Laboratorio Olfattometrico

Design and execution of an environmental odour monitoring campaign

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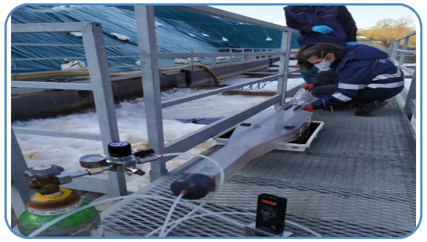
POLITECNICO MILANO 1863

ISOCS Short Course Winter 2023

PRACTICAL SESSION OUTLINE

Case Study Description

- E-Nose monitoring of a Waste Treatment Plant



Demonstration of field activities

- Odour sampling
- Dilution to obtain different concentration level

ISOCS Winter School 2023 E-Nose Monitoring

- E-Nose Training
- Acquisition and processing of monitoring data at Hotel Vallechiara

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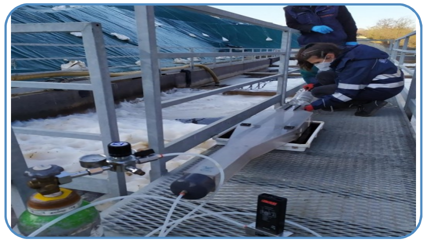

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CASE STUDY: Monitoring of odour emissions from a waste treatment plant

Realization of an **E-Nose Network** at the plant fenceline for a real-time analysis of ambient air aimed at detecting **anomalies in the plant functioning**, thereby preventing odour events at closest receptors.

Monitoring system:

- ✓ **2 E-Noses** installed at plant fenceline, equipped with:
  - 4 MOS sensors with an high sensitivity to volatile compounds;
  - 2 electrochemical sensors sensible H_2S and NH_3;
  - 1 photoionization detector (PID) for VOC detection.

ellona

- ✓ **Weather Station** for continuously measuring wind speed and direction simultaneously with the recording of the electronic noses data.

DAVIS
Davis Instruments

ENVIRONMENTAL MONITORING BY E-NOSES

Analysis of the industrial process

- Plant inspection
- Environmental Permit and Technical Reports

Definition of monitoring sites

- Preliminary chemical and/or olfactometric analyses carried out at emission sources
- Identification of main emission sources
- Parametric dispersion modelling

E-Nose Training

- Sampling at main emission sources
- Olfactometric analysis
- Dilution with odourless ambient air
- Analysis by e-nose of diluted samples
- Data processing

Field Performance Testing & Monitoring

- Execution of specific tests in the field
- Real-time analyisis at monitoring sites

Interpretation of monitoring results

Case Study:

