

Hydrogen sulfide emissions In sewer networks

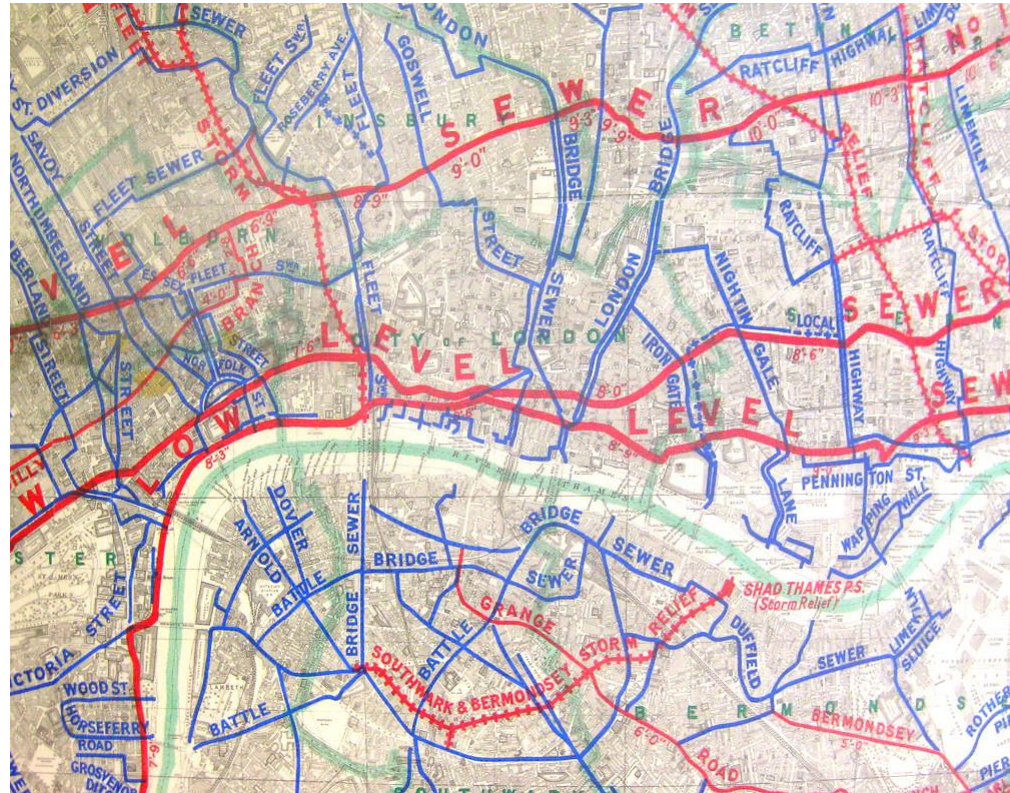
Pierre BUFFIERE
DEEP Research Center

A sewer network...

Waste water collection
(sanitary sewers)

