European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - *EuNetAir*

COST Action TD1105

Protocols, Standards and Methods for Odour Monitoring by Sensor Technologies

Duisburg, Germany, 4 - 6 March 2013

Action Start date: 01/07/2012 - Action End date: 30/06/2016

Year: 2012-2013 (*Starting Action*)

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WG 4 member, Sub-WG 4.2 Lead

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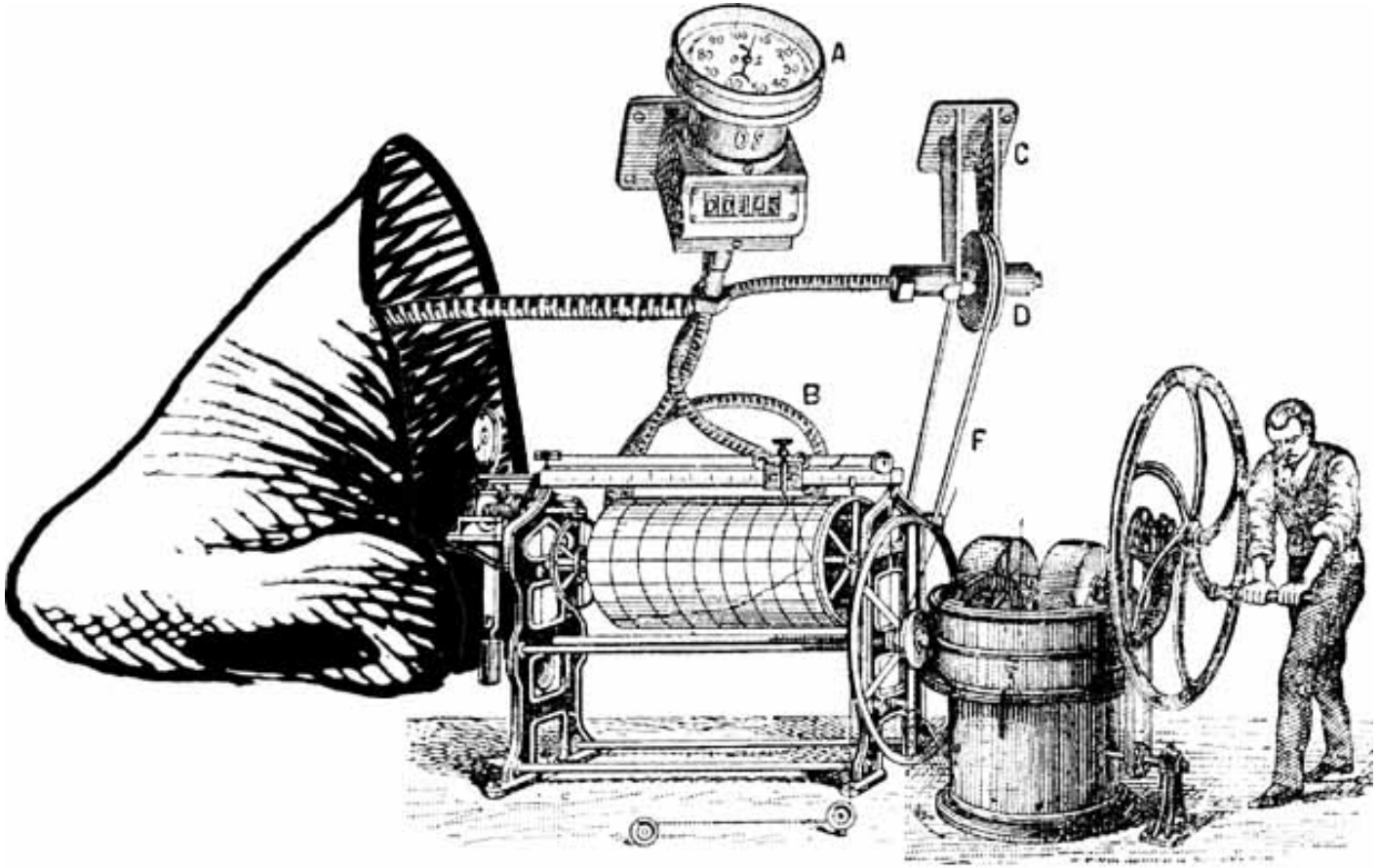
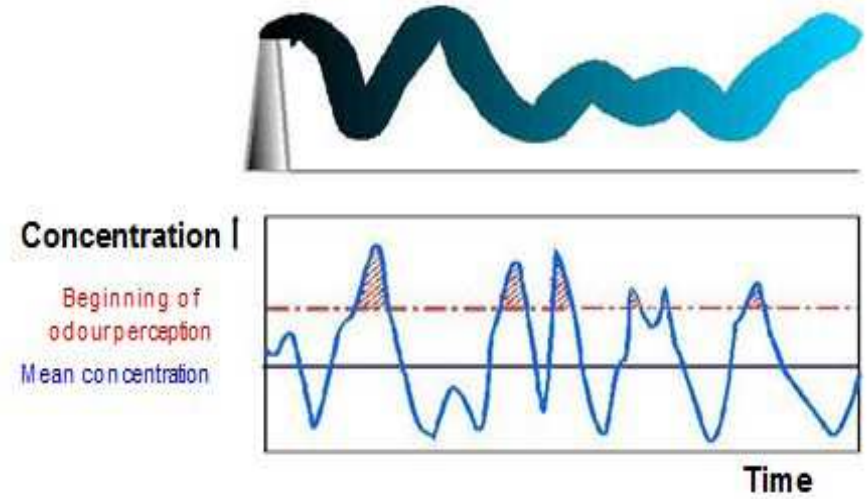
Odour Monitoring by Sensor Technologies ?



