Evaluation of gas emission from closed mines surface to atmosphere

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ABSTRACT: The closed mines are likely to release into atmosphere polluting or/and dangerous gases. The detection and hazard evaluation of those emissions are a complex problem. In order to quantify and qualify these gas emissions and check gas migrations special measuring methods are required. The research done at INERIS resulted in a reliable and appropriate methodology using a flux chamber. This methodology is intended for detecting, quantifying and qualifying gas discharges, but can also be applied to verify the effectiveness of the preventive means used for reducing emissions (sealing operations, gas drainage, etc.).The method has already been applied in an operational manner for diagnosis and appraisal on a number of sites (old mines, landfills, etc.). Although originally designed for measuring methane flows, it is fully useable in or transposable to any similar situation of gas flows emitted by the ground, subject possibly to some specific modifications..

1 SURFACE EMISSION OF FIREDAMP

Experience in different coalfields has shown that gas that is released and accumulates in old underground workings tends to migrate towards the surface. This gas can represent a significant hazard because it may be both flammable and suffocating.

A number of incidents and even accidents resulting from gas rising to the surface have already been noted in different countries (Burrel et al., 1996; Kral et al., 1998).

These events were caused by the following risk situations usually encountered:

- the isolated and concentrated release of firedamp through mine shafts, faults, cracks, etc. providing a direct link between old workings and the surface;

- the build-up of gas in confined or semi-confined spaces (cellars or basements, even dwellings or buildings themselves, but also underground networks, and so on);

- the venting of contained firedamp to the atmosphere (for example where drilling or civil engineering works are carried out near old workings);

- enclosure of a gas-emitting surface (for example, by constructing a building).

2 AIMS AND PRINCIPLES OF THE METHOD

For concentrated emissions or when gas builds up in a confined space, simple measurements of gas concentrations in the atmosphere can be sufficient to detect and evaluate the hazards.

The approach is much more complicated where there is diffuse emission from the ground, because the mere fact that measurable concentrations of gas are present does not always mean that a truly significant flow exists. Moreover certain gases, such as carbon dioxide and methane, may be present in the soil naturally.

Accordingly, in order to be able to detect, quantify and qualify gas discharges of this kind, as well as to evaluate the effectiveness of the preventive means used, it is indispensable to have reliable and proven methods for measuring the flow of gas emanating from the surface of the ground.

With this in view, INERIS has been developing and validating such methods since 1992 (Pokryszka et al., 1995). These methods, which were originally intended for landfills and contaminated ground, quickly found an application in mines.

The latest measurement technique developed is based upon a principle of the accumulation chamber. This is a local and direct type of measurement, that does not depend on assumptions about how gases are emitted into the atmosphere and dispersed. The method involves using a chamber to cover a certain

area to avoid perturbing the environment too much (see figure 1). The gases given off from the covered area then build up in the chamber. In this way it is possible to monitor how the atmosphere becomes enriched in methane. A sample of the mixture is fed to an analyser and then returned to the chamber, so that the gases are recirculated. By monitoring the rate at which the recirculated mixture is enriched in methane, it is possible to deduce the local methane flow at the point in question.

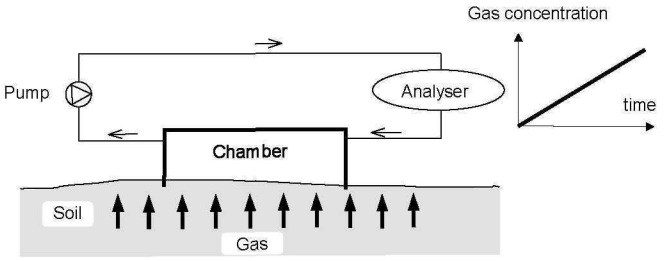


Figure 1. INERIS flux chamber diagram.

The dimensions of the chamber and the operating parameters of the method were optimised at the design stage on a test rig (figure 2) using known gas flows. At this stage it was also possible to determine the influence on the results of the measuring system itself, the nature of the soil, the wind and many other factors, so that due allowance could be made in the calculations.

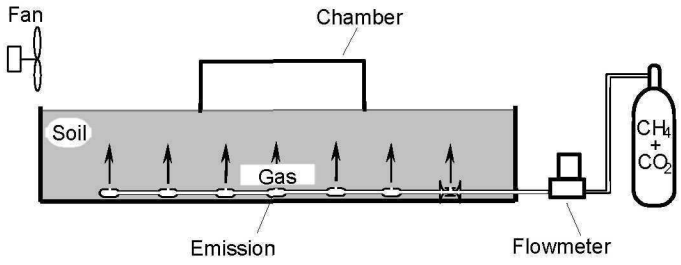


Figure 2. Diagram of test rig for chamber validation.

Following the laboratory validation phase, the method was fine tuned under real conditions. This stage confirmed the relevance of the operating principles of the method defined in the laboratory.

The measurement system used is relatively simple to operate. The total time necessary for an individual measurement is of the order of 5 to 10 minutes, so that a large number can be made in a day (from 40 to over 60 points according to the difficulties of the site).

