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# THE 2008 ELEMENTAL MERCURY VAPOUR POLLUTION ACCIDENT IN THE BRUSSELS CAPITAL REGION: TWO APPROACHES TOWARDS SOURCE IDENTIFICATION

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**Abstract**: On the night of January 22-23, 2008, an exceptionally high elemental mercury concentration was measured by an Hg vapour monitor in the Brussels Capital Region. Simultaneously, very high ozone concentrations were registered at different locations as Hg presence interferes with its determination. During the following days, high mercury at one monitoring station and high (false) ozone concentrations at several locations were measured by the BIME air quality monitoring network. On the night of January 24-25, the mercury concentration reached the maximum of 996 ng/m³, while ozone readings reached 1210 µg/m³.
After the first high mercury concentrations were measured, BIME, the Brussels Institute for the Management of the Environment immediately started an investigation to find the source. By analysing pollutant roses, indicating that the source was to be found near the south of Brussels, and using their knowledge of the industrial activities in and around the Brussels Capital Region, BIME mandated a laboratory to perform emission measurements at potential source locations on January 24th. Analysis of these samples took several days, but they eventually identified a battery recycling plant as the origin of the Hg emissions.
As the mercury cloud was breaking news, other groups in Belgium, not connected to BIME, wondered how their know-how in atmospheric dispersion and environmental measurements could contribute to locating the mercury source. They came up with a conceptual model of the mercury plume, originating in the Zenne valley, being trapped therein by a strong nocturnal ground inversion, till it escaped from the valley. This model explained the multifaceted aspect of most pollutant roses and delivered a strategy to locate the plume origin by a mobile ozone-mercury measuring device. The mobile measurements performed during the night of January 25-26, identified an industrial zone of 100m x 100m as the most likely location of the source, within which the battery recycling plant was located.

***Key words:*** *high (false) ozone, elemental mercury vapour, mobile measurement campaign, ground-level inversion* **.**

## INTRODUCTION

Belgium is a federal state. At the top level are the Federal State, the Communities and the Regions, all three of which are equal from the legal viewpoint. They are on an equal footing but have powers and responsibilities for different fields. Environmental issues, including monitoring and assessment of air quality, belong to the responsibilities of the Regions. The three Regional environment agencies are:

- the Flemish Environment Agency for the Flemish Region (VMM);
- the Brussels Institute for Management of the Environment (BIME) for the Brussels Capital Region;
- the "Institut Scientifique de Service Public" (ISSEP) and the "Service Public Wallonie" (SPW-AWAC) for the Walloon Region.

The three Belgian regions work together in the air quality domain by means of the Belgian Interregional Environment Agency (IRCEL-CELINE). One of the tasks of IRCEL is to inform and/or alert the general public (via press and audio-visual media) and policy makers of episodes with enhanced air pollution.

On the night of 22-23 January 2008, an exceptionally high elemental mercury concentration of more than 50 ng/m³ was measured by an Hg vapour monitor in the Brussels Capital Region. Although the high mercury concentration was measured in the Brussels Capital Region and thus could be considered as a "local regional" problem, it was not at all clear that the mercury source was located inside the Brussels Region. It could not be excluded that the source was located in the Flemish or even the Walloon region. The BIME therefore informed IRCEL of a possible "regional transboundary" air pollution in the Region. IRCEL immediately alerted the responsible environment inspectorates and policy makers in the two other regions and published an alert message on their website which was taken over by the Belgian press agency BELGA.

This message was used by other press agencies and the audio-visual press to inform the public. The 'mercury vapour cloud' was then the most important headline news, till the source of this mercury was detected on Saturday morning, the 26th of January 2008.

This paper gives a time-record of the measured concentrations and shows how these data were used to pinpoint the origin of the mercury vapour plume.

