

Hydrogen-sulfide Control in Pressure Sewers, Theoretical and Practical Aspects

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Abstract

In pressure sewers anaerobic conditions are prevailing, which lead to the formation of anaerobic metabolites from waste water constituents. These can be organic by-products from anaerobic metabolism like alcohols and acids or inorganic compounds like hydrogen sulfide from reduction of sulfate. These anaerobically produced substances can cause odour and corrosion problems both in the sewer system and/or at the WWTP.

Hydrogen sulfide was chosen as the principal indicator for anaerobic conditions; to follow and understand the processes occurring within the sewer pipe.

An in-situ UV-VIS spectrometer was applied for indirect measurement of sulfide and COD; this instrument worked reliably. Again the problem of the influence of a varying wastewater matrix for the development of an appropriate correlation model between the measured absorbance and the desired equivalent parameter (H_2S_{EQ} , COD_{EQ}) was observed. Complementary information could be derived from H_2S -gas measurements in the sewer discharge shaft.

Different Methods to combat H_2S formation in pressure sewers were investigated in some existing sewer systems. Experimental results of H_2S generation were compared with theoretical production rates according to calculation from literature. In most cases the calculated H_2S formation overestimated the measured results. The removal of biofilms from the pressure pipes with different pigging technologies and chemical treatment was only effective for few days. Very successful was the application of different iron salts and nitrate solutions to either precipitate sulfide or to avoid anaerobic condition in the pipe. Equally successful was the application of compressed air for transport or aeration in pressure pipes. The different methods were evaluated for their applicability and economy depending on specific conditions prevailing.

Keywords

hydrogen sulfide, sulfide, COD, sewer networks, elimination of biofilm, removal of produced sulfide, pigging, pneumatic waste water transport, pressure sewer, cost for prevention of H_2S -formation, UV-measurement,

Introduction

The transport of sewage in pressure sewers creates problems due to the production of sulfide by sulphate reducing bacteria under anaerobic conditions. Sulfide causes both corrosion and odour problems in sewage systems and treatment plants (Matsché 2005).

In order to observe the hydrogen sulfide production processes and the effect of different counter measures a prototype monitoring system was installed at a pressurized pipe discharge point (Saracevic 2005).

Controlling the anaerobic processes in pressure sewers is necessary and can be achieved by avoiding the development of anaerobic metabolites. Basically there are several ways to achieve this goal:

- Elimination of Biofilm

- Prevention of H₂S-formation
- Removal of produced sulfide

There are several physical and chemical methods to solve the problem, but only a few of them are economically feasible for wastewater treatment. Technologies such as pipe-pigging for the elimination of the anaerobic biofilm, nitrate dosage and compressed air supply to create anoxic/aerobic conditions and iron salts dosage for the precipitation of produced sulfide can be applied (Lhose, 1986). In this project the application of different methods was tested on several pressure sewer systems to get a perspective of technical and economical advantages or disadvantages and to help making a decision which method could be suitable for specific situations.

The Monitoring of sulfide

Depending on the pH-value hydrogen sulfide is available in different forms. At pH-values below pH < 5 hydrogen sulfide is dissolved as gas in water (H₂S), while in the range of 5 < pH < 9 the hydrogen sulfide ion (HS⁻) is the predominant form. Since HS⁻ is an ion which cannot leak into the atmosphere, no hydrogen sulfide related odour or corrosion problems occur at pH-values of pH > 9.

$$c(H_2S) = [H_2S] + [HS^-] + [S^{2-}]$$

For measurement of total dissolved sulfide (c(H₂S)) only few methods are available (Saracevic 2009). For online measurement of hydrogen sulfide only a few special analyzers are available, which are primarily designed for application within the chemical industry. Aside from the high investment cost these analyzers require a comparably complicated installation and special maintenance by trained personnel. Since the main monitoring goal was to detect periods when hydrogen sulfide was available in critical concentrations an submersible spectrometer was installed to indirectly monitor the Hydrogen sulfide ion (HS⁻) and the COD concentration at the discharge point of the pressurized pipe (Figure 1:). The applied submersible spectrometer measures light absorption in the UV-range (190-350 nm); spectra of measured absorbencies are transformed in equivalent concentrations (c_{eq}) of various substances (H₂S, COD) using statistical regression models. The absorption can be correlated to results from laboratory analysis for a model based calculation of equivalent parameters such as H₂S_{EQ} and COD_{EQ} (Langergraber et al, 2003).



Figure 1: *Measuring point gritchamber (left) and in-situ UV-Spectrometer (right)*

HS⁻ and COD were determined indirectly by means of spectroscopy to monitor the organic content of the wastewater together with HS⁻ concentration. COD concentration gives information about the content

of organic compounds in wastewater and is also essential for sulfate reducing bacteria. Their activity can be decreased in case of a lack of certain organic nutrients in wastewater.

The discharge point of the pressurized pipe was adapted to allow additionally the installation of the H_2S_g sensors (Figure 2).

Primarily, this measurement is used as an indicator of hydrogen sulfide production within the sewer pipe and related odour problems. It also serves as a warning system for toxic H_2S -gas concentrations in the discharge chamber.



Figure 2: Adapted sewer pipe discharge point (left) and H_2S_g sensor (right)

As long as H_2S -gas can be detected in the atmosphere the wastewater certainly contains sulfide. On the other hand, if no H_2S -gas is detected, no conclusions with respect to the sulfide concentration in wastewater can be drawn due to the dependency on the pH-value (Figure 3:).