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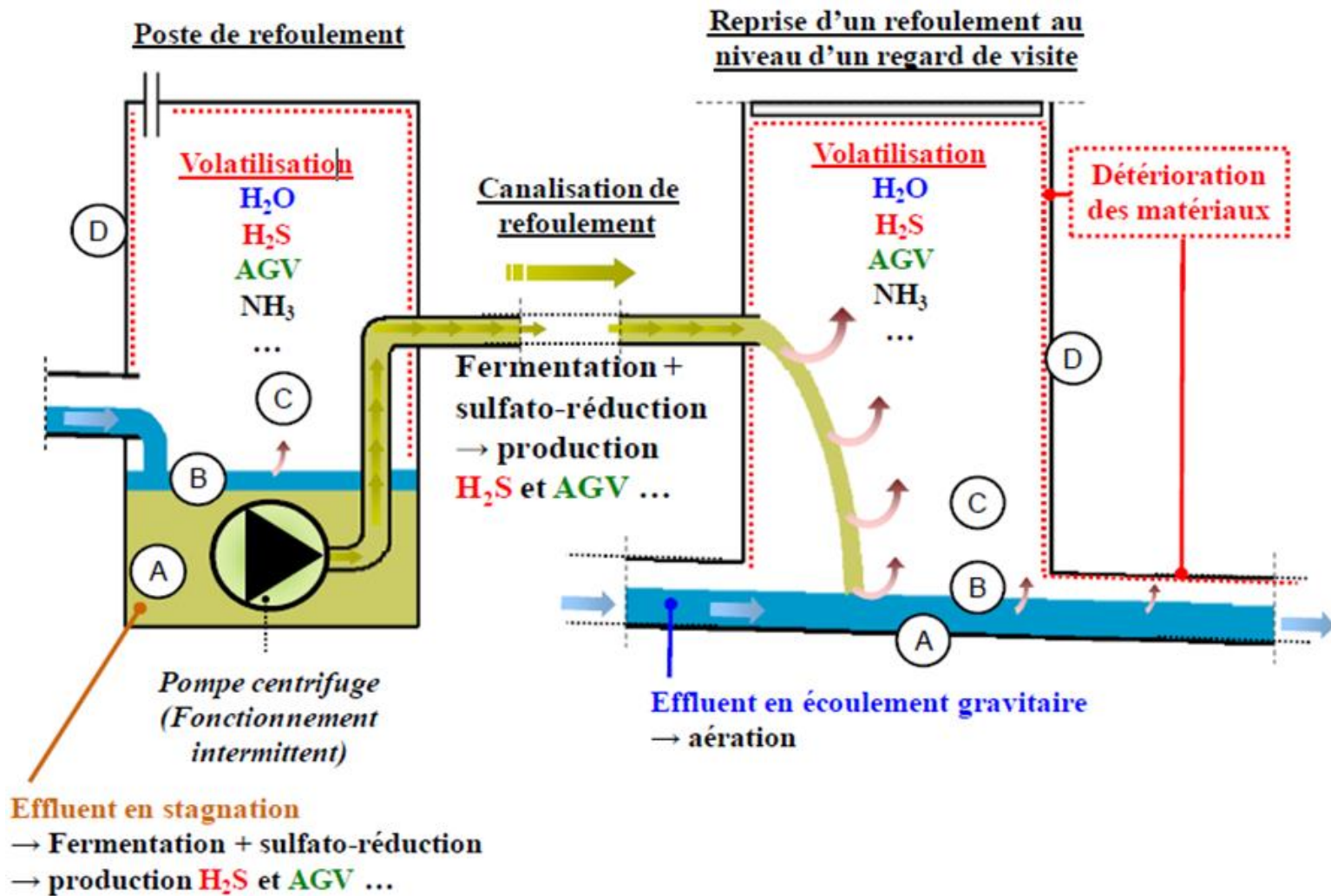
Storm water collection
(combined sewers)



Origin of H₂S in sewer networks

- **Anaerobic decomposition in forced ducts**
- **Anaerobic transformations in gravity sewers**
- **Stagnant zones (pumping stations / Lifting units)**

Origin of H₂S in sewer networks



M. Peyre-Lavigne, PhD Thesis, INSA
Toulouse, 2014

Impact of H₂S

Safety



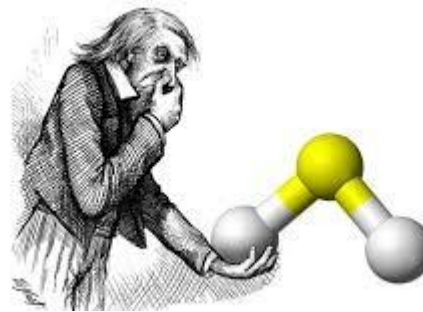
Risk for workers (many cases)

