FLAME IONISATION DETECTOR AND LINEAR KRIGING METHOD FOR LANDFILL CAP LEAKAGE DETECTION

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SUMMARY : Linear kriging method is used in combination with a flame ionisation detector (FID) for methane emission detection and localisation in landfill capping system. A time evolution assessment of top cover leakages may also be assessed. The FID is used for methane semi-quantitative measurement and data are processed with linear kriging method to plot methane emission zones at the landfill surface. The method is easy to implement and less expensive and can be useful for methane emission detection in landfill capping system. The study illustrates an application of the method in a case study in the Cour-au-Bois site.Three campaigns were settled to control methane emission on five landfill cells equipped with definite or provisional capping system. The results shows very weak or absence of emission in the cells covered with definite capping and zones of degassing methane for the provisional ones.

1. INTRODUCTION

Landfills have been reported as the largest anthropogenic source of atmospheric methane in the world (Bogner *et al.,* 1997) and as a significant contributor to global warming in greenhouse gaz scenarios (IPPC, 1996). According to IPPC, landfills account for about 10% of the annual global emission of methane in the atmosphere.

Methane emission from landfills can be reduced considerably by the use of improved management practices. Gaz extraction has been proposed as a means of achieving such a reduction (Richards, 1989).

Unfortunately, caps are not always sealed. In fact, some leaks due to minor features such as fissures and other disruptions may appear in them. These leaks have to be detected, localised so that, it is finally possible to obtain indication for improving the final cover in order to reduce the loss of greenhouse gas and thus achieve the high energy savings and avoid an undesirable environment impact(Cioni *et al.,* 2003).

Fugitive emissions of biogas through landfill capping systems consist mainly of methane and carbon dioxide. Methane emissions are energy and heat reducers as the gaz escapes into the atmosphere prior to valorisation and then causes a cut in exploitation efficiency. Methane oxidation can occur in landfill cover soils. It has been reported to reduce methane emissions by ca . 35% (Reeburgh, 1996). Mostly, attempts are to estimate the landfill gaz for extraction and use as renewable source of energy

Landfills managers need to know methane fluxes through the landfill capping system to assess methane lost from landfill. Assessment of methane lost for exploitation needs to take into account methane oxidised in waste and landfill cover layers as carbon dioxide. Various methods, including static and dynamic closed chambers, mass balance or micrometeorological methods can be used for methane fluxes assessment on landfill surface cover (Taramini *et al.,* 2003). These methods are however expensive for the control need.

In fact, for environment protection control stakeholders need to assert that there is no release of methane in the landfill atmosphere so as to avoid landfill contribution to greenhouse gas effect and world global warming (IPPC, 1996). To attempt this objective, it is not necessary to know fluxes of methane into the atmosphere, perhaps only the relative intensity of releasing (weak, average or high?). In this case, improved methods that are easy to implement, less expensive can be useful.

These are qualities that the method we present hereafter asserts. As an illustration of the method, we carried out in 2000, 2002 and 2004, three campaigns of methane emissions detection through the top cover surface of the landfill of Cour-au-Bois managed by Biffa Waste Service s.a.

2. MATERIALS AND METHOD

2.1 Materials

2.1.1 Site description

The Cour-au-Bois landfill is a 43 ha surface and divided into 7 exploitation cells. The filling of the seventh has not yet started. In 2000 and 2002, at the time of the third and fourth campaigns, 4 cells (C1 – C4) were already filled. The C1 and C2 equipped with definitive capping system and C3 and C4 with temporary capping. The 5^{th} cell was in filling stage and C6 and C7 not started. In 2004, C5 were completely filled and equipped with temporary capping and C6 already started. From 1989 to the earlier 2005, 5,321,249 tons of commercial waste assimilated to domestic refuse was already filled. Among them, 3,498,027 are degradable. The landfill cells surfaces are covered as shown in figure 1 at the moment of measurements.

The landfill is equipped with a gas recovery system. The recovery gas was approximately 46.3 % to 47.4 % CH_4, 39.4 % to 41.4 % carbon dioxide and other gases. The gas is used to generate electricity using a conventional internal combustion generator. A back-up flare is maintained to combust landfill gaz collected by the recovery system that is not utilized by the generators.