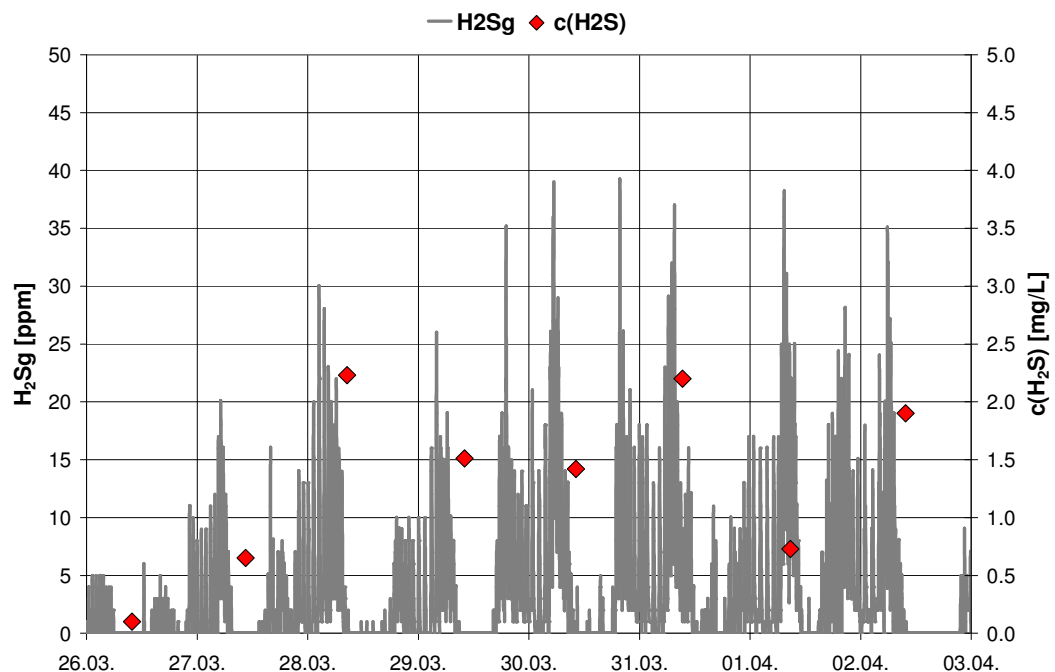


Figure 3: Total dissolved sulfide in the waste water ($c(H_2S)$) and hydrogen sulfide in the atmosphere (H_2S_g) at the pressurized pipe discharge point.

Reference measurements of total dissolved sulfide were carried out using the methylen-blue method and modified field test kit (Saracevic 2009).

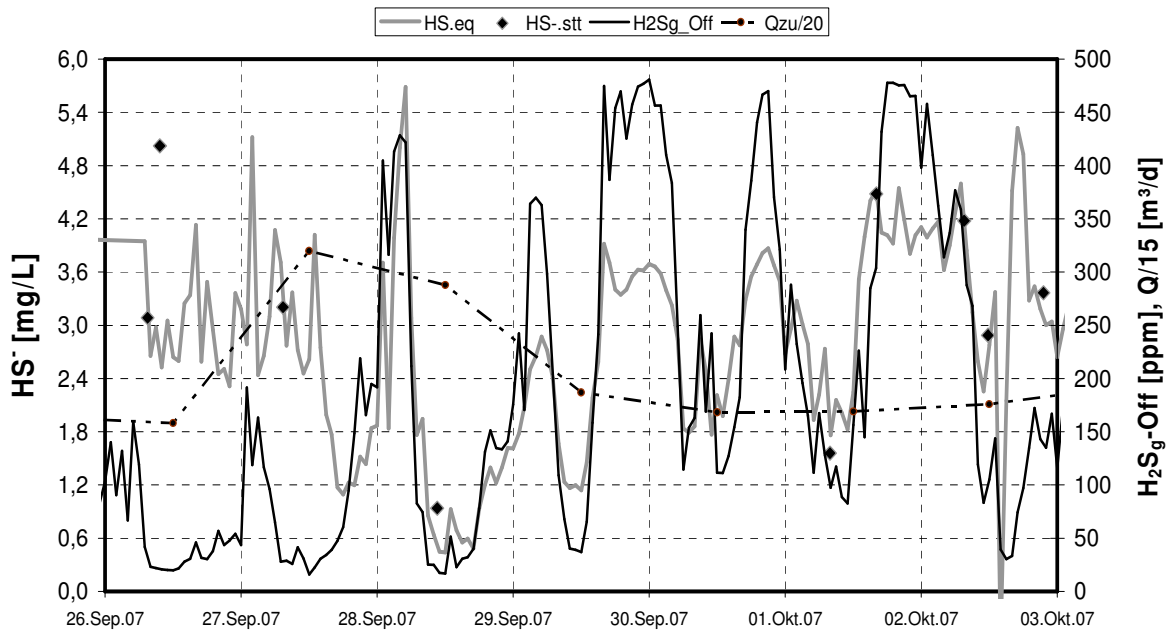


Figure 4: Sulfide components in the influent of WWT

The Figure 4 clearly indicates the good correlation between the continuous measurement of HS^- with UV spectrometer (at 230 nm) and photometric analysis of grab samples taken on the same point. A certain compliance with the H_2S_g measurement was also observed, however the influence of detention time pH and problem with the leak tightness of the discharge point caused some differences. The peak values are caused by the pumping cycles of the pressure pipe. In case of storm water events (influent flow data are daily average values Q_{zu}) the lower waste water concentration resulted in lower sulfide concentrations as can be seen on September 28.