Analysis of the industrial process

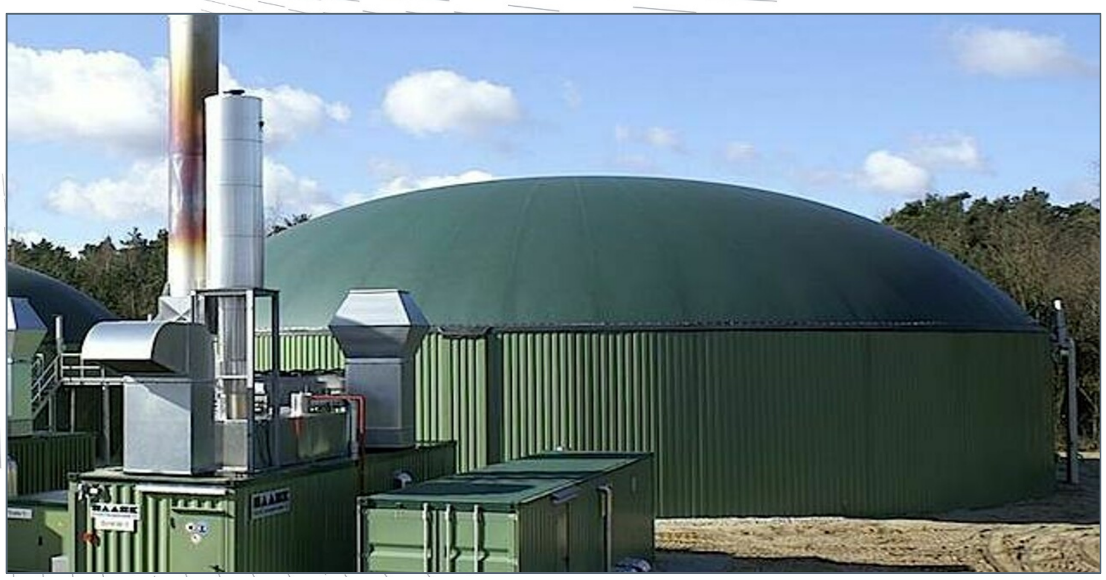
ORGANIC WASTE TREATMENT PLANT

ORGANIC FRACTION OF MUNICIPAL SOLID WASTE
80'000 ton/y

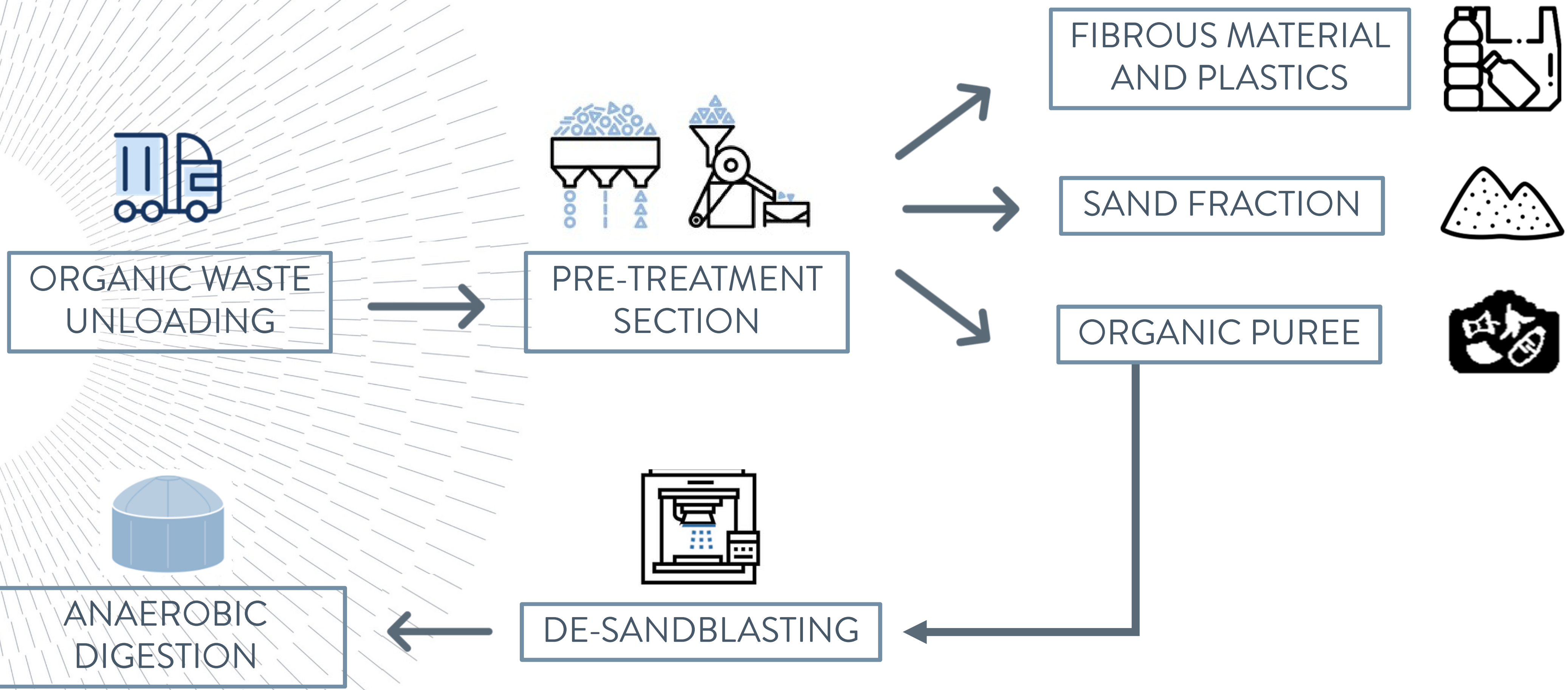
→ **ANAEROBIC DIGESTION**

→ BIOGAS → **BIOMETHANE 4.7 M Sm^3/y**

→ DIGESTATE → **COMPOST**



PRODUCTIVE PROCESS



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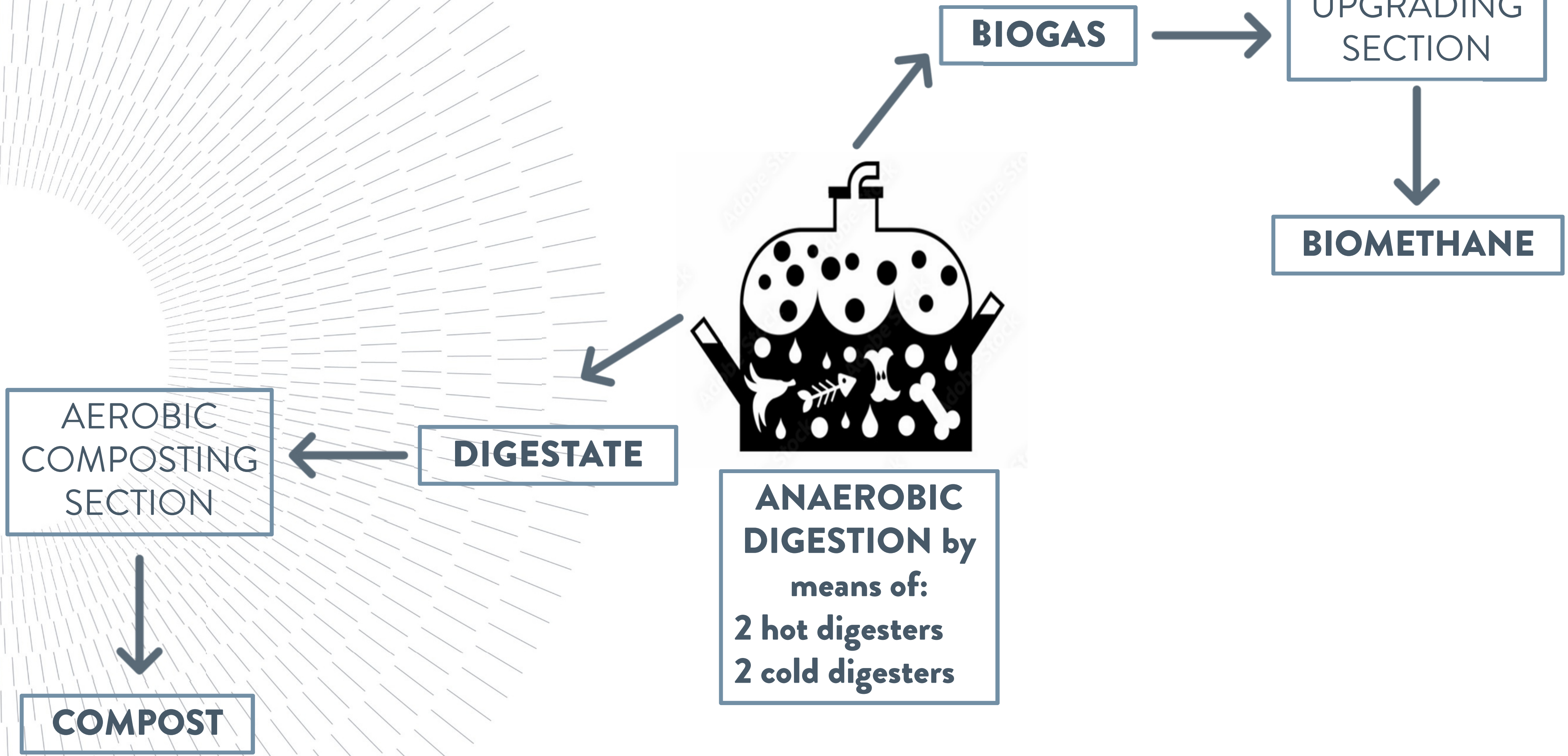


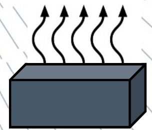
ODOUR PREVENTION AND REDUCTION MEASURES

- ✓ Enclosure of operating and storage areas and use of a **quick-opening gate** to limit diffuse odor emissions during entry and exit of vehicles;

- ✓ Controlling the maintenance of **cleanliness** of squares and material handling areas.

- ✓ Appropriate sizing of **abatement systems**:

Scrubbers for the treatment before biofilter of exhausted air, aspirated from the processing buildings, which are maintained in depression;



Biofilter consisting of 4 parallel sections associated with 4 scrubbers, for the treatment of the exhaust air coming from the various sections of the plant.

AUTHORIZED PLANT EMISSIONS
Environmental Permit

EMISSIONS	SOURCE	ABATEMENT SYSTEM	POLLUTANTS
E02 - E04	Emergency flare for biogas combustion	-	-
E03	Buldings air extraction 4 scrubbers	Biofilter	Dust, Organic acids, mercaptans, NH_3, H_2S, odour and TVOC
E05	Boiler 991 kW	-	NO_x, CO, HCl, TOC, dust, SO_2

Only emission E03 biofilter has been included as odour emission to be considered

AUTHORIZED PLANT EMISSIONS
Limit values

Table 6.7: BAT-associated emission levels (BAT-AELs) for channelled NH_3, odour, dust and TVOC emissions to air from the biological treatment of waste

Parameter	Unit	BAT-AEL (Average over the sampling period)	Waste treatment process
NH_3 (1) (2)	mg/Nm^3	0.3–20	All biological treatments of waste
Odour concentration (1) (2)	ou_E/Nm^3	200–1 000	
Dust	mg/Nm^3	2–5	Mechanical biological treatment of waste
TVOC	mg/Nm^3	5–40 (3)	

(1) Either the BAT-AEL for NH_3 or the BAT-AEL for the odour concentration applies.
(2) This BAT-AEL does not apply to the treatment of waste mainly composed of manure.
(3) The lower end of the range can be achieved by using thermal oxidation.

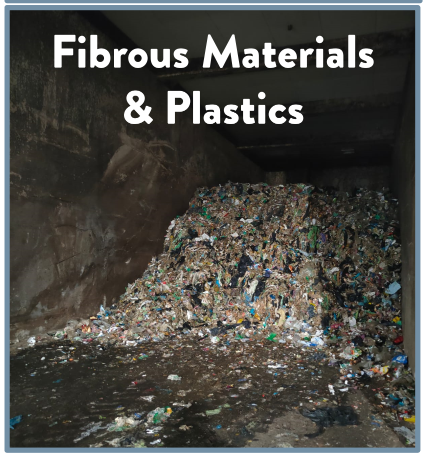
Environmental permit

Parameter	CONC MAX
Odour	**300 OU_E/Nm^3**
Dust	5 mg/Nm^3
Organic acids	0.3 mg/Nm^3
Mercaptans	0.02 mg/Nm^3
Ammonia	3 mg/Nm^3
Hydrogen Sulfide	1 mg/Nm^3
TVOC	5 mg/Nm^3

OTHER ODOUR EMISSIONS

FUGGITIVE LEAKS from:

- **Organic waste storage** and pre-treatments sheds;
- **Plastic storage** and **Compost maturation** shed;
- **De-Sandblasting** section;
- **Biogas upgrading** section;



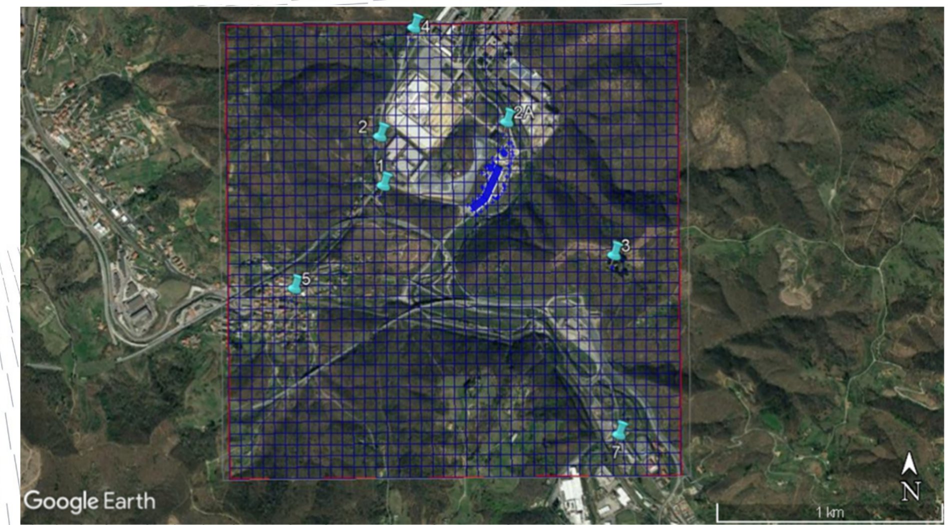
Case Study:

Definition of monitoring sites

WHERE TO INSTALL E-NOSES AT FENCELINE?

