Modelling of Dense Brine Discharges in Oman: Recirculation and Environmental Aspects - A Case Study

W. Verbruggen, R. Morelissen, C.M. Freixa

International Conference on Desalination, Environment & Marine Outfall Systems 2014, Muscat, Oman

16 april 2014
Objective: Illustrate techniques required for a comprehensive assessment of the effluent behaviour

• Introduction
• Near-field aspects
  • Visual disturbance
  • Dilution
• Far-field aspects
  • Inclusion of near-field information
  • Selection of model scenarios
• Conclusions
Objectives of plume dispersion and recirculation studies:
    Optimization of intake and outfall w.r.t.:
    • Compliance with environmental criteria
    • Recirculation potential
Introduction
Spatial and temporal scales

- Currents
- Wind
- Tidal
- Stratification
- Etc.

Near-Field
- Outfall momentum
- Outfall geometry

Far-Field
- Currents
- Wind
- Tidal
- Stratification
- Etc.
Important aspects in the design of a diffuser:

- Energy losses in the diffuser
- Uniform discharge distribution along diffuser
- Optimal spacing of ports
- Possible visual disturbance
- Optimal near-field dilution

Pressure head inside diffuser
Typical values: \( u_0 = 4 \text{ m/s}, \, D = 0.25 \text{ m}, \, \rho_0 - \rho_s = 15 \text{ kg/m}^3 \) \( \Rightarrow \) \( X_L \approx 10 \text{ m} \)

Abessi and Roberts (2014) found that dilution = 1.1-1.2 * H/D in case of water level impact

In our case study: dilution about 30% - 50% lower if diffuser is constructed at too limited water depth

Far-Field Aspects
Model set-up: inclusion of near-field information

Suppose:
- \( Q = 10 \text{ m}^3/\text{s} \)
- \( \Delta S = +30 \text{ ppt} \)
- \( S_{nf} = 10 \)

1. Diluted source only
   - NF-information included at coupling location
   - Not mass conservative
   - Entrainment in FF-model

2. DESA method
   - Mass conservative
   - Entrainment in FF-model


16 april 2014
Far-Field Aspects
Model set-up: inclusion of near-field information

Thermal plume tracer in a stratified water body

Without DESA

With DESA

Thermal plume

Thermal plume
Far-Field Aspects
Model set-up: inclusion of near-field information

Combined thermal and brine discharge

Velocity near the bed

Combined plume tracer along cross-section

Brine discharge

Diffuser combined discharge

16 april 2014
Far-Field Aspects
Model scenarios: Scenario Based Modelling Approach

- Which processes are dominant?
- How does the plume behave (response time, buoyancy, etc.)?
- Which conditions are governing w.r.t.:
  - Recirculation
  - Environmental compliance

Data Analysis

Experience

Set of ambient conditions (normal and adverse)

Test simulations
Far-Field Aspects
Model scenarios: Events

Schematised:
+ understanding system
- relevant?

Unschematised:
+ Realistic
- Governing period?
- Less understanding system

Tests with schematised conditions

Select governing periods
Select relevant schematised conditions
Relevant time scales:

- Response time of the plume
- Operational criterion (6 hours)
- Environmental criterion (day – week)

→ Select conditions that are corresponding to these timescales
In order to accurately and reliably model the dispersion and recirculation of brine discharges, it is necessary to use comprehensive and state-of-the-art modelling techniques:

- Analyse near-field behaviour in detail (water level impact, dilution, etc.)
- Use DESA to include entrainment in FF-model
- Iteratively (e.g. using SBAM) determine a representative set of ambient conditions
- Take relevant time scales into account in the selection of modelling scenarios
Thank you!
Questions?