Real-time Environmental Monitoring of SARS Corona Virus-2, Harmful Bacteria and Toxics in Water and Wastewater Systems

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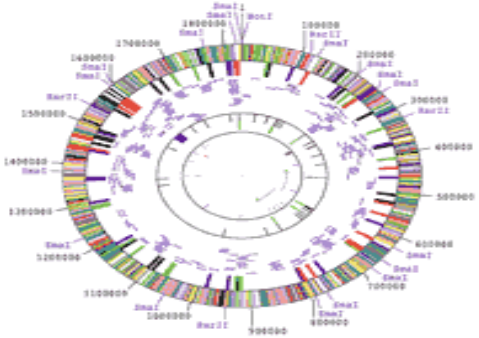
Remtech Europe

Session 11: Innovative Characterization Technologies and Digital Innovation

Speaker: Dr Charles CC Lee



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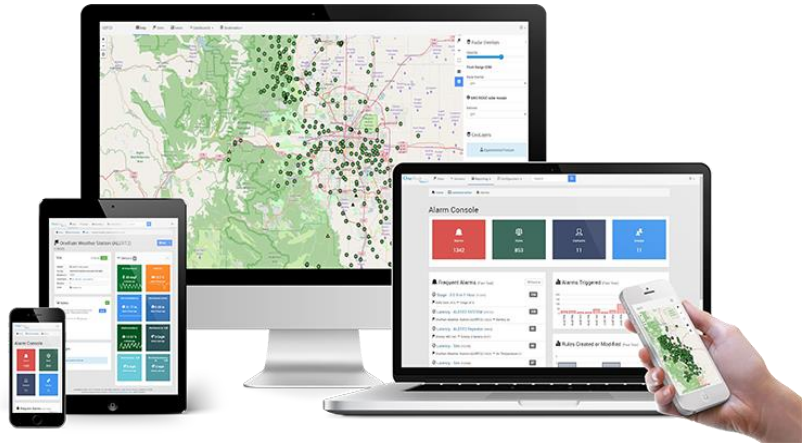
Outline

- What is Real-time 24/7 Monitoring – Water/Wastewater?
- Fluorescence Detection of Cyanobacteria, Toxins, SCV-2 (SARS coronavirus-2)
  - Excitation – Emission spectroscopy (EES)
  - Molecular probes – qPCR
- Wastewater Epidemiology
  - SCV-2 detection in wastewater
  - Real-time scalable cloud system



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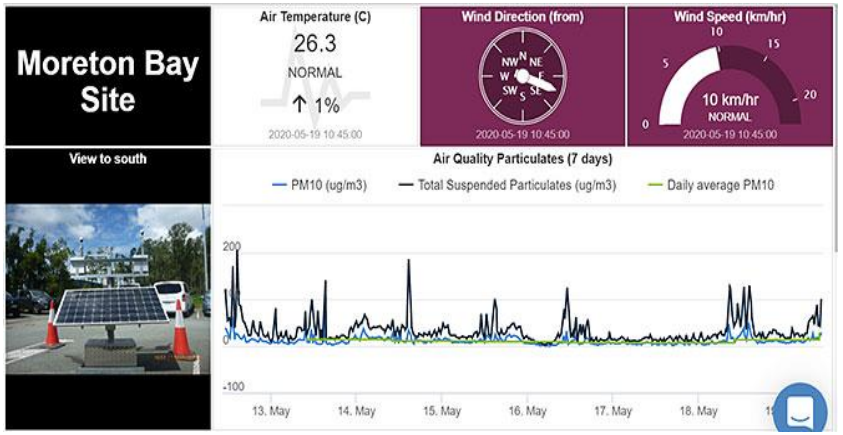
Real-time 24/7 Environmental Monitoring

- Real Field Environment – Complex Natural environment
  - Weather (temp, humidity)
  - Water Quality (pH, nutrients, toxic chemicals, algae, microbes)
- Based on electronic sensors (IoT), instruments, and systems that allow real-time and long-term data acquisition, data-logging, and telemetry
- Serves as early warning system
  - Pollution (air and water)



