USING AUTOMATIC ODOUR MEASUREMENT AND DISPERSION MODELLING SYSTEMS AS EVERYDAY TOOLS WITHIN MUNICIPAL WASTE TREATMENT

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Abstract

The waste and waste water management industry, like many other sectors, faces numerous challenges in meeting its IPPC (Integrated Pollution Prevention and Control) Directive obligations. Not least amongst these obligations is the management of airborne emissions, which are highly likely to be odorous for this industry sector. Thus anything that can assist with the management of odorous emissions should have some value within this sector.

This paper reviews some of the options that are available to those people within the waste and waste water management industry who have an interest in continuously measuring odours and odorous emissions, and automatically modelling the dispersion of these emissions, thereby providing real-time, or at least recently up-to-date, information of such emissions. The technologies outlined in this paper range from relatively low-cost 'plug and play' tactical solutions to more expensive and expansive bespoke systems.

Other papers within this seminar on 'Controlling & Eliminating Odour Emissions from Waste Handling Facilities' contain information on Odour Management Plans, pilot trials, dispersion modelling, satisfying odour complainants, abatement techniques, etc. and it is hoped that this paper will allow readers with an interest in these topics to have a better understanding of some of the practical tools available to them so that they can better manage these.

Key Words

MeasureStar, OdoCheck, OdoNose, OdoScan, OdoWatch, Purenviro

Introduction

In recent years there has been a rapid evolution in the environmental legislation covering, and reporting procedures required by, the waste and waste water management sector. As a result of this the IPPC Directive is now on the statute book for countries within the EU (European Union). As part of the implementation of this legislation waste and waste water management facilities have obligations to measure and manage odorous emissions. Fortunately, alongside the evolution of environmental legislation, there has been a complementary development in technologies that enable operators, consultants, regulators and others within this sector to better manage the implementation of IPPC and improve the performance of their operations.
In addition to the implementation of the IPPC Directive throughout the EU there has been a concerted drive to alter many traditional waste management methods, in response to the

demands of climate change, greenhouse gas reduction, sustainability, etc. such that much more organic waste matter is now being utilised in Energy-from-Waste facilities - many of which are located in urban environments. One result of this change in waste management techniques is that increasing numbers of facilities are being built, with these producing or being capable of producing odorous emissions, in locations where significant numbers of odour receptors are present. This situation has led to a growth in the numbers of complaints about odours and these levels are likely to further increase in the future. Thus the need for tools to help measure, model the dispersion of and manage odorous emissions is more relevant today that at any time in the past. Included in the body of this paper are details of a number of odour measurement and dispersion modelling technologies, some of which maybe integrated, to provide solutions to the waste and waste water sector.

MeasureStar

This technology is used to measure gas concentrations – using electrochemical sensor cells, usually in remote locations, and to transmit the results via GPRS (General Packet Radio Service) Quad Band signal to a computer server from where these can be securely viewed by an authorised operator. The MeasureStar Mobile Gas Sensor series are ATEX-certified for Zone 1 and Zone 2 applications, where potentially explosive atmospheres maybe present. All units are IP (Ingress Protection)-67 rated, and will store up to 440,000 measurements. The gas measurement and results (data) transmission intervals can be set up to maximise battery-life, such that a MeasureStar device can operate remotely for several years. In practice, as the gas sensor should be re-calibrated annually, the measurement and data transfer intervals should be set so that maximum data is acquired and sent as frequently as possibly whilst giving 12 months battery-life. In addition to gas levels, for the chosen chemical, the MeasureStar unit also provides up-to-date information on temperature, battery-life and GPRS signal strength.

Other benefits from MeasureStar Mobile Gas Sensors include the ability to provide alarms, set by the user, to indicate many important factors such as gas concentration above a toxic or explosive level or battery-life at a low level. Furthermore the data from MeasureStar units can be used to control odour abatement or chemical dosing systems and it can be automatically downloaded into users SCADA (Supervisory Control and Data Acquisition) systems. Currently MeasureStar is available with single gas sensors, but dual sensor capability is imminent.

