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# Effective tools for Managing odours from landfill facilities in Ireland

Dr. J.W. Casey *
Dr. B.A. Sheridan*
Dr. M. Henry**
Mr. K. Reynolds**
* Odour Monitoring Ireland , Unit 32 DeGranville Court, Dublin Road, Trim, Co. Meath, Ireland
** Environmental Protection Agency ,Office of Environmental Enforcement, John Moore Road, Castlebar, Co. Mayo, Ireland

Waste management facilities and especially landfill sites produce odours. Like the majority of industries, the operation of landfills, is faced with the issue of preventing odours causing impact to the public at large. Design, operational and management techniques can reduce the impact of odours from landfills. Containment of landfill gas through optimising landfill cover, gas collection systems and management techniques is the only established means of odour minimisation and mitigation from such facilities. The assessment of the effectiveness of such odour minimisation and mitigation techniques is limited utilising traditional sampling and measurement of odours. Traditional odour measurement techniques (e.g. Lindvall hood and EPA flux hood) on facilities which evolve rapidly are very limited in their application and speed on delivery of real-time information. Twenty survey's were carried out on ten licenced Irish landfill facilities in Ireland during the summer of 2007. The study involved landfill capping source monitoring using a continuous integrated Photo Ionisation Detector (PID) /Flame Ionisation Detector (FID) /Global Positioning System (GPS) system operated in kinematic mode to detect areas of potential landfill gas release/flux from the operating landfill surface. This allowed for the generation of detailed Volatile Organic Compound (VOC) geo-referenced contour maps of the landfill operational area which facilitated easy plotting upon the facility base map for visual interpretation. Following the completion of each survey, those areas identified as significant sources of emissions in terms of detected concentrations were communicated to the landfill management team for immediate remediation. The landfill gas collection systems were also assessed with specific emphasis on pipe work size, condensate management, vertical well spacing, vacuum pressure and flare capacity. This survey system provided a number of distinct advantages over other odour measurement techniques to include real-time data, robustness, identification of surface emissions hotspots and implementation of immediate remediation into the facility operational plan. In addition, the information generated provided the landfill management team and regulatory authority with specific details on the effectiveness of landfill cover material, landfill gas collection systems and the location of the installation of additional gas abstraction wells if required. This was

used as a means to manage and mitigate odours from the assessed facilities. In addition, the information can be used by regulatory authorities as a means of assessing the effectiveness of implemented mitigation. This paper will present the results and findings from the study.

# 1. Introduction

Disposal of municipal solid waste in landfills without pretreatment is one of the main methods used to dispose of waste in Ireland. Landfill gas (LFG) is produced continuously by microbial action on biodegradable wastes under anaerobic conditions. The decomposition of the organic component of municipal waste in landfills produces landfill gas containing approximately 50% methane ($CH_4$). Methane is a potent greenhouse gas, it has a global warming potential 21 times greater than carbon dioxide. There is significant motivation towards greater containment of such emissions especially given recent comitments by the European Union on further reductions in greenhouse gas emissions (GHG) by 2020. Landfill gas also contains trace amounts of other compounds, such as hydrogen sulphide, mercaptans and non-methane volatile organic compounds. These other compounds may cause odours or affect local air quality. Uncontrolled landfill gas can also migrate underground affecting groundwater and in some cases may cause explosions in the correct conditions. LFG emissions can be controlled by installing a network of collection wells and directing the gas to combustion plant (e.g. flares and gas utilisation) for the production of electricity, for use as fuel by a nearby industry, and by flaring (i.e. burning). Simply burning the methane to convert it to carbon dioxide reduces its global warming potential by about 95% (Wilcox , 2007).

LFG emissions are highly variable (Maurice et al. 1995) and several different processes may cause these variations. The emission is influenced by the type of degradation, the quantity of abstracted gas, barometric pressure variation (Christophersen et al. 2001) and soil conditions (e.g., higher soil water content or freezing of the soil, dry soil resulting in lower biological methane oxidation) (Maurice, and Lagerkist, 2003). The quality and quantity of emitted LFG depends on the waste composition, moisture content of waste, the landfill degradation state, and the methane oxidation activity in the landfill cover. These processes result in diurnal, seasonal, and spatial variations in emissions that make it difficult to estimate rates from facilities (Maurice, and Lagerkist, 2003).