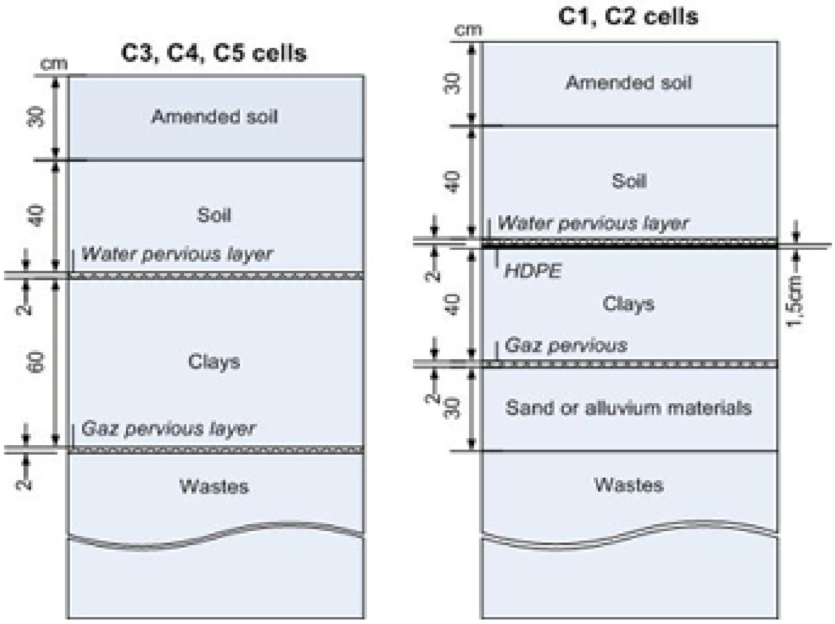

Figure 1. Landfills cell (C1, C2, C3, C4 and C5) caps description

2.1.1 The methane measuring instrument

The methane measure is held with a compact portable gaz detection instrument from Sewerin: Portafid M3K Flame ionisation detector. The instrument is microprocessor–controlled and equipped with an integrated pump sample, connected by a Teflon system to a bell probe to apply directly to the ground for detection of escaping gas at the surface of landfills.

2.1.2 The data treatment tool

The Data are computed with the Geological Data Management (GDM)®, software developed and commercialised by the BRGM, France.

2.2 Method

2.1.1 Methane emission detection

The detection of the methane emissions through the ground was undertaken on the cells whose filling was completed. Table 1 shows the cells in which measurements have been operated for the three campaigns.

Table 1 : Methane detection campaigns operation for the filling cells of the Cour-au-Bois site.

Years	C1	C2	C3	C4	C5	C6
2000	OK	OK	OK	OK	NO	NO
2002	OK	OK	OK	OK	Partially	NO
2004	OK	OK	OK	OK	OK	NO

Methane emissions detection is achieved with a portative FID device. Measurements are taken according to a square grid of 20 meters side over the site.

The instrument calibration is carried out at the beginning of each day by means of gauging methane gas. A recalibration of the zero is carried out regularly on the site using a balloon of Tedlar filled with lab dry air preparation reference.

For each point, four specific measurements are recorded by application of the bell probe on the ground and waiting (a certain time between 30 seconds to 3 minutes) until that the stabilization of the measured result appeared on the LCD screens. The final value is actually chosen as the mean of the four measurements.

During measurement, the landfill gas recovery rate is maintained within the habitual value of use. As rainfall, temperature and atmospheric pressure can impact on methane emissions, it is necessary to operate when the climatic conditions are stable for a few days. Measurements are then undertaken in dry weather conditions and, parallel to methane emissions data acquisition, atmospheric pressure measurements were also carried out.

2.1.1 The data treatment process

The treatment consists in processing methane emission data measured with flame ionisation detector (FID) with Geological Data Management® (GDM®) program using kriging method. The GDM® software helps in data acquisition, geological modelling and interpolation like kriging. The kriging method enables (Cioni *et al.,* 2003) to extrapolate values where measures have not been taken. From the experimental variogram, extrapolation requires to construct an ideal variogram and the singling. For this study, we used linear variograms. This data processing enables detection and localisation of methane escaping through landfill top cover at the soil interface and to map them after data processing.

3. RESULTS

The combination of FID and linear kriging method provides a powerful method which can be used:

- in methane emissions through landfill capping system detection,
- in localisation of leakages in landfill capping system as the tool enables identification of characteristic zones of emission with improvement of a continuous picture of degassing zones and
- in measurement of the intensity of gas escaping through the top cover site leaks this allows observation of the methane degassing relative intensity. In fact, the picture plots curves of isoconcentration for the FID with interval values from 0 to 100 ppm, from 100 to 500 ppm, from 500 to 1000 ppm and superior to 1000 ppm.

The results are presented in figure 3, figure 4 and figure 5 hereafter. These series of measurements highlight four classes of concentration of degassing intensity. Generally, because of high slopes, measurements could not be taken in the right side of the cells C4 and C5. This explains why the maps plotted present straight sides at the right hand side extremity border.