Table 1: Current MeasureStar Mobile Gas Sensors

Gas	Name	Range
NH_3	Ammonia	0-200ppm
NH_3	Ammonia	0-500ppm
CO	Carbon monoxide	0-2,000ppm
Cl_2	Chlorine	0-250ppm
C_2H_4O	Ethylene oxide	0-1,000ppm
H_2	Hydrogen	0-2,000ppm
H_2	Hydrogen	0-20,000ppm
HCl	Hyrogen chloride	0-100ppm
HCN	Hydrogen cyanide	0-200ppm
H_2S	Hydrogen sulphide	0-2ppm
H_2S	Hydrogen sulphide	0-500ppm
H_2S	Hydrogen sulphide	0-1,000ppm
NO	Nitric oxide/Nitrogen monoxide	0-1,500ppm
NO_2	Nitrogen dioxide	0-200ppm
O_3	Ozone	0-5ppm
SO_2	Sulphur dioxide	0-100ppm
SO_2	Sulphur dioxide	0-500ppm
VOC	Volatile Organic Compounds	0-50ppm
VOC	Volatile Organic Compounds	0-300ppm
AsH_3	Arsine	0-1ppm
ClO_2	Chlorine dioxide	0-1ppm
$COCl_2$	Phosgene	0-1ppm
F_2	Fluorine	0-1ppm
HF	Hydrogen fluoride	0-10ppm
N_2H_4	Hydrazine	0-1ppm
O_2	Oxygen	0-25% LEL
SiH_4	Silane	0-50ppm
	Mercaptan	0-50mg/m3
CH_4	Methane	0-100% LEL

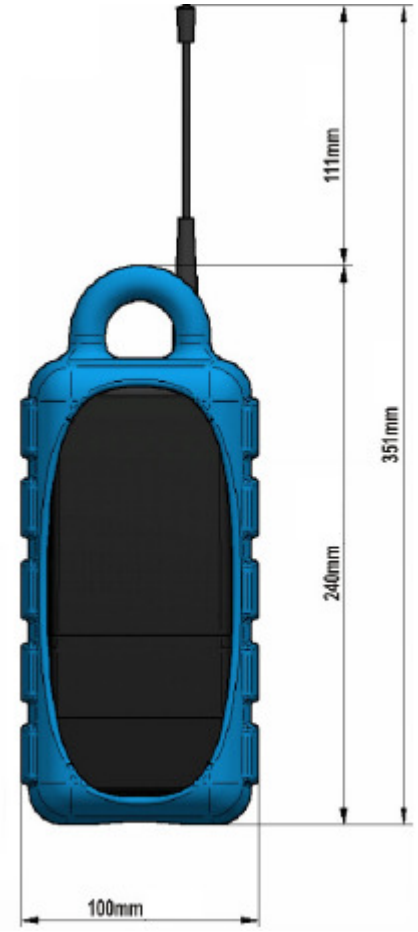

Figure 1: Dimensions of a MeasureStar Mobile Gas Sensor

In operation MeasureStar Mobile Gas Sensors can be deployed underground within sewer systems to measure, and help to control, H_2S (hydrogen sulphide) levels – which can prove corrosive and toxic as well as odorous. Similarly MeasureStar devices can be placed at the site boundary of a landfill or composting site to detect either H_2S, SO_2 (sulphur dioxide) or NH_3 (ammonia) levels. Novel applications for MeasureStar devices are often found by operators within the waste and waste management sector, such as the use of the CO (carbon monoxide) sensor to detect signs of underground fires at landfill sites. With a growing number of gas sensors available there is an increase in the potential to use MeasureStar units in R & D

(Research and Development) projects, such as looking at greenhouse gas emissions from remote sites, etc. The use of MeasureStar to measure 'odours' will actually detect H_2S or other gas levels, which only gives an indication of the likelihood of causing odours at any point, whereas other technologies illustrated in this paper – which use an OdoNose will provide actual odour levels in ou_E/m^3. However, the measurement of H_2S or other gas levels maybe adequate for many facilities in their operations and IPPC obligations.