Over 500 compounds have been identified as contributors to landfill odours (Parker et al. 2002). These compounds are either components of waste placed in the landfills or are degradation byproducts. The main sources of these VOC emissions within landfills are:

- Inadequate Operational and management techniques within the landfill,
- Poor Cover management techniques,
- Faults in capping or gas collection systems,
- Open leachate chambers and tanks,
- Faults in the liners and covers of closed cells; (Chiriac et al. 2007).

Different concentrations and mixtures of VOC's can intensify or reduce odour threshold concentration. Based on this fact, regulation and control of VOC's at source by the application of limits should be examined as one of techniques which may be useful in assisting in reducing the impact of odours and VOC around landfill facilities.

A study assessing LFG collection systems and landfill surface emissions was carried out on 10 licenced facilities in Ireland during the Summer / Autumn period of 2007. The study was commissioned by the Office of Environmental Enforcement (OEE), Environmental Protection Agency, Ireland. The study focused on assessing landfill gas collection systems independently for their capacity to control the release of landfill gas emissions to atmosphere.

### 1.1 Scope

The study was carried out in the following format:

**Phase 1:** Landfill surface emissions mapping was carried out of the entire landfill area at each nominated facility. A meeting was held with the landfill management team after the survey was completed. The purpose of the meeting was to inform the landfill management team of any surface emissions encountered and their significance. The surveyor recorded specific information during the survey such as emissions area and features within the fill area. Recommendations to reduce surface emissions were formed and presented to each landfill manger.

**Phase 2:** An assessment of the landfill gas collection system was carried out. This assessment included flare capacity evaluation, gas flow rate measurements, vacuum pressure measurements across the collection pipe work and a visual inspection of the structural condition of the pipe work. In addition, in some cases, the landfill manager attended the survey and received general guidance on the significance and interpretation of the results gathered throughout the survey.

**Phase 3:** A re-visit of the landfill surface emissions mapping was carried out of the entire landfill area at each nominated facility. A meeting was held with the landfill management team after the survey was completed. The purpose of the meeting was to inform the landfill management team of any surface emissions encountered. The purpose of the re-visit was to compare surface emissions maps from Phase 1 and Phase 3 to ascertain whether recommendations made from Phase 1 and 2 surveys were implemented. In addition, the efficacy of implemented recommendations on reducing landfill surface emissions were determined and quantified.

## 2. Materials and Methods

### 2.1 "Odour hog" monitoring within the landfill's

The "Odour hog" VOC analyser is a portable, intrinsically safe, survey VOC dual monitor, which provides fast and accurate readings of organic and inorganic vapours. A Photo ionisation detector (PID) uses an Ultraviolet (UV) light source (*photo*) to ionise a gas sample and detect its concentration. Ionisation occurs when a molecule absorbs the high energy UV light, ejecting a negatively charged electron and forming of positively charged molecular ion. The gas becomes electrically charged. These charged particles produce a current that is easily measured at the sensor electrodes. Only a small fraction of the VOC molecules are ionised. A PID does not respond to methane. A FID is similar to a flame thermocouple detector, but measures the ions from the flame instead of the heat generated. The FID detects the methane fraction, which provides greater sensitivity in terms of methane surface emissions detection hence why the PID data is also interpreted in some circumstances. Both sensors were calibrated using NPL gravimetrically filled certified reference material isobutylene (10 ppm) and methane (500 ppm and 10,000 ppm) before the survey. Instrument span check were performed during and at the end of the survey inorder to ascertain any sensor drift. This allowed for the determination of any sensor bias and readings were adjusted accordingly where required. Before the commencement of the survey and following completion of the survey, upwind monitoring of the background air was performed to ascertain the background level of VOC's in ambient air not associated with the facility.

