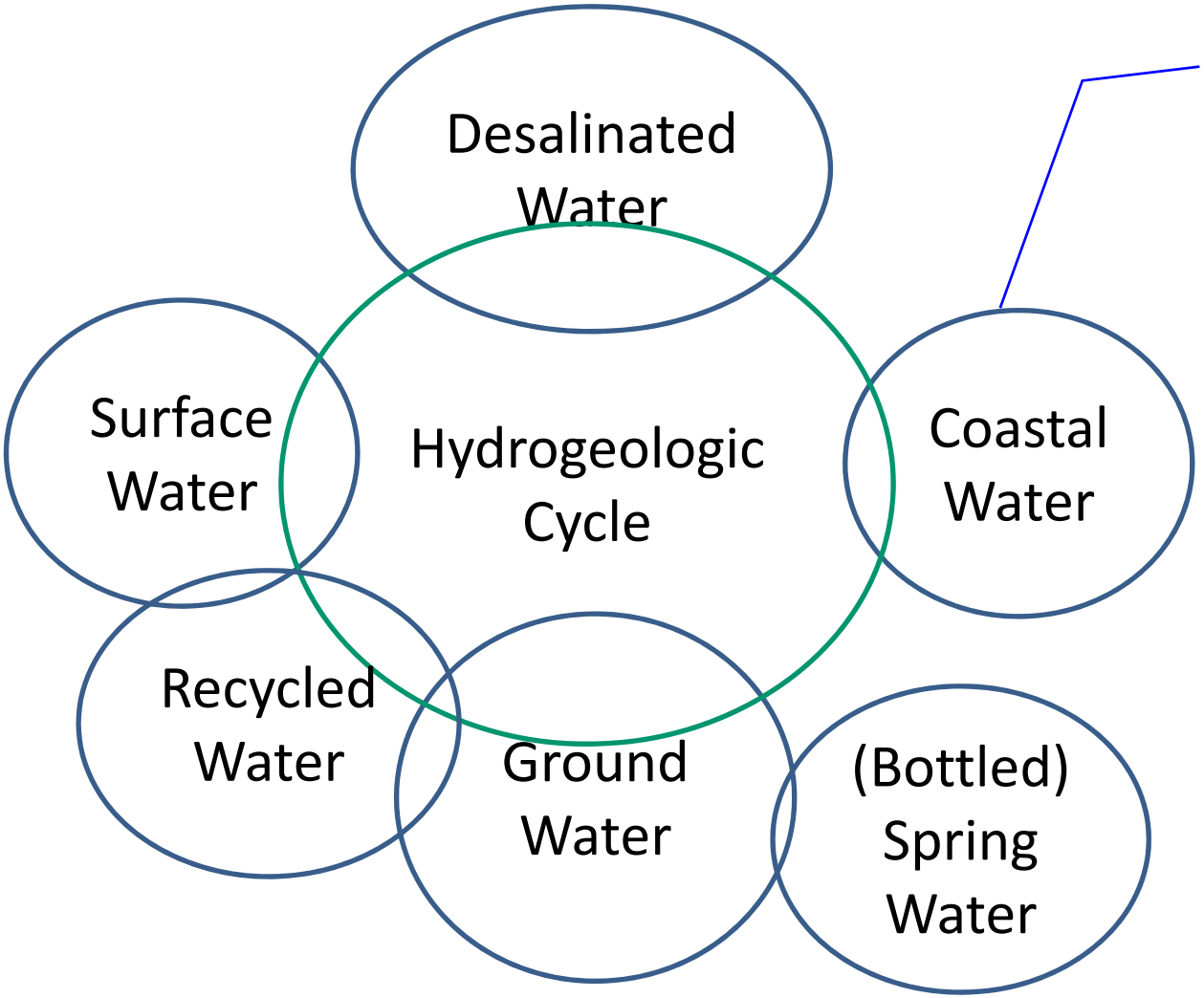
Seawater pollution with algae and petroleum products might endanger the quality of desalinated water, while treatment cost may be exacerbated. Infrastructure risk due to sea level for on-shore plants.

Potable Water in Urban Pipe Networks

- Finished water under quality deterioration (*DBP formation, biofilm/scales release, Legionella spp. outbreaks*).
- Stagnation and intermittent flow in drinking water distribution systems enhance biofilm growth.
- Changes in hydrostatic pressure within drinking water pipes may facilitate pipe leakage and soil/contaminants intrusion.
- Wet/dry alterations cause soil movement (swelling) impacting pipe physical condition failures/leakages.
- Backflow and wastewater intrusion into pipes of drinking water systems poses serious health risk.



