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Odorprep

New frontiers in odor control

23rd March 2021

Statistical evaluation of air concentrations trends of H_2S and NH_3 in mechanical biological treatment plant: criteria for odour automatic sampling

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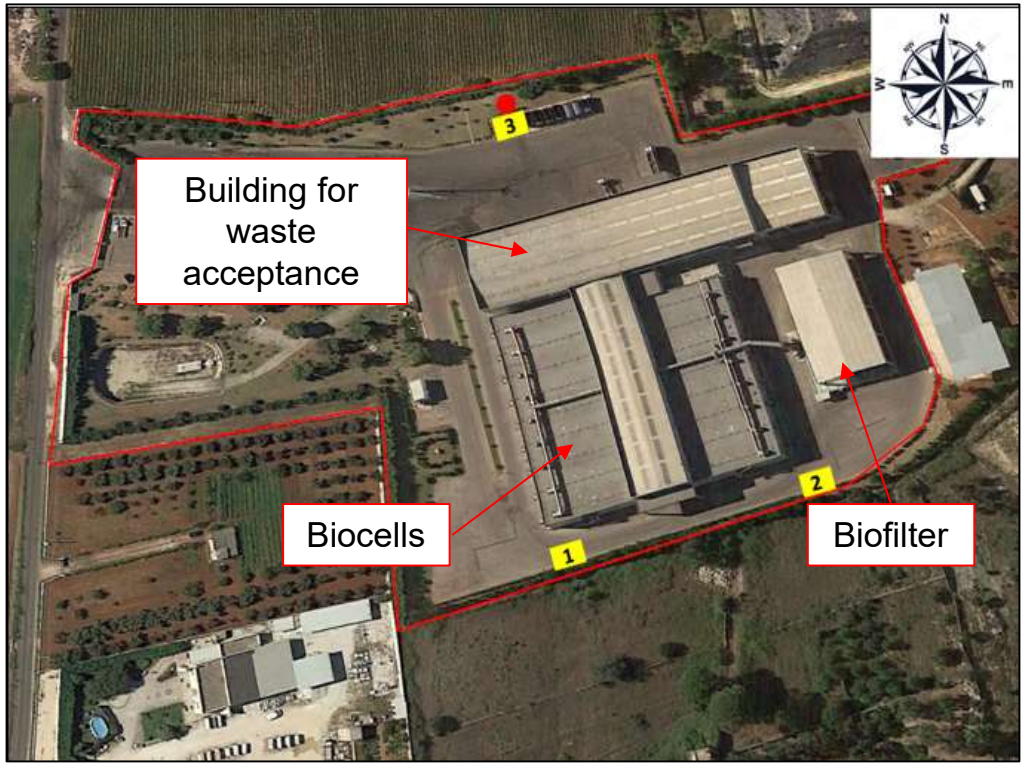
TECNOLOGIA & AMBIENTE

PRESENTATION OUTLINE

- Site description
- Monitoring system
- Goals of the research:
  - ❑Identification of the most suitable monitoring stations and chemical tracers for odour monitoring
  - ❑Defining criteria for odour automatic sampling :
    - *Innovative tools for continuous odour monitoring*: Time series analysis, frequency domain analysys, multivariate analysis
- Lessons learned and Conclusions

SITE DESCRIPTION



MBT plant authorised to receive 550 ton/day of mixed urban waste (EER 20 03 01). 3 Monitoring stations were installed in 2019, located as follows:

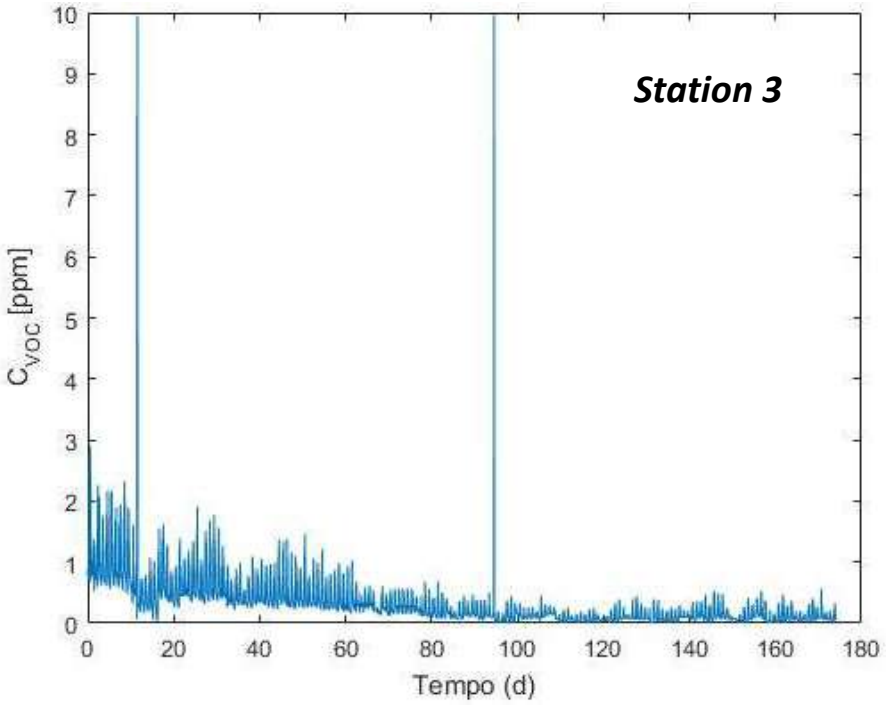
- **Station 3** upstream with reference to winds blowing towards the urban center (1000 m far from the plant): in front of building for waste acceptance
- **Station 1 and 2** downwind, being the first close to biocelles and the second nearby the biofilter