Source: Queensland Dept of Environment & Science

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Fluorescence Detection Technology

Excitation – Emission Spectroscopy (EES) used for detection of phytoplankton, and cyanobacteria in reservoirs and raw water

Pigment	Excitation (nm)	Emission (nm)	Cyanobacteria
Eukaryotic Algae (Phytoplankton)	430-530	685	
Chlorophyll a	435	685	Weak
Phycocyanin (PC)	450-660	650	Strong
Phycoerythrin (PE)	480	610	Strong

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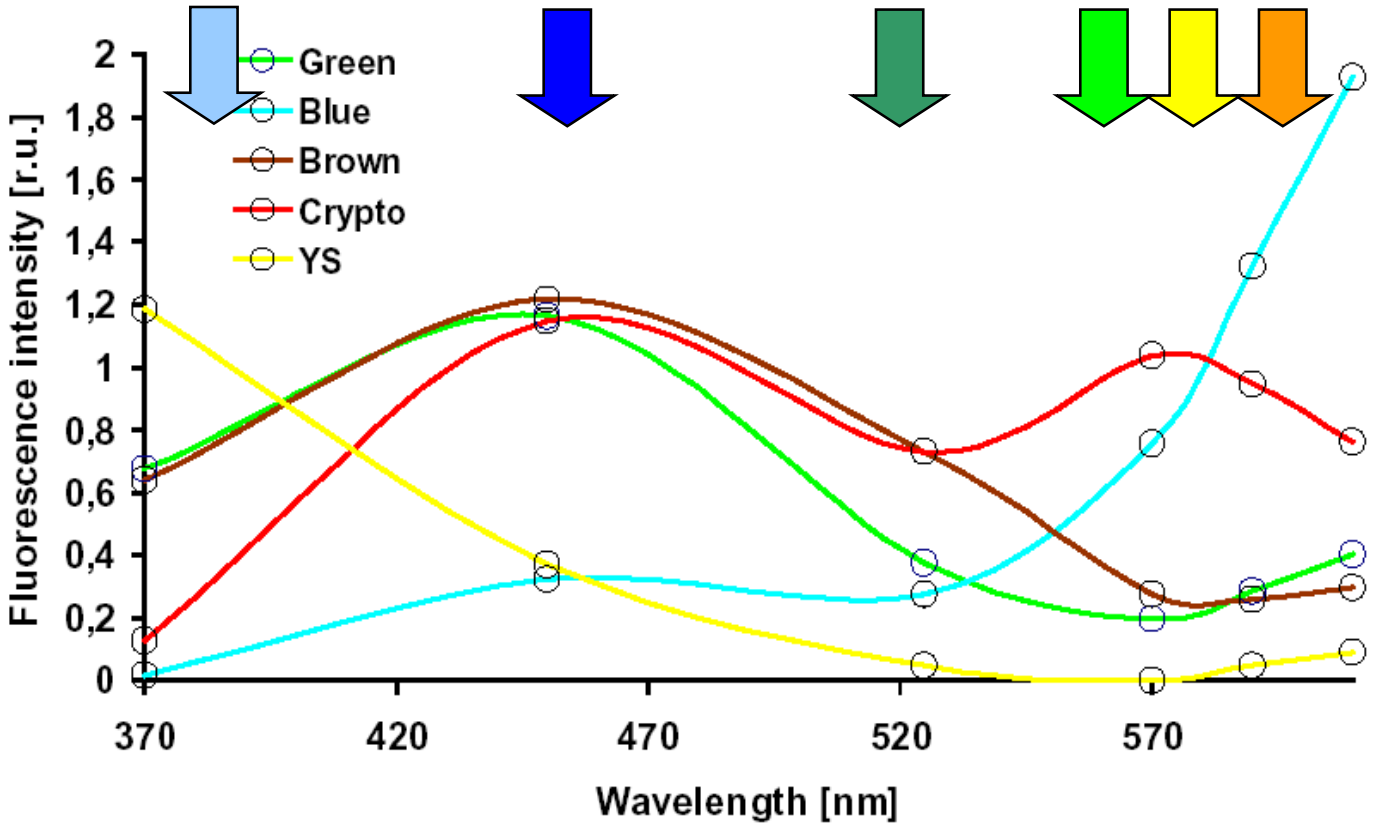
Spectra of Algal Groups