The two installation points were decided on the basis of **parametric modelling study**, aimed at correlating the odor concentration at the plant fenceline with the potential impact on the nearest sensitive receptors.

7 SENSITIVE RECEPTORS

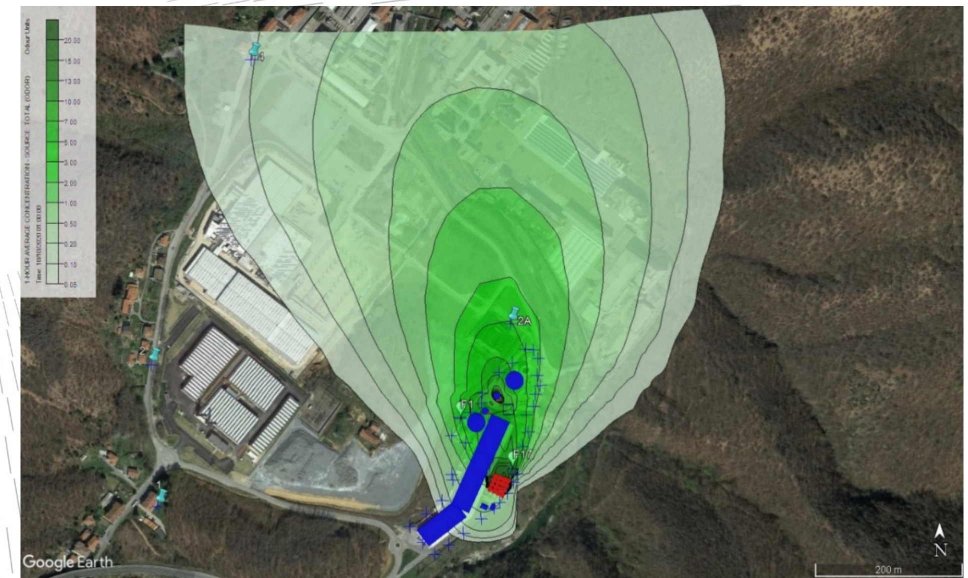


35 RECEPTORS AT THE FENCELINE

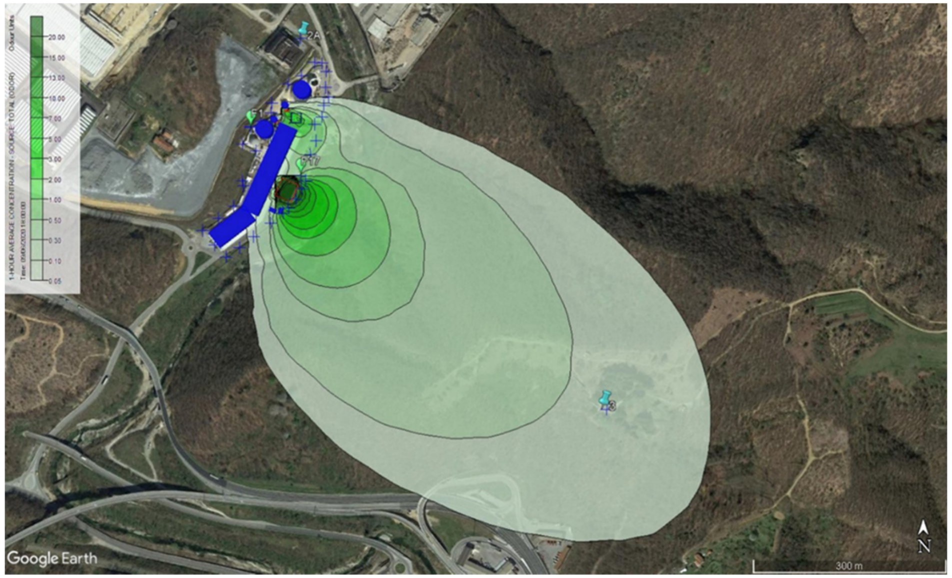
PARAMETRIC MODELLING STUDY

- Sensitive receptors most impacted: R2, R4, R3, R7 and R2A.
- Receptors boundary most effective for monitoring odor emissions: F1 and F17.

STABLE ATMOSPHERIC CONDITION



UNSTABLE ATMOSPHERIC CONDITION



SELECTED E-NOSES MONITORING SITES AT FENCELINE

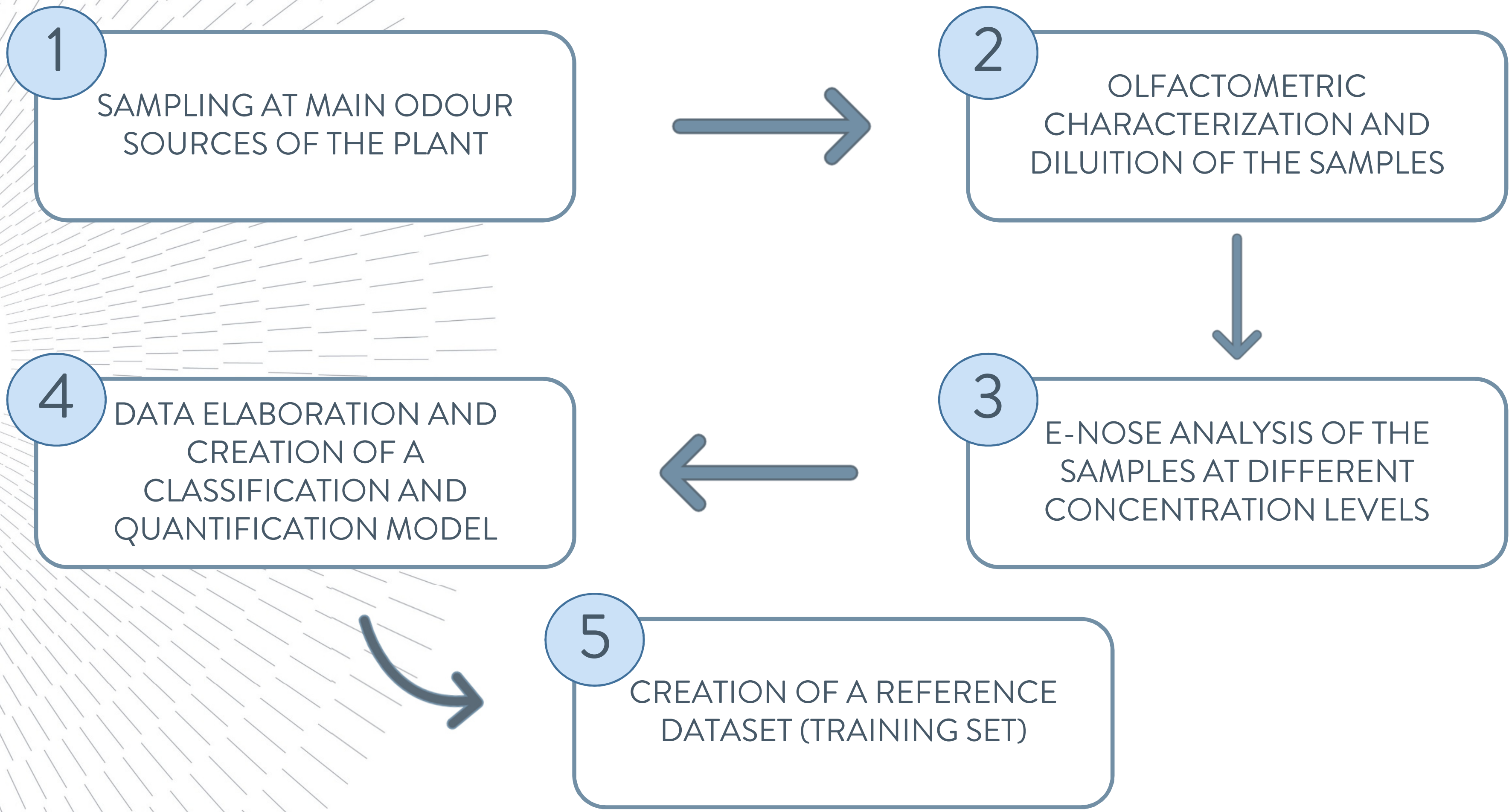
E-Noses installation points:

