CORRELATION BETWEEN ODOUR AND HYDROGEN SULPHIDE CONCENTRATIONS FROM MUNICIPAL WASTEWATER TREATMENT PLANT IMMISSIONS

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Introduction

The main odorous compounds emitted into atmospheric air from wastewater treatment plants (WWTP) are sulfur-containing substances such as hydrogen sulphide, methyl mercaptan, dimethyl sulphide, dimethyl disulphide, ethyl mercaptan, carbon disulphide and carbonyl sulphide. Although all of these odorous compounds may be present in atmospheric air, the most significant odorous compound is hydrogen sulphide (H_2S, being a dominant odorant gas). Depending on the immission of H_2S into the ambient air, the evolution of odour concentration takes place in the municipal wastewater treatment plant.

Materials and methods

Sampling campaign

The sampling campaign covered the year of 2020, for a period of two weeks in early autumn at the municipal wastewater treatment plant with a population of about 2 million, located in south of Romania.

The sample of residual gaseous collected during the sampling campaigns was divided into *two samples*, one for hydrogen sulphide concentration quantification and the other sample to determine the odour concentration by dynamic olfactometry.

The sampling equipment used in the determination of hydrogen sulphide in immissions are: *Gil Air* type sampling pump, capable of ensuring a sampling flow between 0,01-0,03 m^3/h, absorption, made of glass or material resistant to corrosion of absorbent solution/analyte, CINTRA 5 spectrophotometer. And as regards the sampling of odour sources, a *vacuum pump and sampling bags made of a suitable, certified material* were used.

Therefore, both H_2S and odour were monitored at the following marked in **Fig. 1**.