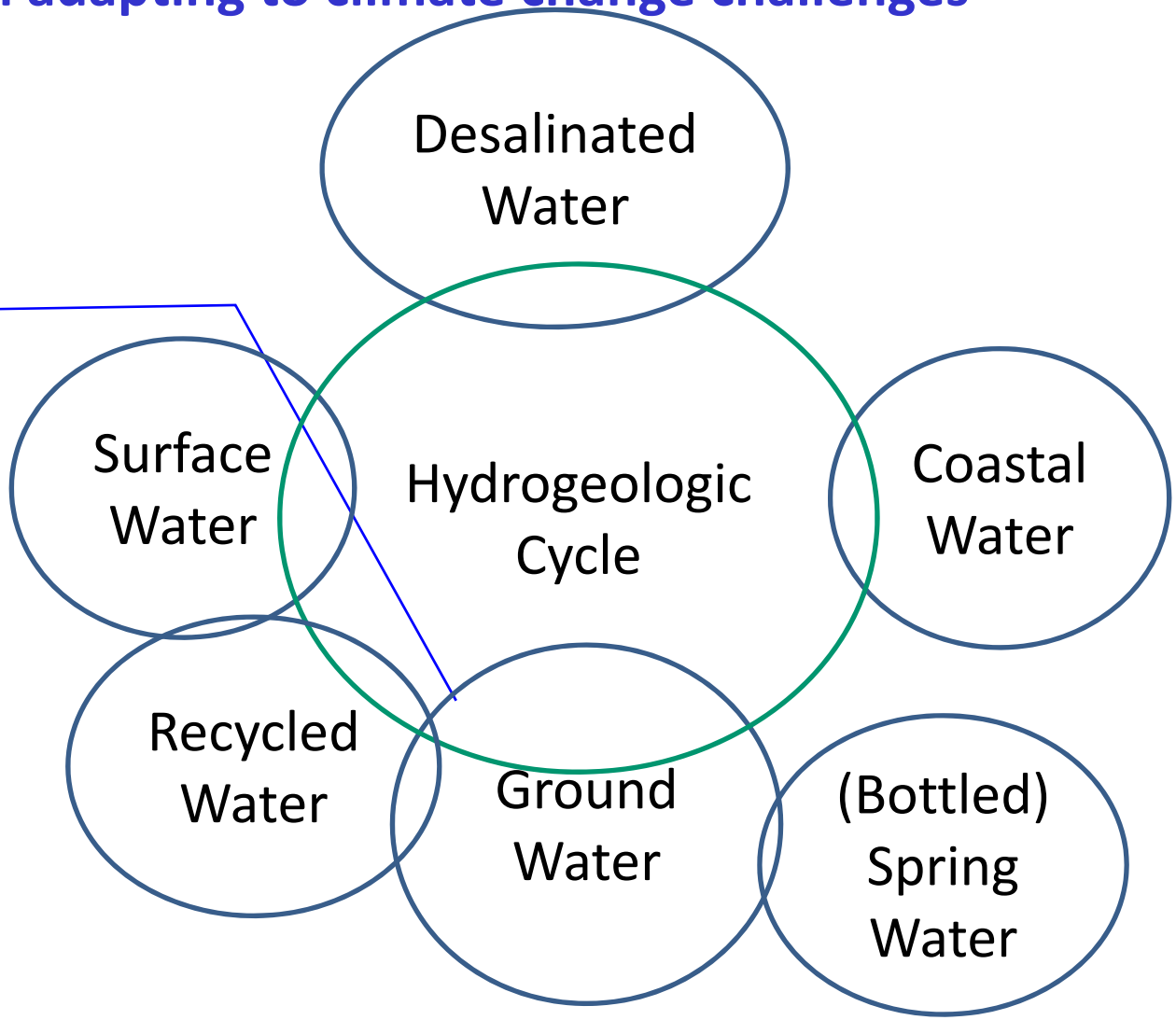
How WE STORE, TREAT AND USE WATER will be key in adapting to climate change challenges



- Fish productivity-Species extinction/migration
- Algal blooms-*Cladophora spp*.
- Dissolved O_2 reduction-Hypoxia-Fish kills
- Coral reef bleaching-zooplankton reduction
- Shell calcification reduction-Ocean acidification
- Coastal flooding by sea level rise(?)

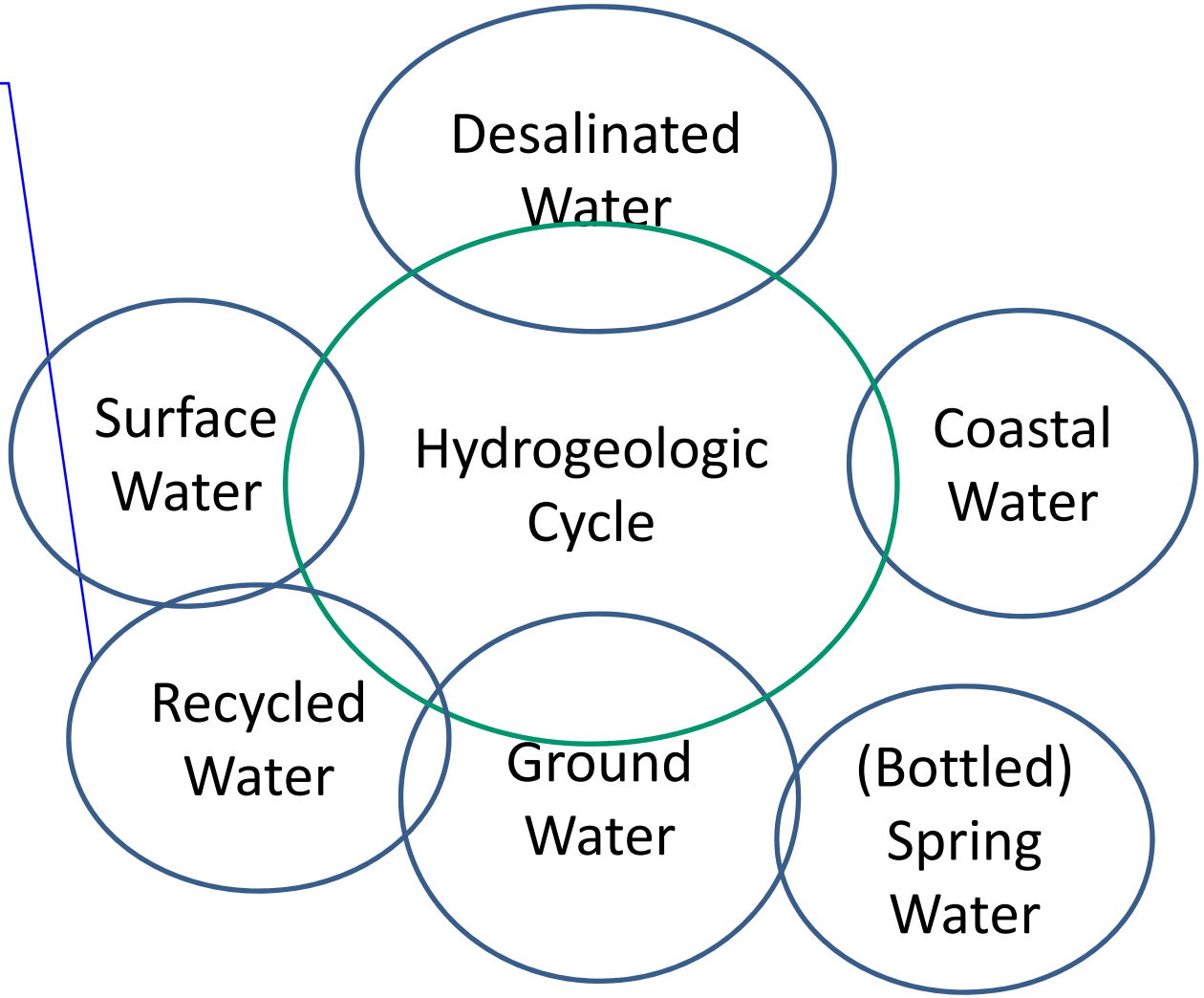
How WE STORE, TREAT AND USE WATER will be key in adapting to climate change challenges