Figures 2 and 3: **Typical MeasureStar installations for H_2S at a wastewater treatment works and for CO (underground and thus invisible within the boreholes) at this landfill site**

Purenviro Online

Purenviro Online is a new on-line (airborne) pollution management system that can be adapted to suit most situations. It integrates on-line dispersion modelling with a management system for handling feedback (odour complaints), improving operational processes and reducing odour impact. The philosophy behind Purenviro Online is to use feedback from neighbours as a parameter by which odour emission impact is continuously measured. Unlike many chemical vapour/gas emissions, odour is a pollution problem only when it causes nuisance. Traditional olfactometry measures odour in ou_E/m^3 and does not reflect hedonic tone. Nuisance is best measured by directly assessing the neighbour's response, which will be a combination of odour concentration and 'acceptance'.

Continuous and anytime communication with neighbours improves relations with them and the feedback received also provides low-cost measurements suitable for managing even complex IPPC/BAT (Best Available Technique) projects – which typically incorporate ongoing evaluations of facility operations and any operational amendments made to these.

Typical application scenarios for Purenviro Online are; facility operators who wish to document to what extent they are the cause for odour complaints, environmental regulators wanting to find out which facility is responsible for which complaint, facility operators wanting to reduce

the cost of handing odour complaints whilst also improving their response to the complainants and satisfying the demands environmental regulators, plus facility operators that wish to improve and reduce odour complaints - thus avoiding major investments in unnecessary odour abatement systems.

Purenviro Online is built around a web-based portal that can be branded, with corporate, corporation or agency devices, and is published on the facility operators, local authorities or environmental regulators web page. Feedback from neighbours is validated by considering this information with the output from the continuous on-line dispersion modelling, which shows immediately whether a complaint is justified or not. Once a decision has been made upon the validity of the complaint the appropriate actions are taken and all details stored within the system for any future analysis or retrieval. All details in the operators log are filed within the system and can be cross-referenced with any odour complaints for a complete picture of the cause and effect of operations. Future weather forecasting can be used to minimise the effects of certain odour-risk operations and the effect of these upon neighbours.

Figure 4: Some inputs and outputs of Purenviro Online.

Inputs into the system include weather data, process data, operational exception reports as well as feedback from neighbours. Weather data is obtained from the national weather centre or from a local weather station. Process data and chemistry measurements are transmitted wirelessly. The communication protocol uses the same GPRS technology as MeasureStar (outlined above) and the two systems integrate seamlessly. As well as using MeasureStar Mobile Gas Sensors to obtain airborne pollutant levels and upload these into Purenviro Online, fixed or mobile MeasureStar Log devices can be used to gather and transmit data from a wide variety of measurement or operational equipment to further enhance the overall view of operational status at any facility. All data entered into Purenviro Online is stored within the system and available to different users with various levels of security.

Purenviro Online differs from other systems by being fully based on 'cloud computing'. A grid of computer servers performs the various tasks and publishes the results as a web application. This structure makes the system cost-effective, as there is no need for the installation of software on

local computers. The key benefit however, is the ability to scale the application from a single site operation (installation), to a Regional waste water operator and onto a National Environmental Agency. The structure of the system is very flexible and as such facility operators may allow regulators to always see the latest, up to date statistics and reports on odour complaints. The design also makes the user interface independent of the actual modelling software. It is thus possible to interface different dispersion models for different clients. Currently, Purenviro Online supports Aermod and Industrial Source Complex. Annually 99.8% availability of the system is guaranteed.

OdoCheck

This is one of three 'groups' of integrated technologies (or products) which have been developed by Odotech Inc., which is a spin- off from l'École Polytechnique de Montréal. The most vital part of OdoCheck is the use of an OdoNose, which is an 'electronic' or 'e-nose' developed over many years. The OdoNose consists of an array of different sensors which are housed in a specially designed cabinet and over which a constant supply of conditioned air or exhaust gas is passed. During this continuous sampling the sensors in the OdoNose provide information on the relative concentrations of the gases present and this information is transmitted to the CCU (Central Control Unit - a powerful PC). Once calibrated or 'trained' on-site, close to a specific odour source, the OdoNose provides continuous 'real-time' data about the strength of this odour in relation to olfactometric testing (EN13725:2003) and in ou_E/m^3.

OdoCheck was specifically developed to fulfil the need to gain more information on odour production from a wide variety of operations carried out by manufacturing and processing industries, including the waste and waste water management sector. Currently most facility operators provide at best rudimentary details about the odour production from their operations or within their site, and this often done in terms of the concentrations of various chemicals which are airborne pollutants. This approach causes two problems.