Context

Odour monitoring = continuous and real time measurements

Why ? Mean values of odour “concentrations”
no explanation of the odour annoyance
Annoyance = FIDO (R) → need continuous recorded data



Interests

- understanding and analysing
- making correct decisions
- improving policies
- reducing management risk

For whom

- Industry managers
- Neighbours
- Panelists
- Local authorities
- Governmental authorities
- Environmental companies

Off-odour emissions **Annoyance**

⇩

environmental problems to solve

??

??

Odour definition

volatile emanation which cause sensations in humans due to the excitation of specialized organs

Chemistry

Single compounds (odorant eg H_2S)
Key compounds (if complex mixture)

Physiology

Perception
Annoyance

Analytical instruments
chemical analysis
(GC-MS; SIFT; FTIR; …)

Sensor technologies
selective sensors (specific? ☺)
optical or chemical
1 sensor, on chip or in multi sensors a

Outputs
chemical concentration (µg/m³)
≠
odour information

Sensorial analysis
dynamic olfactometry,
complaints survey, panellists, field inspection

Senso-instrumental technologies
electronic nose
(Artificial Olfactory System AOS)

Outputs
Odour perception information (ou/m³);
offensiveness, frequency, odour sources (compost, biogas,…)

Sampling
Dispersion models

Sensor technologies in the world of odour

o the best potentialities for odour monitoring - each day more accurate, smaller, cheaper and more intelligent BUT still **several limitations** (drift, humidity, high LOD,…)

o almost performing for single odorants but environmental off-odors = complex mixture and **"odour sensors"** don't exist…yet !!!!

Example: to be self-running, calibration of the devices

calibration with odours?

***No standards** of « compost odour» or « waste odour*

Which "mixture" to compensate the drift?