- Low aquifer and river flow (anoxic zones) deteriorate water quality and increase treatment costs.
- Seawater intrusion-Brackish waters
- Salting-out effect for increased bioavailability of POPs
- Deeper water table pumping—higher costs



How WE STORE, TREAT AND USE WATER will be key in adapting to climate change challenges

- Increased demand
- Treated water quality reduction (xenobiotics)
- Urban storms may increase the contaminant load in treatment plants.



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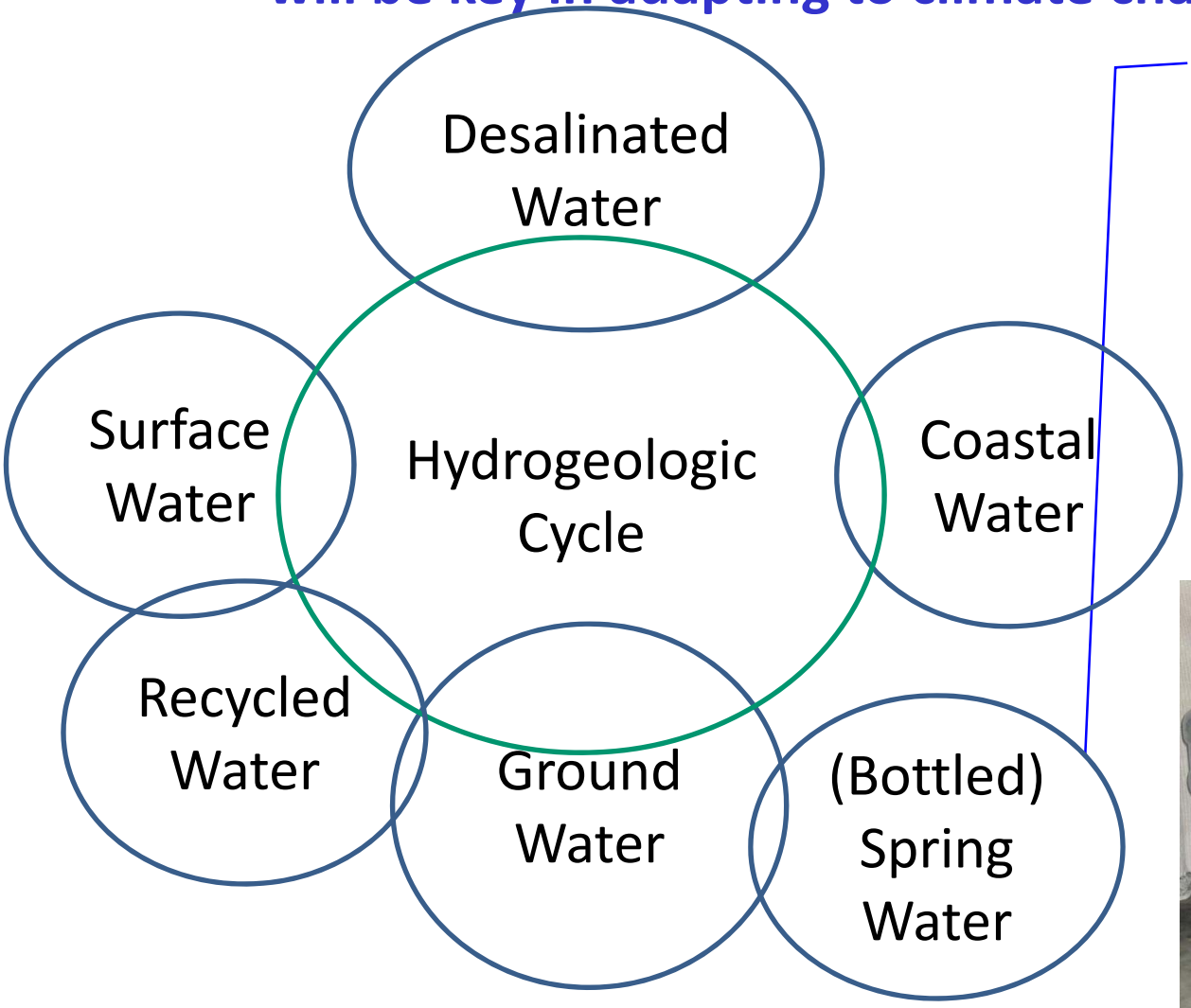