Exposure level	Concentration, ppmv	Symptom
Low	0–10	Irritation of the eyes, nose, and throat
Moderate	50–200	Coughing Hoarseness Shortness of breath Pneumonia Loss of smell (> 100 ppmv)
High	200–500	Changes in respiratory tissue (200–400 ppmv per laboratory animals) Rapid respiratory distress and failure (acute exposure at > 500 ppmv for 1 to 4 hours) ²
Very high	> 2,000	Coma and death after single breath ⁴ Known as “knockdown effect” with immediate immobilization and unconsciousness, possibly from disruption of oxidative metabolism in the brain

Impact of H₂S

Tourists complain

(no money)



Citizen complains

(no reelection)

Impact of H₂S

Asset management

Concrete corrosion

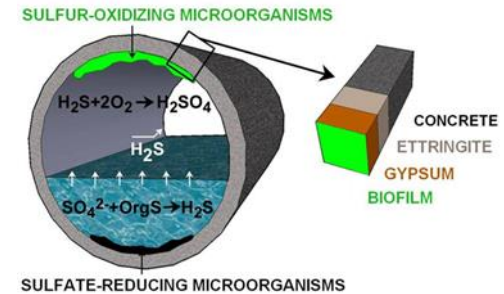
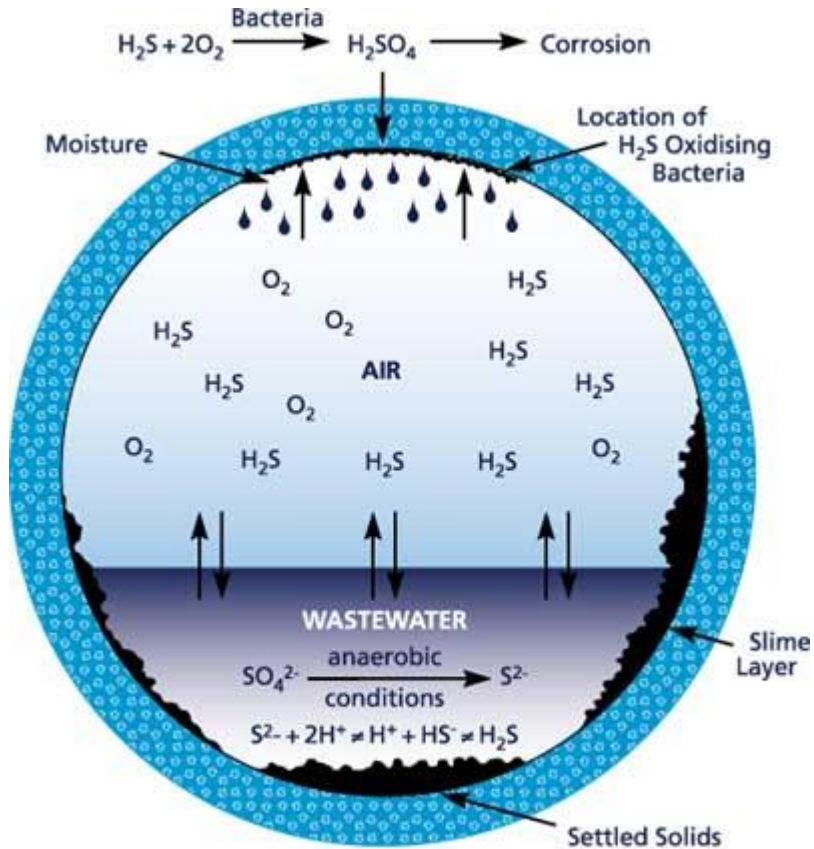


Pipe failure

Leaks

Big economic issues

The fate of sulfur in sewers



Buildup of sulfide in the liquid phase (sulfate reducing bacteria)