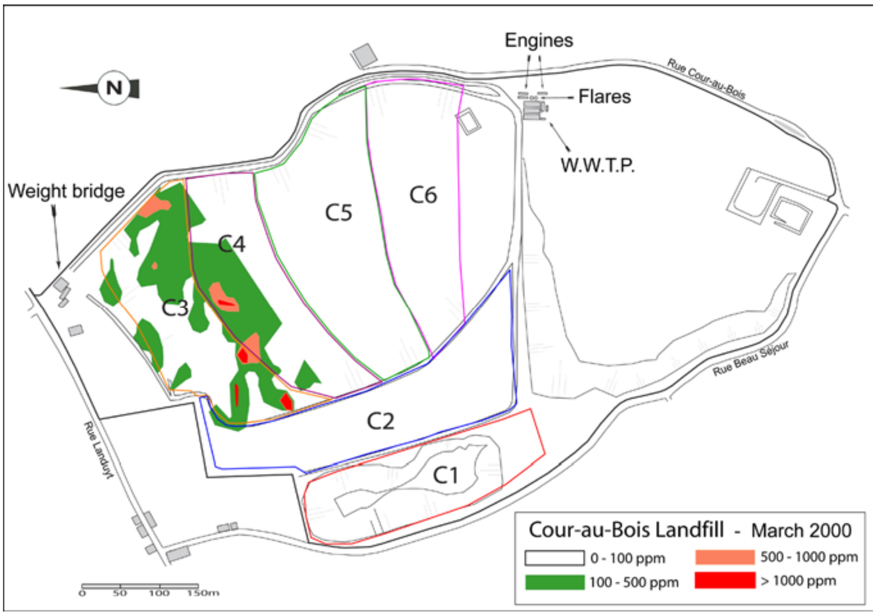

Figure 2 : Methane fugitive emission through the landfill cap during the 2000 campaign.

In 2000, the processed data showed:

- A low or nil (< 100 ppm) methane degassing over and around the cells C1 and C2

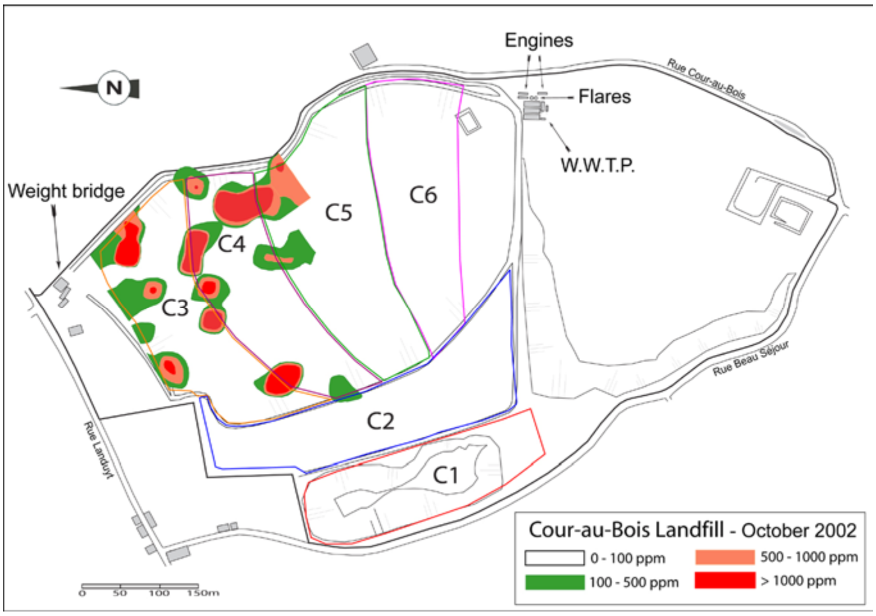

Figure 3 : Methane fugitive emission through the landfill cap during the 2002 campaign.

- For C3 and C4, four little spots of methane emission superior to 1000 ppm surrounded by little wider zones of methane degassing intensity comprised between 500 and 1000 ppm and larger zones of low methane emission intensity. These spots are mainly localised in the cells C3 edge and sides.

In 2002, no methane degassing zone superior to 100 ppm is observed in C1 and C2. There is less large thickness of methane emission of low intensity and more degassing spots of high intensity (> 1000 ppm) situated at the border of cell 3 and 4 and thin zones of methane degassing intensity ranging between 100 and 500 ppm are also present in the shape over and around the limits of the C3 cell.

