Gas emissions in municipal sewer networks in two climatic regions

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1 Introduction and objectives

The presence of gases such as hydrogen sulphide (**H_2S**), methane (**CH_4**) and nitrous oxide (**N_2O**) in wastewater treatment and collection systems, has become a major concern given their contribution to the urban carbon footprint as well as to the problems associated to odours and corrosion. So far, most attention has been placed on gas emissions from Wastewater Treatment Plants (WWTP).

However, **a sewer network can be considered a biological reactor** due to their hydraulic retention time, with different environmental conditions depending on which constructive element is being under study [1]. Gravity sewers are known as aerobic environments, while rising sewers are anaerobic [2]. In addition, elements like wet wells before pumping stations, change their condition depending on the pumping stage [3].

The principal objective of this study is to **quantify gas concentrations (greenhouse gases and odours)** in different elements of the sewer network, different climatic regions and different times of the year in order to **identify key parameters** affecting gas production.

2 Methodology

Two cities from different climate regions were selected as case studies to perform sampling campaigns during Summer 2013 and Winter 2014:

- **Calafell**, Catalonia, Spain (Mediterranean climate)
- **Betanzos**, Galicia, Spain (Atlantic climate)

Five sewer sites were gas monitored with a sounding line and a closed chamber during 1 hour (Figure 1): manholes, wet wells before pumping stations and influent of the WWPTs.

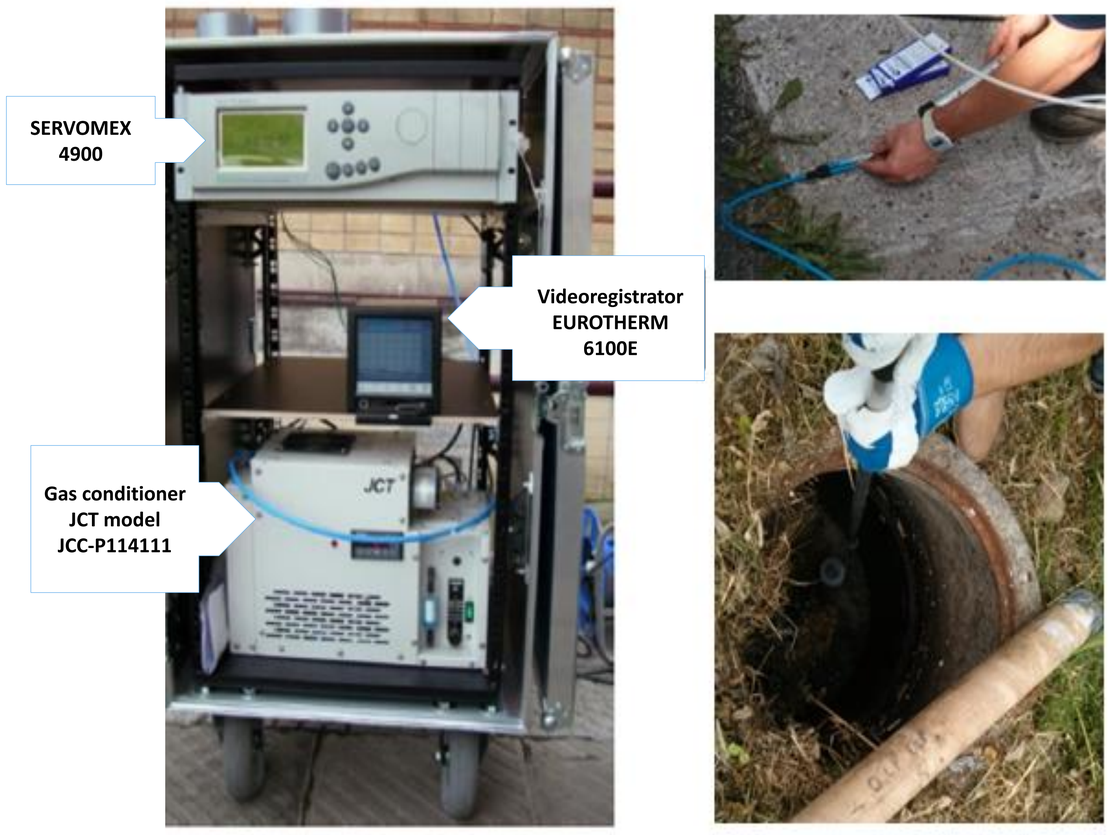

Figure 1. GHG analyser (Left). Hydrogen sulphide measurement and a sampling site example (Right).