BUT for odour monitoring, limitations not only due to the sensors

- ☐ odour perception ≠≠ ∑ each chemical concentration (synergetic effect and inhibition)
- ☐ "reference" odour concentration measurement (EN 13725), accepted uncertainties from the half to the double of the measured value (ou_E/m^3)
- ☐ harsh environment
- ☐ usual dispersion models not adapted to fast fluctuations
- ☐ complex determination of flow rates
- ☐ …

Policies and regulations context

European Guidelines? No European limit values (= America and Asia)

- Country policies (eg. Germany; France; Belgium; Austria; Switzerland; Netherlands)
- Units? odour concentration; odour emission rates; percentiles (eg 1ou/m³ at 98th percentile not exceed 1 ou/m³ more than 2% of the time), chemical concentration; acceptable distance (for animal farming facilities); percentage of complaints
- Specific to the sector
- Source or receptor level
- Different regulations in each "operating permit"

➡ NO HARMONISATION
(European trend is to consider the percentile values and the receptor level)

Measurement/sampling standards?

- 1 European standard: EN 13725 (America: ASTM E679-04) -under revision-
- in preparation: regulation of the methods for field inspection
- Specific to country: (reference Germany VDI)
  chemical analysis; sensorial approaches-in lab after sampling or in field with/without neighbour panelists

Odour Monitoring by Sensor Technologies???

NADA

(sometimes mention of e-nose in permits)

Protocols, Standards, Methods for

Odour Monitoring by Sensor Technologies

?

Protocols, Standards, Methods for Odour Monitoring by Sensor Technologies?

Eg: Electronic nose technology

Best potentialities for the off-odours monitoring, match to the need of the end-users

BUT

even if sensor limitations (high LOD, low selectivity, poor reproducibility)

it is more a complex system comprising:

- a sampling system,
- the sensor array itself,
- the reference data set,
- and the data evaluation/algorithms

to developed for each specific situation

+ dispersion models

Some guidelines would be very useful for the maker and other stakeholders (industrial manager, local authorities, private company, …)

Protocols, Standards, Methods for Odour Monitoring by Sensor Technologies?

Two interesting studies:

1- *Can Electronic Noses be Used to Control Odour Abatement Measures in Sewers?*
[Schwarzboeck T, NOSE 2012]

4 electronic noses tested in parallel in a sewer research channel from the Berliner Wasserbetriebe over a period of 6 months

All e-noses differ in their configuration (different amounts and type of sensors, different sample preparations, different data treatment, …)

Some conclusions:

-"different configuration play a role in the performance"

- different results

-"better" correlation (but no good -R^2 from 0.36 to 0.56-)
of the enose measurement to odour concentration
than the H_2S measurements

Protocols, Standards, Methods for Odour Monitoring by Sensor Technologies?

2- "Addressing the Market Demands for Artificial Olfaction Systems [Atzeni et al, NOSE 2010]"

A market research to assess demands for artificial olfaction systems (AOS):

Conclusions

"general lack of confidence in reliability of odour data using current field methods and dissatisfaction with the costs of conducting lab and field odour assessments".

⟶ **ready market exists for advanced AOS that provide improvements in quantitative odour assessment and in the monitoring of odours on-site**

Questionnaire on the priorities of five key factors in e-nose development (86 respondents):

accuracy →**reproducibility/precision**→ **sensitivity**→ **portability**→ **price**
(highest score) (lowest score)

Protocols, Standards, Methods for Odour Monitoring by Sensor Technologies?

Major issues

- ✓ Calibration methods (cost-effective): sensor drift, replacement of faulty sensors, sensor exchange
- ✓ Comparison to other techniques (cross-reference)
- ✓ **Validation** of the associated pattern recognition techniques and regression models: in the receptor level with the neighbor panelists
- ✓ Recalibration
- ✓ Guidelines on the (minimum) number of data to develop the models…
- ✓ Determination of the accuracy of the given information –honesty-what is the true interpretation of their outputs (uncertainties)
- ✓ Maintenance

CONCLUSIONS

- Lack of harmonization in the general scope of odour legislation
- The management of the odour pollution needs a real time monitoring of the “odour perception”
- Sensors technologies (ST) as artificial olfactory system have the best potentialities for this monitoring
- ST for odour monitoring no yet considered in the policies
- Currently limitations of the technology not hinder it’s development; **in a first step: “user guidelines” would made the ST more credible → last step: standard**
- Collaboration of end-users (stakeholders) and scientists would have the power to merge the requests of each actor