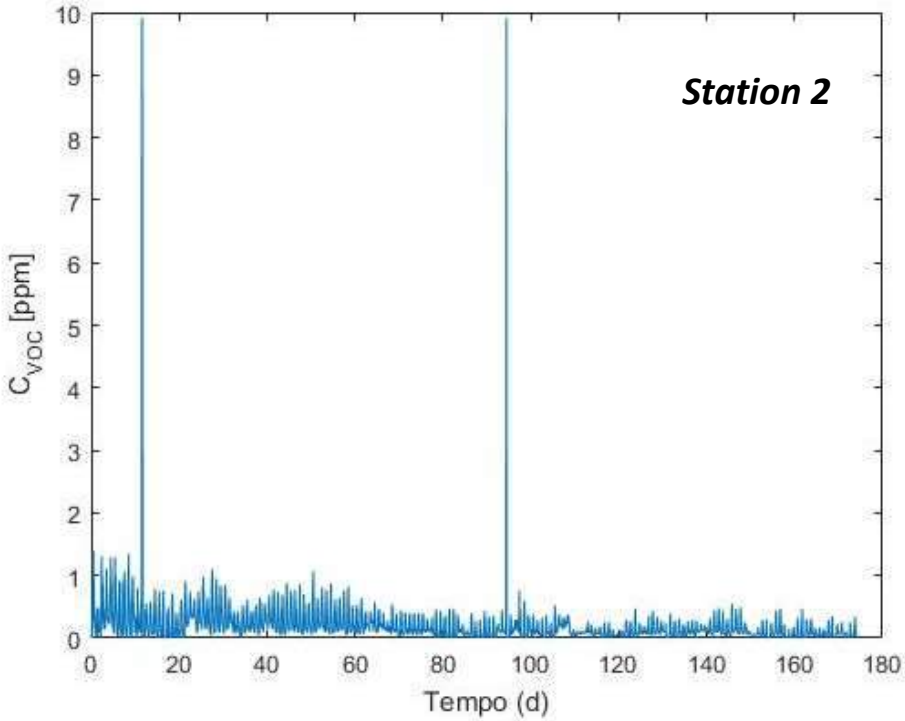
MONITORING STATIONS CHARACTERISTICS

- Model T101 H_2S analyzer (Teledyne API) to measure hydrogen sulfide at levels commonly required for ambient air monitoring.
- Model T201 NH_3 analyzer (Teledyne API) to measure ammonia at levels commonly required for ambient air monitoring.
- Falco fixed VOC Gas Detector (IonScience);
- **OdorPrep® V3**, on-demand air sampling system
- DAVIS Vintage Pro 2 weather station (*only* in station 3);
- Data acquisition, processing and management system

Monitoring Period: **Sept '19 – Feb '20 (175 days)**

TIME SERIES ANALYSIS: UNIVARIATE STATISTIC ANALYSIS 1/2





VOC

On Station 3, the 98th percentile is 1.23 ppb . A daily cyclical component is evident

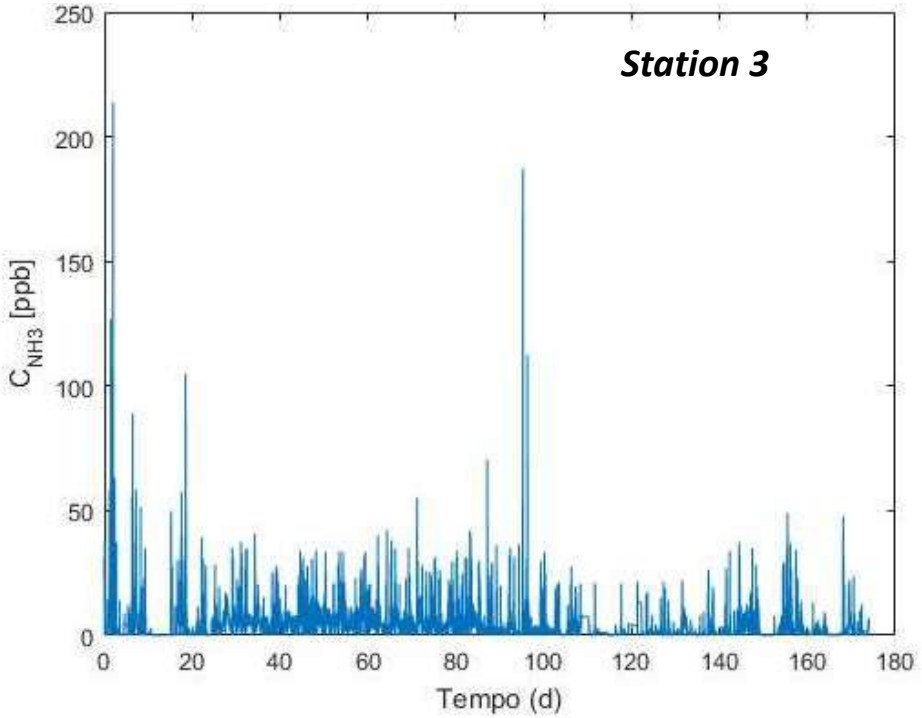
On Station 2, the 98th percentile is 0.74 ppb. A daily cyclical component is evident