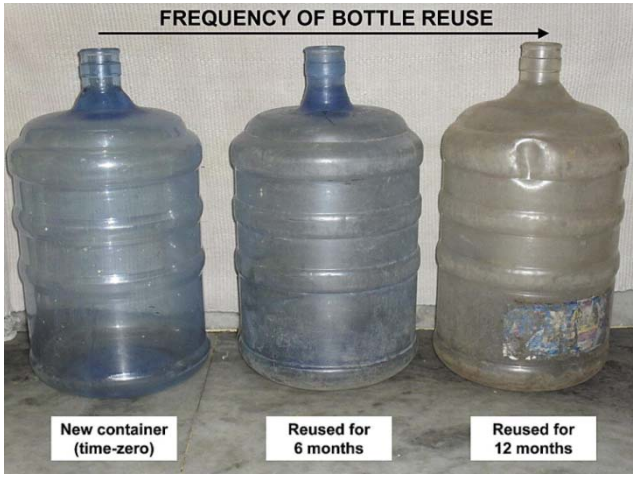
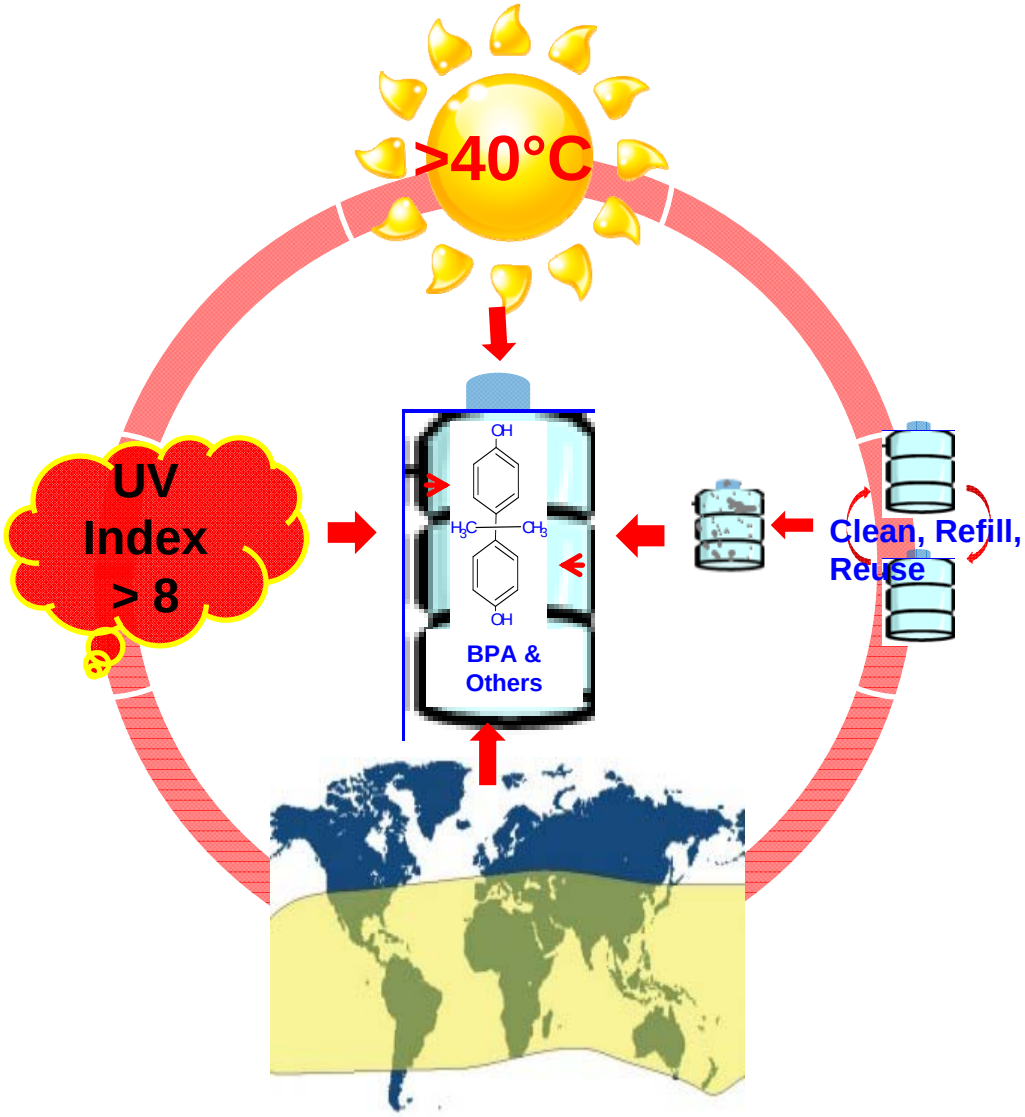


- Increased withdrawal-Spring capacity issues-Shift to bottled water
- Water quality reduction-Brackish waters
- Plasticizer leaching



INFLUENTIAL ENVIRONMENTAL FACTORS ON BOTTLED WATER QUALITY



Water and Health -- Adaptation Measures

1. Before hitting hard on economy, climate change effects on water sectors need to be classified and hierarchically addressed by pertinent agencies.