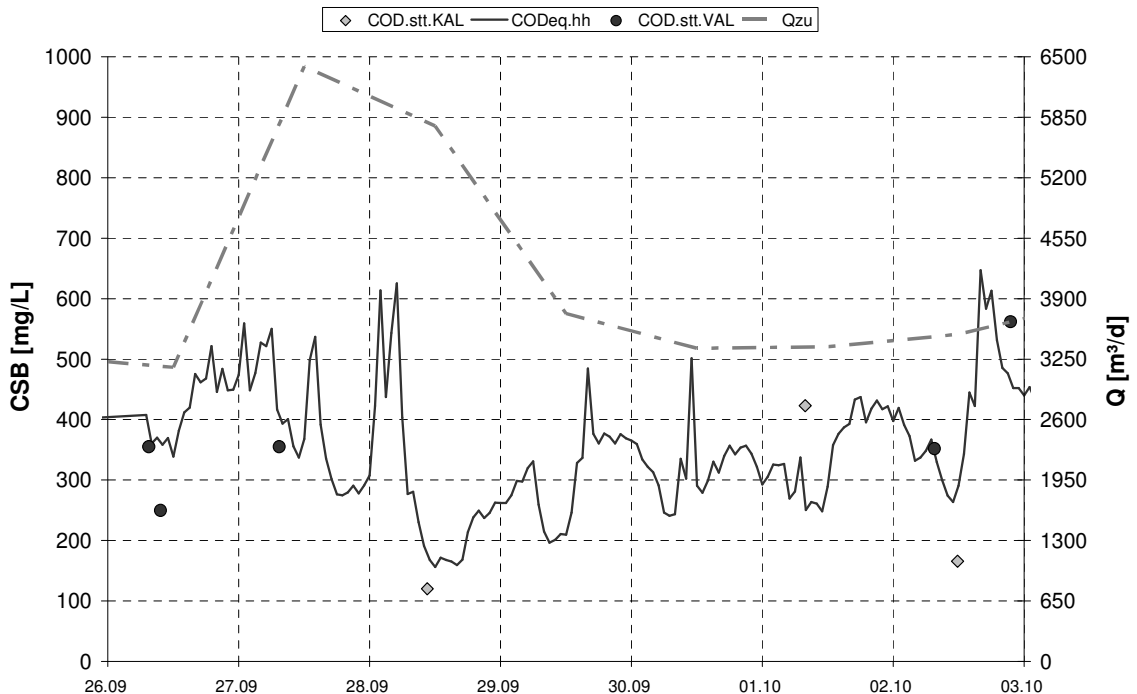


Figure 5: Continuous measurement of the COD in the influent of WWTP with UV spectrometer

With the same probe a continuous measurement of the COD is possible as well (Figure 5). A good correlation with the results of grab samples analysed with test kits on site could be demonstrated as well. The influence of the pump cycles is similar as in the cyclic behaviour of the sulfide measurement (Figure 4).

The treatment of sulfide

Sulfide generation in sewers and waste water facilities is a world wide problem and much research has been done concerning this issue to determinate its causes, effects, prevention and control.

Microbial processes occurring in pressure pipes include aerobic and anoxic reactions as long as oxygen and nitrate are present at the entrance; most of the pipe however is anaerobic for most of the time and typical anaerobic reactions like sulphate reduction and production of organic acids are produced depending on the conditions prevailing. Sulfate reduction leads to the production of hydrogen sulfide which causes a lot of problems in pumping stations, sewers and treatment plants. These problems are not only caused by the intensive odour of hydrogen sulfide but also because of problems in combination with corrosion due to the microbiological formation of sulfuric acid by the oxidation of hydrogen sulfide.



Figure 6: *Processes in sewers (Saracevic 2009)*

Due to the lack of systematic research in Austria several investigations were carried out in different pressure sewers from different waste water treatment plants (WWTP) in order to assess the efficiency of the available technologies to control sulphide generation. All sewer systems investigated were situated in the flat area of eastern Austria (Burgenland, Lower Austria and Styria).

To combat hydrogen sulfide, mechanical methods (pigging, use of compressed air) as well as chemical methods (iron salts, nitrate salts and lime) were examined in different already existing pressure pipes under different operating conditions (Table 1), also regarding their application technology and the economy with consideration of the necessary operating costs.

The selection of the most suitable procedure for the prevention of H₂S-formation and the direct comparison between different measures can only be achieved by testing different technologies under the same circumstance on identical plants referring to their wastewater quality.

Table 1: *Compilation of the procedures investigated*

| WWTP | Pressure sewers (PP) | Symbol | Treatment Methods |
|---------------------|---------------------------|--------|---|
| AWV Fürstenfeld | PP Übersbach | A | Iron salt |
| AWV Seewinkel | PP Pannonia | B | Ironnitrate salt, Pigging with Leca, Lime |
| | PP Lake resort | C | Conventional pigging |
| ABA Guntramsdorf | PP Main pumping station | D | Iron salt |
| | PP BP rest stop | E | Compressed air supply |
| RHV NSW | Collector North | F | Nitrate salt |
| | Collector South | G | Nitrate salt |
| | Collector West | H | Nitrate salt |
| GAV Unteres Zayatal | PP Ringelsdorf-Paltendorf | I | Pneumatic waste water transport |

However it takes several weeks to evaluate one test period. Therefore due to weather changes it was not possible to retain identical conditions for the implementation of different procedures in one and the same pressure sewer. Due to the reasons mentioned above and to gather as much information as possible about the expected operating conditions, different products and procedures had to be investigated on different sites.

The material of all pipes was plastic (PVC, PE), the fittings were stainless steel.

Waste water composition, temperature, pipe dimensions and retention time are decisive factors for sulfide generation. These facts have been considered by different authors in the literature to develop prediction models to calculate sulfide generation in sewers. Some of these models are listed in Table 2.