Firstly, where odours are actually measured by olfactometry, and the results provided in ou_E/m^3, there is invariably insufficient data to provide meaningful analysis. Due to the time taken, and cost involved with, acquiring significant numbers samples for olfactometry laboratory analysis most projects use small yet seemingly practical numbers of such samples. In many cases the numbers of (duplicate or triplicate) olfactometric samples taken, and the subsequent results provided, are limited to single figures, often taken during one short (working) day. With such a small and insignificant number of results it is highly unlikely that the variations which normally occur, even during long-run stable operations – such as sewage sludge dewatering using centrifuges or composting seemingly homogenous substrates, will be identified. In such circumstances this leads the facility operators and their advisors/consultants reaching conclusions and making decisions based upon insufficient data.

Secondly, where analysis of airborne pollutants – usually in ppm (parts per million) of gas per cubic metre of air, is used as an 'indicator' of odour this information has only limited use estimating how much odour is present. It is almost impossible to determine by laboratory means and subsequent manipulation how much odour is actually produced by a mixture of gases. This is due to the fact that odour characteristics and odorous impact measurements/calculations are carried out on single gases only, therefore to do this for a

complex mixture of often reacting gases with different odour threshold levels is inappropriate. Another common problem with the use of chemical analysis of airborne pollutants as an indication of odours is that the mixtures of the gases found varies greatly even during normal operating conditions, and thus the use of continuous monitoring devices for specific gases/groups of chemicals may prove unhelpful.

Proof of this inadequate supply of significant odour concentration data, either due to ultra low-levels of olfactometry measurements and/or concentrations of airborne chemicals being used to represent odour levels, is partially provided by the number of odour abatement systems that fail to adequately control the odours they are supposed to be treating – either due to incorrect technology selection or their size/scale. The resulting failure of such systems is likewise very difficult to prove when using similarly small olfactometry samples.

OdoCheck should be used In order to overcome the poor odour measurement scenarios given above. Once installed and trained on-site, the OdoNose element within this product will provide results in ou_E/m^3 and it will do this once every 2 seconds. Thus in a month OdoCheck will provide the facility operator with around 1.3million results, from which variations in odour production can easily be identified and the correct odour abatement system can be selected and sized. Once installed the selected odour abatement system can then be adequately assessed by the facility operator and any modifications required undertaken using the supplier's resources.

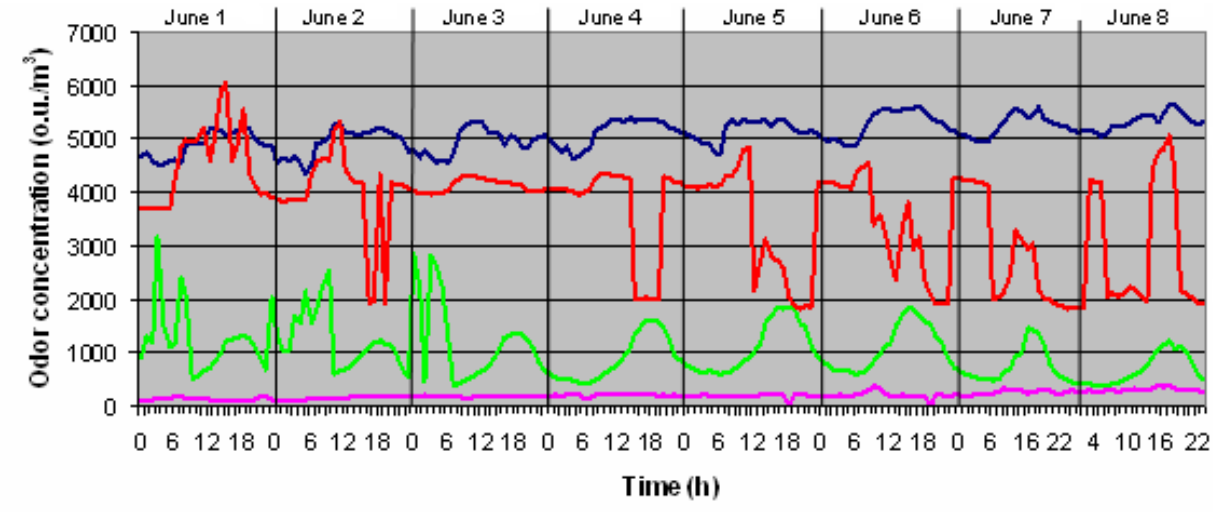

Figure 5: **Typical summary of odour concentration data from OdoNoses used as part of an OdoCheck system. (Showing trends of odour production with significant daily variation)**