- F1: suitable for detecting emissions when wind blows from west and/or north-west direction
- F17: suitable for detecting emissions when wind blows from North to South-East

Case Study:

E-Noses Training

E-NOSES TRAINING: Experimental Procedure



SAMPLING OF MAIN ODOUR SOURCES

SHEDS AMBIENT AIR:
mechanical vacuum pump

BIOFILTER: static hood and mechanical vacuum pump

BIOGAS: digester vent

SAMPLING AT MAIN ODOUR SOURCES

5 Olfactometric campaigns:

- **Winter**

  21/02/2022 – 25/02/2022

- **Spring**

  04/04/2022 -08/04/2022

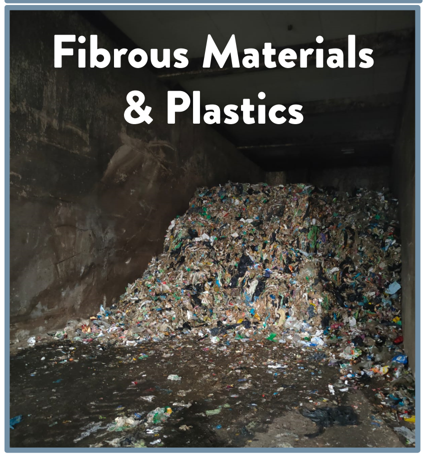
  09/05/2022 – 12/05/2022

- **Summer**

  18/07/2022 – 22/07/2022

- **Autumn**

  24/10/2022 – 28/10/2022



TRAINING OLFACTOMETRIC CAMPAIGNS: Summary

	N°. Collected samples Winter	N°. Collected samples Spring	N°. Collected samples Summer	N°. Collected samples Autumn	N°. Samples presented to each E-Nose
Biogas	2	7	4	4	65
Biofilter	4	6	6	4	46
Organic Waste	2	4	3	2	34
Fibrous Materials & Plasti	2	2	0	3	21
Digestate	1	0	2	0	9
De-Sandblasting	2	2	4	1	29

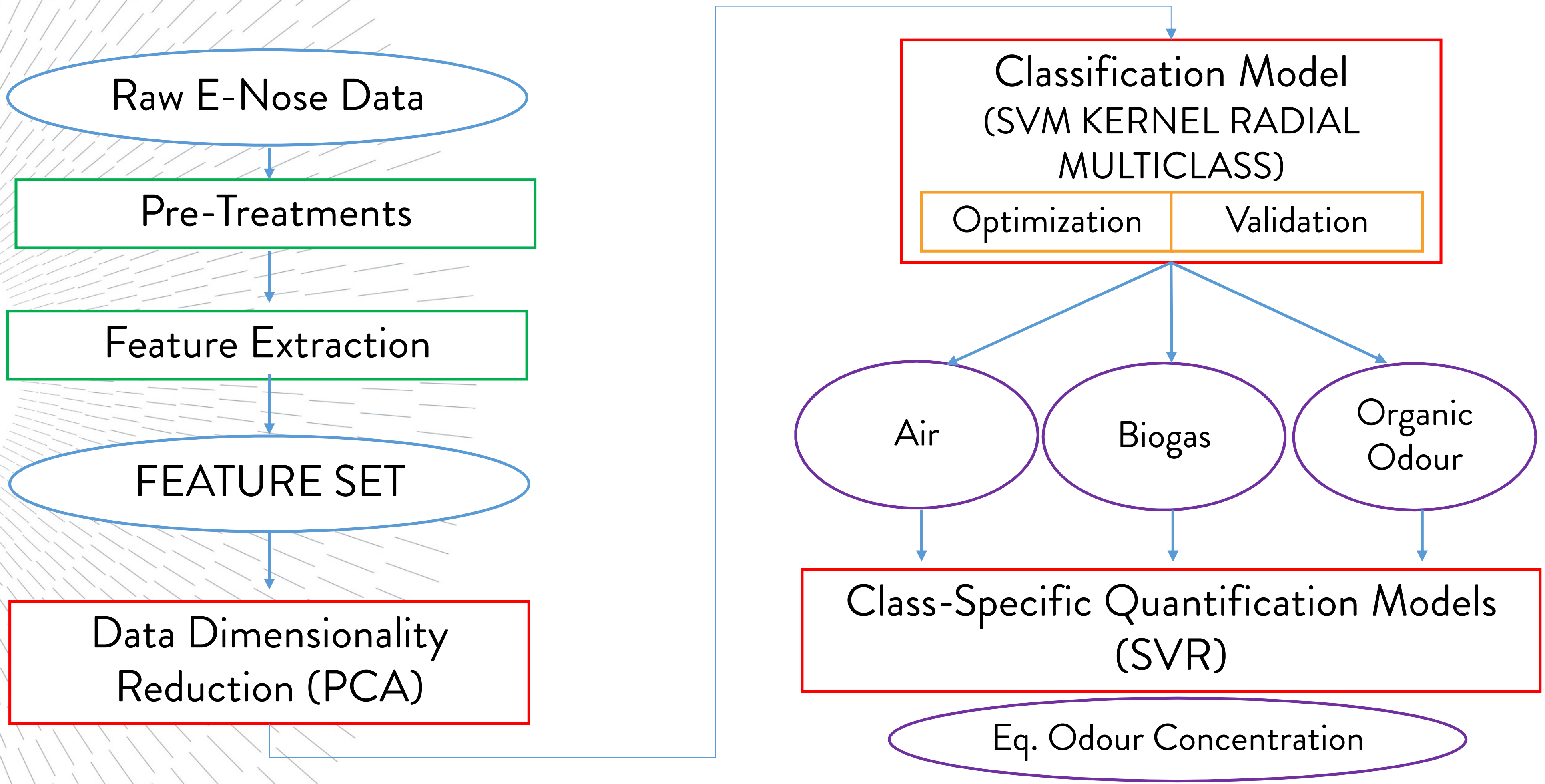
	N° E-Nose Analyses	C_{od} range [ou_E/m^3]
Air	26	15 – 50
Organic Odour	139	18 – 1904
Biogas	65	12 – 1954

OLFACTOMETRIC ANALYSIS AND SAMPLE DILUITION

DYNAMIC OLFACTOMETRY
Assessment of samples' odour concentration [ou_E/m^3]

DILUITION
samples at different concentration levels are obtained by mixing defined volume of samples collected at source with odourless ambient air