Table 2: Summary of prediction models for sulfide generation

| Analysis | Parameters | Equations |
|---|--|---|
| Thistlethwayte (1972) | BOD ₅ , Sulfate concentration, Temperature, Diameter, Flow velocity | $\frac{d[S]}{d[t]} = 0,5 \cdot 10^{-3} \cdot u \cdot BOD_5^{0,8} \cdot [SO_4]^{0,4} \cdot 1,14^{(T-20)} \cdot r^{-1}$ |
| Boon, Lister (1975) | COD, Temperature, Diameter, Flow time | $\frac{d[S]}{d[t]} = 0,228 \cdot 10^{-3} \cdot COD \cdot 1,07^{(T-20)} \cdot r^{-1} \cdot (1 + 0,37 \cdot D)$ |
| Pomeroy (1959) | BOD ₅ , Temperature, Diameter, Flow time | $\frac{d[S]}{d[t]} = 1,0 \cdot 10^{-3} \cdot BOD_5 \cdot 1,07^{(T-20)} \cdot r^{-1} \cdot (1 + 0,37 \cdot D)$ |
| Hadjianghelou (1984) | Temperature, Diameter, Flow time | $\Delta S = \frac{0,975 \cdot t}{D}$; $\Delta S = \frac{0,67 \cdot t^{1,07}}{D} \cdot 1,07^{(T-20)}$ |
| ATV-A 116 (1992) | Diameter, Flow time | $\Delta S = \frac{C \cdot t}{d}$ |
| Nielsen, Hvitved-Jacobsen, Raunkjaer (1998) | COD, Temperature, Diameter, Flow time | $rs = a \cdot (COD_{sol} - 50)^{0,5} \cdot 1,03^{(T-20)}$ |

where,

| | | | |
|--------------------|--|----|---|
| [dS]/[dt] | Sulfide generation (mg/l/h) | r | Hydraulic Radius (m) |
| BOD ₅ | Biochemical oxygen demand (mg/l) | t | Average retention time in pipe (min) |
| COD | Chemical oxygen demand (mg/l) | d | Diameter of pressure pipe (cm) |
| COD _{sol} | dissolved chemical oxygen demand (g O ₂ /m ³) | rs | Rate of sulfide formation (g S ₂ -/m ² h) |
| SO ₄ | Sulfate (mg/l) | a | Correction coefficient for waste water matrix |
| u | Flow velocity of wastewater in pressure sewers (m/s) | M | Sulfide Flow coefficient for filled pipe (m/h) |
| T | Temperature of wastewater (°C) | ΔS | Sulfide concentration (mg/l) |
| D | Diameter of pressure pipe (m) | C | Coefficient for type of pipe (for vacuum = 1; for pressure = 2) |

Similar to Pomeroy (1959), the Boon and Lister (1975) model considers parameters COD, diameter of the pressure pipe and retention time (Rt) in their model. Thistlethwayte (1972) additionally uses the concentration of sulfate in his equation for sulfide formation. The Hadjianghelou model (1984), resulted out of the simplification of different models. His equations show a possible comparison between a pressure pipe and a biofilm reactor in terms of sulfide production.

Changes in the matrix of wastewater (industrial or municipal), which have an impact on the activity of microorganisms and therefore on sulfide generation, are only included in the model of Nielsen and Jacobsen (1998).

In the descriptive literature, where the relation between wastewater quality, temperature and retention time is depicted, no reference can be found about the initial level of sulfide in wastewater which has a

significant influence on the intensification of the sulfide generation in pressure sewers connected in series.

In order to characterise the sulfide generation potential for each of the investigated pressure sewers previous to the treatment procedure sulfide concentrations were analysed at the discharge point of pressure sewer over a period of several days. Analytical procedures for investigations are described elsewhere (Saracevic 2009). Thereafter the measured values were compared with the values calculated from the different models mentioned. The results are shown in Figure 7. Different sewers resulted in different sulfide generation potentials. The calculated values according to Boon and Lister and Hadjianghelou give the best agreement with the experimental values.

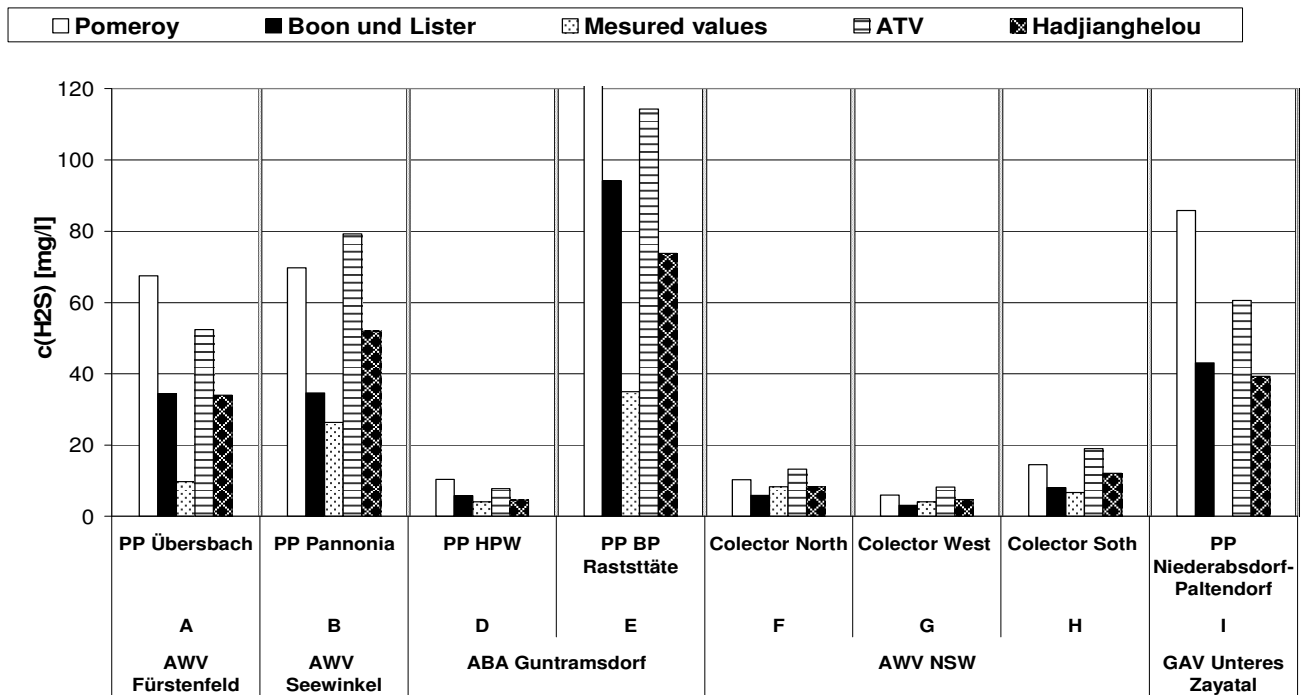


Figure 7: Modifications of calculations for the potential of sulfide formation in comparison of analysed sulfide concentrations

