Decentralised Water and Wastewater Treatment

Risk Assessment and Management Model

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Decentralised wastewater treatment is....

"The collection, treatment, and disposal/reuse of wastewater from individual homes, clusters of homes, isolated communities, or institutional facilities, as well as from existing communities, at or near the point of waste generation."

(Crites and Tchobanoglous 1998).
Decentralised Treatment

• On site systems
  • Cesspools, septic tanks + drainage fields, aerobic and bio-filter units

• Cluster, neighbourhood, community systems.
  • Large septic tanks + dispersal
  • Up to larger systems which resemble centralised treatment systems
Risk Analysis and Management Model

Developed via Quantitative Microbial Risk Assessment (QMRA)

'QMRA uses the best measurements about microbes’ behaviour to identify where they can become a danger and estimate the risk (including the uncertainty in the risk) that they pose to human health.' (CAMRA 2013)

In this study the QMRA process is used to explore alternative management action effectiveness at each case study site.
In this study the category of management actions evaluated and compared include:

(Category 1) Baseline, or existing water and wastewater management actions.

(Category 2) Management actions which call for an increase or improvement of centralised treatment.

(Category 3) Management actions which include the addition of decentralised treatment to the baseline treatment scenario, Category 1.

(Category 4) Management actions which rely solely on decentralised treatment (even if this requires the exclusion of existing centralised treatment networks and facilities).
The QMRA process components are as follows:

1. Planning and Scoping (also Problem Formulation)
2. Hazard Identification and Characteristics
3. Dose-response assessment
4. Exposure Assessment
5. Risk Characterization
QMRA Process

Planning and Scoping (also Problem Formulation)

1) Define the purpose of conducting a QMRA.

2) Description of the system under study
Hazard Identification and Characteristics

1) Description of hazard characteristics
   • Survival in water
   • Resistance to treatment

2) Description of waterborne transmission
   • Cause of waterborne transmission
   • Cause of waterborne outbreaks
   • Comparison of waterborne transmission versus other transmission routes
Hazard Identification and Characteristics (continued)

3) Description of Illness
   - Illness Type
   - Illness Duration
   - Incubation Time of Illness
   - Death rates of Illness
   - Describe protective immunity and secondary transmission for illnesses related to 'index pathogens'

4) Sensitive populations more prone to infection from illness are identified
Hazardous Events

1) Previous drinking water outbreaks for waterborne transmission of 'index pathogens'

2) Sanitary Survey

3) Historical Data

4) Control Measures
Exposure Assessment

1) Pathogen Occurrence in Source Waters

2) Methods of Detection

3) Recovery Efficiency

4) Viability/Infectivity

5) Specificity

6) Monitoring of Index Pathogen Occurrence in Untreated Drinking Water
Exposure Assessment

7) Assess the Elimination of Index Pathogens During Treatment

8) Site Specific Assessment of Index Pathogen Removal by Water Treatment

9) Post Treatment Contamination: Changes of Water Quality During Storage and Treatment

10) Consumption of Drinking Water

11) Exposure Estimation
Dose-Response Assessment

1) Human Feeding Studies

2) Host Characterisation: Immunity and Susceptibility to Infection

3) Health Outcome: Infection to Illness
Risk Characterisation

1) General Approach
2) Tiered Approach
3) Risk Assessment Using Epidemiology
4) Risk Management
Water Balance Model
Environmental Impact Assessment

- Public Wastewater
- Agricultural Runoff
- Surface Runoff
- Industrial Discharge

Barriers (Treatment)

Discharge

Receiving Waters

- DO
- Nitrogen
- Phosphorus
- BOD
Cost Estimation

An economic analysis of the management action categories is completed based on the following:

1. Cost of water and wastewater treatment system construction
2. Cost of distribution systems (pipe infrastructure)
3. Cost of land required for treatment systems
4. Energy costs for operating and maintaining systems
Model Objectives

Explore the effectiveness of existing water and wastewater management actions versus the effectiveness of new management actions which incorporate decentralised or hybrid treatment.

Effectiveness of management actions compared via the health and environmental trade-offs estimated using risk assessment and management model developed during QMRA.
Model Objectives

Trade-offs

- Human health impacts vs. treatment system costs
- Environmental impacts vs. treatment system costs
- Treatment system energy requirements vs. costs
Concerning Climate Change

Water reuse potential in decentralised systems
  • Invaluable potential to meet public and agricultural water needs in drought stricken areas

Energy Usage vs. Cost Trade Off
  • Potential to analyse and prioritize management options which act to reduce energy usage and associated GHG production.

Hazardous Events
  • An event or situation that may lead to the presence of a hazard in drinking water
  • Ex: high pathogen loads in source waters from rainfall or treatment or distribution network failure
  • Frequency of hazardous events increased by climate change induced flooding, hurricanes, tsunamis must be considered in risk assessment and model
Case Studies

1. United Kingdom
   Predominantly centralised treatment
   EU Health and Environmental Regulations
   Data acquisition easier than developing countries

2. Hungary
   As of 2006:
   65% connected to wastewater collecting system
   57% connected to wastewater treatment system
   (United Nations Statistics Division 2011)

Under EU Health and Environmental Regulations
Case Studies

3. Asunción, Paraguay

- 40% of rural population had access to improved sanitation
- 66% to an improved water source
- 90% of urban population had access to improved sanitation
- 99% of urban population had access to improved water source
- Sewerage coverage in Greater Asunción is very low – with only 33% connected to the sewerage system

(World Bank 2009)

Relatively non-existent wastewater treatment

Complex mixture of public/private water providers
Conclusions

1. Currently there is a global transition from centralised water and wastewater treatment to decentralised or hybrid systems.

2. The QMRA framework (via the development of a risk assessment and management model) can be utilized to determine the effectiveness of water resource management plans including decentralised water and wastewater treatment.

3. Particular attention must be paid to deterministic/stochastic variables within model and their subsequent influence on model results.
Conclusions

4. Hazardous events must be assessed within the QMRA with particular consideration of climate change impacts (increased rainfall and associated flooding, more frequent hurricanes, droughts, etc.)


References