If knowledge is power, then adequate knowledge about odour production at a facility will enable the most appropriate and correctly-sized odour abatement system to be selected and installed. The subsequent performance of this odour abatement system can then also be properly monitored, by OdoCheck, so that it meets the supplier's warranty/guarantee of performance. For these two reasons any investment in OdoCheck is likely to have a short-term payback in terms of maximising performance - of capital and equipment, and significantly reducing risk. Typical applications for OdoCheck are where new or improved odour abatement

systems are being sought and thus odour production or emission data over a significant period of time is sought.

OdoScan

This product was developed to allow facility operators and environmental regulators to monitor the atmospheric dispersion of the odours produced by specific or unknown facilities, when little information is known about odour strength. These users are also able to record and manage odour complaints in a very effective manner, by responding to complainants with accurate information about weather conditions at the time of the complaint, justifying the complaint or not and logging such incidents for future reference.

The assets, or infrastructure, employed within OdoScan consist of a specially selected weather station and a CCU (a powerful PC with specially developed proprietary and odour dispersion modelling software installed). The system also includes all the necessary data transmission equipment to enable the system to be fully integrated. OdoScan also uses specific olfactometry data, taken at known odour sources and throughout the year, to provide a site specific and relatively accurate picture of odour production on-site. As many facilities operating with an IPPC permit are required to undertake regular olfactometry testing, these results can be utilised within OdoScan, which then combines this data with real-time weather data to provide minute-by-minute odour dispersion maps which can be used to validify or refute nuisance odour complaints.

OdoScan can also be used by local environmental regulators who wish to identify sources of odour complaints in a mixed manufacturing location, where there maybe several facilities that release odorous airborne emissions and are thus potential culprits for specific odour complaints. Complainants about odours are notoriously bad at identifying specific odours from individual facilities within a mixed manufacturing location, which makes the job of the environmental regulator doubly hard in identifying and taking action against the facility that is actually releasing the emissions that are causing nuisance odour complaints.