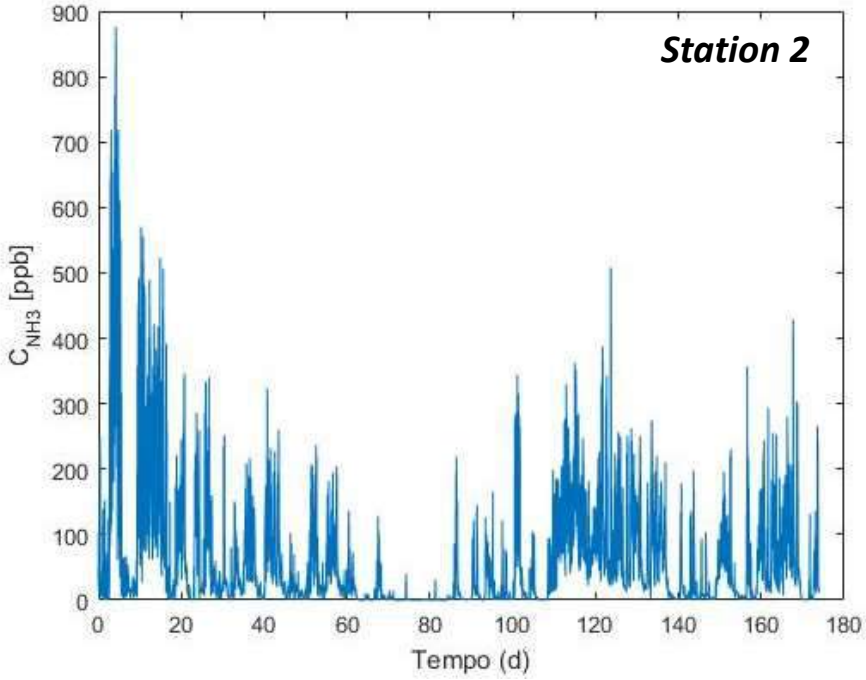
Few peaks (registered in both station on day 10 and 94)

Station 1 shows a behaviour similar to Stations 1 and 3

It seems that VOC is not related to the fluctuation of emissions from the plant

TIME SERIES ANALYSIS: UNIVARIATE STATISTIC ANALYSIS 2/2





On Station 3, the 98th percentile is 17 ppb .

On Station 2, the 98th percentile is 303 ppb.

NH_3

Station 1 shows a behaviour similar to Station 3

The monitoring station closer to biofilter shows much higher concnetrations for NH_3, so the latter may be a good parameter to be related to odour emissions form the plant

TIME SERIES ANALYSIS: PERSISTENCE ANALYSIS

Persistence analysis: searching for time intervals in which a certain threshold value ***y*** has been exceeded consecutively for more than ***x*** minutes.

Some instruments have a measuring frequency of 1/300 s (1 value each 5 minutes); also the weather station has the same acquisition frequency.

Although odours can be perceived by citizens for a few seconds, it is unlikely that emission fluctuations at the source varying for less than a few minutes will have a strong impact on receptors, due to atmospheric dispersion.

For such reason, the time scale that defines odour persistence in the plant is 5 minutes.

As for the threshold values, the following choice was made: for each odour surrogates (VOC, H_2S, NH_3), 3 values were selected, i.e. 2 values below the 98Th percentile and one value above that.

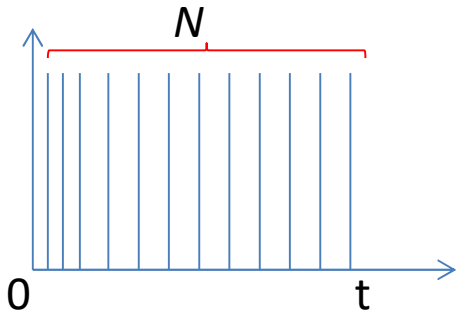
Data of Station 1 and 3 are in the same order of magnitude, while Station 3, especially for ammonia, shows higher values.