Some of these models were applied to the pressure sewers involved in this project. For the big diameter sewers (G pipe and H pipe in AWV NSW and D pipe in Guntramsdorf) all sulfide predictions and the measured sulfide concentrations are more or less in the same magnitude. However, for the smallest diameter pipes A, B and E models predict even three times higher sulfide concentrations in comparison to the measured ones. Especially the prediction models from Pomeroy and ATV (1992) overestimate sulfide generation while Boon and Lister and Hadjianghelou often get similar predictions, which are also closer to the real values. Moreover, none of these prediction models take into account many pressure sewers connected in series with intermediate pumping stations, which was the case in many of the sewer systems considered. There is an enhancement of sulfide generation in the following pressure pipes if the incoming sewage is already septic.

Based on several data from different pressure lines in Austria a new model for estimate of sulfide formation potential has been developed. But the used approach is implicitly connected with the underlying dataset; the model is primary useable on pressure lines, which are applying with the boundary conditions, like those which were used for developing this model.

The following data from the selected pipe lines was known or has been ascertained over the course of field experiments:

| | | | |
|---|---------------------------|------------|---|
| D | Diameter of pressure pipe | t | wastewater retention time in pressure pipe |
| L | Pressure pipe length | COD | Chemical oxygen demand of wastewater |
| Q | wastewater quantity | ΔS | Sulfide-concentration at the end of the pressure pipe |
| T | wastewater temperature | | |

Tabelle 3: Data of the pressure pipe, which have been used to develop the model

| Pressure pipe Symbol (Table 1) | PP Length | PP Diameter | Wastewater flow | COD | Temperature | Retention time | Sulfide-conc. ΔS |
|--------------------------------|-----------|-------------|-------------------|----------|-------------|----------------|--------------------------|
| | m | m | m ³ /d | mg/L | °C | h | mg/L |
| A | 4150 | 0,200 | 297-394 | 410-917 | 12,2-16,8 | 7,8-10,3 | 0,7-11,7 |
| B | 3220 | 0,150 | 106-191 | 222-1090 | 16,0-19,5 | 7,1-12,7 | 9,3-44,5 |
| C | 4380 | 0,275 | 142-205 | 71-101 | 15,0-18,0 | 6,6-9,5 | 0,1-3,5 |
| E | 1800 | 0,090 | 29-33 | 890-1530 | 9,4-15,1 | 8,3-9,5 | 5,6-43,9 |
| F | 4560 | 0,443 | 2306-11448 | 60-690 | 14,2-19,1 | 1,5-7,3 | 0,1-17,0 |

A method of the Multivariate analysis; PLS-Partial Least Square (Wold (1985)) - has been used to define the influence of the mentioned magnitudes on the sulfide formation potential. By use of the PLS process the following model for the sulfide formation potential could be generated:

$$\Delta S = 2,4 * T + 0,017 * CSB + 1,22 * t - 0,0038 * D - 28,72 \quad (1)$$

with:

- ΔS Sulfide-concentration at the end of the pressure line [mg/L]
- T Wastewater temperature [°C]
- COD Chemical oxygen demand [mg/L]
- t average retention time in the pressure pipe [h]
- D Diameter of pressure pipe [mm]

Figure 8 shows the comparison of the results from the new in Vienna (TU Wien) developed model with results of other models known from the literature with the same dataset. The TU-Wien model gets the high value of regression coefficient; in the region below $c(\text{H}_2\text{S}) = 10 \text{ mg/L}$ every model shows noteworthy variations to the reference level.

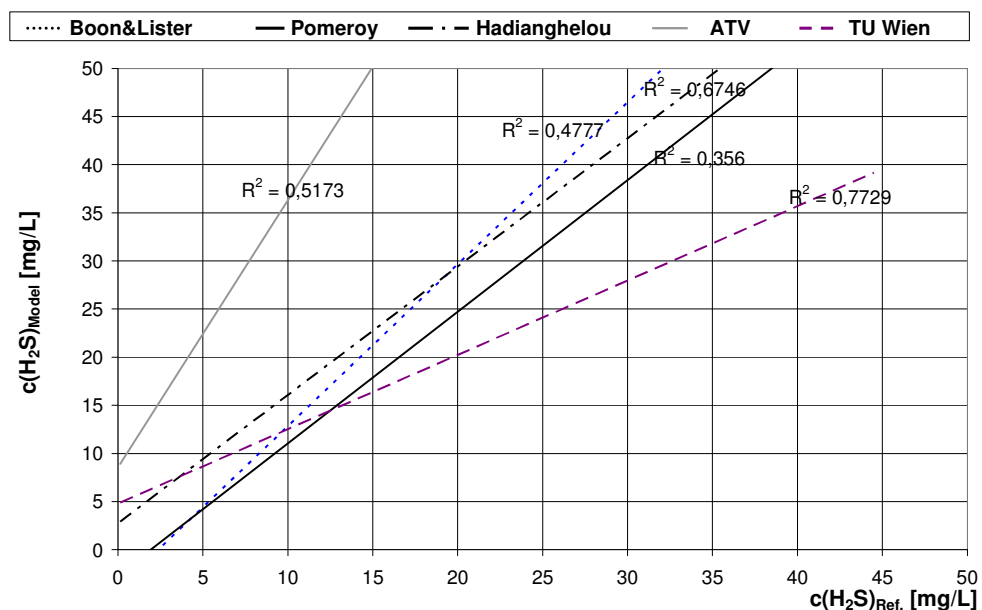


Figure 8: Comparison of results from different models for the calculation of sulfide formation potential using the dataset from Table 3.