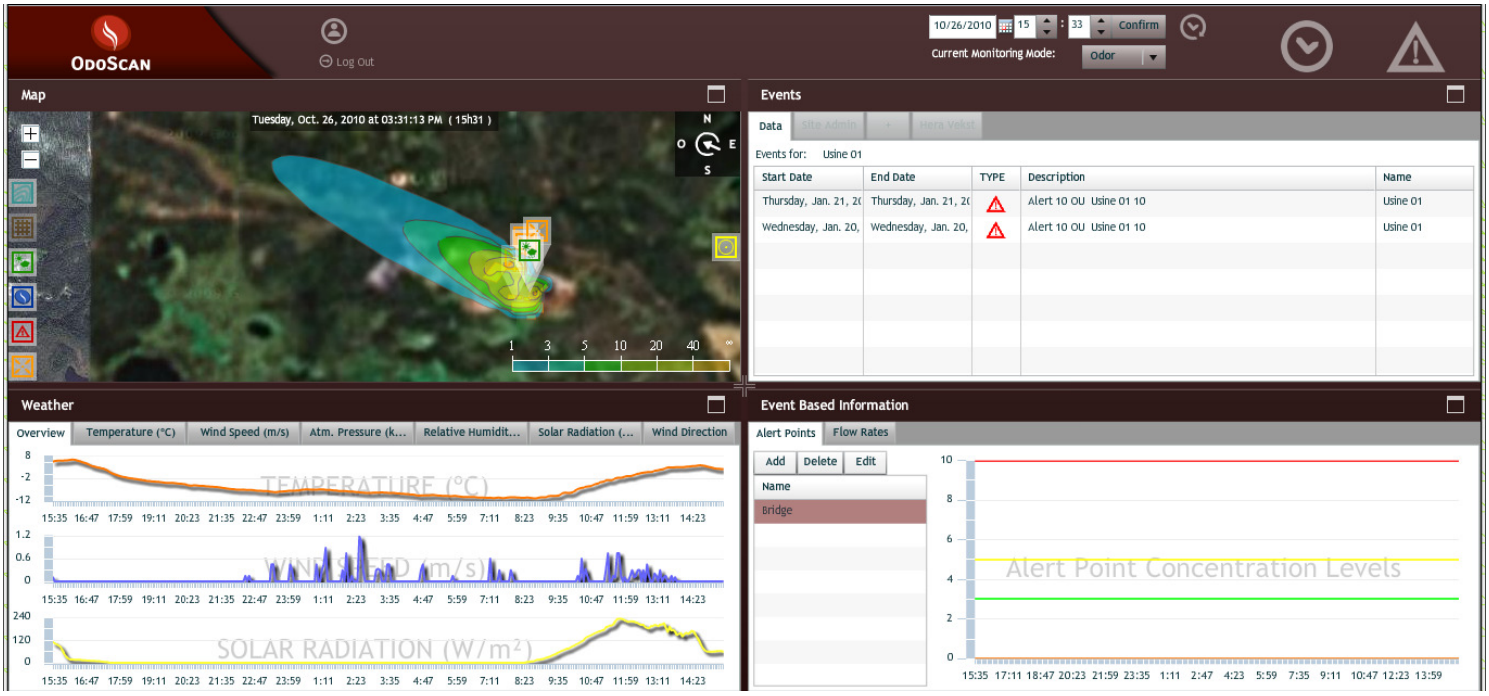

Figure 6: **A screen from OdoScan showing the main elements of the systems output. (Clockwise from top left – an odour dispersion map with an odour plume, a diary of complaints or events, odour alarms for any relevant specific location and data from the on-site weather station)**

Should a local environmental regulator, which in the case of the UK could be either the local Department of Environmental Health or regional Environment Agency office, wish to use OdoScan as a tool for registering odour complaints, showing the general public what real-time odour dispersion is taking place in the area of their jurisdiction or responsibility, this can be done with such a system available on their website. Such an asset can then be promoted within the locality as the main tool for the public to use in order to make odour complaints, see what is happening to their complaint and to get an overall view of odour dispersion from various facilities at the time of their complaint. In such an installation the various facilities within the location can also provide the environmental regulators with details of their odorous emissions, in terms of olfactometry sampling results, and these can be used within the system to provide a clearer picture of what is happening regarding odour dispersion on a day-to-day basis.

OdoWatch

This product represents the zenith of the technical options for any Continuous Emission Measurement System (CEMS) for odours. It uses all the technology and intellectual property available from Odotech Inc. to deliver a strategic system capable of offering the largest facility operator the most sophisticated tool for continuously measuring odour production and the atmospheric dispersion of these odours. A facility can start-up with either an OdoCheck or OdoScan system, depending on their immediate requirements, and upgrade this over time into a full-scale OdoWatch system. During the ongoing development and implementation of the

Odour Management Plan for a large facility the number of OdoNoses employed within an OdoWatch system can be increased to provide extensive enterprise-wide continuous measurement of odours, all of which is supported by the extensive capability of the software installed on the CCU.

An OdoWatch system consists of an OdoNose, or number of OdoNoses, an on-site weather station, a CCU (see OdoScan above) and all the transmission equipment required to wirelessly transmit data from the OdoNoses and weather station to the office housing the CCU. Thus continuous real-time odour production and dispersion data is given to operators within the facility, and externally via the internet should this be required. Security of data is provided by various levels of authorisation and protection.

In addition to providing immediate status data an OdoWatch system represents a powerful tool with which to carry out operational 'what if' planning/modelling. If an odour abatement system is planned for a significant odour source within the site how will this effect the overall odour production, considering the accumulation of odours from multiple sources within the site and what will be the subsequent effect be outside the site boundary? Such planning thus enables facility operators to maximise the effectiveness of investments in odour abatement systems by prioritising the installation of these such that they have the greatest positive effect upon odour production and effect.