The following thresholds were chosen

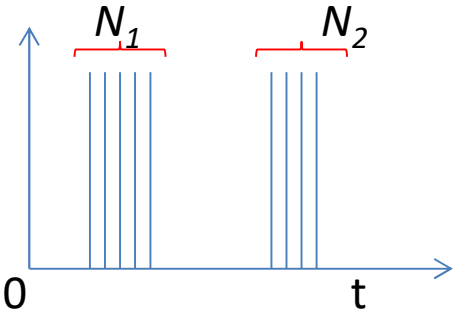
	Stations 1 and 3	Station2
VOC	1	1
	1.5	1.5
	2	2
H_2S	0.5	0.75
	0.75	2
	2	5
NH_3	10	70
	40	300
	70	500

PERSISTENCE ANALYSIS

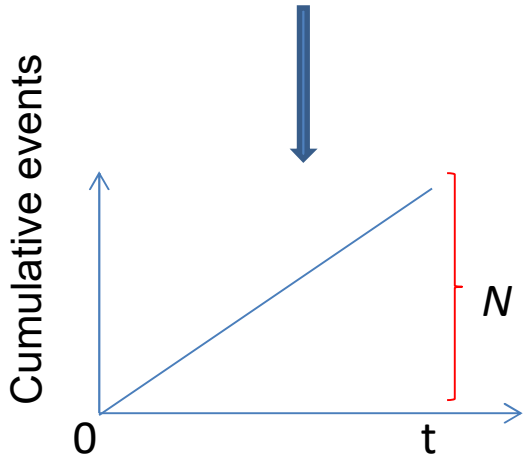
Temporal distribution of persisting events