2. Interdisciplinary efforts need to be initiated by engaging plethora of expertises, ranging from engineers, economists, health scientists, biologists, environmental scientists, and others as needed.

3. Coastal infrastructure sustainability and maintenance, Sea level rise?

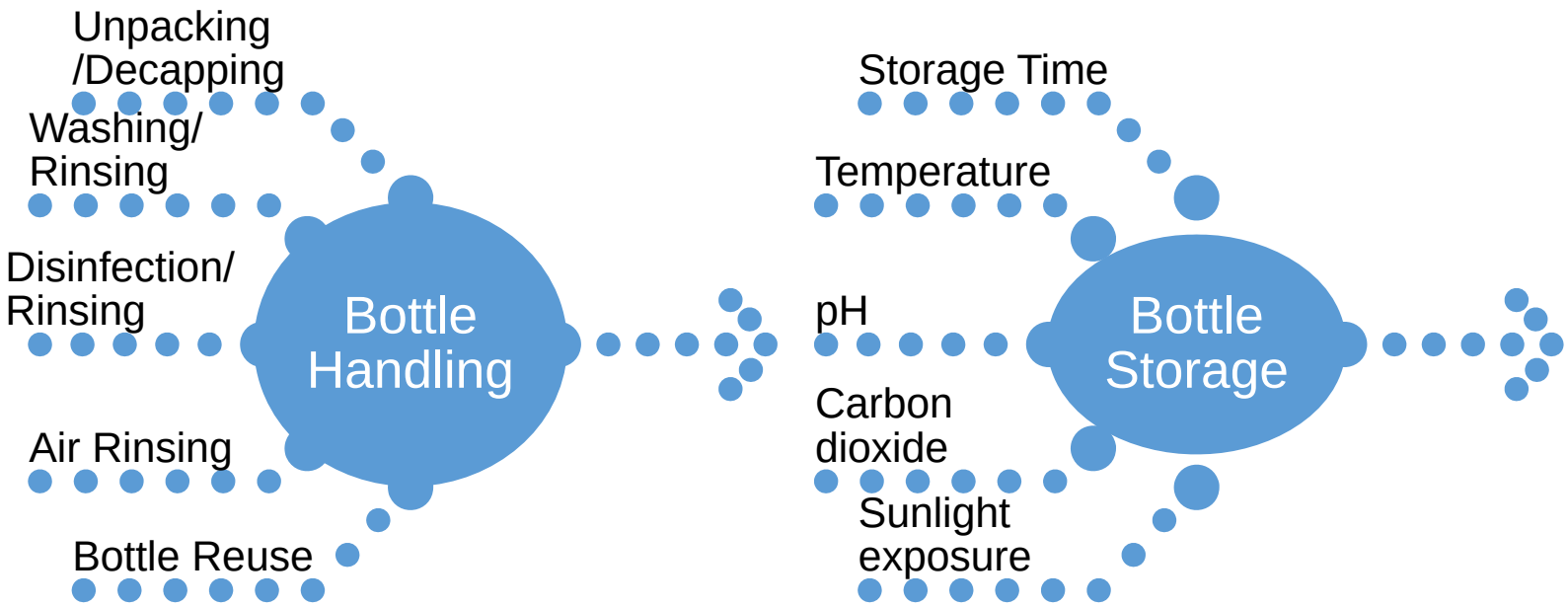
4. Disaster management and preparedness plans