DATA PROCESSING



PRE-TREATMENTS: Compensation of humidity variations

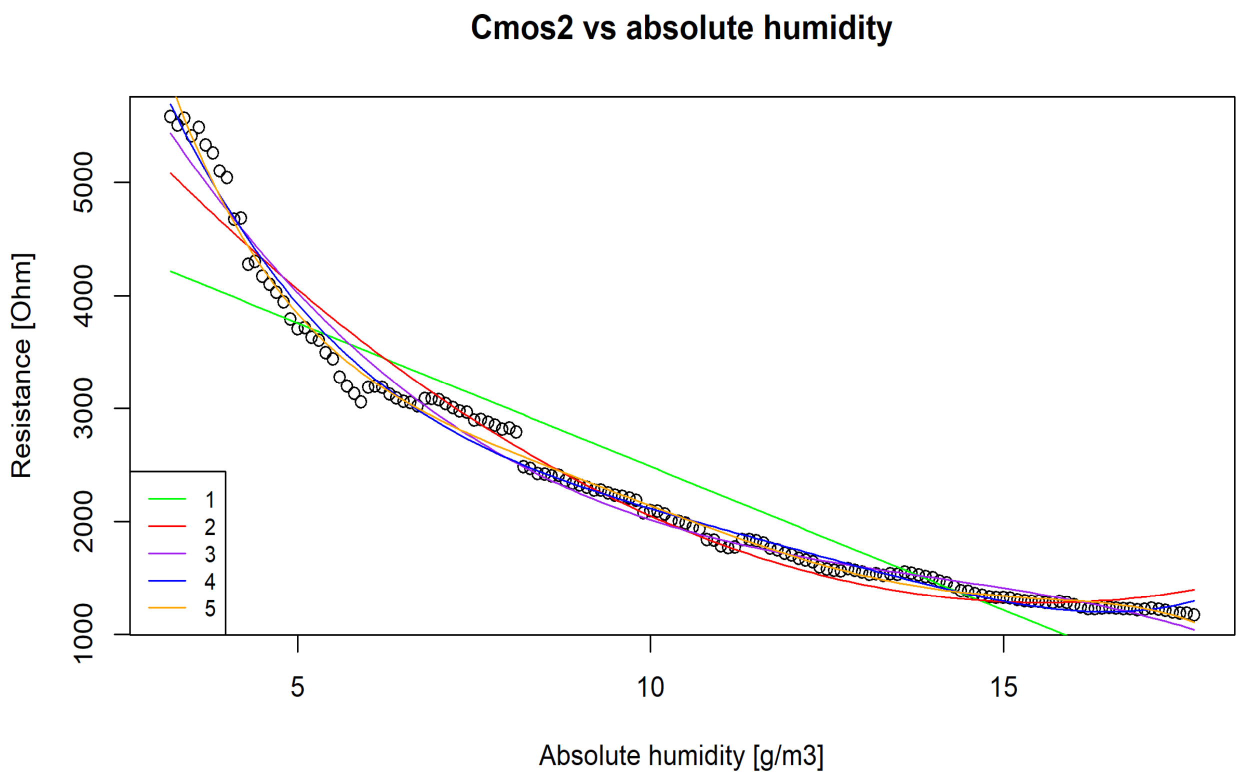
Sensor resistance is recalculated based on **absolute humidity** measured during the analysis.

Polynomial regression models are implemented on training data, including analyses at different humidity levels:

$$R = 9227.04 - 1478.03 * AH + 99.47*AH^2 - 2.37*AH^3$$

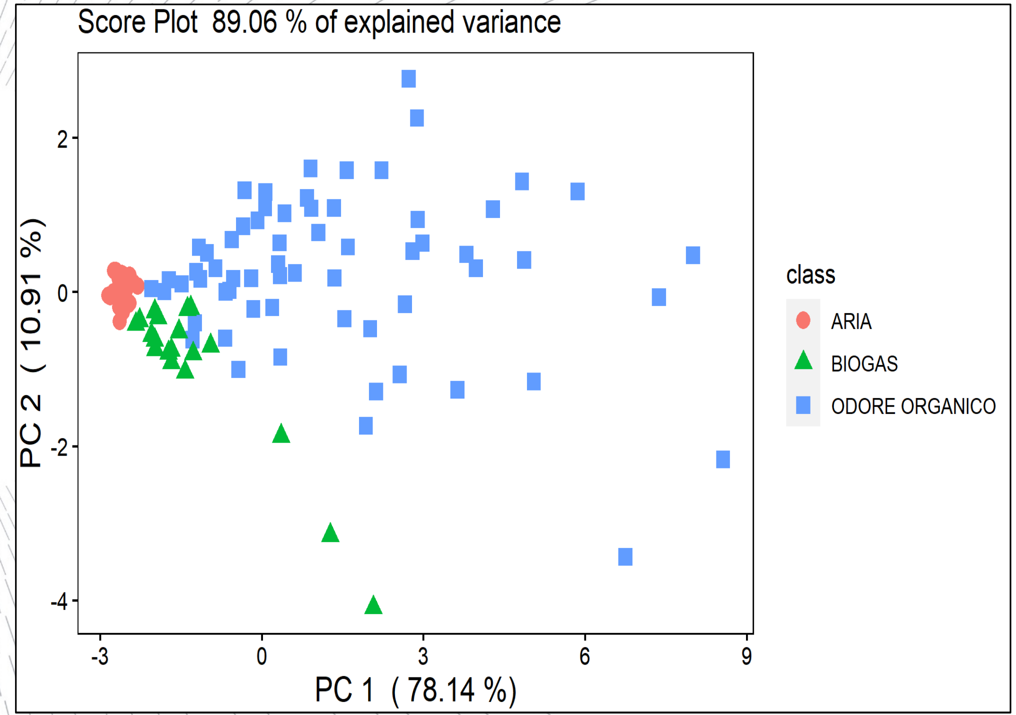
R -> sensor resistance

AH -> absolute humidity

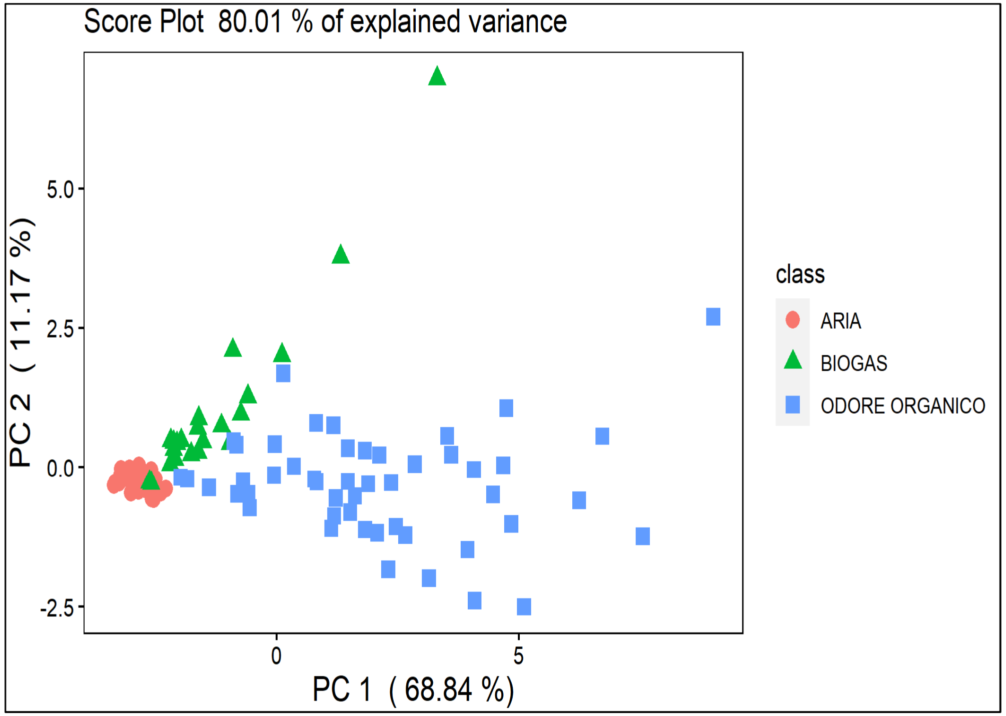


TRAINING DATA

E-Nose 1



E-Nose 2



Case Study:

Performance Testing in the field

FIELD PERFORMANCE TESTING

Verification of the **IOMS performance** rather than hardware requisites by means of **specific verification tests** in the field after IOMS training for the specific monitoring