The calculated or analysed values of sulfide concentrations are a useful basis to calculate the appropriate dosage for the chemical substances to prevent problems related to hydrogen sulfide production (Figure 9).

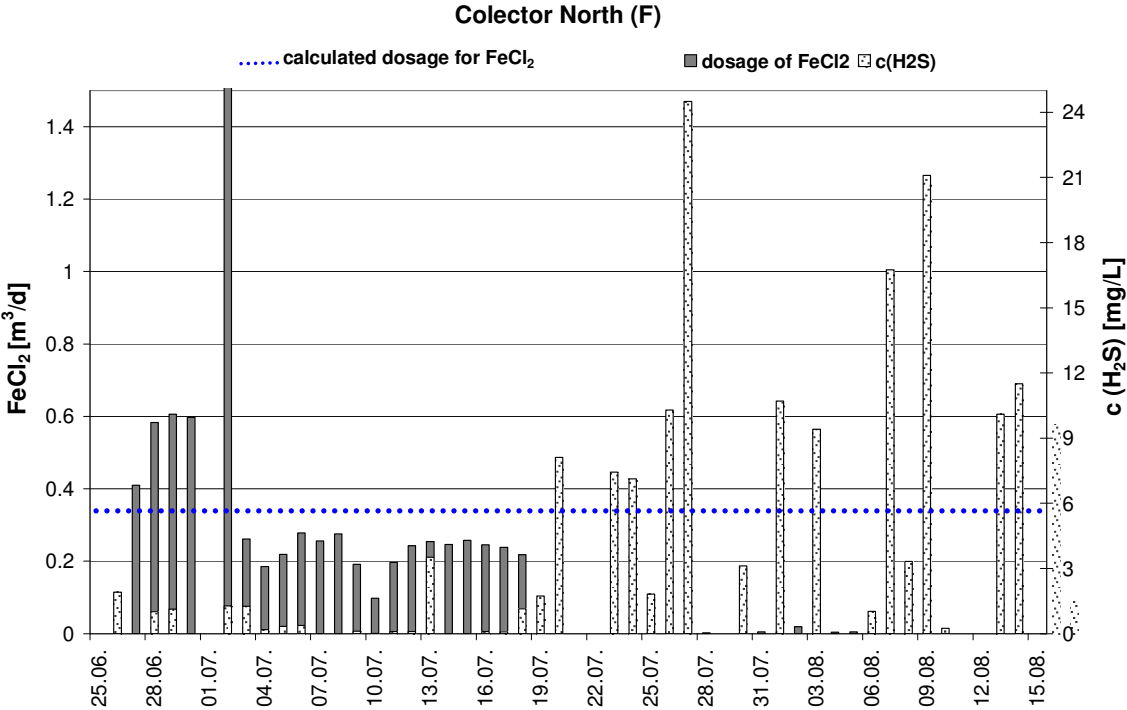


Figure 9: Calculated and experimental values for FeCl₂ dosage in Colector North (F)

However, side reactions have to be considered in the chemical consumption. Examples of these side reactions are the consumption of nitrate-oxygen for degradation of organic carbon compounds or the formation of iron phosphate.

Figure 10 shows the comparison between the practical and the stoichiometrical consumption of active components in relation to eliminated sulfide and amount of treated waste water.

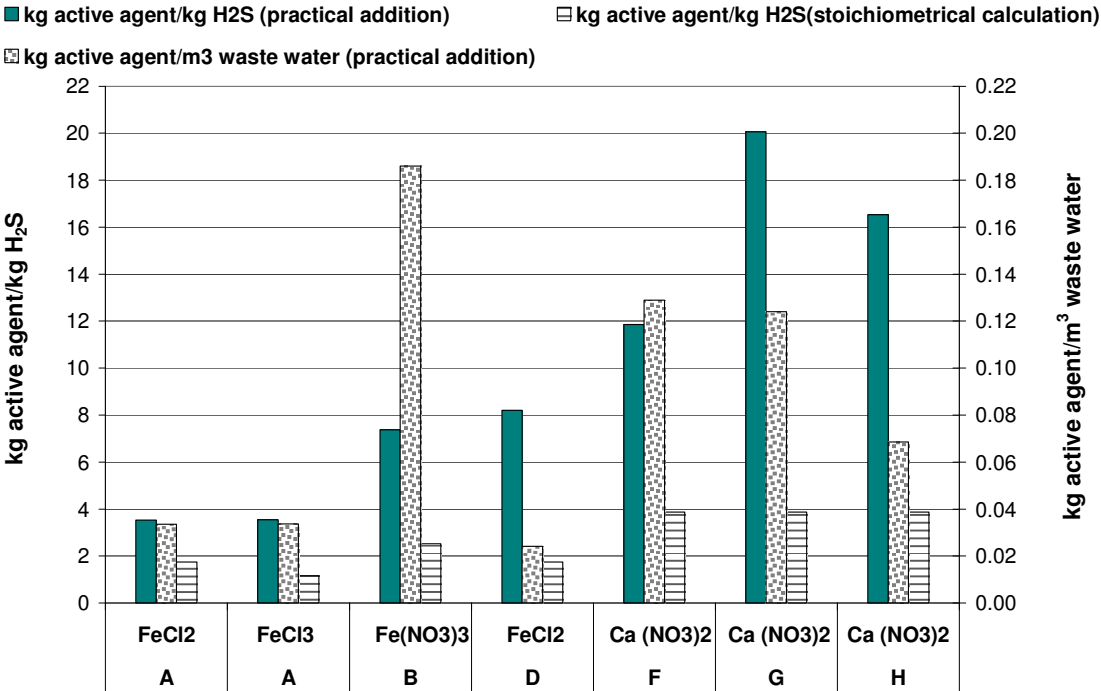


Figure 10: Practical and the stoichiometrical calculated consumption of active agent

In some of the cases the practical consumption was 2-5 times higher than the theoretical value, due to the above mentioned side reactions or possible overdosage.