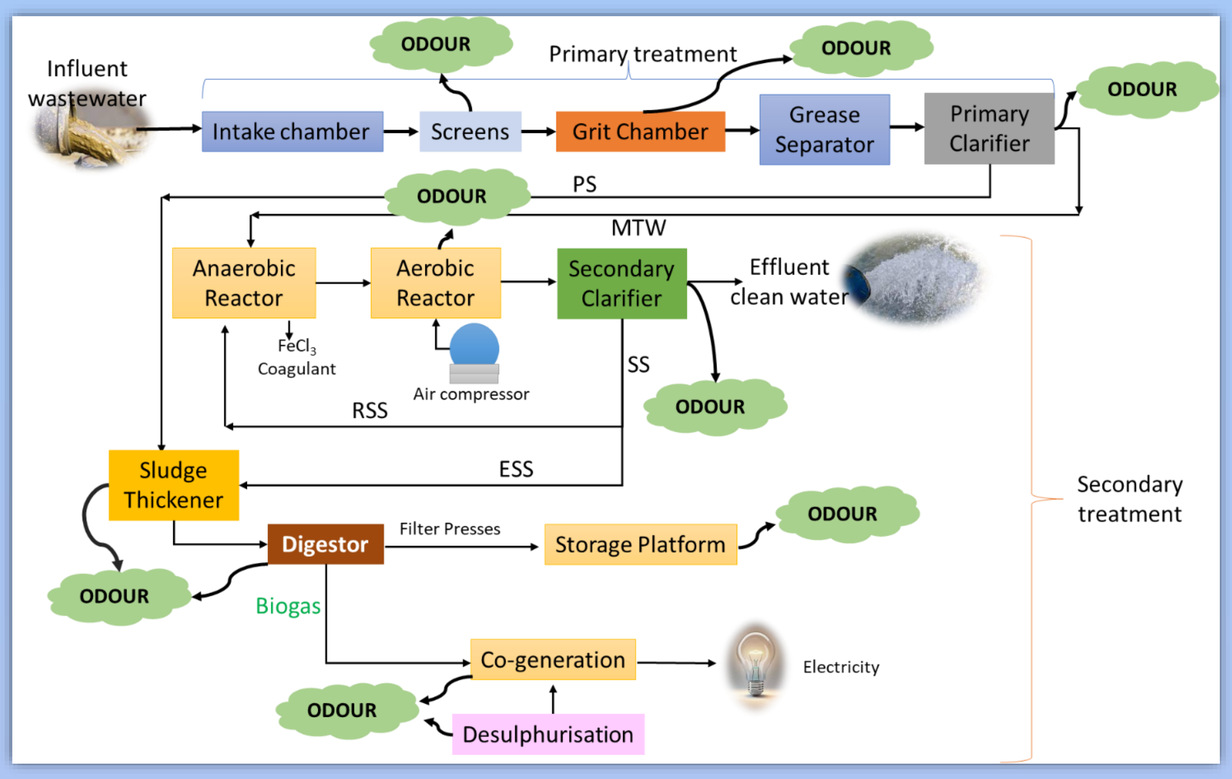

Figure 1. Scheme of municipal wastewater treatment process and the sampling points: *Primary Sludge-PS, Mechanically Treated Water- MTW, Secondary Sludge-SS, Recycled Secondary Sludge-RSS, Excess Secondary Sludge-ESS*.

Odour *Measurements*

Odour sampling involved collecting a volume of 10 L of odorant gas with a vacuum device, in containers that do not affect the quality of the sample (special certified nalophan bags). The odour analysis was performed with the dynamic olfactometry method, EN 13725 (2003) based on sample dilution until the detection threshold is reached, by the four human evaluators.

H_2S detection

Sampling of hydrogen sulphide in ambient air was performed by retention in specific absorbent solution (zinc hydroxide, $Zn(OH)_2$),by bubbling a residual gaseous effluent with a sampling flow of 1.5 L / min, internally validated method. By aspiring a measured volume of H_2S gas and S^{2-} ions retained in the absorbent solution it reacts in acidic medium in the presence of Fe^{3+} ions with paradimethylphenylenediamine, forming tetramethyldiaminodiphenylthiazine chloride as a reaction product, exhibiting maximum absorbance at 670 nm.

Results and discussion

In order to evaluate the correlation between the odor concentration and H_2S in the immissions of a municipal treatment plant, the following steps were completed, **fig. 2**.

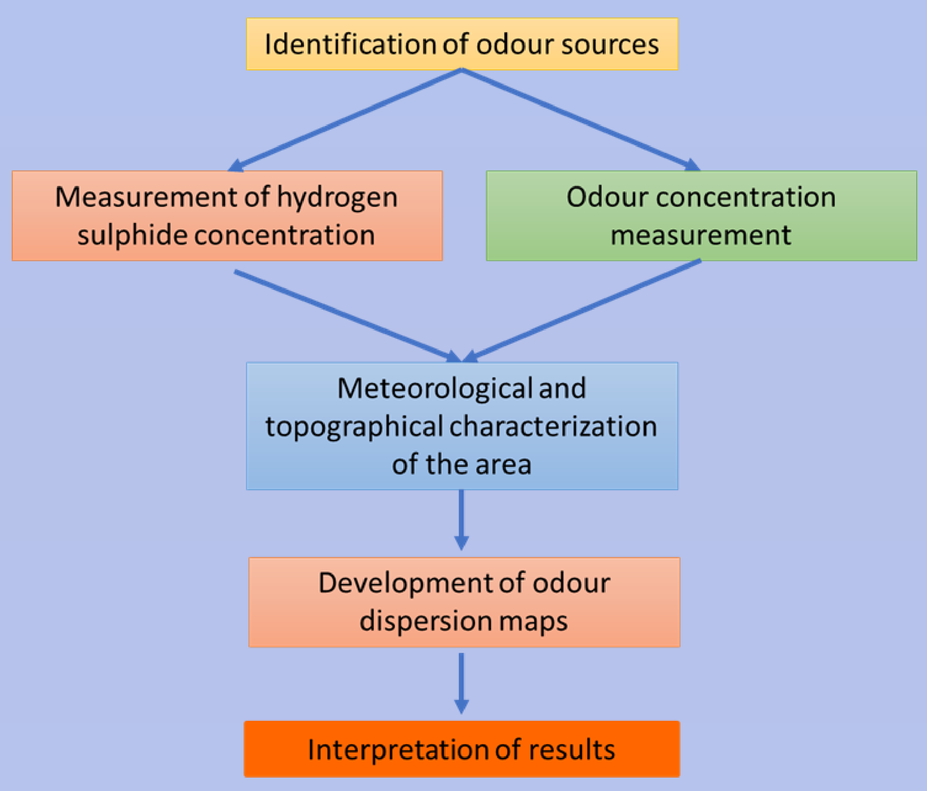

Figure 2. Block diagram for impact assessment due to exposure to odor and hydrogen sulphide in municipal wastewater treatment plant

In terms of odour concentrations, a maximum value of approximately 36 000 ou_E/m^3 was recorded in the Sludge pumping station **fig. 3**. The major source of high H_2S concentrations was *the sludge pumping station*, followed by *the digester*.