- Odour detection
- Odour classification
- Odour quantification

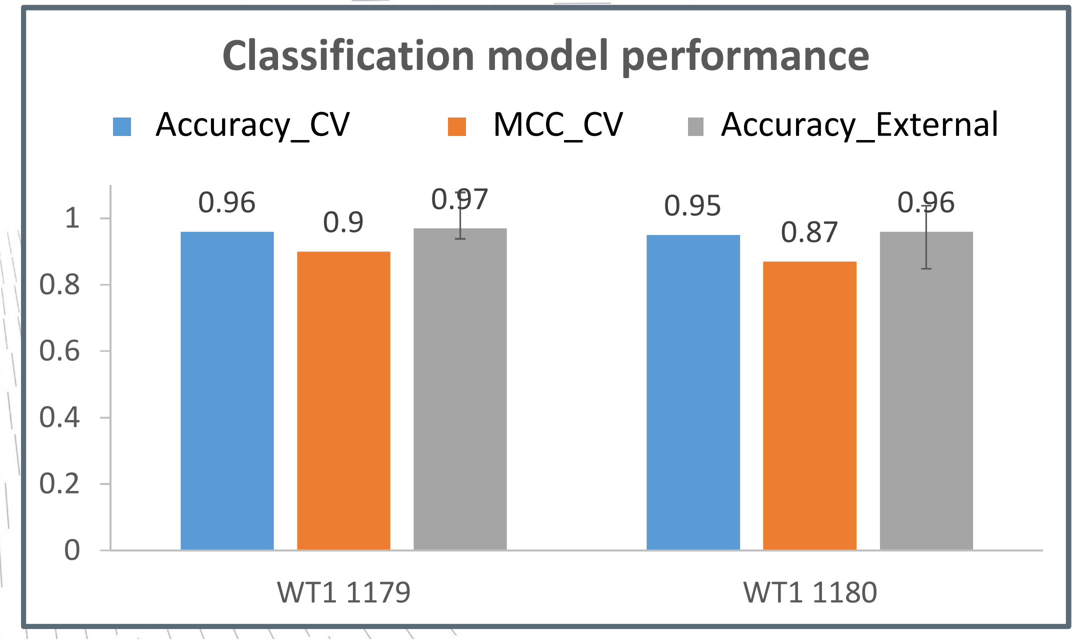
FIELD PERFORMANCE TESTING: Experimental Procedure

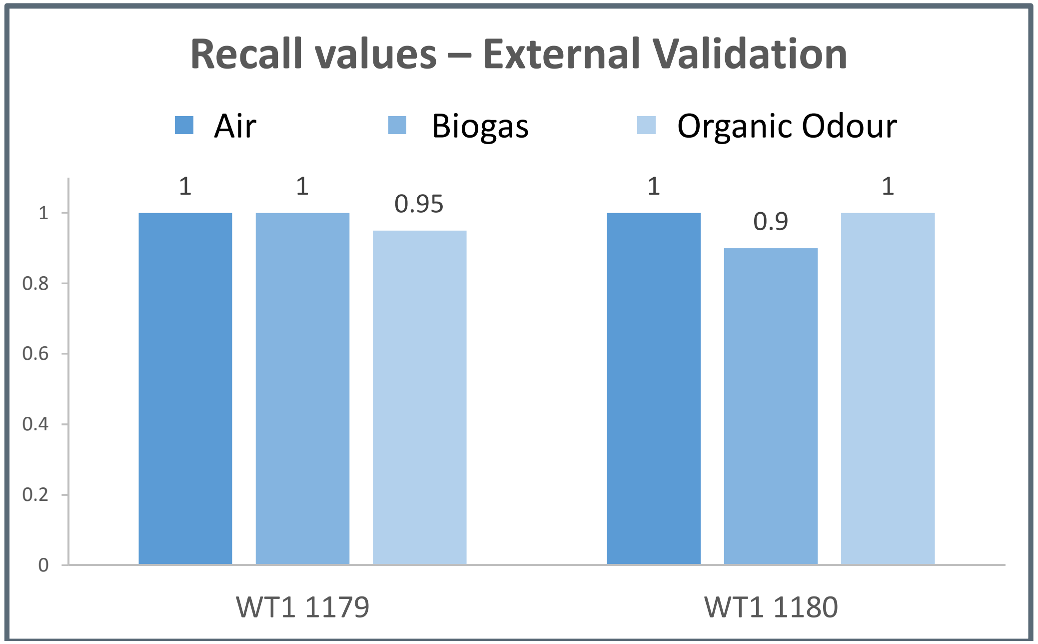
1. SAMPLING AND OLFACTROMETRIC CHARACTERIZATION OF SAMPLES INDEPENDENT FROM THE TRAINING SET
2. PREPARATION OF SAMPLES AT DIFFERENT CONCENTRATION LEVELS
3. E-NOSE ANALYSIS UNDER MONITORING OPERATING CONDITIONS
4. COMPARISON OF ODOR CONCENTRATIONS ESTIMATED BY E-NOSE WITH THE ONES DETERMINED BY DYNAMIC OLFACTOMETRY
5. DETERMINATION OF MODEL INDICES ACCURACY

FIELD PERFORMANCE TESTING: Classification

E-NOSE 1		REFERENCE		
		AIR	BIOGAS	ORGANIC ODOUR
PREDICTION	AIR	4	0	0
	BIOGAS	0	9	0
	ORGANIC ODOUR	0	1	15

E-NOSE 2		REFERENCE		
		AIR	BIOGAS	ORGANIC ODOUR
PREDICTION	AIR	4	0	0
	BIOGAS	0	10	1
	ORGANIC ODOUR	0	0	19





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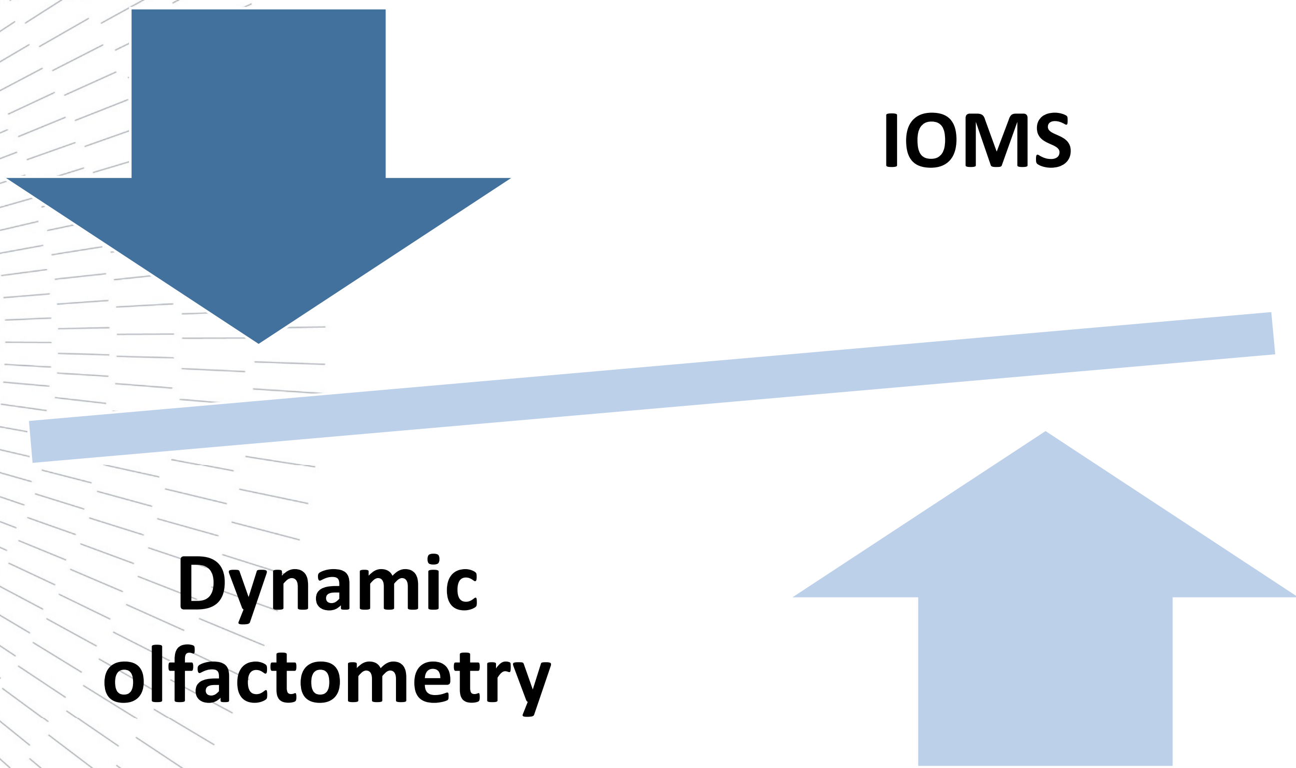

