Data analysis and dispersion modeling of the odor emissions from a wastewater treatment plant in Oliva (Valencian Community, Spain)

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Abstract

Wastewater treatment plants (WWTPs) play a fundamental role in the protection of the aquatic environment because they prevent pollutants from reaching it. However, when located next to residential areas they can produce odor nuisance, which is the case of the WWTP Camping San Fernando in Oliva, Spain. The main goal is to resolve whether or not perceptible H_2S concentrations can occur in the residential area in question due to the odorant emissions. To this end, two measurement campaigns were carried out covering around 220 days in total. By means of a thorough data analysis it could be shown that the probability for these residential areas to be affected is the highest from June to August between 7 p.m. and 7 a.m. Moreover, the daily H_2S concentration patterns also fit to this conclusion. In order to substantiate that, dynamic olfactometry measurements were conducted by two expert panelists in addition to the employment of the AERMOD model. With this conservative Gaussian dispersion model, it was possible to determine under which conditions H_2S concentrations above the perception threshold of 0.00047 parts per million (ppm) can occur at the residential dwellings. The most realistic scenario suggests that no perceptible concentrations occurred during any of the studied periods. However, the worst case scenario, which assumed constantly high volume outflows of the WWTP, showed that it is indeed possible. With the on-site olfactometry measurements and analysis of wind data, it could be confirmed that the wind direction is the deciding factor whether or not an odor can be noticed at a specific place. Different locations on the WWTP site and at the boundary to the dwellings yielded no perceptible odors during the olfactometry measurement times. Finally, concerning the modeling results, all the scenarios tested confirmed that the concentrations remain significantly below values hazardous to health at all places of interest, both for the WWTP staff and the local residents. The recommended 15-minute average exposure limit for H_2S is 10 ppm, whereas the maxima from the model output next to the emission source remained below 1 ppm.

Methods

Gas detector Dräger Polytron 7000:

The measurement accuracy related to H_2S is either $\leq \pm 3\%$ or $\leq \pm 0.5$ ppm whichever is the greater value.

Dynamic olfactometer Nasal Ranger:

Odor concentration measurement in European Odor Units (OU_E) categorized from 1-5 in odor intensity with values above 15 OU_E being the group which indicates highest offensiveness.

Atmospheric dispersion model AERMOD:

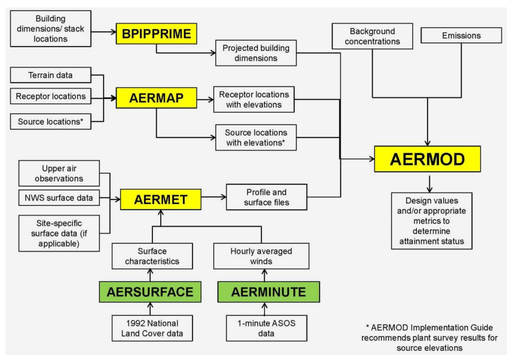

Figure 1: AERMOD workflow including preprocessor models.

Conclusions

When occurs the nuisance: Residential area most likely affected in summer from 7 p.m. to 7 a.m.

How often: Most accurate model results say never, alternative results state between once a day up to once a week.

How high reach the concentrations: Neither workers nor residents are subjected to H_2S concentrations hazardous to health (10 ppm short-term exposure limit as average during 15 consecutive minutes). Most accurate model result states that odorants do not occur in perceivable concentrations at the dwellings.

Essential variables: Wind speed and direction for odorant transport, temperature for generation due to positive correlation to sulfur-reducing bacteria and tourism

Minimum concentration at source for nuisance: Values at least as high as the H_2S long-term exposure limit of 5 ppm need to occur at the canalization entrance.

Correlation odors - odorant concentrations: No correlation could be found due to selective olfactometry measurements.

Correlation volume outflow - odorant concentrations: A positive correlation appears plausible.

