Water Security and Monitoring Technology

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Topics

- To establish a fresh water database
- Chemical composition and microbiological tests
- An ongoing monitoring of the quality of treated water flowing to consumers
- Set up an emergency response plan for water quality in emergency situations

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Mission

The mission of utilities is to provide cost effective and high quality potable water to meet the present and future demands of our people.

A complex strategy to secure that goal has evolved over many years using World Health Organization (WHO) and USEPA as quality benchmarks for potable water in Singapore.

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Drinking Water Standards

- World Health Organization (WHO)
- European Community (EC)
- United States Environmental Protection Agency (USEPA)

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Water Quality

Singapore derives its water supplies from reservoirs and rivers located in both Malaysia and Singapore.

To be considered as a safe and acceptable source of drinking water, the reservoir and river waters must be free from contaminants that present an acute health risk and provide an acceptable and low chronic health risk (toxicity). While in Singapore, the World Health Organization (WHO) and United States Environmental Protection Agency (USEPA) drinking water standards must be met.

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Water Quality Monitoring

- To characterize waters and identify changes or trends in water quality over time;
- To identify specific existing or emerging water quality problems;
- To gather information to design specific pollution prevention or remediation programs;
- To determine whether program goals, such as compliance with pollution regulations or implementation of effective pollution control actions are being met; and
- To respond to emergencies, such as spills, floods and terrorist attack.

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Water Database

- Use of analytical methodologies of internationally acceptable standards for all analysis, such as USEPA, Standard Methods, etc.
- Establishment of an effective sample acquisition, recording, preservation, and distribution system that delivers the samples in a safe and rapid manner to the laboratories participating in the project.
- Use of a certified analytical laboratory. The laboratory accreditation programs require extensive site audits and ongoing performance evaluations. The laboratory should routinely join the inter-laboratory proficiency tests.

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Water Database

- The laboratory should follow strict QA/QC protocols. For each analysis, it should maintain records of instrument calibration, matrix effects, duplicates, blanks, and spikes should fall well within acceptable levels of performance. All records are to be thoroughly documented and saved.
- Development of a satisfactory data management system that ensures expeditious delivery of the data in a form compatible with the requirements of the customer.
- The sample management system is to ensure timely delivery and quick turn-around times and that includes contingency plans for the use of alternate analytical laboratories.

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Water Testing Technology

- **Microbiology**
  - Coliform
  - Giardiasis
  - Crypotosporidiosis

Traditional Method: Culture/ Incubation

New method: Polymerase Chain Reaction (PCR)
or Real Time-PCR

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Water Testing Technology

- Chemicals
  - Metal cations
  - Ions
  - Organics

Metals: Flame Atomic Absorption Spectrometry (FLAA)
Graphite Furnace Atomic Absorption Spectrometry (GFAA)
Inductively Coupled Plasma spectrometry (ICP)
Inductively Coupled Plasma spectrometry-Mass Spectrometry (ICP-MS)

Ions: Ion Chromatography (IC)

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Organic Contaminants

Until today, there are still a large number of organic contaminants that are not currently regulated or are still pending to be regulated under USEPA drinking water regulations. This includes a selected variety of Volatile Organic Compounds (VOCs), Semi-Volatile Organic Compounds (SVOCs) and Non-Volatile Organic Compounds (NVOCs) that requires periodical monitoring under the Safe Drinking Water Act (SDWA).

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WHO Organic Residues

- **Disinfectants and disinfectant by-products**

1 Disinfectants
2 Chlorophenols
3 Chlorinated acetic acids
4 Halogenated acetonitriles

- **Organic constituents**

1 Aromatic hydrocarbons
2 Chlorinated benzenes
3 Chlorinated alkanes
4 Chlorinated ethenes
5 Miscellaneous

- **Pesticides and herbicides**

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New Organic Contaminants

Pharmaceuticals

Hormones/Mimics

Antibiotics

Blood Lipid Regulators

Nonopioid Analgesics/ Nonsteroidal Anti-Inflammatory Drugs

Beta-Blockers/ß$_2$-Sympathomimetics

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New Organic Contaminants

Pharmaceuticals

- Antidepressants/Obsessive-Compulsive Regulators
- Antiepileptics
- Antineoplastics
- Impotence Drugs
- Tranquilizers
- Retinoids

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New Organic Contaminants

Personal Care Products

- **Preservatives**
- **Disinfectants/Antiseptics**
- **Sunscreen Agents**
- **Nutraceuticals/Herbal Remedies**

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Special Organic Contaminants Monitored in Singapore

Signature compounds

- Ethylenediamine tetraacetic acid (EDTA)
- Napthalene dicarboxylic (NDC)
- Nitroloacetic acid (NTA)
- Alkylphenol polyethoxylates (APEO) and
- Alkylphenol carboxylates (APEC)

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Organic Contaminants Monitored in Singapore

