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Executive Summary

The National Environmental Technology Centre (NETCEN) and South Holland District Council have measured air pollution levels at Westmere County Primary School, Sutton Bridge, from July 1998. This report summarises the second year of data collected, from August 1999 to July 2000. The results from the first year of operation are given in report AEAT/EEQP/00020.

The pollutants measured at the site are nitrogen oxides (NO_x) and ozone (O_3). NO_x is produced in combustion processes and by motor vehicles. O_3 at ground level is produced by chemical reactions between pollutants such as organic compounds, often emitted in other parts of the UK or Europe, particularly during hot, sunny weather. The monitoring site also records wind speed and direction.

The data collected from the site have been summarised and compared to current air quality standards set by various bodies, which are described in the text of this report. The data are also compared to those from other local air quality monitoring stations in the east of England.

The results show that the Air Quality Standards and Objectives for NO_2 has not been exceeded and levels within Sutton Bridge are low. The highest average concentration of NO_2 was detected from the south-east; this may be attributed to the power station, road traffic or other sources around the Sutton Bridge area.

The results show that the following air quality standards have been exceeded:

- O_3 concentrations exceeded the AQS objective daily maximum of running 8-hour means on 29 days during the period; the objective permits only 10 days with 8-hour averages over 50ppb.

- The EC Population Information Threshold for hourly average O_3 concentration was exceeded four times (4 hourly averages above 90ppb)

- The O_3 concentrations were "high" as defined by DETR banding for four hourly averages during the period.

Due to the nature of ground-level ozone formation, sources of ozone and its precursors outside the district may cause the ozone levels to exceed the air quality standards. It is recognised that reduction in ozone concentrations in the UK will require action on a European scale. As a result, the objectives for ozone are not to be included in Local Air Quality Management.

The concentrations of NO_2 and O_3 measured at the Sutton Bridge site were generally similar to those measured at a rural monitoring site in Cambridgeshire. Concentrations were generally much lower than were measured in nearby urban areas, such as Norwich and Lincoln.

Contents

1 Introduction

The National Environmental Technology Centre (NETCEN, part of AEA Technology Environment) has been appointed by South Holland District Council as consultants for the purpose of monitoring air quality at Sutton Bridge. The study of air quality in the town has been necessary as part of the planning consent for the construction and commissioning of a 790MW gas fired power station close to the town. An air quality monitoring site was installed in July 1998. The pollutants measured are oxides of nitrogen (NO_x consisting of nitric oxide, NO and nitrogen dioxide, NO_2) and ozone (O_3). This report covers the second year of operation from 1 August 1999 to 31 July 2000.

Oxides of nitrogen are produced mainly by combustion sources, particularly motor vehicles. NO is not recognised as harmful to health, but it is readily oxidised in the atmosphere to form NO_2. There is evidence that NO_2 in high concentrations causes inflammation of the airways in humans, and may affect lung function.

Ozone is produced by a complex set of chemical reactions in the atmosphere, involving volatile organic species and UV light. The chemical pollutants required for ozone formation may be emitted some distance from the UK, and peak ozone concentrations in the UK are observed during periods where air masses from the continent move over the country. The highest concentrations are frequently observed over the south and south-east of England. The background ozone concentration in unpolluted air is approximately 36ppb.

2 Monitoring Methods

2.1 EQUIPMENT

A continuous automatic monitoring site has been installed at Westmere County Primary School, Sutton Bridge. A map showing its location, is shown separately. The site is fully self-contained, and is equipped with the following:

- Continuous automatic analysers for NO_x and O_3
- Datalogger, modem and telephone line for collection and transmission of data to NETCEN
- Air conditioning to ensure reliable analyser performance
- Compressed gas mixtures of NO and NO_2 at near-ambient concentrations for calibration of the NO_x analyser
- Sensors for wind speed and direction

The principle of operation and expected accuracy of the analysers are given in Table 1.