Acid / base Sulfide equilibrium (H_2S / HS^-) $pK_a = 7$

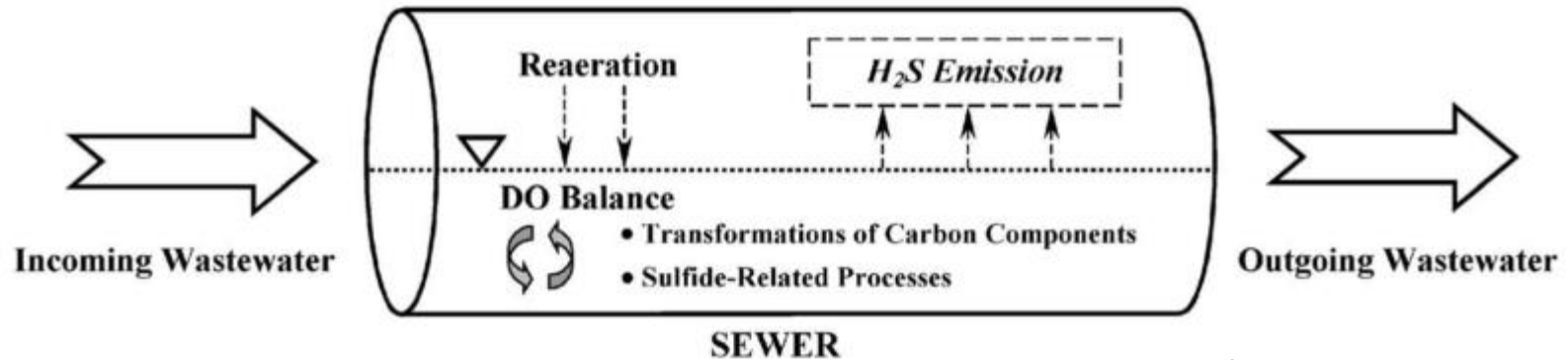
Sulfide emission (H_2S)

H_2S oxidation (walls) to H_2SO_4

Important factors for H₂S production

- **Temperature**
- **Redox potential / dissolved oxygen**
- **pH**
- **Residence time (distance)**
- **Flow conditions**