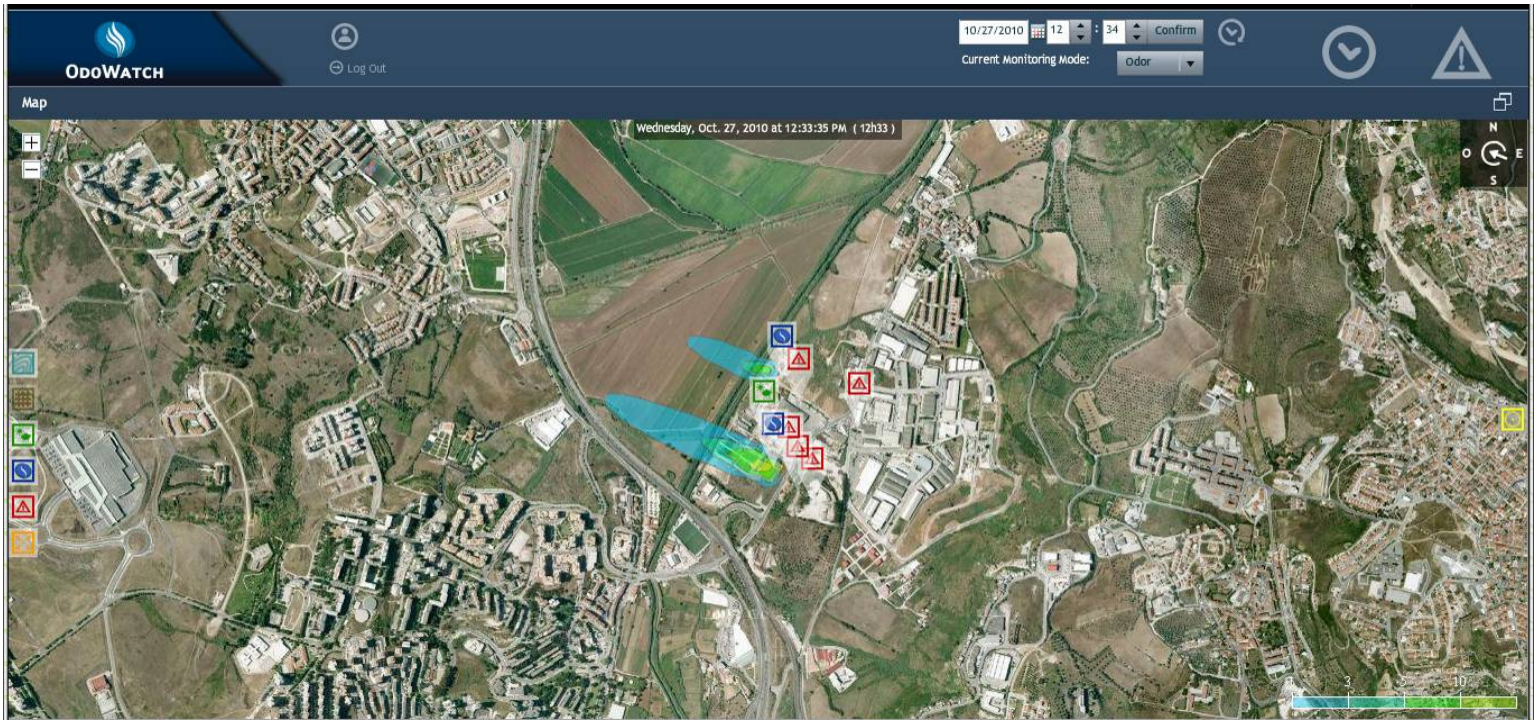

Figure 7: **A screen from OdoWatch showing an odour dispersion map with an odour plume. (Showing plume dispersion towards the NW and not effecting any receptors)**

Further uses of OdoWatch at a facility include the ability to look at future weather patterns, using forecast data, and to consequently amend operational procedures so as to minimise the effect of odour production upon local receptors and also to control abatement systems – where possible, to maximise their efficiency whilst maintaining adequate odour control. Where required an OdoWatch system can be set-up so as to provide alarms about likely odorous events to both internal operators and external receptors – the latter based upon their exact location in the area surrounding the facility. These alarms can then be used by facility operators to amend their operations, and reduce the impact of their activity, and/or set-up so that they automatically send, via SMS or e-mail, warnings to their neighbours that warn them of the likelihood of an odorous emission from site. Such pro-active management of odour production and their effect upon neighbours has proven to significantly reduce the number of future odour complaints due to the actual reduction in odorous emissions and the effective management of complaints.