Table 1: Principle of operation and accuracy of analysers used

Pollutant	Analyser type	Method of operation	Expected accuracy
Ozone	API M400	UV absorption	±11%±2ppb
Oxides of nitrogen	APIM200A	Chemiluminescence	±10%±2.5ppb

2.2 OPERATION OF SITE

The routine site operations are carried out by SHDC staff, who have received full training by NETCEN and Enviro Technology Services plc, the suppliers of the monitoring equipment. Data collection, validation and reporting are carried out by NETCEN. NETCEN also supply QA/QC services, consisting of the following:

- Traceable calibrated compressed gas mixtures for the routine calibration of the NO_x analyser
- 6-monthly audits of analyser performance
- Ratified datasets on a six-monthly basis

NETCEN have been awarded UKAS accreditation (calibration laboratory no 0401) for the calibration of compressed gas mixtures and ambient air quality monitoring equipment. The site is operated to the same protocols as the DETR automatic urban network, to ensure that the data from the Sutton Bridge site are directly comparable to national network data.

The monitoring equipment is covered by a service contract with the manufacturers UK agent, to ensure reliable operation and prompt repair of faults and breakdowns.

2.3 DATA REPORTING

The data are collected daily by NETCEN, and are inspected for faults or irregularities. The provisional monitoring data are then sent electronically to SHDC on a daily basis. Monthly reports, including summary statistics are supplied by NETCEN. The final ratified dataset is reported annually.

2.4 DATA CAPTURE

The data capture for the pollutants measured were very good, with less than 1% data loss. The exception to this are the wind speed and direction sensors, which became faulty on a number of occasions. As a result of this, the equipment suppliers have installed new, solid-state sensors to improve reliability.

3 Results and Discussion

3.1 PRESENTATION OF DATA

The data from the monitoring survey for the 12 months of operation (August 199-July 2000) are summarised in tabular form, in Appendix 2. The summary also compares the data with relevant Air Quality Strategy (AQS) and EC Directive standards and guidelines. These are detailed in Appendix 3.

3.2 COMPARISON WITH AIR QUALITY STANDARDS AND OBJECTIVES

Relevant Air Quality Standards and guidelines are given in Appendix 3. These have been subject to recent revision.

3.2.1 Air Quality Standards

NO_2:
The current AQS[1] contains two objectives for NO_2:

- The objective for the hourly mean to be 105 ppb, to be exceeded not more than 18 times per year, by 31 December 2005. This brings the AQS standard in line with the EC Daughter Directive limit, see below.
- For the annual mean, 21 ppb to be achieved by 31 December 2005.
- A new national objective for protection of vegetation, 16ppb (as NO_x) has been adopted for 31 December 2000. This is aimed at the protection of vegetation and ecosystems, and is not to be included in Local Air Quality Management.

The maximum 1 hour mean NO_2 concentration measured in this survey was 44ppb; well within the current and proposed objectives for this parameter. The overall mean for the whole 12-month period was 9 ppb; well within the annual mean limit of 21ppb.

O_3:
The current AQS contains one provisional objective for O_3

- Daily maximum of running 8-hour mean of 50ppb not to be exceeded more than 10 times per year

This remains provisional whilst other European countries set their own commitments for the reduction in emissions of O_3 precursors, such as volatile organic compounds (VOCs). This objective is therefore not to be included in Local Air Quality Management.

This value was exceeded on 29 days during the period, with exceedences recorded in August 1999 (10 times), September (5), April 2000 (2), May (4), June (5) and July (3). There were a total of 248 occasions on which the running 8-hour running mean exceeded 50ppb.

3.2.2 EC Directives

NO_2:

(i) Existing EC Directive[2] on NO_2, EEC 85/203: this specifies that the 98th percentile of hourly means over the calendar year must not exceed 105 ppb. The 98th percentile of hourly NO_2 means in this survey was 28ppb, i.e. well within the limit

(ii) Under EC Directive 96/62, (the "Framework Directive[3]"), provision has been made for re-evaluation of the above NO_2 Directive. New, more stringent limits for this and other pollutants are contained in the first Daughter Directive[4] on oxides of nitrogen, sulphur dioxide, PM_{10}, and lead. This Directive was adopted in 1999. The limits for NO_2 are as follows:

- Hourly mean limit 105 ppb, to be exceeded not more than 18 times per year, by 1 January 2010.
- Annual mean limit 21 ppb, to be achieved by 1 January 2010.
- Annual mean limit of 16ppb (as NO_x) for the protection of vegetation, to be achieved by July 2001

From the data collected at Sutton Bridge, neither the maximum hourly mean of 44ppb or the annual mean of 9ppb exceeded these limits. The average NO_x concentration was 12ppb, below the EC vegetation limit of 16ppb.