- Dioxins
- Polychlorinated biphenyls (PCBs)
- UNEP list of persistent organic pollutants
- Herbicides frequently used in Singapore golf fields
- Antibiotics

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Table 1 The compatibility of various instrumentation and analytes

	Non-volatile Organic Compounds	Semi-volatile Organic Compounds	Volatile Organic Compounds
HPLC-DAD	×	×	
HPLC-MS/MS	×	×	
P&T-GCMS			×
GC-MS		×	
GC-ECD		×	×
P&T-GC/ECD			×
GC-FPD		×	×
GC-NPD		×	×

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Emergency Response

There are two areas in which a situation warrants an emergency response:

- Natural or manmade accidents like floods and spills which if left untreated, will have devastating effects on the community's water supply

- Since September 11 international terrorist attack, the vulnerability of water system to deliberate attack or sabotage has to be reviewed

  On 23 May 2002, Senate of US approved US$3 billion to improve the nation' ability to bioterrorist and other emergencies (vote: 98-0)

Under such circumstances, an ERP program should be activated immediately to respond to any such situation

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Emergency Response

This work contains three tasks viz,

- **Set up an emergency response plan for monitoring the water quality in emergency situations**
- **Develop new analytical screening methods for special tests and for the monitoring programme and**
- **Ensure our facilities have the capacity and proficiency to identify and confirm biological threat agents**

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Emergency Response Plan (ERP)

Emergency Response Plan (ERP) is a guide for which actions and decisions can be based on to govern the immediate response to an emergency.

This includes

- **How an Utility Department will remedy the problems caused during an emergency and recover from it**

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Emergency Response Plan (ERP)

- The intent of the ERP is to identify certain responsibilities delegated to various teams and employees, present details of the notification procedures, and describe alternate measures and response actions.

- As part of the Emergency Response Plan, prompt identification of the chemical and biological contaminants must be carried out in order to implement effective control/decontamination measures.

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Emergency Response Plan (ERP)

- The ERP should include procedures for site operation, emergency event assessment and identification of a deliberate contamination on-site and in the laboratory when a event occurs.
- A drill will be exercised to assess the efficiency and effectiveness of the emergency response force and how practical is the ERP.
- It is anticipated that by following the procedures detailed in the plan, an event will be handled orderly, professionally, effectively, and efficiently by the emergency response force with minimum delay.

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Sudden Occurrence of A Pollutant

- Changes in the behavior or properties of on-line Biological Early Warning Systems (BEWS) may indicate the sudden occurrence of a pollutant not detected in conventional, analytical warning systems.
- Examples include the dynamic fish test, dynamic mussel test, dynamic water flea test, delayed algal fluorescence, and aquatic toxicity tests such as Microtox-OS©
- Effects of pollutants are detected rather than concentrations
- Because of the variety of ways that toxic compounds can exert their effects, the utilities may consider using multiple types of bioalarm and employing species from different trophic levels.
- The installation of such systems implies the acceptance of a certain risk of false positives.

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Sudden Occurrence of A Pollutant

Possible weapons could be used by individuals to contaminate public drinking waters:

- **Pathogenic Microorganism**
- **Biological Toxins**
- **Chemical Warfare Agents and Industrial Chemical Poisons**
- **Radioactive Substances**

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ERP program

- Set up an emergency response plan for monitoring the water quality in emergency situations;
- Determine the most likely chemical, physical and biological agents, which can be used to contaminate drinking water sources by terrorists;
- Develop new methods for special tests and monitoring program;
- Develop a tiered water-monitoring plan using selected test methods for each of the three tiers of testing;
- Optimize the use of the methods and train chemists and technicians in the laboratory to use and interpret newly established methods;

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Establishment and Development of Emergency Response Plans/ Protocols

Laboratory Preparedness

- Methods to rapidly determine if water quality has been degraded with a contaminants
- Analytical methods to determine the specific nature and agent used in the contamination
- Equipment is readily available

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Establishment And Development Of Emergency Response Plans/ Protocols

Pre-event

- Identify and ensure the on-site laboratories develop the proficiency to conduct “rule-out” testing, sample packaging and handling, and referral of suspected chemical, radioactive and biological threat agents to a higher level laboratory. Ensure that LRN approved protocols are developed and distributed.
- Maintain written plans for staff availability during a public health emergency
- Develop laboratory communications plans and protocols for disseminating information to emergency response partners during a public health emergency
- Establish written policies and procedures for rapid identification
- Develop policies to address evidence chain of custody procedures

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Establishment And Development Of Emergency Response Plans/ Protocols

Event

- Ensure a system is established that provides rapid rule-out testing, referral, identification, confirmation, and characterization of chemical and biological threat agents to include rapid reporting of results during a bioterrorist event
- Deploy adequate number of staff trained to understand their role in the laboratory system to carry out the established system during a public health emergency
- Evaluate system effectiveness through agency-wide and system-wide post event reviews/critiques

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The End

Thanks

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