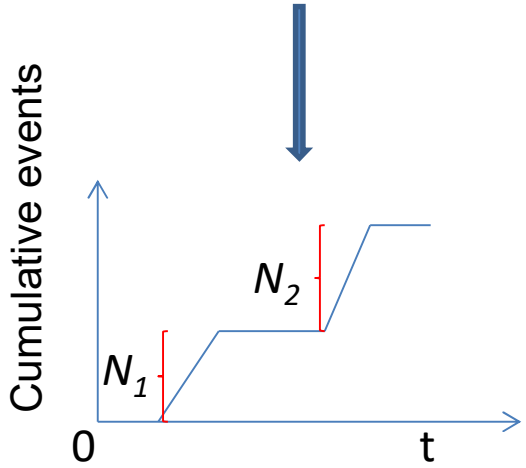


N persisting events uniformly distributed during monitoring period

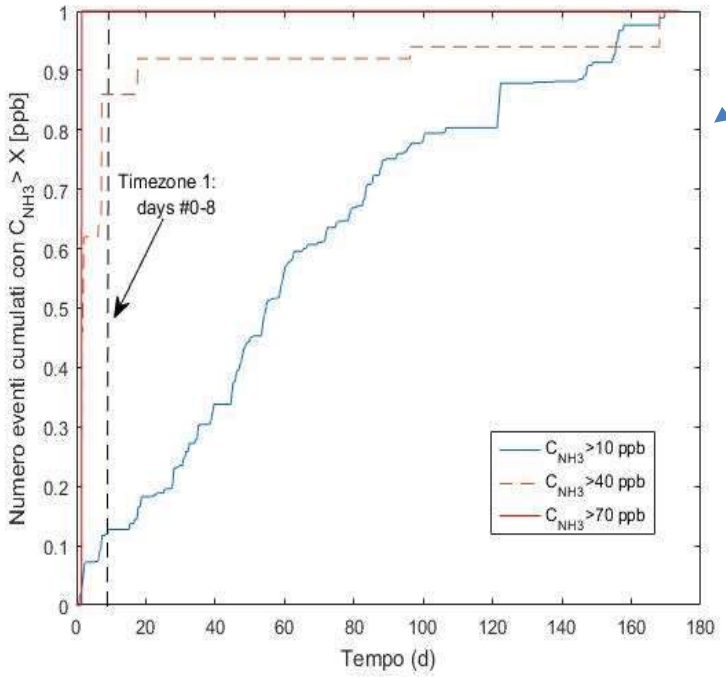


N persisting events distributed during two specific time intervals



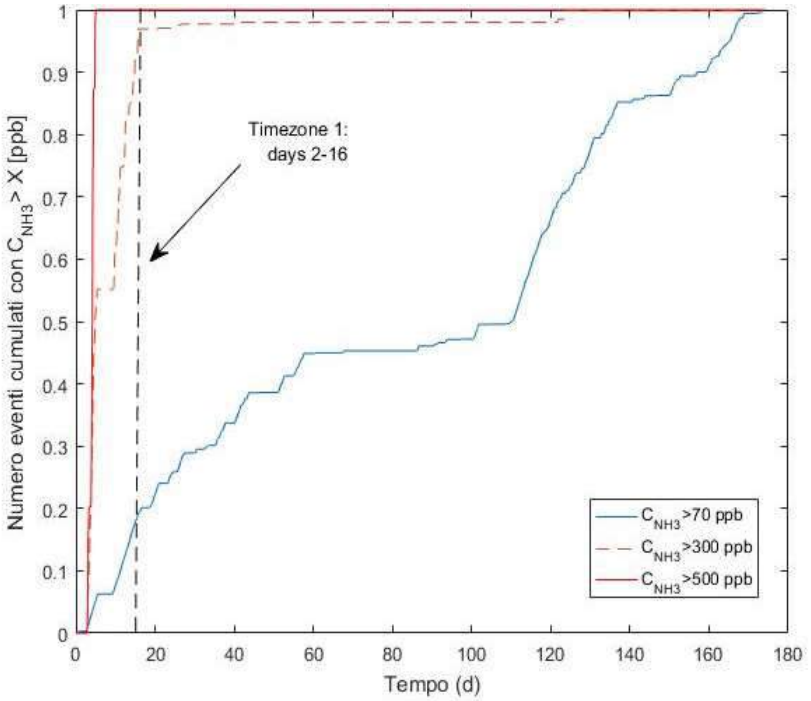


PERSISTENCE ANALYSIS ON NH_3



On Station 3, events >10 ppb are quiet frequent (uniform distribution); extreme events (c> 70 ppb) occur in the first days of monitoring.

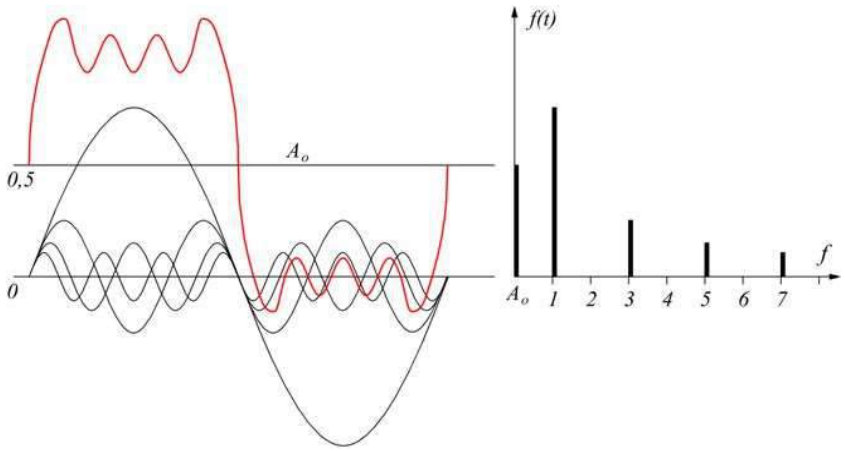
On Station 2, events >70 ppb are quite frequent; extreme events (c> 500 ppb) occur in the first days of monitoring.



During the first days of monitoring high and persistent values of ammonia were recorded nearby the biofilter (Station 2)

FREQUENCY DOMAIN ANALYSIS

By observing the data during the monitoring period, it appeared that the odour concentration varied periodically on daily basis, as this is clearly associated with the daily operations of waste treatment occurring at both sites. In order to verify the significance of other periodic behaviours and gather insights on temporal scales of mechanisms causing odour emissions during waste treatment, spectral analysis was carried out.