H₂S emissions in gravity sewers



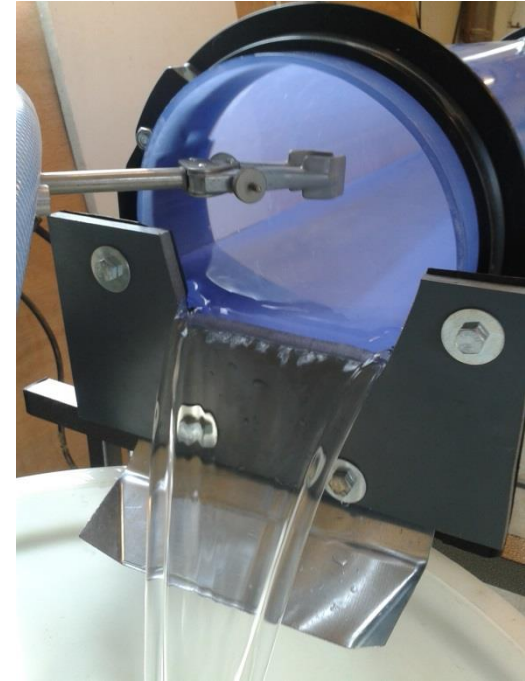
Yongsiri *et al.*, 2005

Emissions flux is due to mass transfer: $N = kla (C - C^*)$

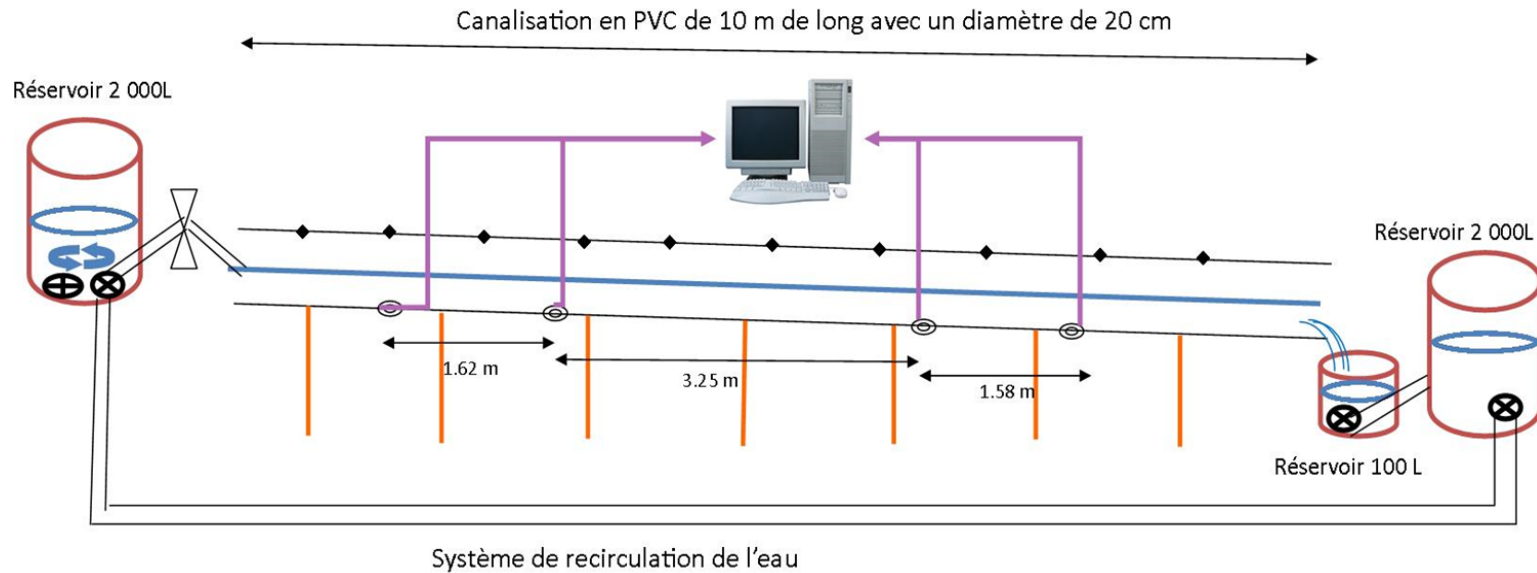
Question 1: how to assess mass transfer coefficients in open-channel flow?

Question 2: how to measure the mass transfer coefficient for H₂S?

Experimental set-up for $k_L a$ in open-channel flow



Experimental set-up for $k_L a$ in open-channel flow



Parameters

- Slope (0.03% - 1%)
- Water flow rate
- Liquid height (adjustable weir)
- Velocity range $0.1 - 1 \text{ m.s}^{-1}$

Method: OXYGEN

- Reoxygenation (clear water)
- Dissolved oxygen vs. distance (6)

Assessment of $k_L a$ in open-channel flow

Mass balance

$$\frac{\partial C}{\partial t} + u \frac{\partial C}{\partial z} + k_L a (C - C^*) = 0$$

- Stationary flow (u constant)
- Steady-state for O_2 concentration
- Plug flow ($Pe > 100$)

$$C(z) - C^* = e^{-\frac{k_L a}{u} z}$$

Mass transfer coefficient $\text{H}_2\text{S} / \text{O}_2$

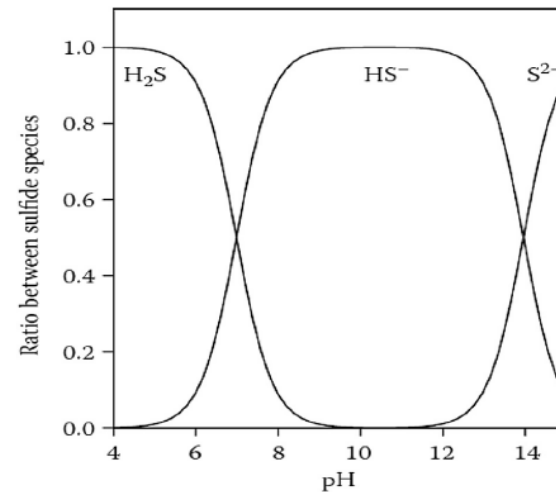


Oxygen:

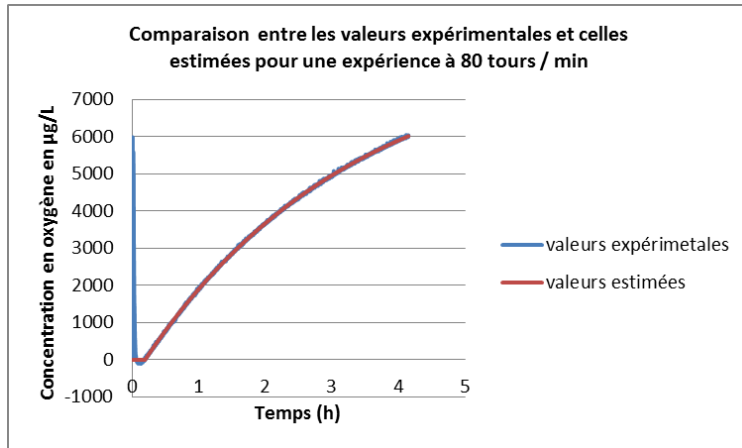
Reoxygenation method (under controlled mixing)
Measurement of C vs time (Oxymeter)

H_2S :

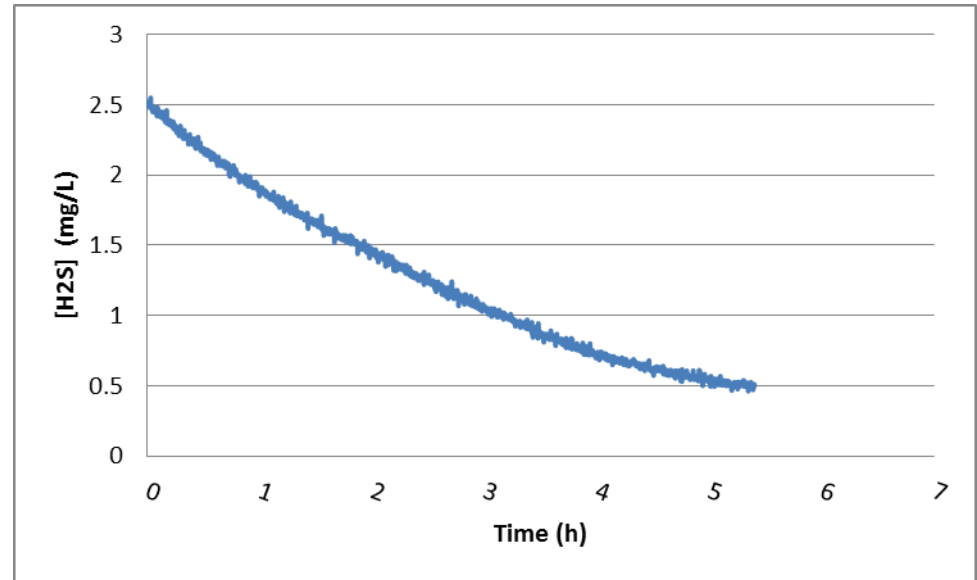
Sursaturation method
Addition of Na_2S ($\text{pH } 10$)
Addition of HCl ($\text{pH } 3$)
On-line measurement of total sulfide (Aqua-MS© probe)