The influence of side reactions can clearly be seen on the example of pressure sewer RHN NSW, where nitrate was added as acting agent. The differences between the practical and theoretical values were much bigger in the F pipe as compared to the H pipe. The reason for the higher practical consumption was certainly the anoxic consumption of nitrate in all three cases. However, pipe F had the highest diameter and therefore the lowest specific biofilm surface which resulted in a lower nitrate consumption. Pipe H had the smallest diameter and the highest specific biofilm surface. The reason for the even higher consumption in the G pipe is only partly the diameter but could mainly be explained by an overdosage due to problems with the dosing equipment.

A comparison of the practical addition based on specific consumption for eliminated hydrogen sulfide and on specific consumption per cubic meter treated waste water can lead to erroneous conclusions. This can clearly be seen in the case of sewers B and D. Sewer B is a small diameter pipe with concentrated waste water. Therefore the sulfide concentration observed was very high and a high specific dosage per cubic meter waste water was needed. In case of pipe D, the big diameter and the low waste water concentration resulted only in low sulfide concentrations leading to low specific dosage per cubic meter treated waste water. If the comparison is based on the eliminated sulfide both sewers exhibit similar demands of active agent.

Table 4: Prices and characteristics of different products to combat production of H_2S

| Product | Product prices (barred box) | Product prices (tank) | Active agent | kg active agent/100 kg product | mol active agent / kg product | Active agent price (barred box) |
|----------------------------------|-----------------------------|-----------------------|-------------------|--------------------------------|-------------------------------|---------------------------------|
| | €/T | €/T | | kg/100kg | mol/kg | €/mol |
| Bellair green ($FeCl_2$) | 345 | 235 | Fe^{2+} | 14 | 2,51 | 0,137 |
| Bellair green plus ($FeCl_3$) | 427 | 255 | Fe^{3+} | 13,8 | 2,47 | 0,173 |
| Donau klar classic ($FeCl_3$) | 245 | 145 | Fe^{3+} | 13,8 | 2,47 | 0,099 |
| Anaerite 263 Hi ($Fe(NO_3)_3$) | | | Fe^{3+} | 7,39 | 1,32 | |
| | 790 | 400 | NO_3^- | 24,61 | 3,97 | |
| | | | Fe^{3+}, NO_3^- | 32,0 | 5,29 | 0,149 |
| Nutriox ($Ca(NO_3)_2$) | 240 | / | NO_3^- | 33,88 | 5,46 | 0,044 |

In Figure 11 the costs for the different sulfide treatments based on m^3 of treated waste water, length of the pressure pipe and removed sulfide load are presented. More significant information about the expected treatment costs is certainly obtained on the basis of eliminated hydrogen sulfide since an efficient treatment depends on the removed load of hydrogen sulfide. Sewage of similar quality can produce significantly different amounts of sulfide depending on retention time and diameter of the pipe and sewage temperature and COD concentration. The treatment costs at the pipe B (AWV Seewinkel) and pipe H (RHV-NSW) can serve as an example. In the case of pipe B concentrated sewage from a holiday resort with separate sewer system was pumped to the WWTP in a relatively small pipe (diameter 150 mm) which resulted in very high sulfide concentrations (up to 40 mg/l). Therefore the costs for treatment based on cubic meter were extremely high as compared to the pipe H (RHV NSW) (ratio 1:9). Costs based on eliminated sulfide are still somewhat higher because of the higher price of agent used, however the ratio is reduced to 1:1,5.