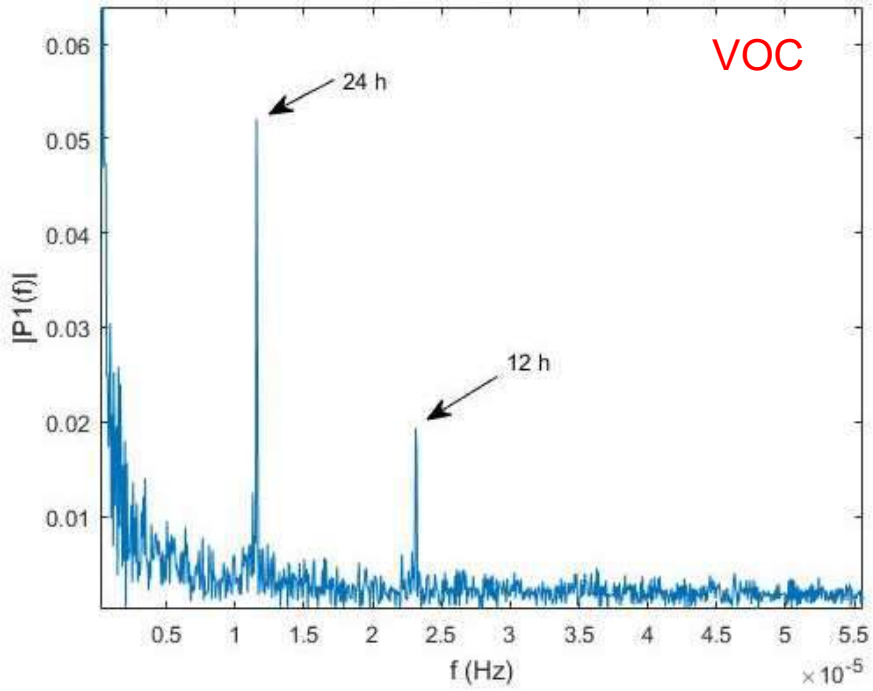


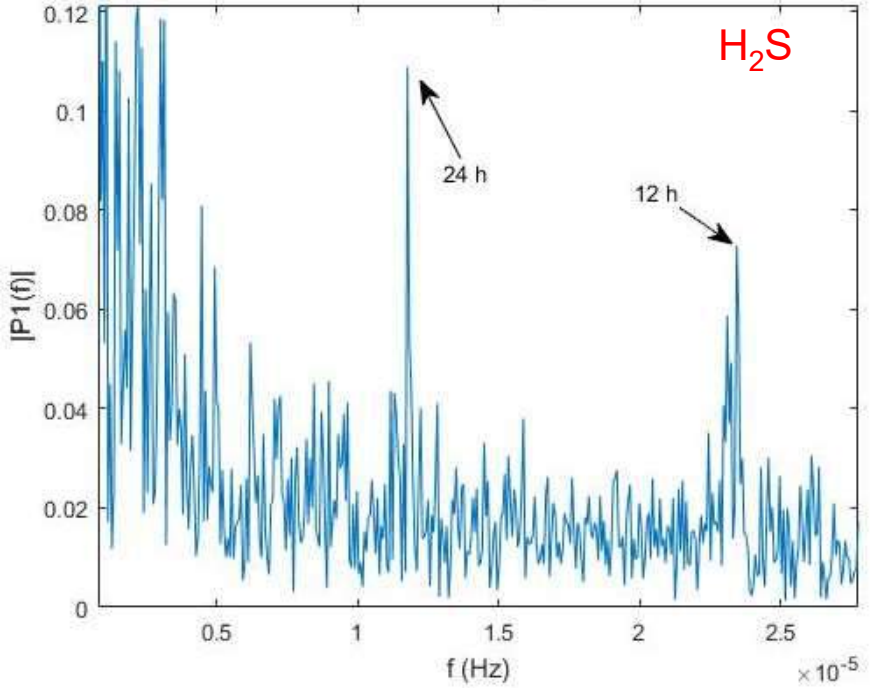
A time series can be represented in terms of its frequencies, that is, it can be broken down into the sum of appropriate periodic functions referring to all the possible cyclicities that this series can assume.

Spectral analysis allows you to determine which are the most important frequencies

FREQUENCY DOMAIN ANALYSIS

Station 2: VOC and H_2S

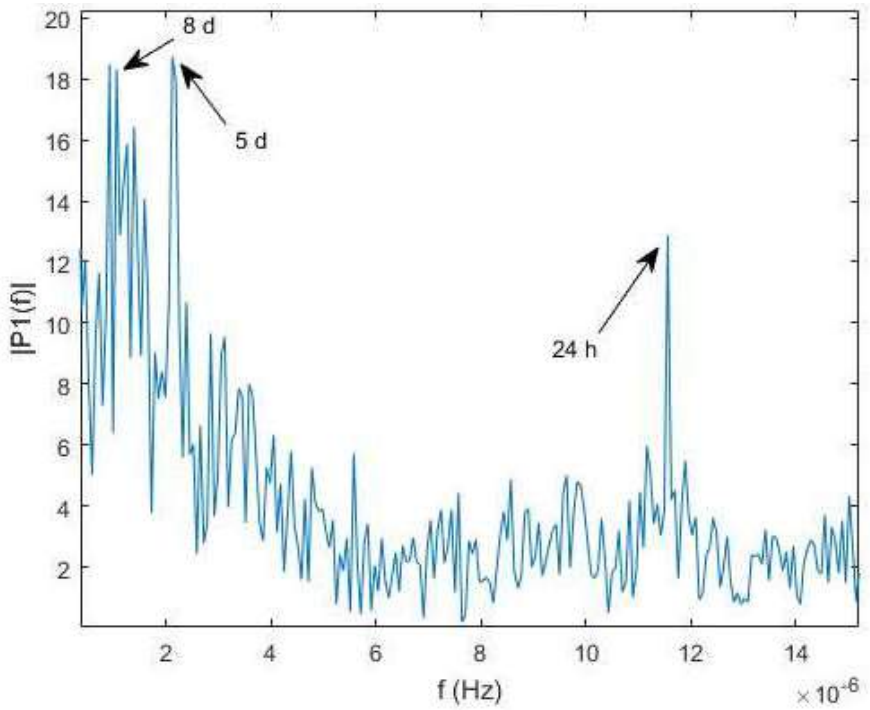




Odour fluctuations are daily and occur also on 12-hours basis, as it is related to fluctuations in atmospheric conditions (Planetary Boundary Layer). For VOC, lower frequencies harmonics are not as evident as H_2S: near the biofilter, H_2S concentration seems to be influenced by some factor having periodicity of days