## THE BIME AMBIENT AIR QUALITY MONITORING NETWORK

The Brussels Capital Region, one of the three Regions in Belgium with nearly complete autonomy on environmental matters, has a population of approximately 1.048.000 people (2008) and a surface of 161 km$^2$. Its telemetric network for air pollution control has eleven fixed measuring sites. All stations are equipped for NO and $NO_2$, 6 of them for PM10, 5 for PM2,5 and 7

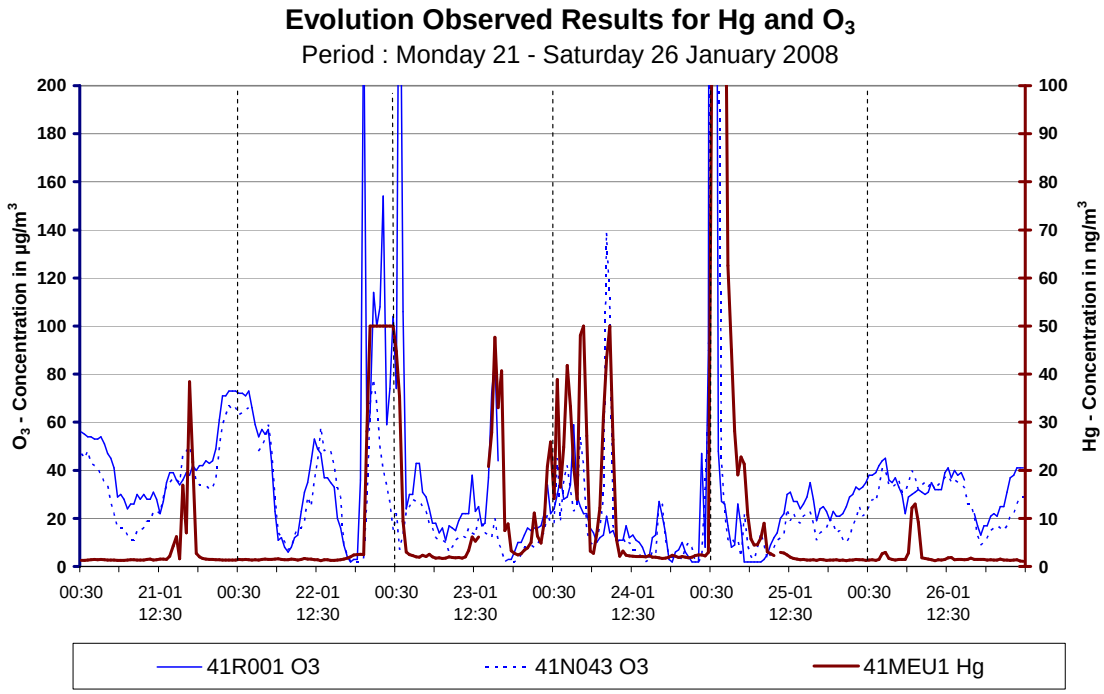


Figure 1: Evolution of observed results for Hg vapour (red line, axis on the right) and Ozone (with Hg-interference). Period: Monday 21 – Saturday 26 January 2008

for ozone. One station, situated in the north, contains a mercury vapour analyzer for the surveillance of the Brussels municipal waste incinerator. Three meteorological stations are also part of the network.

The UV photometric ozone analyzers are based on the principle that ozone molecules absorb UV light at a wavelength of 254 nm. Two types of analyzers were in use during the considered period: the Thermo Environmental ozone analyzer, model 49C and the Environnement O3-41M.

Mercury Vapour is measured by a Tekran analyzer, model 2537A. The detection is based on the UV fluorescence, at 254 nm, of Hg molecules. For selectivity reasons the Hg vapour is first trapped on a gold trap (Au-Hg amalgam) and then released by thermal desorption. In this way the Hg analyzer has become insensitive to ozone interference, but the ozone analyzers may indeed be sensitive to Hg vapour interference, if the Hg concentration is far above the normal ambient level of 2-6 ng/m$^3$ (Ying Li *et al.*).