Using the continuous kinematic "Odour hog" with integrated GPS, the landfill was surveyed for potential surface emissions areas. Those areas identified were geo-referenced and highlighted for remediation. This technique is useful for comparison in surface emissions area within the same landfill facility on different audits but is not for cross comparison of VOC surface emissions between landfills due to a number of factors including, mass flow of VOC on the day of measurement, relative odourous nature of the detected compounds within individual facilities, etc. The surface emissions maps generated for the particular facility can be used to assess the effectiveness of implemented mitigation techniques and to qualitatively assess the nature of surface emissions from the facility.

## 3. Discussion

### 3.1 Method

The method adopted for this study proved very effective in quantifying surface emissions from the surveyed facilities. The method has a number of distinct advantages over other measurement techniques.

- The method provided real time accurate information to the landfill management team pertaining to surface emissions, which allows for immediate action toward mitigation.
- The method has greater spatial coverage than odour measurement techniques utilising the lindvall hood or USEPA flux chamber.
- The method is markedly more cost effective than olfactometeric-based odour measurement techniques.
- The method was pro-active rather than re-active in approach, which yielded more positive results (in comparison to downwind monitoring).
- The method gave the landfill manager and regulator real information in terms of the extent of surface emissions from the surveyed facilities.
- The comparison of the maps before and after allowed the regulator to assess the effectiveness of the facilities implemented mitigation strategy.

- A review of international guidance on surface emission mapping and limits. Surface Limits of 100 ppmv VOC's are utilised for instantaneous readings in open areas in the international community. A limit of 500 ppmv around all features to include vertical wellheads, leachate chambers and side slope risers is utilised in the international community. A limit value of 50 ppmv average surface area limit over a 200 $m^2$ area is utilised in the international community for all areas within the operating landfill. These limits are based on a review of UK Environment Agency (Environment Agency 2004), USEPA, and Southern Californian Air Quality District (SCAQD, 1985) guidance and achievable levels within operating facilities. These limits could be considered in Ireland as a means of controlling GHG's and odours from facilities.

The phased approach will be refined in 2008 to include a risk assessment check sheet, which can be utilised by the regulator during standard auditing procedures.

**3.2 Key study findings**
There are a number of key findings apparent from the data collated during the study. These included:

- **Vertical gas abstraction wells:** Problems with vertical abstraction wells were encountered on all 10 facilities. Insufficient vertical well construction and LFG abstraction gave rise to surface emissions from the immediate area in the vicinity of the vertical gas abstraction well. Insufficient gas abstraction augments into a number of key identifiers to include: poor sealing aound the vertical well head, inadequate condensate removal from gas abstraction pipework, inadequate applied gas vacuum pressure upon well head, poor control of gas flow from vertical well heads due to inadequate gas flow control valve design.
- **Side slope risers:** Problems with respect to surface emissions from leachate slop risers were encountered on 8 facilities. The problems included inadequate seal between the underliner and overlying clay cover on tempoary capped facilities, inadequate sealing of cable and pump pipework entry points on head of side slope riser and in some circumstances the absence of landfill gas abstraction from the side slope riser. Since leachate slope risers provide a direct connection into the waste body it is important to ensure that engineering design takes account of methods to reduce landfill gas migration and surface emissions.
- **Flanked areas within temporary and active cells:** Flanked area surface emissions was encountered on 8 of the facilities surveyed. Surface emissions from flanked areas arises largely due to inadequate construction of flanks to take account of the possibility of storm water etching. Nine of the facilities flanked areas had constructed sloped flanks. Two facilities utilised either flank benching or the installation of a prefabricated geo-membrane. These two methods provide sufficient protection of the flanked area to storm water etching and were effective in reducing surface emissions.
- **Intermediate and Temporary capped areas:** Intermediate and Tempoary capped area surface emissions were encountered on 8 facilities. The most signficant cause of such emissions were a result of cover material type and insufficient cover material depth. Selecting appropriate cover material and

depth is very important towards ensuring effective capture and containment of landfill gas. Certain cover materials encountered on a number of facilities did not lend themselves to effective containment of landfill gas. This was a result of the characteristic of the cover material (e.g. highly pearmeable), cover material depth and application (insufficient tracking). This results in turning back (gas flow) of the gas management system to prevent the ingress of Oxygen into the waste body which could result in a landfill fire. Clay material tracked adequately appeared to provide the most effective intermediate cover although the careful selection of suitable clay is important to prevent perching and breakout of leachate.