5. Climate change and public health education and learning

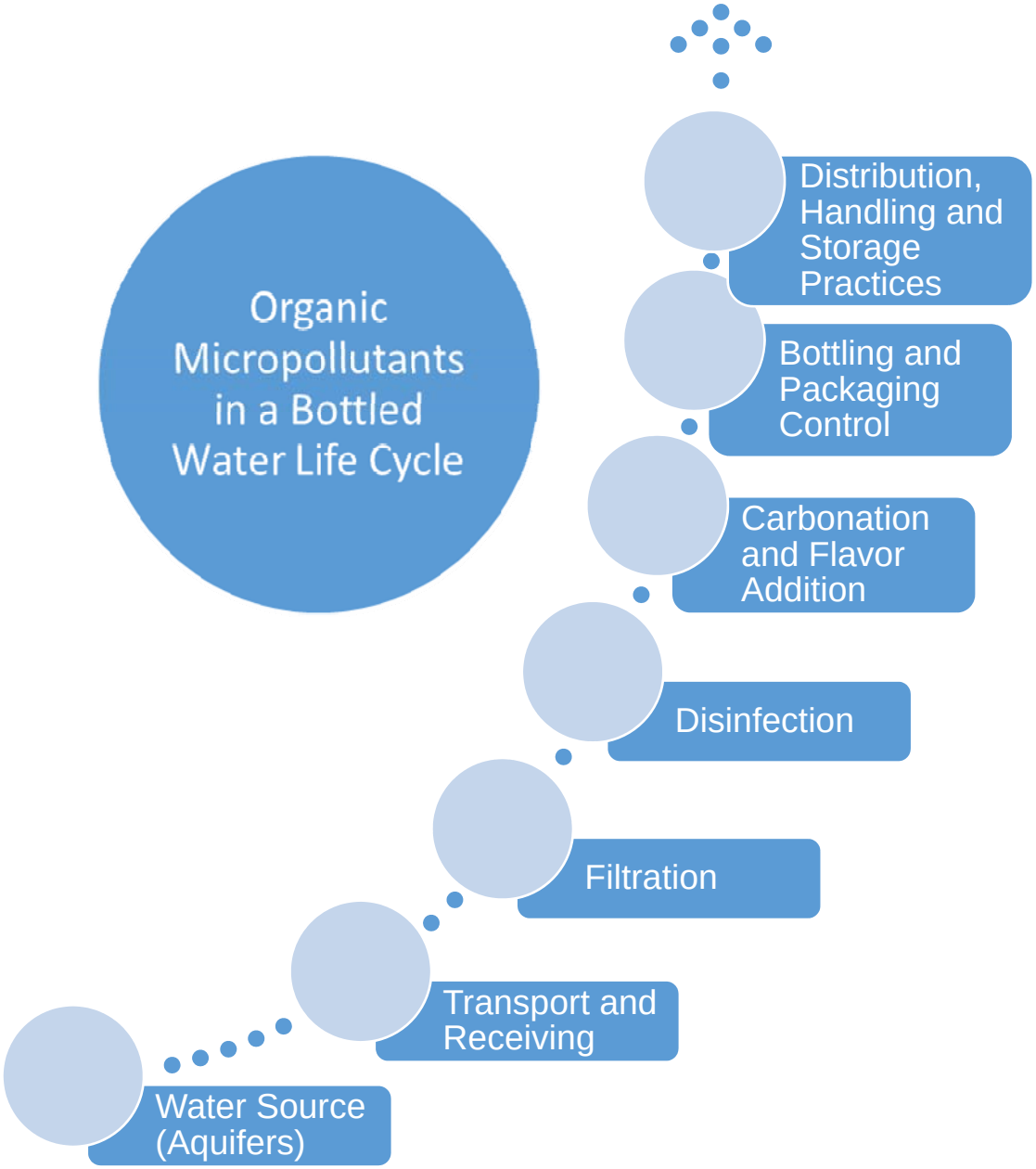
Acknowledgement

- Water and Health Team of the Cyprus University of Technology

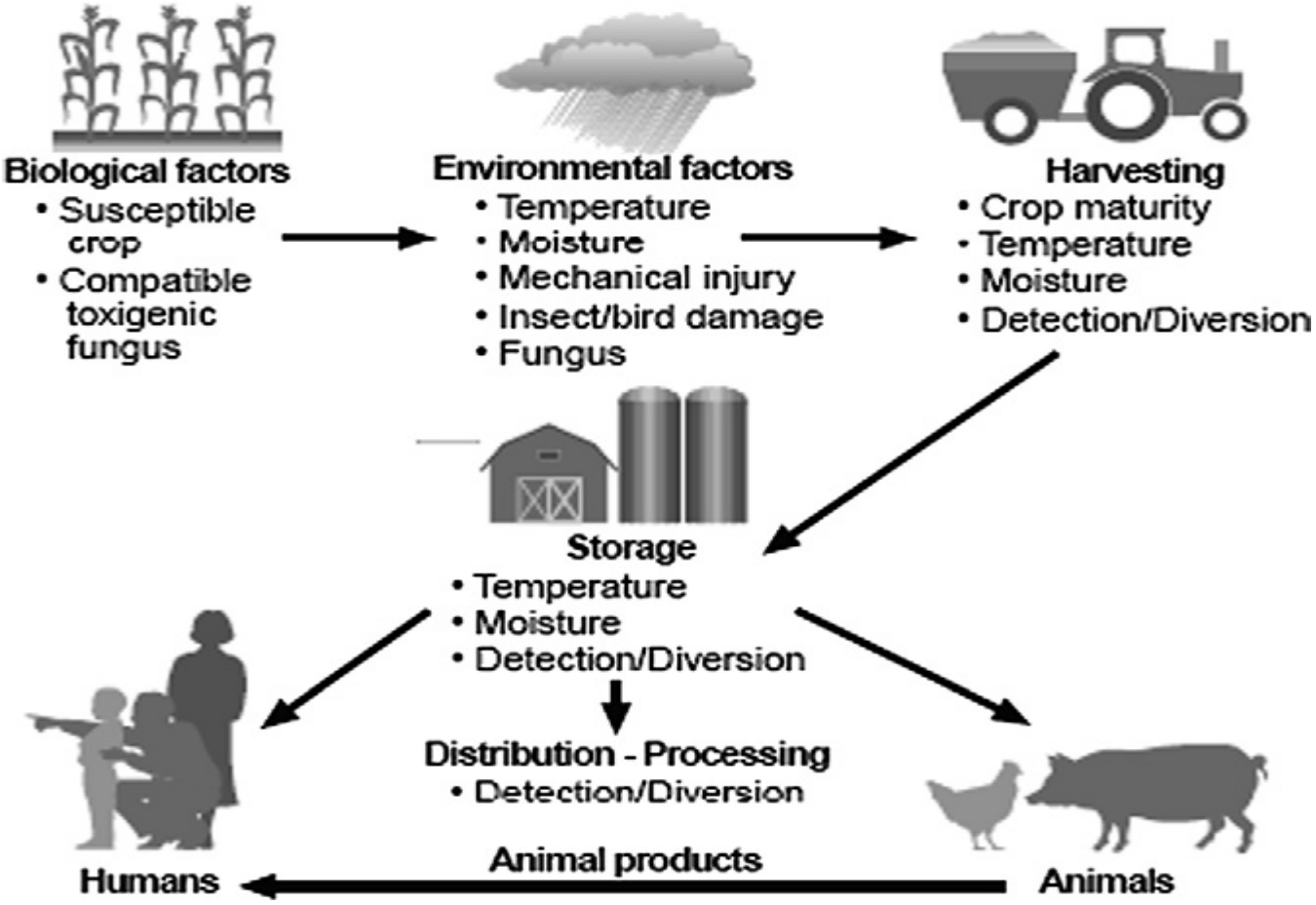
Understudied Life Cycle Stages Affecting Bottled Water Quality at the point of Use