Excitation wavelengths

Spectra of different algae

Real-time 24/7 Monitoring Available

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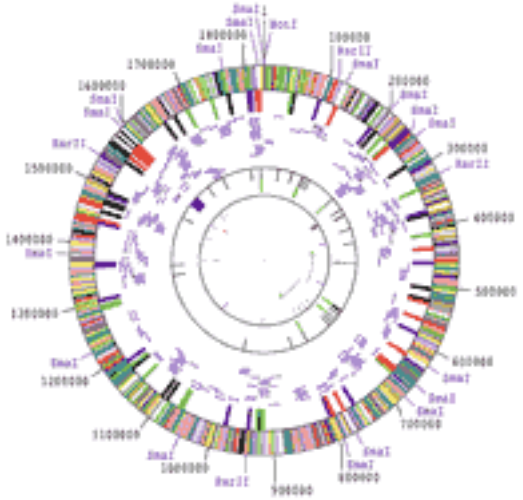
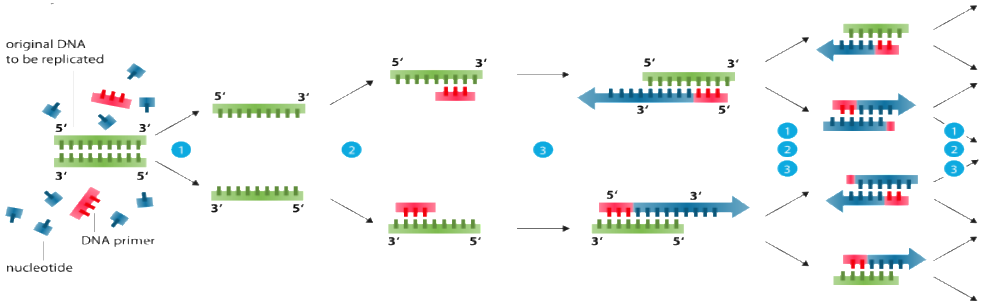
Molecular Probes

- Human Genome Project (1990-2003): to determine the DNA sequence of the entire human genome. 3.3 billion base pairs.
- 1995: First bacterium genome sequenced *Haemophilus influenzae*. 1.8 million bp
- Early 2000: First applications of quantitative real-time polymerase chain reaction (qPCR) to monitor toxic phytoplankton
- PCR – most powerful tool in molecular biology





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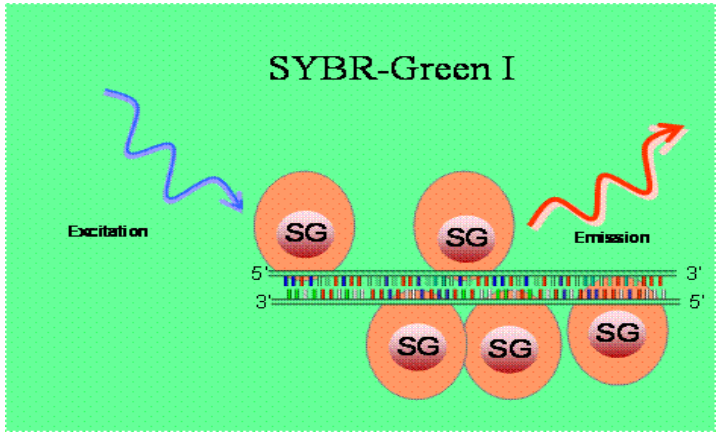
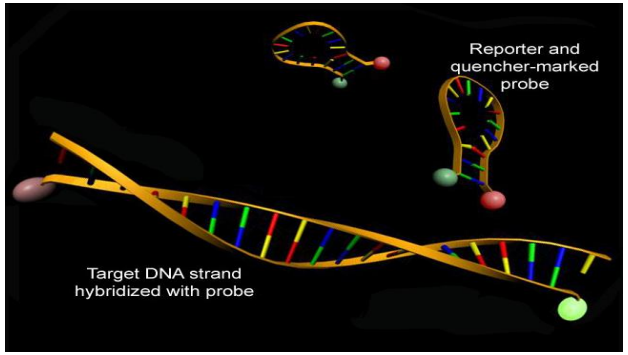
qPCR