EuNetAir WG4. Target analytes 2013

Odorants

- H_2S and organic thiols (mercaptans)
- **Action:** A state-of-the-art summary of sensors / analyzers (First draft May 2013)

General odour scope for next year, 2014

EuNetAir WG4, Road map 2013

- "**state of the art"** of some important and commercially available**, low cost gas sensors / analyzers**
- Summarise possible and most common applications for a certain gas sensor
- Produce lists of tests, "**test protocol**", that should be used in order to validate sensor specifications. These protocols and corresponding test results could later be used for creation of modern standards
- Identify test sites which could be used for field testing of sensors and sensor networks, if EuNetAir partners and other companies (in Europe or elsewhere) would like to provide sensors
- Initiate laboratory and field testing at national accredited test laboratories.

- At present it is unclear if we should produce a general standard for a specific analyte, advise on improving current standards or write application standards
- If we choose certain application standards, who should direct which main applications to focus on? Comments from other EuNetAir members or EuNetAir MC are highly appreciated
- CEN contacts are important for quickly implementing any future new standard.
- For European SME:s in EuNetAir it is hard to add a lot of work on writing standards – we must focus on surviving in economically tough times. Could EuNetAir or someone else provide financial support?

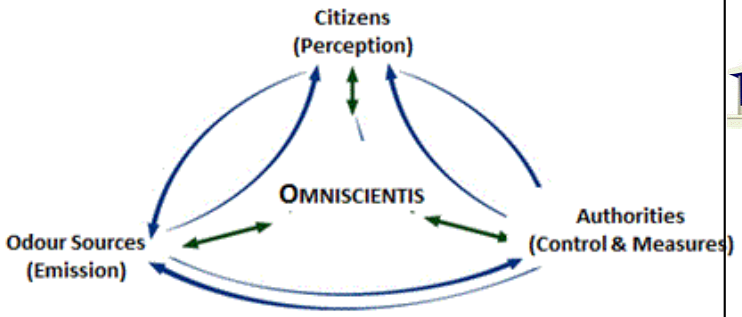
http://www.omniscientis.eu/

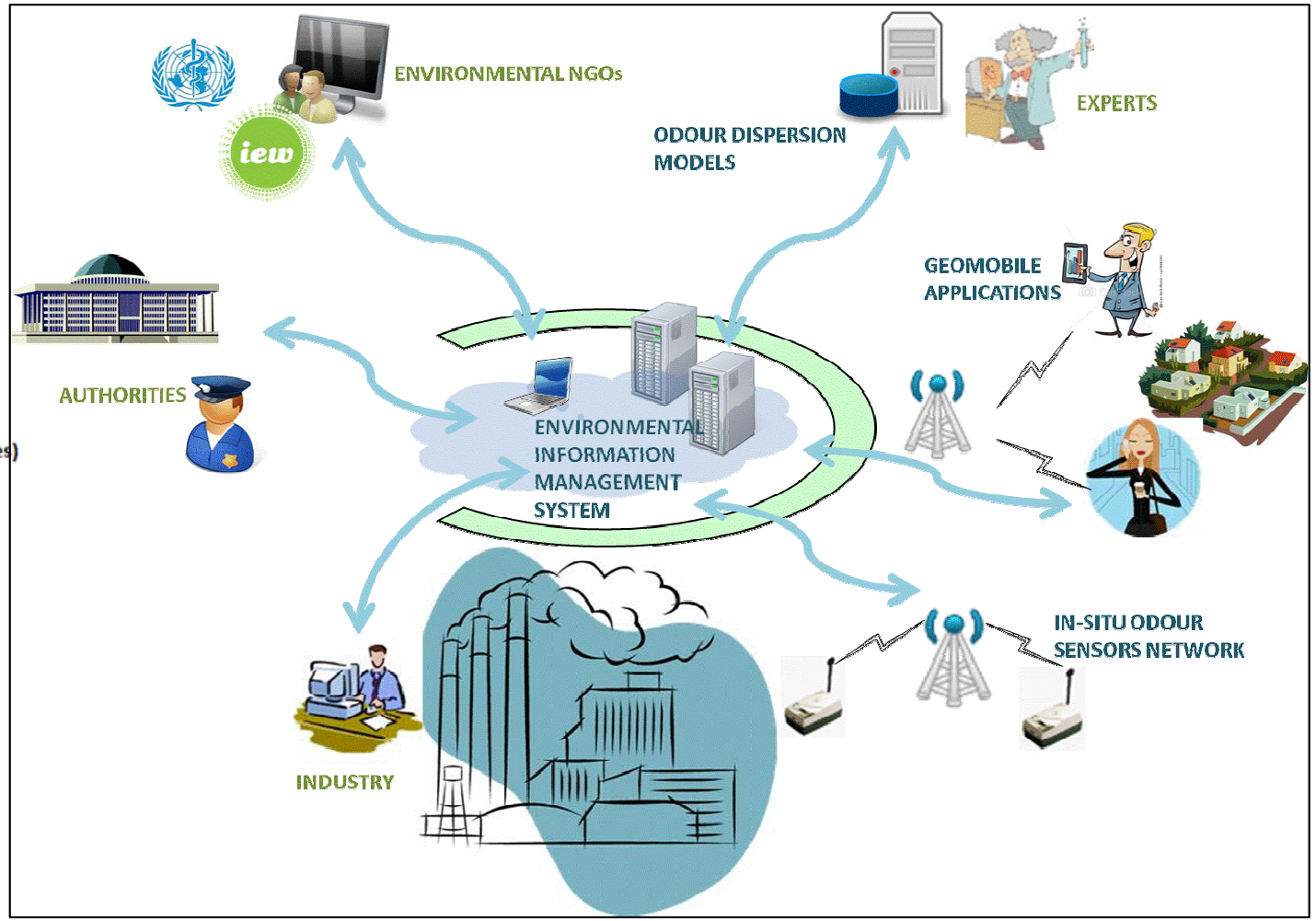
SEVENTH FRAMEWORK PROGRAMME

Omniscientis

Odour MoNitoring and Information System based on CItizEN and Technology Innovative Sensors