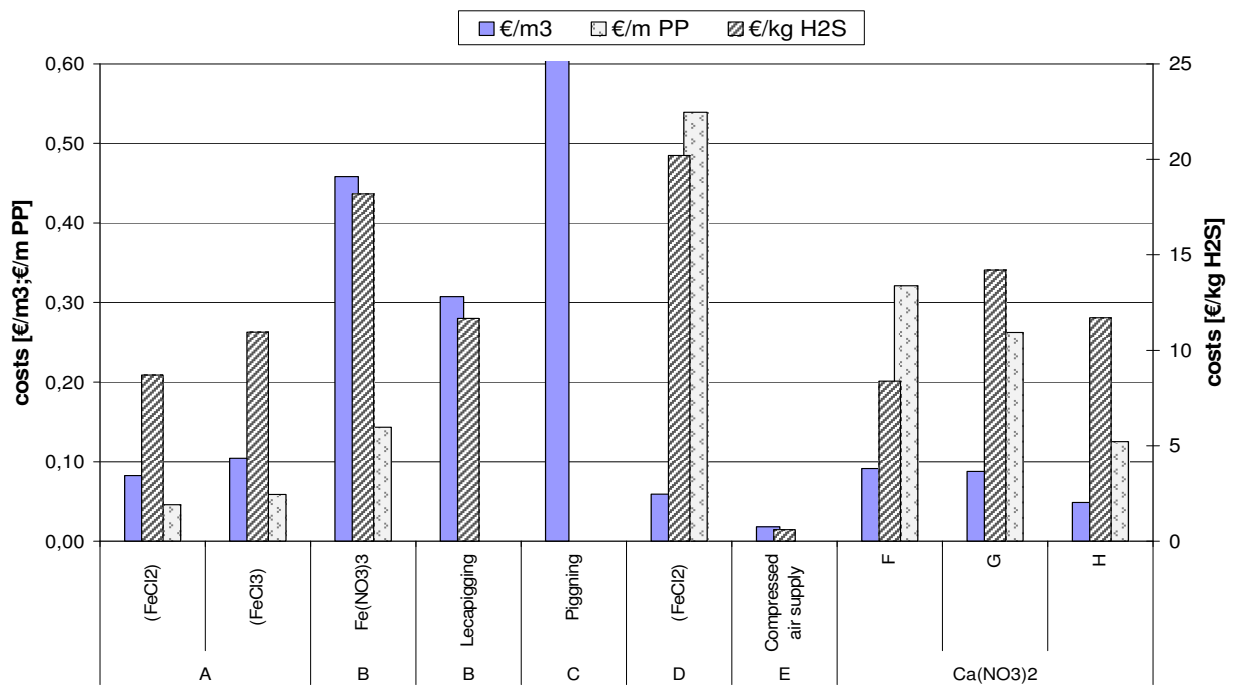


Figure 11: Costs of sulfide treatment based on sulfide formation, wastewater quantity and length of pipe

A relation between the length of the pressure pipe and the demand of active agent consumption could not be proved to be relevant.

The prices of the chemicals also depend on the delivery quantity. For consumption below 5 m³/a chemicals can be delivered and stored in barred boxes. For higher consumptions it is cheaper if delivery is carried out in tanks bigger than 10 m³, which would reduce the prices significantly (Table 4).

Conclusions

Due to the technical know-how achieved in this project, a summary of different applications according to different procedures for the prevention of sulfide is given in Table 5 where the following aspects are considered:

1. Properties of the pressure pipe:
 - Possible application for existing and new sewers
 - Diameter of the pressure pipe (>200 mm or < 150 mm)
 - Pipe material (steal or plastics)
2. Operational conditions:
 - Retention time of wastewater in the pressure pipe (< 3 h or > 6 h)
 - Waste water temperature (< 10 °C or >15°C)

The technical details are discussed elsewhere (Saracevic, 2006).

For the evaluation of the applicability of the investigated sulfide treatment procedures five categories were selected:

- ++ high suitability
- + suitable
- + - limited suitability
- + - - only suitable under specific conditions
- not suitable

Table 5: Criteria of applications for different procedures for the prevention of sulfide

| technology | pressure pipe | | size (DN) | | material | | retention time | | waste water temperature | | influence on WWTP |
|--|---------------|-----|--------------|--------------|----------|---------|----------------|---------------|-------------------------|------------|--|
| | existing | new | large >200mm | small <150mm | steel | plastic | short < 3 Std. | long > 6 Std. | low <10°C | high >15°C | |
| Conventional pigging | + | + | + - | + | + | + | / | / | / | / | |
| Pigging with Leca | + | + | <300 | >80 | + | + | / | / | / | / | |
| Lime | + | + | + | + | + | + | + - | + | + | + | |
| Flush water | + | + | + - - | + | + | + | + | + - | + | + | |
| Zeolith | + - | - | + - | + | + | + | - | - | + | - | |
| Nitrate salt - Ca(NO ₃) ₂ | ++ | + | + | + | + | + | + | + - | + | + - | reduced denitrification capacity at the WWTP |
| Ironnitrate salt – Fe(NO ₃) ₃ | ++ | + | + | + | + - | + | + | + | + | + | phosphorous precipitation |
| Iron salts (Fe ²⁺ ;Fe ³⁺) | ++ | + | + | ++ | + - | + | + | + - | + | + | phosphorous precipitation |
| Compressed air supply | + | ++ | <500 | ++ | + | + | + | ++ | + | ++ | reduced denitrification capacity at the WWTP |
| Pneumatic waste water transport | / | ++ | <400 | ++ | + | + | + | ++ | + | ++ | reduced denitrification capacity at the WWTP |

++ high suitability + suitable + - limited suitability + - - only suitable under specific conditions - not suitable

Some of the information of Table 5 is discussed subsequently. The qualification ++ (high suitability) applies generally for nitrate or iron salt addition in existing pipes. The development of an extensive biofilm in pipes with diameter < 150 mm in case of nitrate addition reduces the free cross sectional area and therefore the flow conditions in the pipe. For this reason the use of iron salts is advantageous.

The application of compressed air or the pneumatic transport of waste water had the highest number of ++ qualifications, however the decomposition of easily degradable compounds reduces the denitrification capacity in the WWTP. This is also true for nitrate addition. Because of economical reasons in many cases the addition of iron salts can be useful since precipitated FeS can be oxidised in the aeration tank and Fe^{+3} can serve as precipitant for PO_4^{-3} . The addition of nitrate has been applied quite successfully since the necessary dosage can be adapted to the particular situation. A combination with a special pigging method (Matsché, 2005) can reduce the chemical costs significantly.

In pressure pipes with small diameter and long retention time the use of compressed air has been very effective and economical and can be added to existing facilities. If a new pressure pipe is planned the installation of a pneumatic system should be taken into consideration because this kind of waste water transport cannot be added to existing facilities.

The treatment with chemicals in existing pipes is recommended, which can be easily re-fitted. For the choice of the chemicals to be used to abate hydrogen sulfide, it is necessary to compute the sulfide formation potential under local conditions, which makes it then possible to estimate the amount and costs of chemicals required.

The applicability of UV Spectroscopy for continuous sulfide and COD measurement in sewer system has been successfully demonstrated.

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