EVALUATING SEWER CORROSION CONTROL OPTIONS

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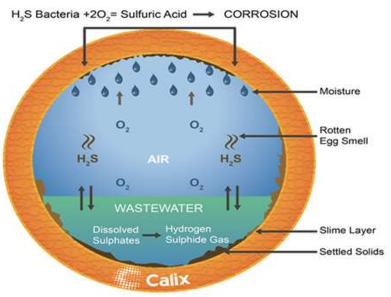
Introduction to the problem



- Sulphate reducing bacteria (SRB) produce hydrogen sulphide (H_2S) consuming sulphate and organic carbon
- H_2S is released into the atmospheric portion
- H_2S is metabolized by the bacteria to the Sulphuric acid(H_2SO_4) in the surface of the concrete

Governing factors for H_2S formation and the emission

1. Sulphate reducing bacteria

- $SO_4^{2-} + BOD \xrightarrow{SRB} H_2S$

- **Anaerobic condition**
- **SRB grow in biofilm attached to the submerged walls**
- **Thickness of the biofilm determine H_2S production rate**

Governing factors for the H_2S formation and the emission

2. Biodegradable organic matter (BOM)

- **Electron donor**
- **BOM concentration > 100 mg/L**
- **Minimising BOM in to the sewer lines is practically impossible**

3. Sulphate SO_4^{2-}

- **Usually sufficient amount (>90 mg/L) in sewer not limiting**

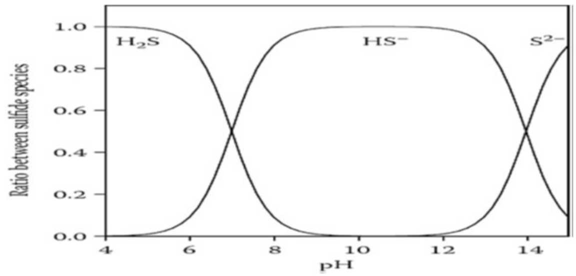
4. Temperature

- **Affects the growth of SRB,**
- **max H_2S production rate at 35 °C**

Governing factors for the H_2S formation and the emission

4. pH

- Sulphide can exist in water as H_2S ,HS^- ,and S^{2-} according to the pH.
- Sulfide is emitted only as H_2S



5. Sewer Hydraulics

- High flow Velocity reduces the thickness of the biofilm

Introduction to the problem

- Structural damages of the sewer line
- Cost water utilities billions of dollars each year.
  Annual asset loss of around $14 billion in the United States alone
- H_2S control technically difficult and costly

Sewer corrosion Controlling methods

1. **Reduce H_2S Production**
   - Inhibit SRB activities
   - Dosing Oxygen
   - Increase pH
2. **Reduce emission**
   - Increase pH
   - Other chemical dosing methods
3. **Protect crown Surface**
   - Inhibit microbial environment of the sewers' crown
   - Neutralising H_2SO_4 acid by increasing pH
4. **Produce sewer lines using special material**

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Mitigation strategies of H_2S production & emission

Chemical mitigations

1. **Increase pH**

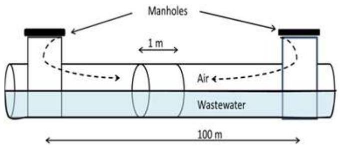
   Metal hydroxides

   $Mg(OH)_2$, $Ca(OH)_2$, NaOH
2. **Addition of metal chloride**

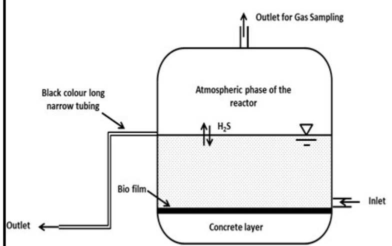
   $FeCl_2 + H_2S \rightarrow FeS_{(S)} + 2HCl$
3. **Addition of oxygen**

