Watermatex Conference 2015

3088488: Model assessment of odour and corrosion in sewer network

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Outline of presentation

- Objective
- MIKE URBAN Hydraulic Sewer Model
- Prediction and Assessment of \( \text{H}_2\text{S} \)
  - Measurements
  - Retention Time
  - WATS Model
- Mitigation options
- Conclusion
Objective

• Develop a calibrated hydraulic model of the sewerage system of Salalah, Oman

• Apply the hydraulic model integrated with WATS to predict the formation of hydrogen sulphide at time step level for the entire sewerage system

• Undertake an assessment of the results to establish an odour and corrosion control system strategy
MIKE URBAN Hydraulic Sewer Model
Morten Just Kjølby
MIKE URBAN – Hydraulic Engines and Hydrogen Sulphide

ASSET GIS

MIKE URBAN

MOUSE
- Advection Dispersion
- Biological Processes H2S-WATS

SWMM5
- Advection Dispersion

MIKE 1D
- ECOLAB H2S-WATS
MIKE URBAN – GIS integration

- Establishment of an Asset GIS system for the city (ArcGIS 10.1)
- Model Elements
- Status Flagging
- Naming Conventions
MIKE URBAN – Model Elements – Nodes and Gravity Pipes

- **Nodes (No = 8415)**
  - Manhole, Basin, Junction, Outlet
  - Headloss

- **Pipes (No = 8377, 420 km)**
  - **Gravity (No = 7927, L = 367 km)**
    - Diameter = 0.08-1.40 m, HDPE
  - **Rising mains (No = 450, 35 km)**
    - Diameter ranges 0.10 - 0.80 m, HDPE
  - Grinder Network (17 km)
  - Friction
Pump Configuration and Operation

- 34 APS pumping stations
- 3 MPS main pumping stations
- Pump Definition (WetWell -> ToNode)
- Pump Type (Q-H, Q-dH or Constant Pump)
- Pump Operation
  - Start Level, Stop Level
  - Variable Speed
  - RTC
Pump Diagram
Wastewater Loads and Temporal Variation

- 2012-2013 population projection
  - 155,082 persons
  - 32,602 m3/day

- Model scenarios set up to 2016, 2020 and 2024

- Low and High season
Hydraulic Model Calibration & Verification

- Calibrated to volume (daily) at MPS1, MPS2 and MPS3 (SCADA data)
- Calibrated to flow measurement locations (mobile flow gauges)
MIKE URBAN Sewer Model of Salalah

- Represents existing network conditions
- Model calibrated
  - to volume SCADA data
  - to flow metered by mobile flow meter data
- Usage
  - Assessment of design jobs, priority infrastructure planning etc.
  - Assessment of existing network (H₂S, mitigation options)
02. Prediction and Assessment of H$_2$S

Morten Just Kjølby
Measurements

- **H₂S in air phase [ppm]**
  - Max H₂S varies [0.20 – 859]

- **H₂S and pH in sewer liquid [mg/l]**
  - Max H₂S varies [0.15 - 9.88]
  - pH varies [5.90 – 7.43]

- **Lab Analysis of waste water [mg/l]**
  - BOD varies [270 – 330]
H$_2$S levels and typical exposure symptoms

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0 - 10 ppm</td>
</tr>
<tr>
<td>Irritation of the eyes, nose and throat</td>
<td></td>
</tr>
<tr>
<td>Mod</td>
<td>10 - 50 ppm</td>
</tr>
<tr>
<td>Headache</td>
<td></td>
</tr>
<tr>
<td>Dizziness</td>
<td></td>
</tr>
<tr>
<td>Nausea and vomiting</td>
<td></td>
</tr>
<tr>
<td>Coughing and breathing difficulty</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>50 - 200 ppm</td>
</tr>
<tr>
<td>Severe respiratory tract irritation</td>
<td></td>
</tr>
<tr>
<td>Eye irritation / acute conjunctivitis</td>
<td></td>
</tr>
<tr>
<td>Shock</td>
<td></td>
</tr>
<tr>
<td>Convulsions</td>
<td></td>
</tr>
<tr>
<td>Coma</td>
<td></td>
</tr>
<tr>
<td>Death in severe cases</td>
<td></td>
</tr>
</tbody>
</table>