- Real-time in the laboratory (and hand-held)
- Not real-time in the field (prototypes)
- Applied to monitor toxic cyanobacteria population shifts in diverse aquatic ecosystems worldwide
- Targets toxin-producing genes: detects and quantifies
- Identification of gene clusters responsible for the synthesis of toxins: microcystins, nodularin, saxitoxin





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Wastewater Epidemiology: SARS COV-2

- Applications: detect polio in countries. Opioid abuse in communities.
- SARS-CoV-2 viral material: Found in stool - collected in sewage systems
- qPCR detection in sewage samples correlates with the arrival of Covid-19 into different communities
- Significant amounts of viral material in Boston sewage weeks before cases arrived in March

"Every person that is using the toilet has a voice"

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Wastewater Epidemiology: SARS COV-2

- 400+ WWTP testing SCV-2 by Biobot analytics
- Similar results in UK, Netherlands, US, Australia

"Evidence suggests that we can potentially see a signal in wastewater before we see a spike in infections in the community"

Huge potential to predict COVID-19 infections in communities before actual clinical detection

2nd or 3rd wave!

Scientists are continuing to fine-tune and reproduce a test before it can be rolled out as part of a Covid-19 alert system.

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Application in Singapore

- Outbreak in foreign workers' (FW) dormitories
- Wastewater treatment plants: SCV-2 RNA levels detected late March 2020 correlated with increase in FW dormitories cases
- Pilot program (NEA interagency team): monitoring wastewater in manholes of 20 dormitories. Additional indicator complementing covid-19 clinical tests. Guides the progressive clearance of the dormitories.

Source: NEA leads scientific team wastewater surveillance trials for assessment of covid-19 transmission

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Application in Singapore

- Early intervention:
  - Viral material detected prompts swab tests leading to more detections and isolation of cases, including asymptomatic ones.
  - Facilitates targeted swabbing strategy and mitigates COVID19 spread

- Labor Intensive
  Sampling: ISCO samplers
  SCV-2 Analysis: PCR in lab

Source: NEA leads scientific team wastewater surveillance trials for assessment of covid-19 transmission

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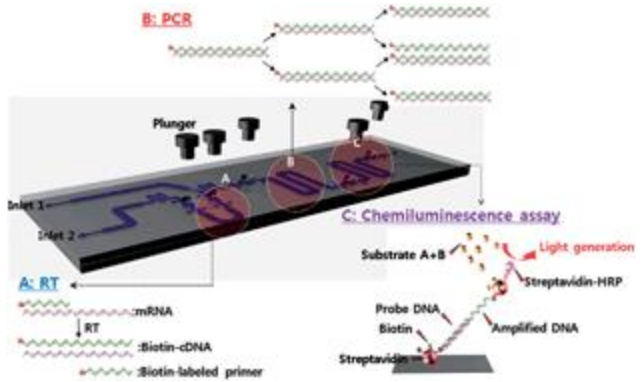
Real-time SCV-2 Wastewater Monitoring Future

Utilises a simple, scalable and cost-efficient framework.