The flow densities that can be determined depend on the capabilities of the analyser used for measuring the concentration of a given gas in the chamber. For methane, measured with a resolution of 1 ppm, it is possible to measure flows ranging from under 0.1 up to 4000 $Ncm^3/minute/m^2$.

If it is necessary to determine the total flow from a given surface area, the point measurements are made using a spatial sample approach adapted, on a case-by-case basis, to the local emission conditions and to the desired precision of estimation.

The local values measured are then interpolated and extrapolated using specific methods (for example, geostatistics), in order to estimate the total flow and to supply other necessary data, such as surface mapping, the spatial variability of the flow, and so on.

The exact procedures involved in this method are protected by a European patent (No. 96-05996, filed on May 14th 1996 and entitled "Measurement of gas flows through surfaces").

3 TYPICAL APPLICATIONS

The method has been applied in a operational manner for diagnostics and appraisals at a number of sites (old mines, waste dumps, landfills, and so on). Two typical cases are presented here.

3.1 Emission of firedamp from an old coal mine

Measurements made for preventive purposes on land located above an old coal mine revealed methane concentrations in the soil exceeding 40% in volume. Since the site was accessible to the public, INERIS was called in to evaluate the risk.

Using the chamber method, significant gas flows were measured, that were capable of creating dangerous accumulations on the surface (figure 3).

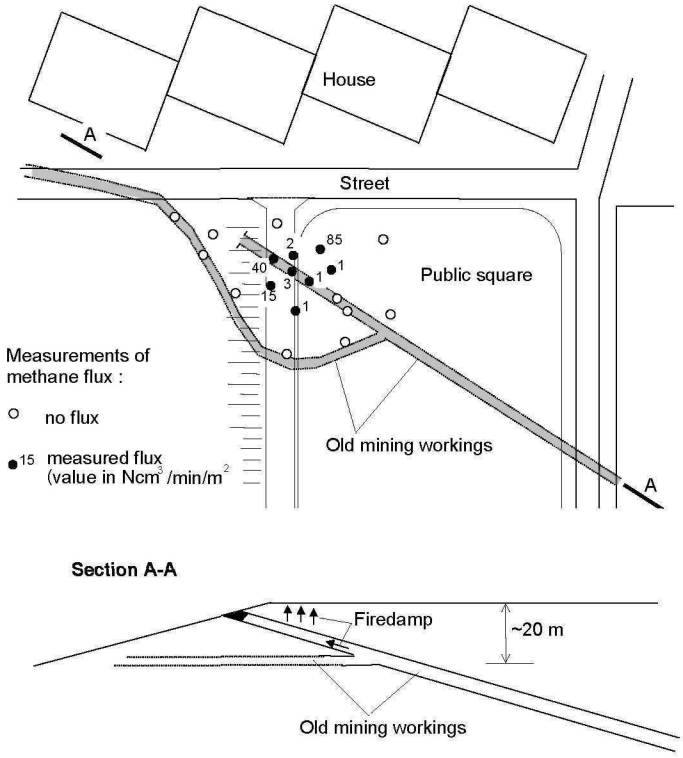


Figure 3. Measuring of firedamp emission on the surface of a closed coal mine.

3.2 *Emission of gas from a MSW landfill*

Municipal Solid Waste (MSW) landfills are substantial source of biogas emissions, with methane as a major component. In certain cases these emissions can represent a fairly considerable risk, notably as regards explosion.

As part of an investigation for the French Ministry for the Environment, INERIS conducted a measurement serie to quantify the flow from a dump covering 8 hectares Emission mapping was also done, involving 400 measurements over the area studied (figure 4).

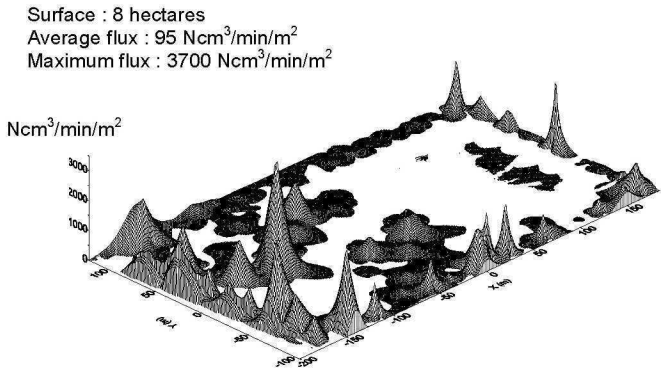


Figure 4. Mapping of methane emission from a landfill.

4 CONCLUSIONS

The research done at INERIS resulted in a reliable and appropriate methodology for quantifying the complex phenomenon of the emission of gas flows from a land area.

The methodology is intended for detecting, quantifying and qualifying gas discharges, but can also be applied to verify the effectiveness of the preventive means used for reducing emissions (sealing operations, drawing off gas, etc.).

The method has already been applied in an operational manner for diagnosis and appraisal on a number of sites (landfills, old mines, etc.). Although originally designed for measuring methane flows, it is fully useable in or transposable to any similar situation of gas flows emitted by the ground, subject possibly to a few modifications of detail.

The method is protected by European patent No. 96-05996.

5 REFERENCES

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