![Graph showing H$_2$S levels and temperature over time]
Max H$_2$S in air phase [ppm]
MIKE URBAN – Options for prediction of H₂S in sewers

H₂S formation – screening
- Retention Time
- Empirical Equations
- Z-Formula Concept

H₂S formation – more detailed
- WATS Model

Measured [ppm in air phase]
Measured and modelled by MIKE URBAN WATS in liquid phase
Measurements (H$_2$S in Air) and Retention Time
MIKE URBAN - WATS

Source: Tanaka et al. 2000
### MIKE URBAN WATS Model Input – Initial Values (Salalah)

<table>
<thead>
<tr>
<th>No</th>
<th>Component</th>
<th>Type</th>
<th>Default Value</th>
<th>Variation in model scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>COD</td>
<td>Dissolved</td>
<td>600 mg/l</td>
<td>600 mg/l</td>
</tr>
<tr>
<td>2</td>
<td>DO</td>
<td>Dissolved</td>
<td>1 mg/l</td>
<td>1 mg/l</td>
</tr>
<tr>
<td>3</td>
<td>pH</td>
<td>Dissolved</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>Temperature</td>
<td>Temperature</td>
<td>30°C</td>
<td>30-35°C</td>
</tr>
<tr>
<td>5</td>
<td>SO4</td>
<td>Dissolved</td>
<td>150 mg/l</td>
<td>150 mg/l</td>
</tr>
<tr>
<td>6</td>
<td>Water Age</td>
<td>Retention Time</td>
<td>0</td>
<td>Calculated in by the model</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Wastewater entering the model is given age = 0</td>
</tr>
<tr>
<td>7</td>
<td>H2S</td>
<td>Dissolved</td>
<td>0</td>
<td>Calculated in by the model</td>
</tr>
<tr>
<td>8</td>
<td>HS</td>
<td>Dissolved</td>
<td>0</td>
<td>Calculated in by the model</td>
</tr>
<tr>
<td>9</td>
<td>TotalHS</td>
<td>Dissolved</td>
<td>0</td>
<td>Calculated in by the model</td>
</tr>
</tbody>
</table>
MIKE URBAN – WATS – Result

• Result Items - selected
  - COD, DO, pH, SO4
  - Total HS, H2S, HS-, S--
  - Accumulated Release of H2S to air phase

• Time Series
• Longitudinal Profile
• Animation
Example of map output showing the maximum daily TotalHS concentration in water (mg/l) along all pipes in the sewer network. The rising mains after pumping stations clearly show up as pipes where TotalHS builds up.
Example: TotalHS (mg/l) - low flow (during night)
Results: Total HS (mg/l) – high flow (during day)
Example: Acc. H2S release - horizontal map and time series
03.

Mitigation Options
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Mitigation Options

- Assessment of the sources (water supply, industry)
- Optimize Pump Operation – to reduce retention time
- Chemical Dosing
  - pH regulation
  - Inject oxygen
  - Nitrate based chemicals (inhibition)
  - Iron based chemicals (precipitation)
Chemical Dosing and Scrubbers

1: Force this path dosing nitrate
2: Precipitate sulfides with iron
3: Remove in scrubbers
Optimal odour and corrosion dosing strategy (Salalah)

- Optimise pump operation (High / Low season) – reduce retention time
- Based on the MIKE URBAN WATS predictions - critical locations are identified as dosing stations
- The dosing strategy aims at dosing Nitrate based chemicals at upstream PS and Iron based salts at downstream PS.
- Implementation needs to be simple
  - Two step dosing during day
  - Two strategies – low and high holiday season
- The strategy is then verified by MIKE URBAN WATS incl. dosing simulation
Conclusion
Morten Just Kjølby
Conclusion

• The integration of the MIKE URBAN hydraulic model with WATS model provides a fully dynamic solution for predicting the formation of hydrogen sulphide and release to air for the complete sewerage network

• Supports the assessment of various mitigation options to achieve an optimal and cost effective solution
Thank you
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