Living Lab approach





SPACEBEL

Université de Liège

ODOMETRIC

TU Graz
Graz University of Technology

KTT-iMA
Kunz Technologie Transfert - Richter & Röckle

APS TECHNOLOGY

tudor
PUBLIC RESEARCH CENTRE HENRI TUDOR

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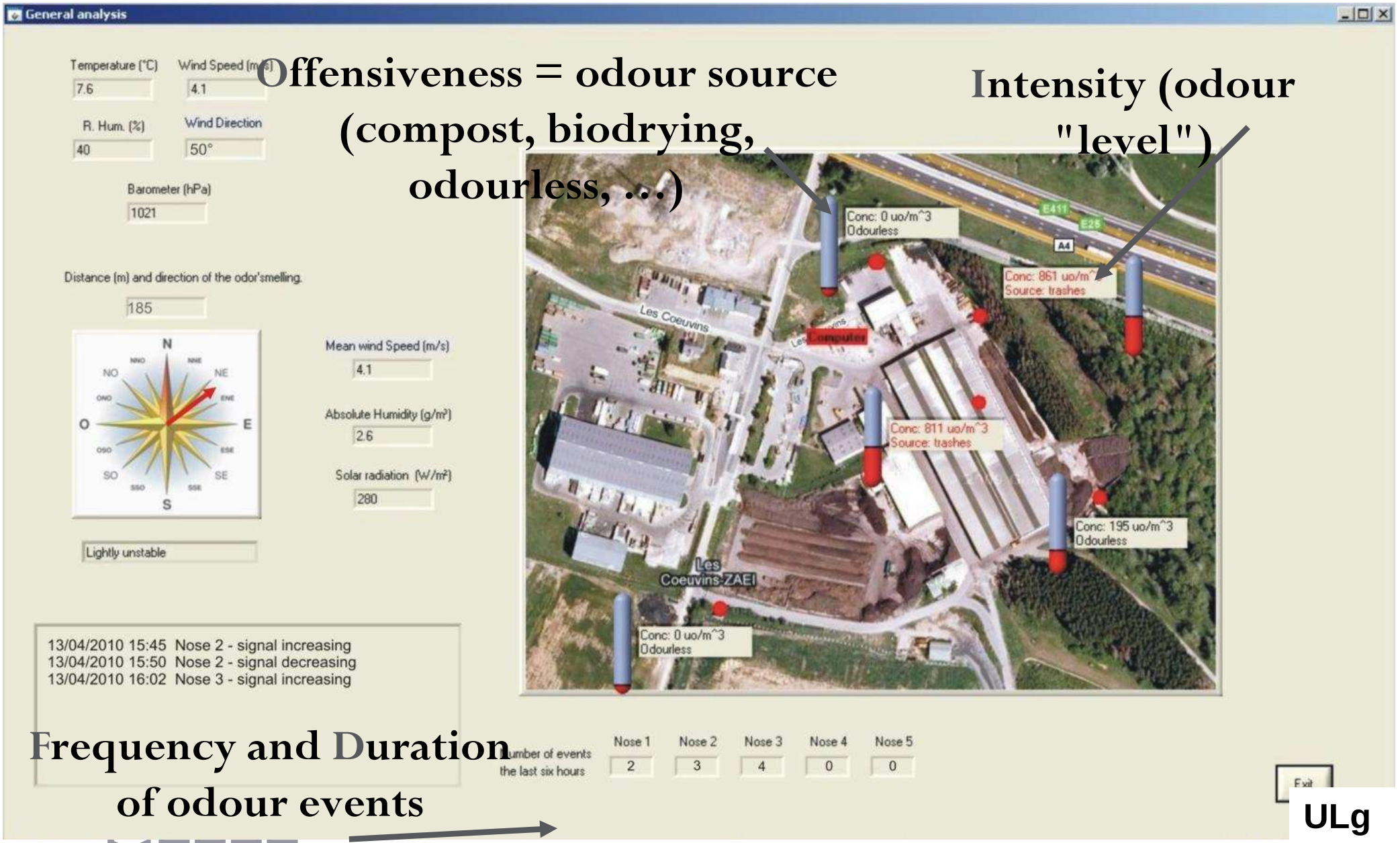
BURGO ARDENNES


General analysis
Temperature (°C)
7.6
Wind Speed (m/s)
4.1
R. Hum. (%)
40
Wind Direction
50°
Barometer (hPa)
1021
Distance (m) and direction of the odor'smelling.
185
N
NNO
NNE
NO
NE
ONO
ENE
O
E
OSO
ESE
SO
SE
SSO
SSE
S
Mean wind Speed (m/s)
4.1
Absolute Humidity (g/m³)
2.6
Solar radiation (W/m²)
280
Lightly unstable
13/04/2010 15:45 Nose 2 - signal increasing
13/04/2010 15:50 Nose 2 - signal decreasing
13/04/2010 16:02 Nose 3 - signal increasing
Offensiveness = odour source (compost, biodrying, odourless, ...)
Intensity (odour "level")
Conc: 0 uo/m^3
Odourless
E411
E25
A4
Conc: 861 uo/m^
Source: trashes
Les Coeuvins
Computer
Conc: 811 uo/m^3
Source: trashes
Conc: 195 uo/m^3
Odourless
Les
Coeuvins-ZAEI
Conc: 0 uo/m^3
Odourless
Frequency and Duration of odour events
Number of events the last six hours
Nose 1
2
Nose 2
3
Nose 3
4
Nose 4
0
Nose 5
0
Exit

ULg

Thanks for your attention

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Polluted atmospheres
Arlon (Belgium)

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