STAGES OF MICROPOLLUTANTS INTRODUCTION



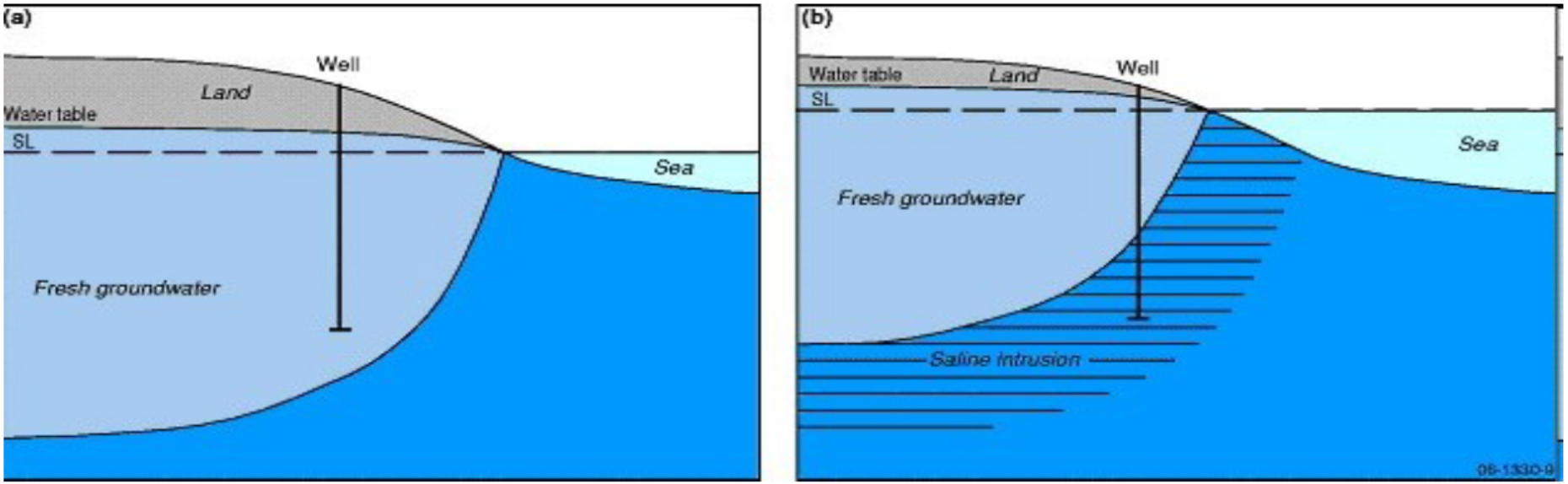
Climate Change and Aflatoxins



Reference: [1]Patterson and Lima, 2010. How will climate change affect mycotoxins in food? Food Research International 43 (2010) 1902–1914;
[2]CAST. (2003). Mycotoxins: Risks in plant, animal, and human systems. Ames IA, Council for Agricultural Science and Technology.

Sea Rise and SaltWater Intrusion

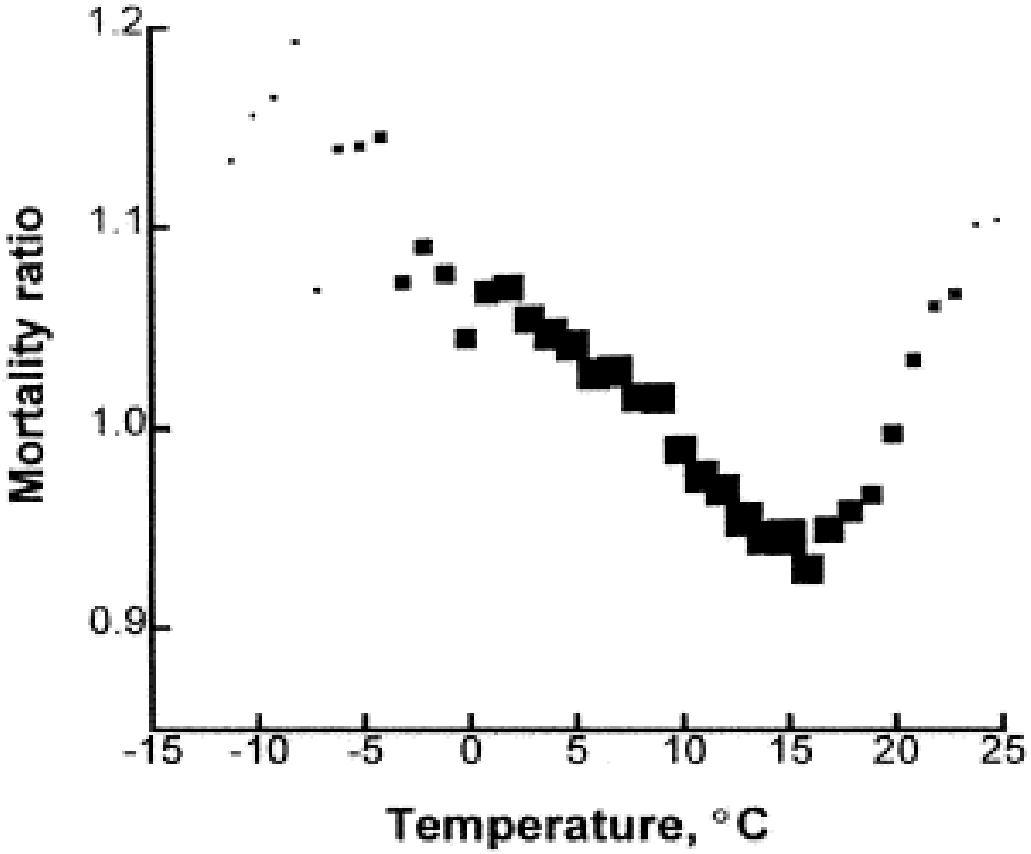
- Average estimated sodium intakes from drinking water ranged from 5 to 16 g day^{-1} in the dry season, compared with 0.6–1.2 g day^{-1} in the rainy season. The annual hospital prevalence of ***hypertension*** in pregnancy was higher in the dry season (OR = 12.2%; 95% CI, 9.5–14.8) than in the rainy season (OR = 5.1%; 95% CI, 2.91–7.26) (Khan et al., 2011, EHP).
- Increases in water salinity may increase POP/pesticide bioavailability due to salting out effect.