**TIME SERIES OF ELEMENTAL MERCURY AND (FALSE) OZONE**

Figure 1 shows the time series of mercury vapour and ozone (with Hg-interference) at two monitoring sites 41R001 and 41N043 in the Brussels Region. On Monday the 21$^{st}$, increased Hg values up to 38 ng/m³ were measured in the afternoon between 15h00 and 17h30 in the north part of Brussels ((Figure 2). It is the first observation of the mercury vapour plume. However, this value did not draw much attention, as the Hg monitor stands close to the municipal waste incinerator.

In the night from Tuesday the 22$^{nd}$ to Wednesday the 23$^{rd}$ January, between 17h00 and 1h30, the mercury vapour concentration was recorded as an out of range value, which means the concentration was higher than 50 ng Hg/m$^{3.}$ At the same time, recorded ozone values at several places in Brussels (Figure 2) were:

- 142 µg $O_3$ /m³ at B006, Bruxelles Europarlement Schumann
- 78 µg $O_3$ /m³ at N043, Haren
- 308 µg $O_3$ /m³ at R001, Molenbeek-Saint-Jean

The link between the increased mercury vapour concentration and the unrealistic ozone readings was immediately made.

The next night, from Wednesday to Thursday, mercury vapour concentrations up to 50 ng/m³ were measured, but the ozone concentration readings were not spectacularly high, except for one half hourly value value of 139 µg/m³ at N043, Haren.

In the night from Thursday the 24$^{th}$ to Friday 25$^{th}$, between 0h30 and 5h30, one ozone reading went up to 1218 µg/m³, and the mercury monitor, whose upper range had been increased, produced a one half hour reading as high as 996 ng/m³.

Finally, in the night from Friday to Saturday, a mercury vapour concentration of 12 ng/m³ was measured.

## FIRST APPROACH FOR SOURCE IDENTIFICATION: BIME

BIME's Air Laboratory alerted several other services, amongst them BIME's Inspection Service, the Interregional Cell for the Environment and the Environmental Administrations and Institutes of the two other Belgian Regions: the Flanders Region in the North and the Walloon Region in the South. The main objective was to gather relevant information available at different levels, supported by several air pollution experts, in order to have as quickly as possible a realistic demarcation of the source area.

Analysis of the Hg interfered ozone pollution roses (Figure 2) gave a strong indication that the source area had to be located near the South of the Brussels Capital Region. With the Flanders Region at the boarder and the Walloon Region at approximately 10 km, contact and information lines were kept open via the Interregional Environmental Agency.

Important human and material means were employed to detect the source. Contacts with the environmental inspection services in Flanders and Walloon permitted to exclude sources on their territory. Using their knowledge of the industrial activities in the Brussels Capital Region, BIME mandated a laboratory to perform emission measurements at potential source locations on January 25th, among which a battery recycling plant for lead batteries and a sludge incinerator.


Figure 2: Brussels Air Pollution Network: 95the percentile Rose for Ozone (with Hg interference). Period : Monday 21 – Thursday 25 January 2008