FREQUENCY DOMAIN ANALYSIS

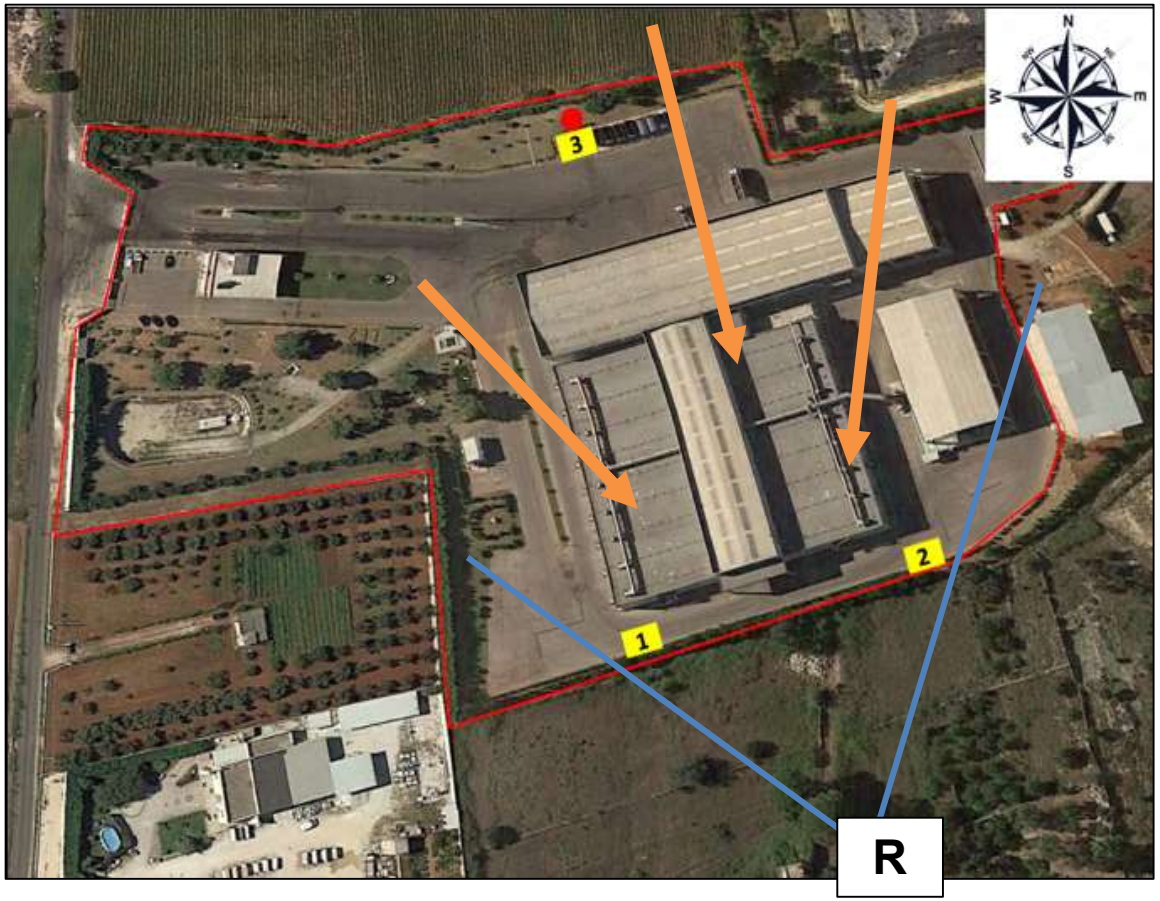
Station 2: NH_3



As for H_2S, ammonia concentrations show cyclical components at **5 days and 8 days**.

It is very likely that these fluctuations are associated with the emissions that follow the cycles linked both to the waste acceptance in the plant (which takes place 6 days a week in the winter period and 7 days a week in the summer period) and to waste biostabilization (which has a duration of 14 days).

MULTIVARIATE STATISTIC ANALYSIS

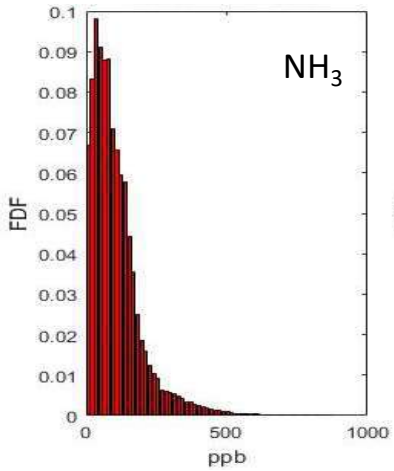


Being R the receptor, it can be defined the sector of upstream winds, i.e. the wind directions that can influence the odor peircived by the receptor.