3 Results and Discussion

Figure 2 shows an scheme of the sewer networks analysed, and in Table 1 reports the concentrations measured for each gas both in summer and in winter for the two case studies. Concentrations are reported in micrograms per liter of air.

Table 1. Concentrations measured in the sewer network of Betanzos and Calafell (PS: Pumping Station, MH: Manhole)

BETANZOS		1. As Cascas PS	2. As Cascas MH	3. Marina St MH	4. Main PS	5. WWTP influent
CH4 (ppm_v)	Winter	238	123	12.8	22.2	43.3
	Summer	1684	42.2	30.6	64.5	291.5
N2O (ppm_v)	Winter	0.0	0.0	0.0	0.0	0.0
	Summer	0.0	0.0	0.0	0.0	2,3
H2S (ppm_v)	Winter	0.0	0.0	0.0	0.0	0.0
	Summer	0.0	0.0	0.0	0.0	0.0

CALAFELL		1. Baixador PS	2. Victor Català St. MH	3. Mas Mel PS	4. Creu Roja PS	5. WWTP influent
CH4 (ppm_v)	Winter	n/m	14.7	46.5	131,7	46.8
	Summer	2.7	194.4	353.8	489	234.5
N2O (ppm_v)	Winter	n/m	0	0	3.6	0
	Summer	0	3.3	4.6	10.3	0
H2S (ppm_v)	Winter	n/m	0	0	0	3.0
	Summer	0	0.5	1.0	2.5	2.0

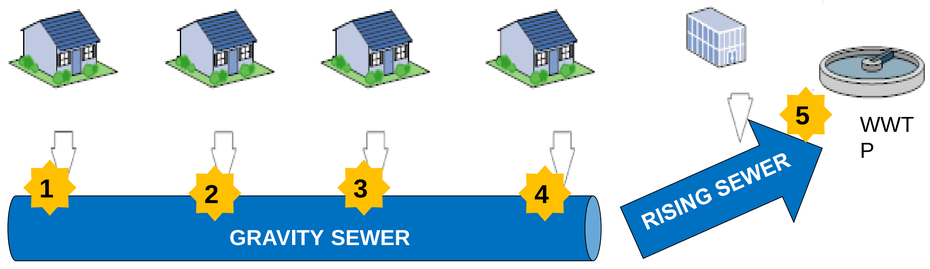

Figure 2. Schematic representation of the sewer network and sampling sites.

In general, the highest gas concentrations were observed in Calafell (Mediterranean climate) in summer. Therefore, high temperature contributes to the production of these species.

- Higher concentrations of CH_4 (up to 1684 ppmv) than N_2O and H_2S were found. As the responsible bacteria for H_2S and CH_4 formation compete for the same electron donors [4], higher amounts of CH_4 correspond to lower values of H_2S. The highest amount of H_2S (2.5ppmv) was observed at the Creu Roja Pumping Station in Calafell.
- Different constructive elements of the network were analysed to cover different environmental conditions of the system. In general, wet wells were found to be the sampling sites with the highest concentrations of CH_4 and H_2S (up to 1684 ppmv of CH_4 and 2.5 ppmv of H_2S). In contrast, the lowest concentrations were measured in manholes. In wet wells, pumping events increase turbulence, favouring gas release [2], and in between, they have anaerobic environments which are suitable for CH_4 production.
- **Emission factors** can be calculated in the influent of both WWTP considering temperature, air and water flow. Values up to **24.6 Kg CH_4/yr** and **0.5 Kg N_2O/yr** were obtained in Betanzos and up to **18.6 Kg CH_4/yr** and **0.5 Kg H_2S/yr** in Calafell.

4 Conclusions

After this analysis, we can conclude that seasonality and therefore, temperature, is a key parameter in gas production. The results indicate that **high temperature favours these emissions**. In addition, wet wells before pumping stations seem to be the constructive elements where higher concentration of CH_4 and N_2O is found. As a result, it can be concluded that **turbulence is an important parameter in gas release.**

Reported values are expressed in a volume of air. Future measurements of dissolved gases must be conducted in order to compare the gas formation and the gas release to the atmosphere. Emission factors were calculated only for the influent to correlate wastewater flow, but the contribution of the rest of the network needs to be taken into account in order to compare the results with WWTP emissions.

These values highlight that the contribution of direct emissions in sewers to overall gas emissions from wastewater systems are significant, and the presence of N_2O is not negligible in sewer networks.

5 References

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