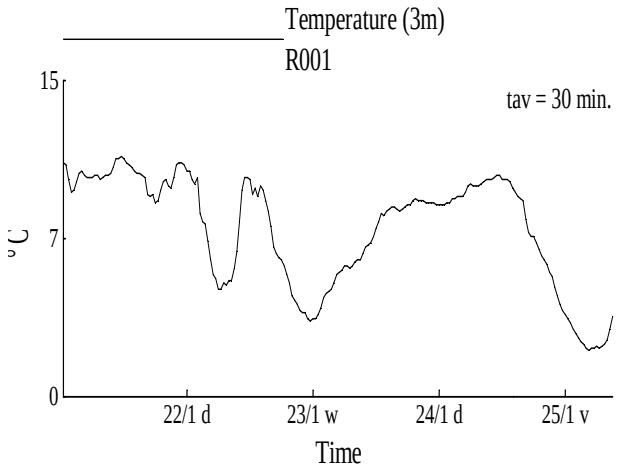


Figure 3: Evolution of temperature from Monday 21, 0h00 till Friday morning 9h00

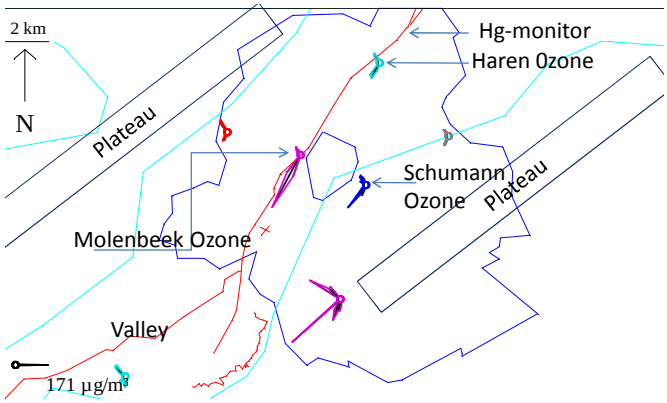


Figure 4: Location of the mercury monitor and of some ozone monitors, some pollutant roses for ozone (night 22-23 January, 95-Percentile), and a schematic representation of the Zenne valley and the surrounding plateaus. Red lines: Zenne river and Sea Channel, cyan lines: transition from valley to plateau, blue lines: Brussels city centre ('Coeur d'Europe') and border of Brussels Region.

## SECOND APPROACH FOR SOURCE IDENTIFICATION: BY MODELLING AND MOBILE MEASUREMENTS

VITO is a Flemish government organization that positions itself as an independent and client-oriented research organization towards the industrial sector and as one of the driving forces behind Flemish innovation policy and a structural government partner in a number of other policy themes, such as energy and the environment (http://www.vito.be/VITO/EN/HomepageAdmin/

Home/WetenschappelijkOnderzoek/RuimtelijkeMilieuaspecten/). The air quality modelling group masters a number of models[2] ranging from the very local scale (Envi-met, IFDM) up to the continental scale (Aurora). The local scale modelling experts often work in close collaboration with members of the environmental analysis team, especially when these deal with emissions, concentrations in ambient air, deposition and accumulation in soil of very specific pollutants such as heavy metals, dioxins and PCBs in the surroundings of very specific industrials sites.

On Friday morning, January 26th, Vito was contacted by IRCEL with the question whether their modelling experience could be relevant for the identification of the mercury source. We were given the times series of half-hourly Mercury and (false) Ozone measurements (Figure 1) and of simultaneously measured wind speed, wind direction and temperature (See Figure 3 for temperature). So we could make and analyse a set of pollutant roses of mercury and (false) ozone for individual nights, individual days, and investigate different statistical parameters such as average or percentile value per wind sector. None of these quick analyses, allowed to identify the potential mercury source with greater precision than had already been done by BIME, but we noticed some interesting features about the mercury plume.

- Most high concentrations were measured during the night;
- Weather was most of the time overcast, but during night time, some short periods of open sky did occur. (See the synoptic meteorological data for Brussels at e.g. http://meteo.infospace.ru/wcarch/html/e_sel_stn.sht?adm=21 .) Some of these open-sky conditions led to a quick drop of temperature (Figure 3);
- Part of Brussels, including most of the monitoring sites where high (false) ozone measurements had been measured, are situated in the Zenne valley. The peak values of the pollutant roses point into the valley. Outside the valley, on the surrounding plateau, (very) high (false) ozone concentrations had been measured only at the Shuman-building (Figure 4).

So the idea emerged that the mercury plume originated somewhere in the Zenne valley, and that the plume was, during part of the night, trapped in the valley by a ground inversion.

This model of the mercury plume, simple as it is, suggests that the source could be easily located during the night by a mobile laboratory van, equipped with either a mobile Mercury monitor or/and an ozone monitor that is sensitive to Hg vapour interference.