Discussion

In this paper are details of a number of complementary technologies available to those with an interest in the automatic measurement of odours and their atmospheric dispersion. Those outlined in this paper represent robust tools for practical application in many industries, including the waste and waste water management sector. The technologies outlined here provide a wide range of capabilities and functionality and it is hoped that facility operators and environmental regulators have an appreciation of the distinction between these differing technologies. In order to illustrate the differences between the technologies outlined a matrix of capabilities is given below. No mention is made of the cost of the technologies listed here, as this is a technical paper not a commercial promotion. Needless to say there are differences in the prices of the systems outlined here and a short table giving comparative cost implications is also given below.

Table 1: An illustration of various functionalities of the technologies listed within this paper. (Green = capable, orange = partially able in conjunction with other listed technologies and red = not able)

	MeasureStar	Purenivro	OdoCheck	OdoScan	OdoWatch	Olfactometry
Provides data in ou_E/m_3						
Provides data in ppm						
Acceptable methodology for IPPC Directive						
Availability of 'real-time' odour readings or gas data						
Availability of 'real time' dispersion modelling						
Continuously monitors odours						
Allows odour production trends to be identified						
Enables odour abatement systems to be properly specified						
Ensures that odour abatement equipment performs properly						
Can be used to warranty new odour abatement equipment						
Able to monitor and adjust odour abatement equipment						
Reduces operating costs by controlling abatement equipment						
Odour threshold alerts (alarms) can be set						

Archives historic data						
Enables complainants to be effectively managed						
Significantly reduces odour complaints						
Allows easy data transfer via WWW						
Allows data transfer into SCADA systems						
Predicts future odour dispersion						
Allows 'what if' models to be run						

Table 2: An indication of relative prices of the technologies listed in this paper. (Note that the 'ratio' is not linear, i.e. € is not half of €€)

Technology	Size of user(s)	Relative price indication against other listed technologies
MeasureStar	Single source at single site	€
Purenviro Online	Single site/source to National coverage	€ to €€€
OdoCheck	Single source at single site (possibly temporary)	€€
OdoScan	Single site to Regional coverage	€€
OdoWatch	Single source or multiple sources at single site	€€€€ to €€€€€€

Conclusions

There are several technologies that can be used by operators of waste and waste water management facilities, and other manufacturing/processing industries, which can assist with the effective management of their odour production, odour abatement and IPPC obligations. Many of these technologies can also be used by environmental regulators to ensure that such facilities meet their IPPC obligations. Whether used by facility operators or environmental regulators these technologies often improve the ease of communication between, and accuracy of information available to, users and odour complainants. As such these technologies provide cost-effective tools for facility operators and environmental regulators, in meeting their varied obligations.

1. Technology Selection - The technologies listed in this paper represent a good selection of those available for operators and regulators to help them meet their requirements for controlling odours by proper measurement and dispersion modelling, yet others are available and being developed which may have similar merits to these listed. The decision upon which technologies could be deployed in any situation should be decided upon following candid discussions between the potential users and the suppliers of such systems. During these discussions the technical, commercial and political requirements of each prospective user should be clearly indentified and prioritised. Following this analysis it is then a matter of matching the appropriate technology to the full set of requirements of the user, and consideration given to how the systems might evolve with further requirements in the future. In considering the latter, users should protect their investment in the technologies they choose to employ.

2. Return on Investment - Each of the listed technologies has a ‘pay back’ for the user, be they a facility operator or environmental regulator. As this is a technical paper the details of the numerous and varied methods by which the costs of employment of any system is not covered here. The exact costs and how these can be recovered or offset during operational use of the selected systems will be discussed during negations between the supplier and prospective user. Needless to say each installation must have some significant payback as all users are likely to work within budgetary constraints and must therefore justify any investment in their selected technologies and the deployment of these.