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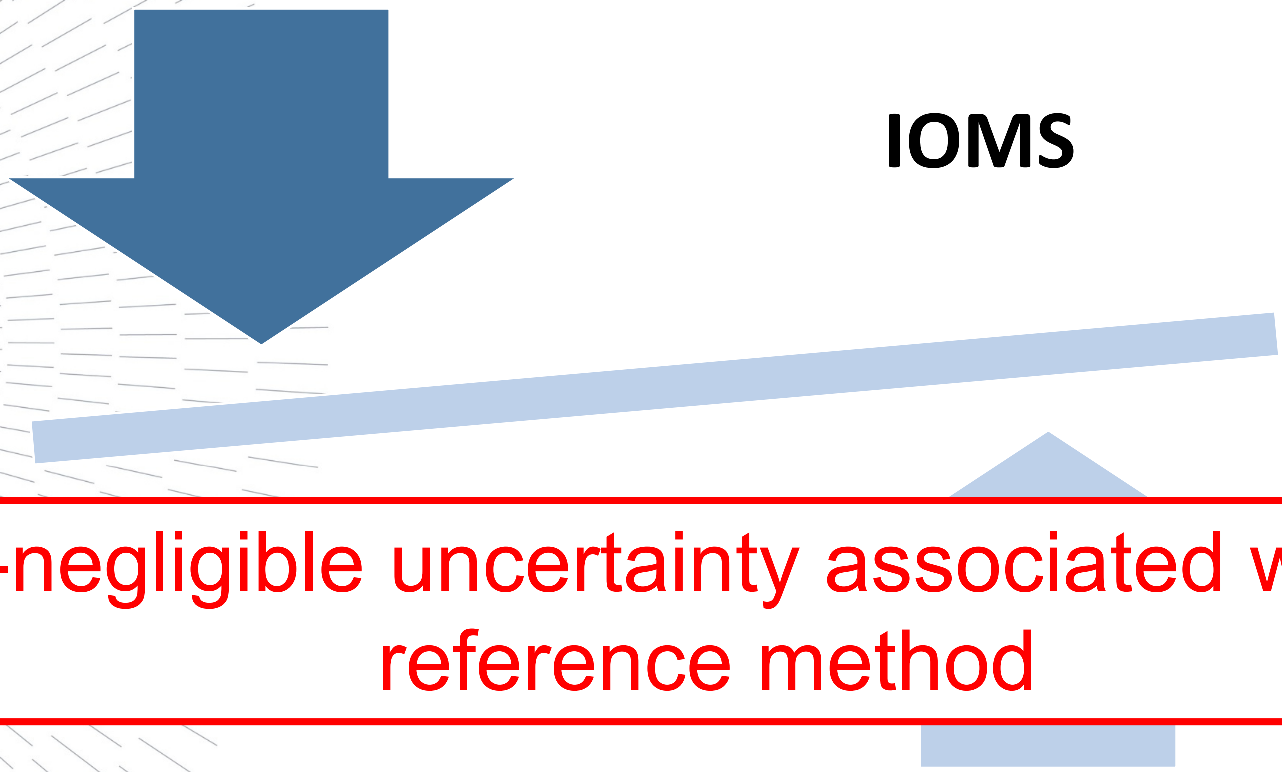
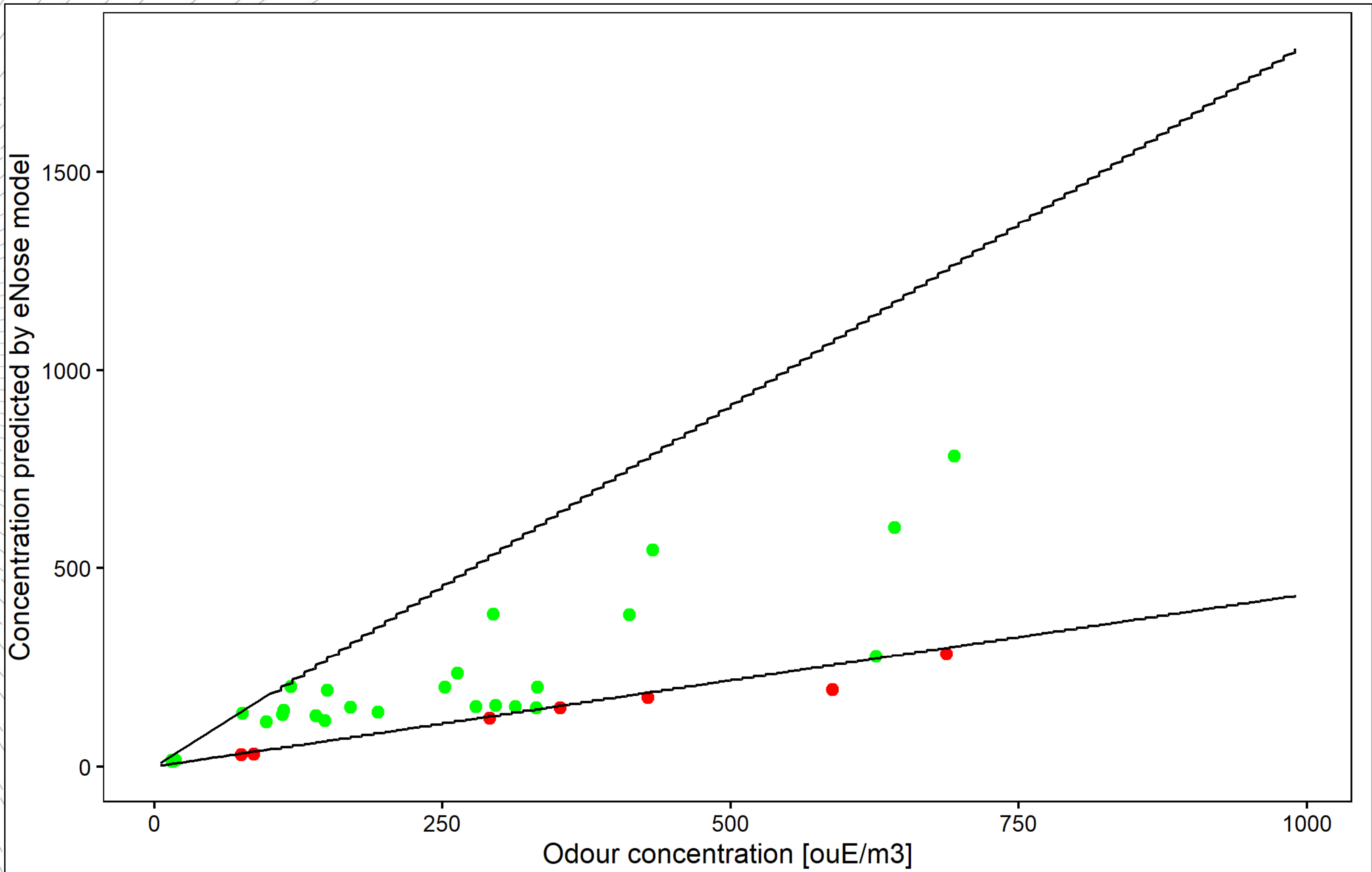