## RESULTS OF THE OZONE AND MERCURY MEASUREMENTS USING THE MOBILE LABORATORY SYSTEM AEROMAX

Using this mobile system, equipped with an ozone monitor (Thermo 49C Ozone Analyzer), a Hg-emission monitor (VM-3000, MI, 0,1-100 µg / m³) and a weather station on the roof a 5 m height, grid measurements were performed at this region with suspected source in order to pinpoint the source more precisely. The measurements were performed during 3 consecutive nights.

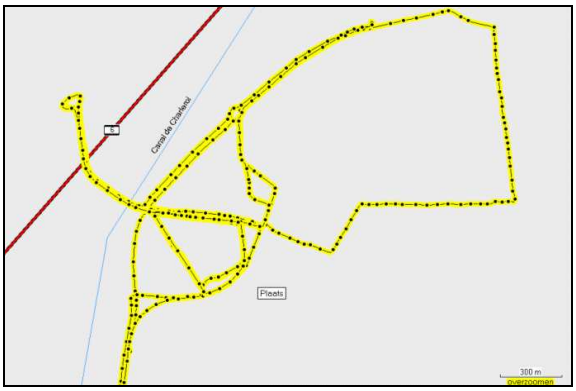


Figure 5 : Overview of the screening-traject.

On the night of 25/01 to 26/01, the grid measurement followed a route in the area of the Zenne Valley (from Drogenbos to Anderlecht and Forest), which attempted a cross wind driving in order to locate a plume of a potential mercury emissions. Using a more extensive screening based on a difference measurement (compared to background), the plume could be defined in the Paapsemlaan (Figure 5) over a trajectory of 50 to 100 m where increases of 20 to 1000 µg / m³ for O3 and 5 to 25 µg / m³ for Hg were measured.

## THE SEQUEL

Based on this information, the plant operator was informed on January 27th of the possibility his plant was the cause of the mercury pollution. He voluntarily interrupted the activity until the availability of the emission measurement results.

[2] A Long respectively Short Description of Envi-Met, IFDM and Aurora can be found in the Model Documentation System of the European Topic Centre on Air and Climate Change.

In order to exclude other sources of mercury pollution, the following 2 nights (when at both the sludge incinerator and the battery processor no activities took place) more screenings by mobile measurements were performed around the factory and the area downwind and crosswind of the suspected source area. No more mercury vapour was found.

The emission measurements results undoubtedly identified the plant, and more specifically the melting process, as the origin of the mercury pollution on January 29th.

Once the source had been undoubtedly identified, the environmental inspection service ordered an immediate shut down of the melting activity. An investigation started in collaboration with the judicial services. An official report was transferred to the public prosecutor. The judicial investigation is still going on.

As a complementary investigation to evaluate the impact of the pollution on the human health, the BIME mandated a soil investigation bureau to perform measurements in the surroundings of the factory. All results were transmitted to the federal service in charge of human health in order to obtain scientific advice on the possible dangers for the neighbours of the high mercury concentrations.

The mercury pollution has led to the conclusion that an important quantity of batteries containing mercury can be found in the recycling circuit for lead based vehicle batteries.

The melting activity of the battery recycling plant was interrupted for four months. During this period, corrective actions were taken by the plant operator, such as the adaptation of the air treatment system by adding an active coal treatment and a continuous surveillance of mercury emissions. The environmental permit of the plant was adapted to include more severe emission norms.

**CONCLUSIONS**

Local, harmful plume air pollutions are seldom seen today. Air quality monitoring networks do capture, sometimes by 'accident', local air pollution incidents. In this case the tremendous sensitivity of the ozone measurements for Mercury triggered off an identification process. Although combined with highly sophisticated calculation tools the absolute localisation of a plume remains a difficult task. The combination of the adequate measuring equipment in a mobile measuring unit was the right tool to finalise all efforts and to pin-point the plume origin. The joint effort of local authorities combined with the flexible approach of scientific institutes was a meaningful combination to solve the problem.

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