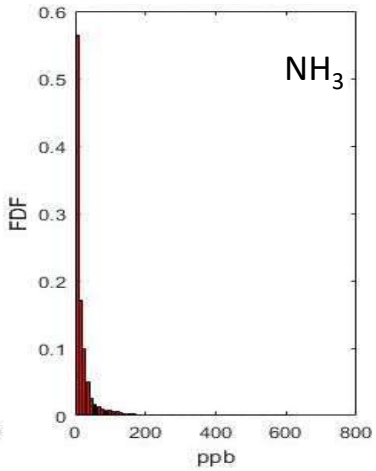
In the present case, the wind sector ranges from NNW to NNE

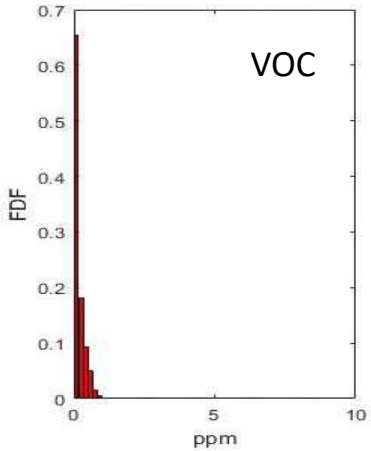
MULTIVARIATE STATISTIC ANALYSIS

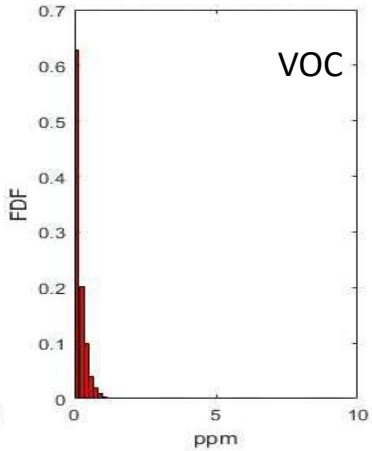
Wind sector NNW-NNE



Out of wind sector NNW-NNE







Station 2 is located downstream of biofilter 2 when winds blow in the sector NNW-NNE.

The frequency density functions show that higher NH_3 concentrations are detected when wind directions belong to sector NNW-NNE.

On the other hand, for VOC in Station 2, there is little difference when considering wind blowing from the sector NNW-NNE and other directions.

This strenghtens the idea that NH_3 is the parameter much related to emission fluctuations from the biofilter than H_2S or VOC.

LESSONS LEARNED

In the case of a plant equipped with multi-instrumental odour monitoring (not IOMS):

- H_2S and **NH_3** have common time intervals of persistence of events, unlike VOC
- spectral analysis highlighted cyclical behaviors related to the waste treatment process for H_2S and, most evident, for **NH_3**; for VOC there is a cyclical trend on a daily basis for all monitoring stations.
- For H_2S and **NH_3** the upstream/downstream differences between source and monitoring stations are evident by analyzing the wind directions, unlike VOC.

In the present case study, VOC is not an appropriate parameter to be used in defining criteria for automatic odour sampling; observations suggest that NH_3 is the parameter most related to the odour emission sources.

Without IOMS, great care is required in choosing the most suitable sensor(s) to capture odorous events related to the operation of the plant.

CRITERIA FOR ODORPREP AUTOMATIC SAMPLING 1/2

- If criteria for activating Odorprep on the basis of monitoring data from the different analysers are sought, the following conclusions can be drawn:

  1. NH_3 should be the only parameter to activate the automatic sampling as its concentration is clearly related to biofilter emissions (MULTIVARIATE STATISTIC ANALYSIS) and time series show cyclical components related to time scales characteristic of waste treatment process (FREQUENCY DOMAIN ANALYSIS)

  2. A time window of 5 minutes beyond which to find the exceeding of a certain threshold is adequate for taking into account *medium* and *high persistence* events

  3. On the basis of time serie analysys (UNIVARIATE STATISTICS and ANALYSIS OF PERSISTENT EVENT), a threshold of 500 ppb could have been proposed for activation; however, analysis showed a total number of 79 events of concentration higher than such value for 5 consecutive minutes. These events, during the monitoring period, generated a very low number of reports from citizens (4), so there is no evidence that such value may be related to nuisance to population.

A *pre-alert* threshold was introduced: each time the pre-alert threshold is exceeded for 5 minutes, it will be recorded on a web platform and an e-mail will be sent to local EPA.

CRITERIA FOR ODORPREP AUTOMATIC SAMPLING 2/2

The Odorprep automatic sampling thresholds were proposed as follows:

- -) (**pre-alert**) register event and send mail to local EPA if NH_3 concentration in Station 2 exceeds 500 ppb for 5 minutes

- -) (**alert**) activate Odorprep sampling if NH_3 concentration in Station 2 exceeds 750 ppb for 5 minutes

Thank you for your attention!

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