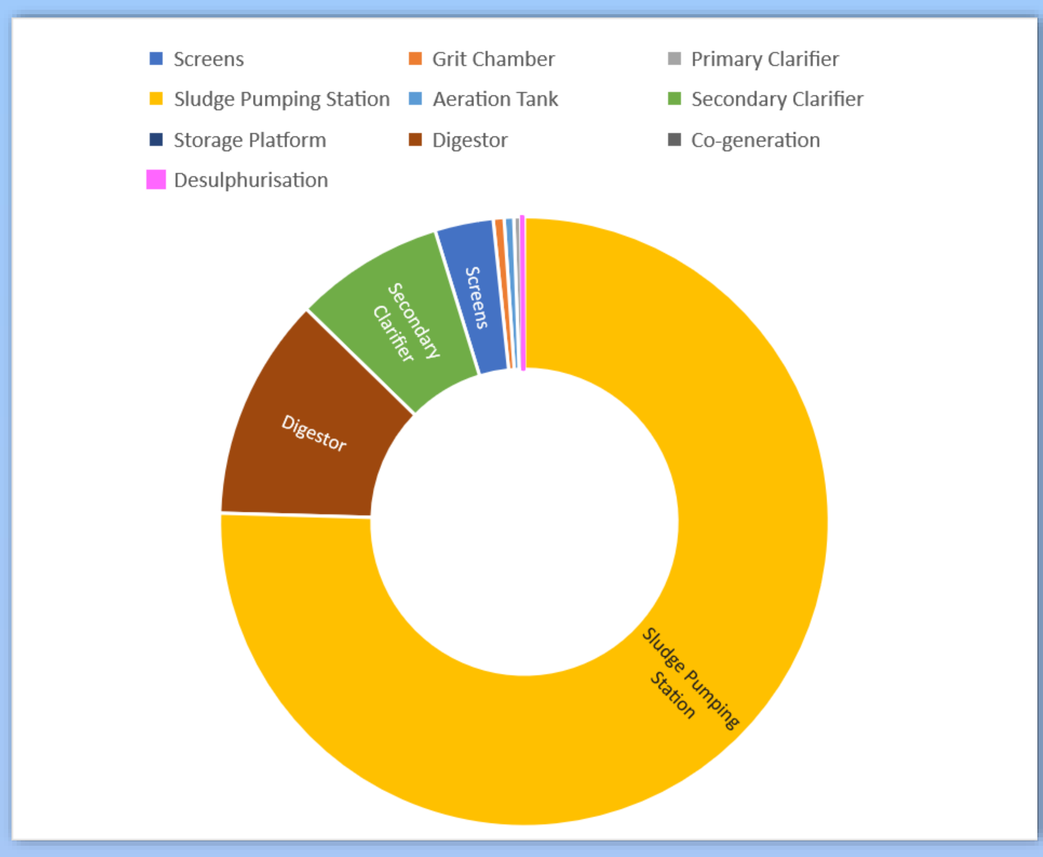

Figure 3. Major odour sources identified on wastewater treatment plant areal

The results obtained in **fig. 4** showed the correlation between hydrogen sulphide and odour concentrations, indicated a significant increase in odour concentration with increased in hydrogen sulphide immission concentrations. The main major sources of odour within the treatment plant are associated with admission works, biological decomposition processes of organic matter or sludge processing. However, the aeration activated sludge system has successfully achieved desulfurization of approximately 99% of H_2S through degradation and absorption processes.