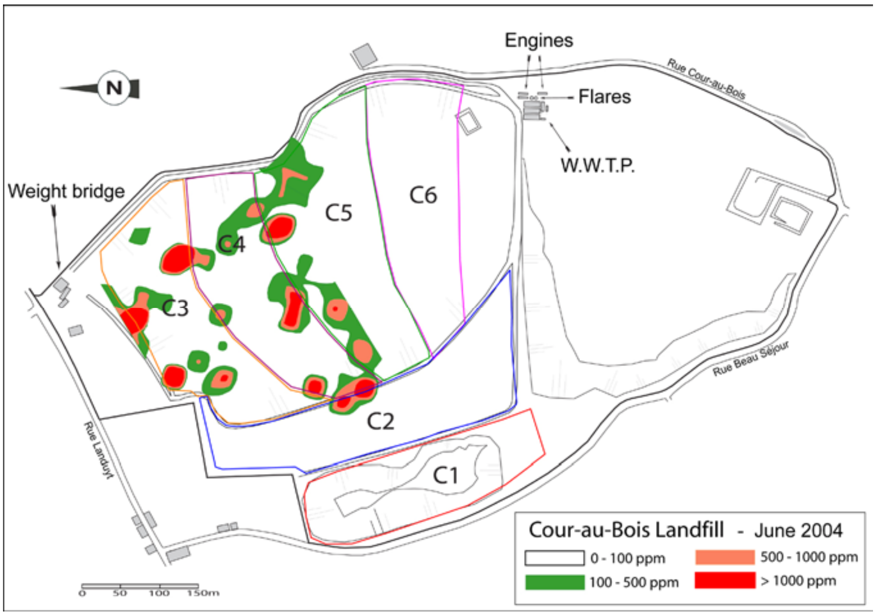

Figure 4 : Methane fugitive emission through the landfill cap during the 2004 campaign.

In 2004, the C1 and C2 still have no spot of methane degassing zone superior to 100 ppm. The spots are still located at the border of C3 cell. The spots are less large but remain about equal in number.

4. DISCUSSION

4.1 Landfill cover leakage detection

Measurements of methane emission intensity obtained are primarily qualitative. Indeed, the measuring instruments used do not allow to carry out quantitative measurements because of particular non control of the duration of measurement and the incapacity to control the pressure inside the bell probe. Nevertheless, this instrument is sufficient to determine the presence or the absence of gaseous emission in a point of measurement and also to give a relative importance of this release.

4.2 Landfill cover leakage zone localisation

The localisation of methane emission zones is mapped after data processing with linear kriging method. As figures 3, 4 and 5 show for the four or five cells filled at the time of the campaigns :

- cells 1 and 2 did not show spots of degassing methane zones. This is a satisfactory observation as these cells are filled with inert waste and are the ones in which definite cover capping comprising 2 mm thin layer of HDPE is implemented at the time of measurement.
- cells 3, 4 and 5 show many spots of methane emission intensity higher than 1000 ppm at the time of these series of measurements. These spots are generally surrounded with spots of medium intensity (500 to 1000) ppm, and spots of low degassing intensity. This result is not surprising as these cells are not equipped with definite capping system. In fact, as shown in figure 1, the covers of these cells are not equipped with HDPE sealing membrane. This explains occurence of leakage zones at the surface ground.

For methane emission degassing zones, two factors can be advanced :

- the lack of effectiveness of the methane degassing network installed on the cells C3 and C4 and,
- the perviousness of the provisional or the final covers posed after the cells filling process.

4.3 Leakage zones evolution over time

The results of the detection campaigns achieved in Cour-au-Bois site assert the evolution of methane emissions through the landfill cap during the campaigns 2000, 2002 and 2004 and give an idea of degassing system and of efficiency of operated works.

Comparatively with the results obtained at the time of first FID campaign in April 2000 (figure 2), we can observe that the landfill of Cour-au-Bois presents methane emissions through the landfill surface more important in 2002 than in 2000. In particular the C3 cell shows obvious signs of degasification at the time of the 2002 campaign. Indeed, we observed high values of methane emission intensity which we did not measure in 2000. This increase in methane emission through the landfill capping surface between the 2000 and 2002 campaign is confirmed by the 2004 campaign which shows nonetheless less spots of methane degassing zones. The remaining spots between 2002 an 2004 are encore present in the cells borders in the cell sides.

5. CONCLUSIONS

The method presented in this paper can be used by landfill operators and environmental control agents for detection and localisation of methane emissions through the capping system. The method also enables observation of the relative intensity of methane degassing. Attention should be paid to the fact that; (1) methane degassing intensity is relative and not absolute and (2) the methane measured is underestimated as, in the more shallow layers of the soil, methane can be oxidized into carbon dioxide.

The method was improved and used by Institut Scientifique de Service Public (ISSeP) since 2000 to detect methane emission at the landfills top cover soil interface and to localise leakages zones in the capping system.

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