! Un-negligible uncertainty associated with the reference method

FIELD PERFORMANCE TESTING: Quantification

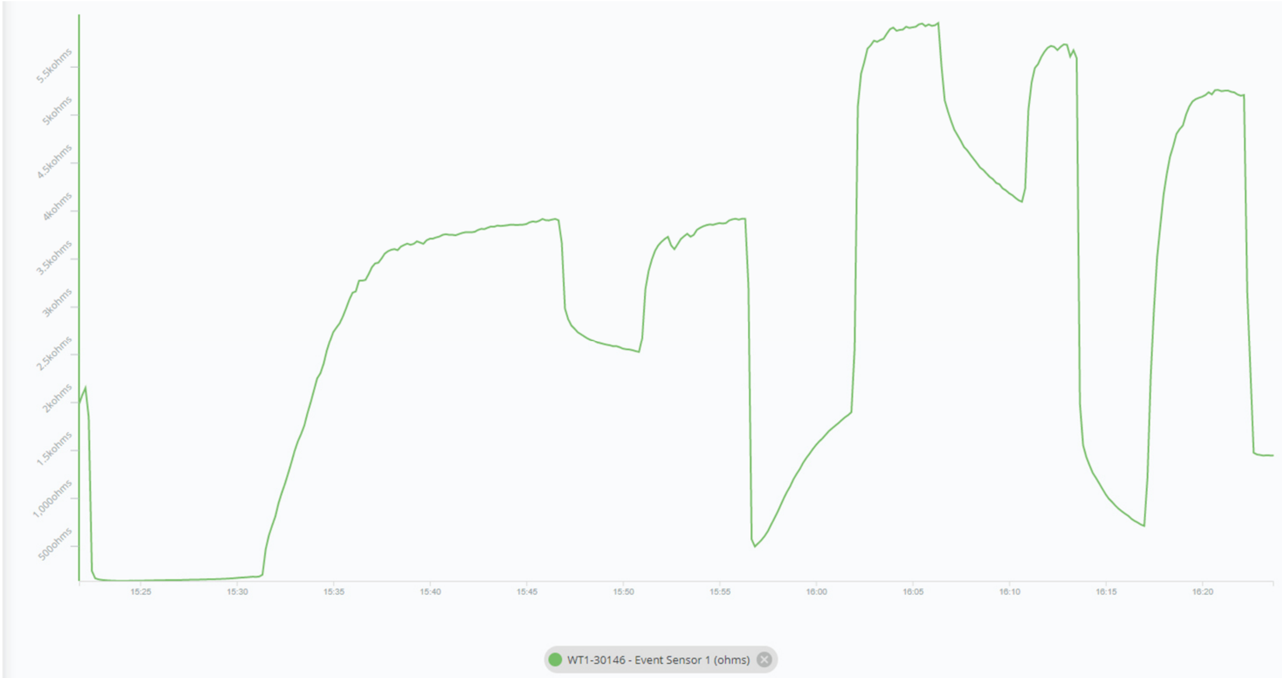


Case Study: Monitoring & Result interpretation

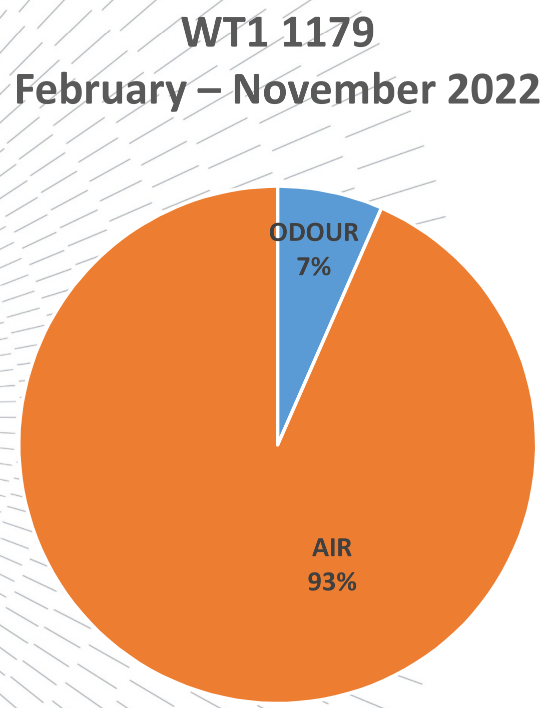
MONITORING PHASE

E-Noses **continuously analyse the ambient air** at the plant fenceline, recording sensor responses with a frequency of 1 Hz.

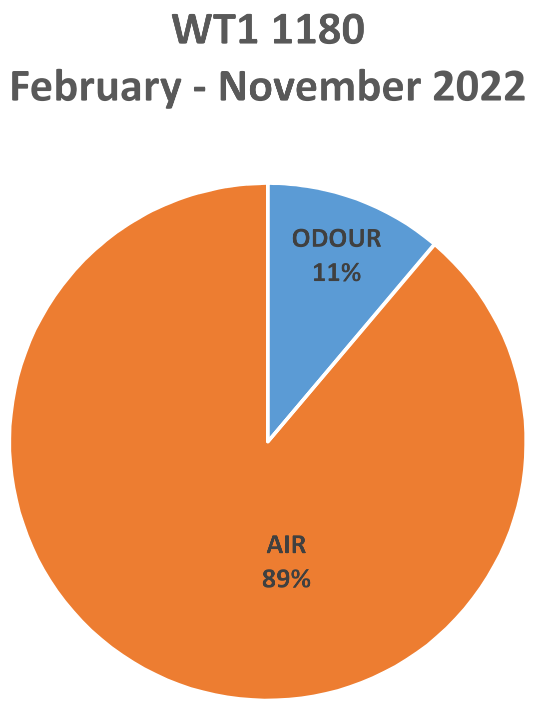
Real-time E-Nose Response



MONITORING PHASE
Odour impact and odour concentration ranges at fenceline



Mainly organic odour events



95° percentile: 174 Cod_eq

98° percentile: 201 Cod_eq

95° percentile: 132 Cod_eq

98° percentile: 182 Cod_eq

IMPLEMENTATION OF VARIABLE ALARM THRESHOLDS

ODOR CONCENTRATIONS CONTINOUSLY MEASURED BY THE INSTRUMENTS AND PROCESSED ON THE BASIS OF THE VALIDATED MODEL

+

METEOROLOGICAL DATA ACQUIRED BY THE WEATHER STATION INSTALLED AT THE PLANT

ODOUR OBSERVATIONS MADE BY HUMAN "SENTINELS"

Definition of variable **variable alarm threshold**, which change as function of the local **metereological conditions**, potentially responsible for odour events in the vicinity of the plant

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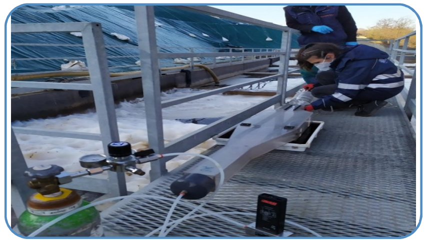

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VALLECHIARA MONITORING

3 Odour Emission Sources:
- Slalom
- Giant Slalom
- Downhill

Aim

Assessment of odour impact in terms of odour events

Duration:
- Starting date 15/10/2022
- Ending date 20/10/2022

ELLONA SOFTWARE
https://ellonasoft.io/login

Accounts for ISOCS attendees

- Loging: ISOCS_1
- Password: ISOCS_user_1

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- Password: ISOCS_user_2

- Loging: ISOCS_3
- Password: ISOCS_user_3

- Loging: ISOCS_4
- Password: ISOCS_user_4

- Loging: ISOCS_5
- Password: ISOCS_user_5

Thank you for your attention

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ENVIRONMENTAL MONITORING BY E-NOSES

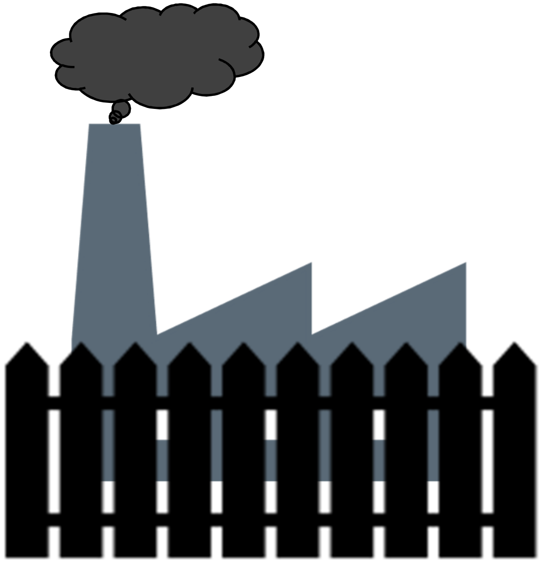
A DETECTION

B CLASSIFICATION

C QUANTIFICATION

RECEPTOR

FENCELINE



EMISSION