- **Permanent cap integerity:** Permanent gas membrane cap integerity issues were encountered on 3 facilities. Although not significant, permanent capping should be integrity for leakage when capping works are completed using surface emissions monitoring.
- **Temporary cap integrity:** Temporary capping usually occurs in Ireland utilising a final clay cover of up to approximately 0.50 m. Although surface emissions from open areas in the tempoary capped cells were not significant, some leakage was encountered around vertical well heads and intercell joins. Insufficient application and compaction of clay around the vertical well head resulted in emissions. It was noted that tempoary capping alone does not provide a sufficient barrier to landfill gas emissions from the waste fill area.
- **Flare and gas utilisation abstraction capacity**. Flare and blower capacity problems were encountered on 5 of the facilities. Insufficient gas abstraction upon the waste fill area was resulting in the build-up and emission of landfill gas from the landfill. Sufficient blower vacuum pressure capacity was not available to ensure the effective delivery of vacuum pressure along the gas main. The build-up of landfill gas within the landfill cells resulted in pressurisation of the collection system which was quickly noted within the survey. Following the improvment of flare blower vacuum pressure and volume capacity, landfill surface emissions quickly dissapiated.
- **Surface emission limit values:** Proposed surface emission limit values were exceeded on all facilities during the Phase 1 survey. Improvments in surface emission limit values occured on 2 facilities following the implementation of remediation works. Persistent surface emission locations were noted on 8 facilities which require additional works. One facility that achieved significant reductions in surface emission from the landfill through remediation achieved a marked reduction in odour complaints.

## 3. Conclusions

The following conclusions were drawn from the study:

- Landfill surface emissions were assessed at 10 licenced facilities in Ireland during the summer/autumn period of 2007,
- Landfill gas collection systems were assessed, for structure, design and abstractive capacity on the same facilities,
- The technique for the assessment of surface emissions proved very effective in monitoring and quantifying VOC emissions at the 10 facilities,

- The technique allows for the comparison of surface emissions maps from subsequent monitoring events. This can facilitate greater understanding of emissions concentrations and geographical locations within the facilities for both the landfill management team and the regulator. The results of a survey are available within one day of the survey by means of a color coded contour map. The location of persistent surface emissions allows for the focused investigation and application of remediation to such areas.
- Considered surface emission limit values are presented in this paper for the control of landfill gas emissions from landfills in general. Surface Limits of 100 ppmv VOC's are considered for instantaneous readings in open areas. Surface limits of 500 ppmv are considered around all features to include vertical wellheads, leachate chambers and side slope risers. Surface limits value of 50 ppmv average over a 200 $m^2$ area (20 individual measurement points minimum) should be considered for all areas within the operating landfill. As a follow on from this project, it is proposed to utilise surface emissions quantification in conjunction with reverse dispersion modelling to ascertain the overall collection efficiency of the installed gas management plant. This will allow for the direct assessment of fugitive GHG levels from a operating landfill. A number of key findings have been outlined which will help reduce fugitive emissions from such facilities. These include: correct flare capacity, correct pipe work sizing and orientation, correct vertical well structure and density, management procedures for reducing incidence of blockage due to condensate build-up and oxygen in-gress all of which can lead to reduced landfill gas abstraction. All elements pertaining to the landfill gas collection system should be carefully designed to minimise the landfill gas emissions to atmosphere. Surface emissions monitoring in conjunction with a thorough investigation of the installed collection infrastructure at landfills is the most effective means of reducing emissions of landfill gas with entrained odours.

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