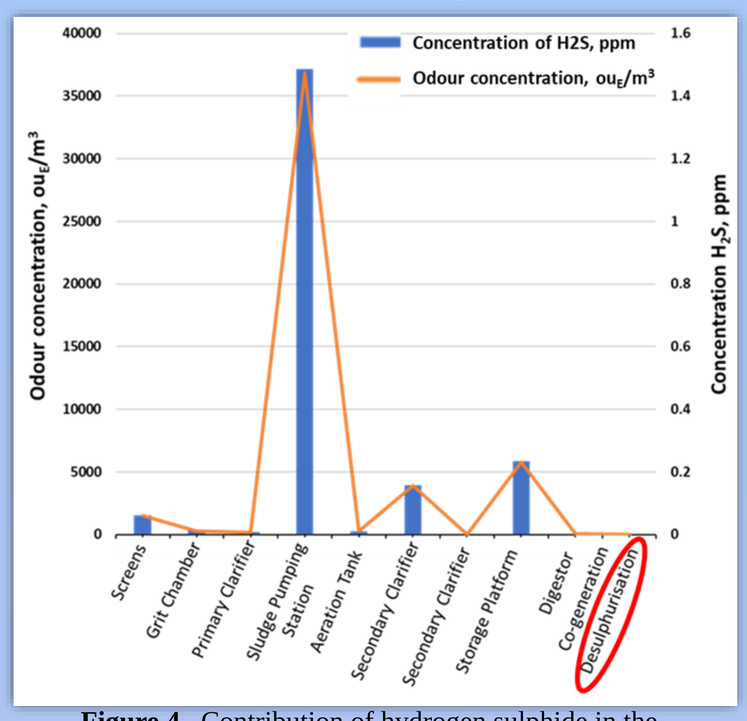

Figure 4. Contribution of hydrogen sulphide in the determination of odour concentration

In addition to the estimation of the odor level, the placement of sensitive receptors was carried out, by placing them in the closest residential areas, in the vicinity of the treatment plant. Table 1 highlights the results obtained following the introduction of these sensitive receptors. The highest concentrations were found in point 4-4.04 OU_E/m^3, followed by point 1-3.87 OU_E/m^3. Although point 4 was located at a distance of 1000 m, it is located on the prevailing wind direction, NE. The predicted values for the concentration of H_2S were calculated based on the ratio between the concentrations determined by the smell and those of H_2S, 25 000. The estimated values of H_2S in residential, they were far below the maximum allowed concentrations. The safety level of the residents was respected.

Table 1. Point receptors inserted into sensitive areas - "Highest values"

Point	Coordinates (Stereo 70)		Distance to the unit (m)	Odour concentration, OU_E/m^3	Predicted concentration H_2S, ppm
	x	y		"Highest values"	
1	598198.68	321882.88	50	**3.87026**	**0.00015481**
2	599430.7	321449.07	1000	0.24823	9.9292E-06
4	597402.87	323144.08	1000	**4.04557**	**0.000161823**
5	599552.47	323244.76	1100	1.89741	7.58964E-05
3	596572.92	321347.08	1500	0.20362	8.1448E-06

Conclusions

In conclusion, the analysis of odour concentrations within the municipal wastewater treatment plant correlated with a major source of H_2S immissions such as sludge pumping station, where *maximum value of 36 000 OU_E/m^3* was recorded. Ambient temperature played a significant role in the volatilization of H_2S, thereby influencing odour concentrations, and the correlation between hydrogen sulfide and odour was evident.

Although H_2S had a very low detection limit, experimental results indicated the absence of risks to human health. Based on mathematical modeling, the maximum odour concentrations that can be found at sensitive receptors were between *0.2-4 OU_E/m^3*.

The location of the sensitive receptors demonstrated that the main wind direction had a significant impact on the odour levels perceived by them.

It was confirmed a direct link between the degree of air loading with H_2S and the determination of the odour concentration in the municipal wastewater treatment plant, which was essential in the process of odour assessment and quantification. In terms of olfactory perception, there was a directly proportional relationship between the concentration of odour and that of *H_2S, with a ratio of 25 000*. This makes the odour perceived by humans more intense as the concentration of H_2S increases, and this relationship is characterized by a constant and predictable increase in odour intensity with increasing H_2S concentration.