- Sensors collect data: PCR-on-a-Chip
- Installed in clusters of Manholes
- Installed in WRPs
- LoRaWAN network server -

Information is directed to the IBM Cloud for processing, storage and analysis on a cloud portal/platform

- The cloud portal identifies, measures and detects SCV-2 through the cloud portal



PCR-on-a-Chip

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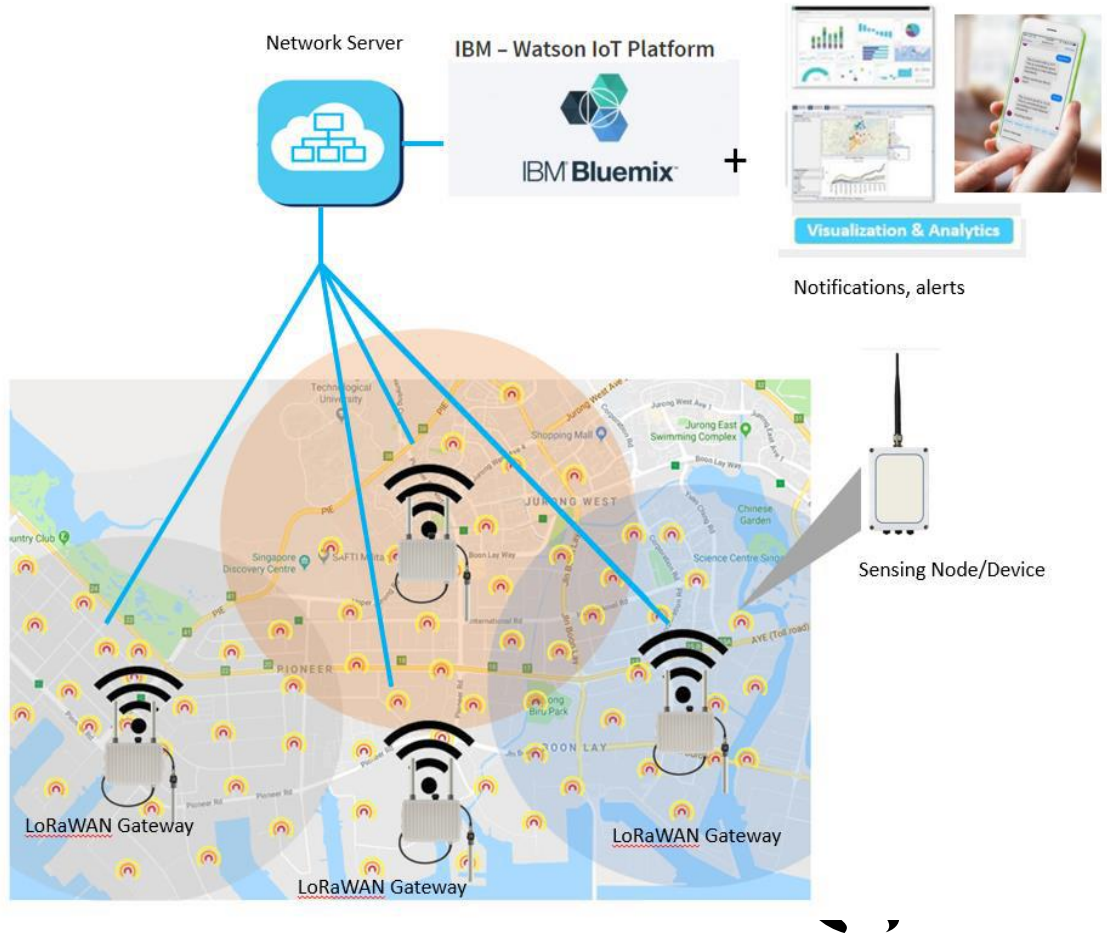
Real-time SCV-2 Wastewater Monitoring Future

- Users access a web-based portal to track, monitor, visualise and analyse
- System issues alerts when pre-threshold conditions are exceeded - community lockdown



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