Results

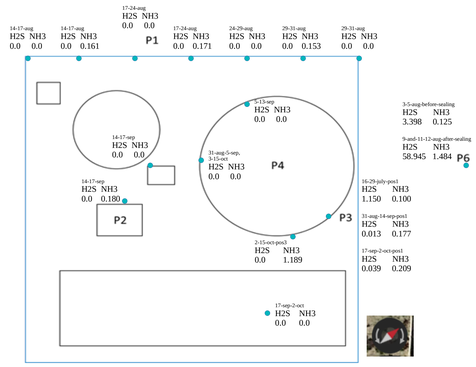

Figure 2: 75% quantiles of H_2S and NH_3 concentrations in ppm at the WWTP. NH_3 was considered negligible.

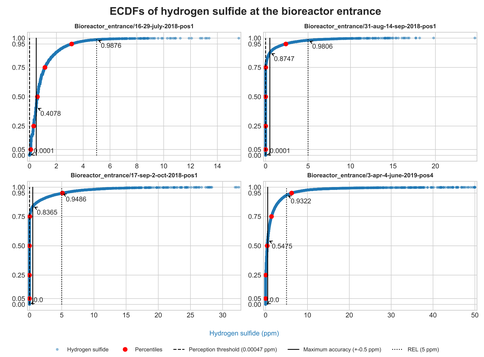

Figure 3: H_2S concentrations in ppm at the main emission source. Certain concentration limits are highlighted, such as the perception threshold of 0.00047 ppm.

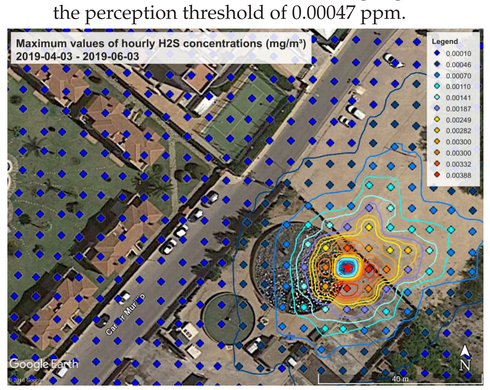

Figure 4: Odor contour map with H_2S concentrations in mg/m³. Thus, the perception threshold is 0.0007 mg/m³ here. The star marks the emission source at the canalization entrance.

Figure 5: Wind rose during July 2018. Represents conditions during summer with the wind blowing chiefly eastward in direction of the dwellings.

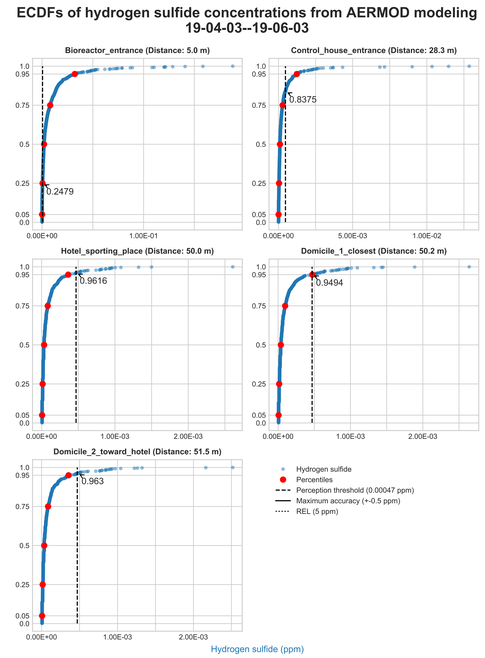

Figure 6: Modeled H_2S concentrations in ppm with alternative model results at 5 locations of interest. The perception threshold can be exceeded even at the dwellings (compare fig. 3).

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Future Research and Recommendations

Continuous long-term monitoring gas, wind, temperature, volume flow and odor measurements. Therewith regular application of dispersion modeling, if possible in real-time. Utilize instruments with accuracies up to ppt to measure H_2S concentrations close to the perception threshold of around 0.00047 ppm, as they can occur away from the source. Carry out population surveys and deploy electronic noses instead of doing dynamic olfactometry. Employ CALPUFF as model alternative and include building downwash effects.