Extended Heat Periods and Heat Waves

1. Heat Stress may be overwhelming for patients suffering with cardiovascular or respiratory disease, diabetes, and other chronic diseases.

2. Need to estimate heat related mortality and compare it with the increased air pollution mortality due to the use of air conditioning in Peak demand seasons (summer).



Example of the impact of the average air temperature on daily mortality in humans. These data represent the mortality (324.7 deaths per day) in The Netherlands from 1979 to 1987.
The size of each block is proportional to the sample size. Data and graph modified from Kunst et al. (1993).

Shortened Gestational Age with Heat Stress Periods

•Gestational age at delivery determines fetal maturity at birth.

•Shorter gestational age at delivery was documented to be the primary cause of perinatal mortality, both in Europe and US.

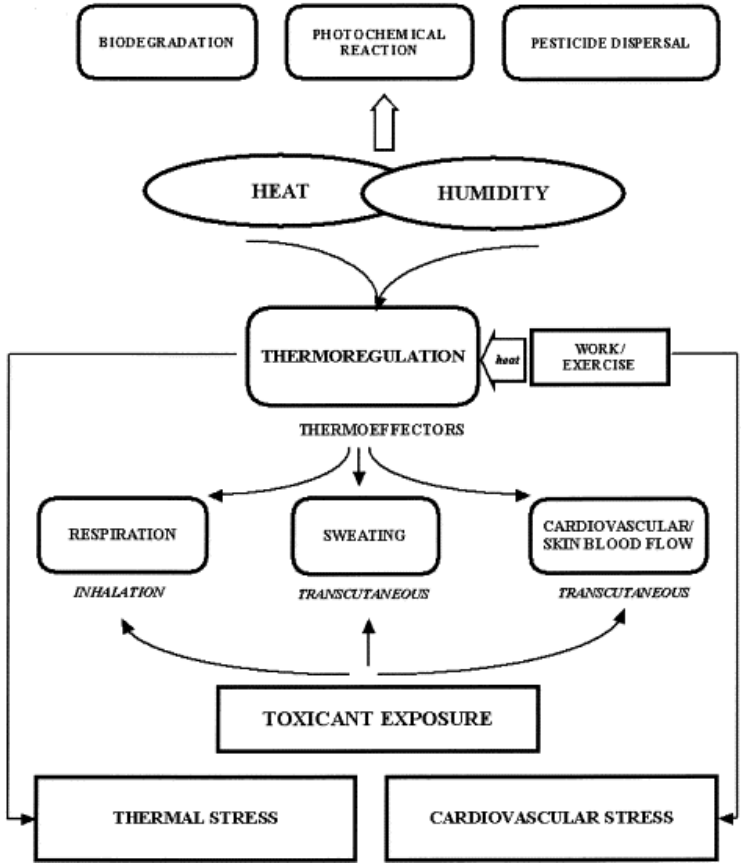
•Risk increases with decrease in gestational age.

•A 5-day reduction in gestational age was observed when subjects were exposed to 32 °C (Heat Index) on the day before delivery ($p = 0.03$)

Dadvand et al., 2011. Climate Extremes and the Length of Gestation. Environmental Health Perspectives.

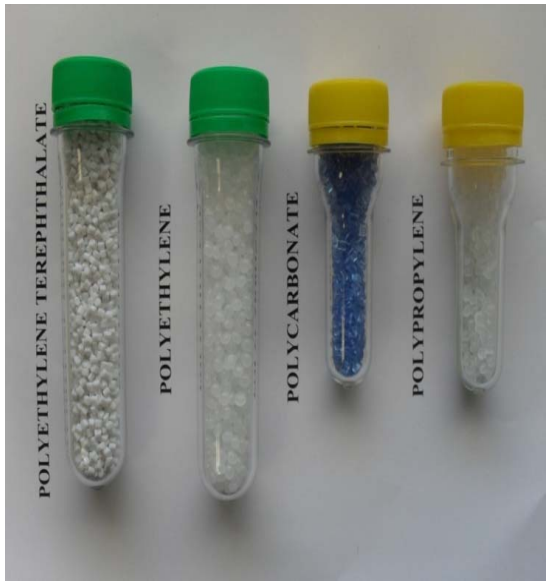
Stress-Pollution Interactions

- Temperature effects may be acting as an effect modifier towards the toxicity of a pesticide during an animal study (Gordon C.J., 2003, Environ. Res.). For example, toxicological experiments with rodents for a pesticide showed no-effect level at 5 mg/kg at relatively warm ambient temperatures when literature showed 75 mg/kg as a no-effect level.



(Gordon C.J., 2003, Environ. Res.)

EMERGING CONCERN(s)…
water contact materials



PLASTIC ADDITIVES AS WATER CONTAMINANTS