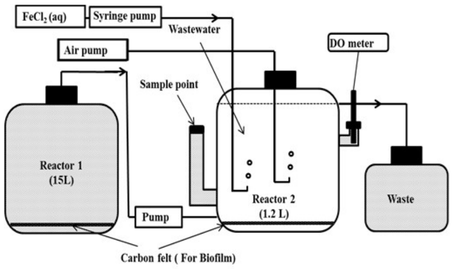
   $H_2S + 2O_2 \rightarrow H_2SO_4$

- Simulate sewer system in the laboratory

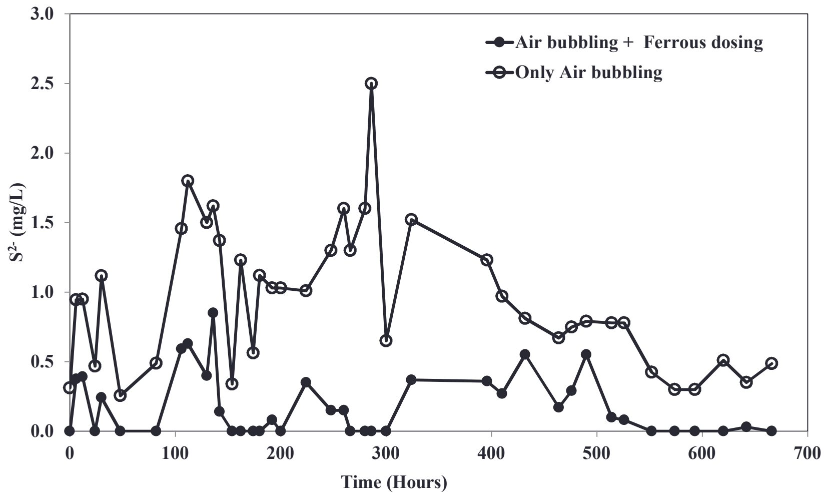


Cross section diagram of the typical sewer line

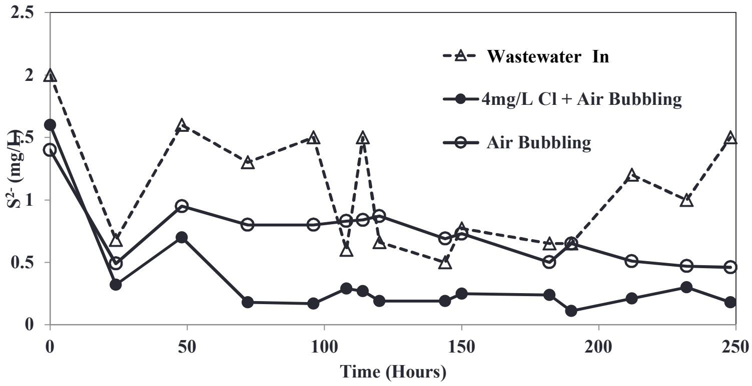




Combining Air bubbling and Ferrous dosing



Combining Air bubbling and Chlorine dosing



Developing a Model

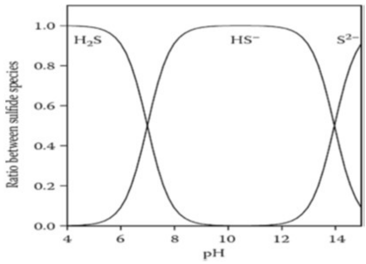
Importance of the model

- Can predict H_2S concentration in the gas and liquid
- Predict the situation which can not implement in the laboratories
- Identify the ideal places to dose chemicals
- Easy to do related calculation based on model behaviour

Progress on Model

$$\frac{dC_{H_2S}}{dt} = k_{H_2S}.[1 + k_{cat1}.C_{Fe}].(C_{TS^{2-}} - 0.57C_{Fe} - C_{HS^-}).C_{DO}$$

$$\frac{dC_{HS^-}}{dt} = k_{HS^-}.[1 + k_{cat2}.C_{Fe}].C_{HS^-}.C_{DO}$$



$$\frac{dC_{DO}}{dt} = -x_1.\frac{dC_{H_2S}}{dt} - x_2.\frac{dC_{HS^-}}{dt}$$

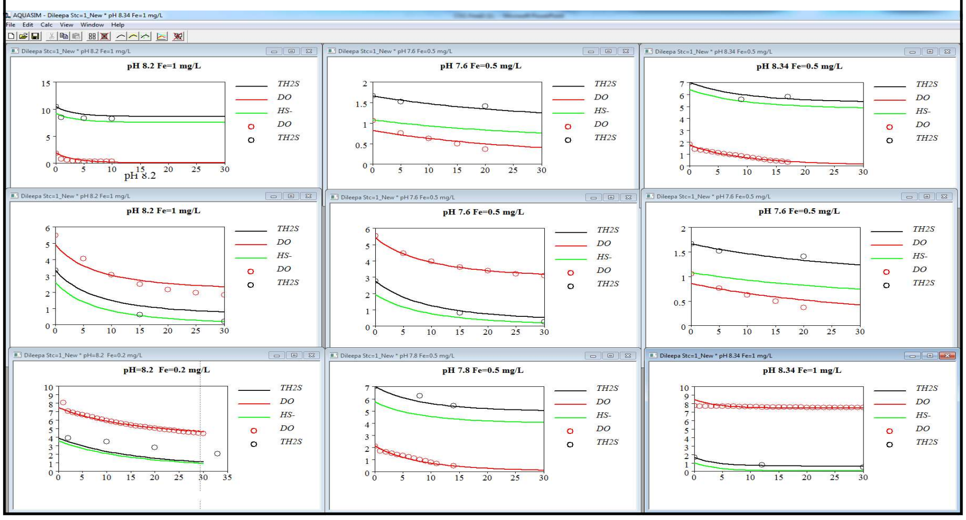
$$C_{TS^{2-}} = C_{H_2S} + C_{HS^-} + 0.57C_{Fe}$$

$$C_{HS^-} = \frac{K_{a1}.(C_{TS^{2-}} - 0.57C_{Fe})}{10^{-pH} + K_{a1}}$$

k_{HS^-} = oxidation coefficient HS^-[1/h/ (mg/L)]
k_{cat}= catalytic oxidation coefficients [1/ (mg/L)]
$C_{TS^{2-}}$=concentration of total S^{2-}in liquid [mg/L as S]
C_{Fe} = concentration of ferrous ion [mg/L]
C_{HS^-}=concentration of HS^- in liquid [mg/L as S]
C_{H_2S}=concentration of total H_2S in liquid [mg/L as S]
$x_{1,2}$= H_2S, HS^- stoichiometric oxidation coefficient
K_{a1} = First dissociation constants

Progress on Model

The AQUASIM package.



Publications

Evaluation of a combined treatment to control gaseous phase H2S in sewer
D Rathnayake, G Kastl, A Sathasivan
International Biodeterioration & Biodegradation 124, 206-214

Hydrogen sulphide control in sewers by catalysing the reaction with oxygen
D Rathnayake, A Sathasivan, G Kastl, KCB Krishna
Science of the Total Environment 689, 1192-1200

Thank you