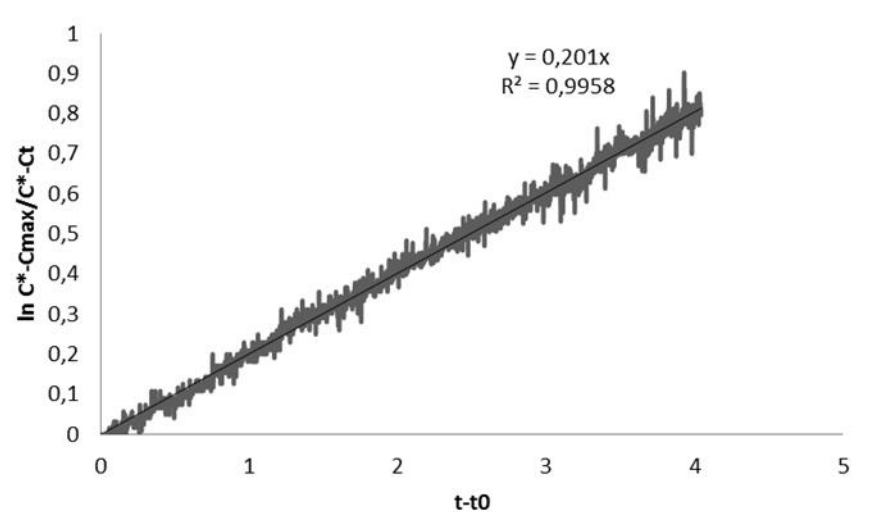
Mass transfer coefficient H_2S / O_2



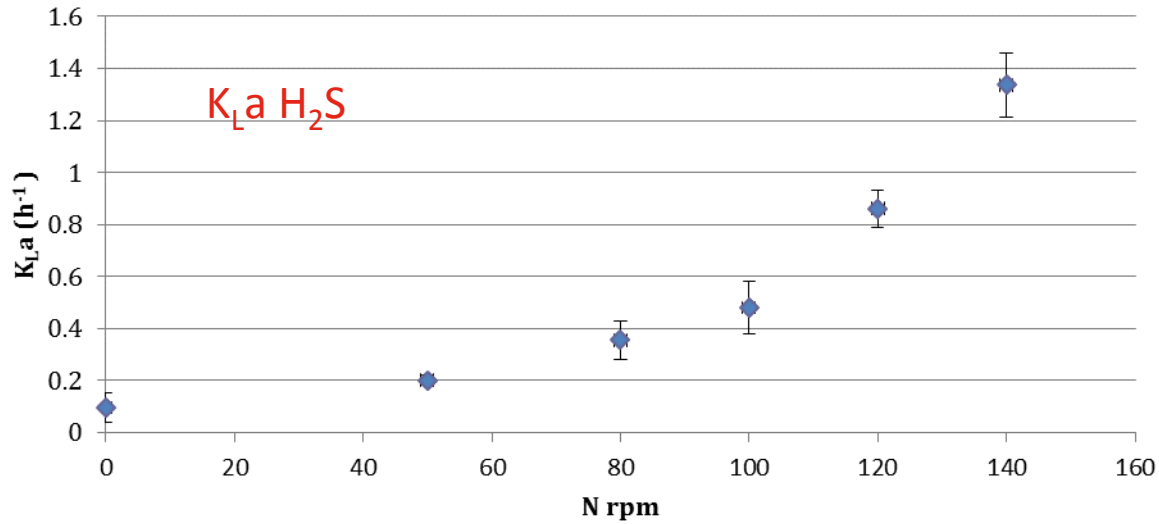
O_2 Reoxygenation



H_2S Desaturation



Mass transfer coefficient for H₂S



$$k_L a = A + B \times N^{3.1}$$

Perspectives

- Correlate $k_L a$ H_2S and $k_L a$ O_2
- Correlate $k_L a$ in open-channel flow (velocity / slope / height)
- Combine production / emission models for H_2S in sewers



Merci!

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(rendez-vous at the POSTER SESSION : S02- 279)