O_3:

The EC has set threshold limits relating to population exposure for O_3 concentrations:

- Population Information Threshold for hourly averages of 90ppb
- Population Warning Value for hourly averages of 180ppb
- Health Protection Threshold for fixed 8-hour means of 55ppb

Under the EC Directive, the DETR must inform the public if a network site exceeds 90ppb as an hourly average O_3 concentration, or if it expects a site to exceed 180ppb. This is not applicable to the Sutton Bridge site, but the 90ppb threshold was exceeded on 4 hours during the year.

3.2.3 DETR Air Quality Bands

NO_2 concentrations remained in the DETR "low" band throughout the year. O_3 hourly average concentrations were in the "low" band for 8250 hours, "moderate" for 453 hours and "high" for 4 hours (on two days). The maximum hourly average ozone concentration of 93ppb occurred on 1 August 1999.

3.3 METEOROLOGICAL MEASUREMENTS

The wind speed and direction roses are given in Appendix 4, together with timeseries plots for these parameters. The wind direction rose shows the proportion of time in which the wind blows from each of 16 sectors. The wind speed rose shows the average wind speed in each of these sectors. Similarly, the pollution roses show average concentration of each species measured in each of the direction sectors. Data measured during periods of low wind speed ($<0.1 ms^{-1}$) are disregarded in the pollution roses. The power station is situated at a bearing of approximately 155° from the monitoring site, and the average concentrations of pollutants in the sector 150°-160° has been calculated in each case. Note, however, that the town of Sutton

Bridge itself may contribute to measured concentrations in this direction, and it is not possible to say with certainty what the likely source of pollution may be.

The wind direction rose shows that for the majority of the time during the year, the wind was from a south-westerly direction. Northerly and easterly winds were infrequent during the monitoring period. Wind speeds were more evenly distributed throughout the 16 sectors, except for easterly winds, which were lighter on average. This may be partially due to the low frequency of this direction of wind. This pattern is very similar to that of the previous year.

The NO and NO_x concentrations clearly show the maximum average concentrations to be from the south-east and west, and the average concentration in the 150°-160° sector is 2.5ppb. NO is a primary pollutant (i.e., produced directly from pollution sources, such as combustion or road traffic), and thus this can be attributed to a local source. The NO_2 plot again shows a significant contribution from the south-east (11.2ppb in the 150°-160° sector). NO_2 is a secondary pollutant, and may be produced by oxidation of NO in the atmosphere. The higher concentrations of NO_2 from this direction may be due to the conversion of NO from a local source as it moves towards the monitoring site.

Ozone is not emitted directly by sources; ozone is produced by the reaction of various pollutants in the presence of sunlight. Highest levels are always observed in the summer. The background tropospheric O_3 concentration in unpolluted air is approximately 36ppb. The ozone plot shows a reasonably even distribution, with a maximum in a north-easterly direction. This is as might be expected, as any ozone mixing with the locally-produced NO will gradually react, producing NO_2. The highest concentrations in the north may reflect the lack of depletion of background ozone, as there are no significant sources of ozone sinks in this direction. The highest ozone concentrations recorded (1 August 1999) were measured during a period of generally light and variable winds. High ozone levels were also recorded at the DETR sites at Norwich and Wicken Fen on this day.

4 Comparison with other Monitoring Sites

The data from Sutton Bridge are compared with data from local DETR automatic network sites-Wicken Fen (rural site close to Newmarket), Lincoln Roadside (NOand NO_2 only) and Norwich Centre. The data from these sites are given in Tables 2 (O_3), 3 (NO) and 4 (NO_2). Note that Lincoln Roadside ceased operation in December 1999.

Table 2: Comparison of Ozone Statistics with DETR sites: August 1999-July 2000

O_3	Sutton Bridge	Lincoln	Norwich	Wicken Fen
Max 15-min mean	97ppb	-	131ppb	97ppb
99.9%ile 15-min mean	87ppb	-	110ppb	87ppb
Max hourly mean	93ppb	-	120ppb	95ppb
Max 8-hourly mean	88ppb	-	110ppb	88ppb
Max 24-hourly mean	76ppb	-	76ppb	58ppb
99% daily max. 24hr mean	54ppb	-	57ppb	51ppb
Mean	28ppb	-	23ppb	22ppb
Data capture	99%	-	96%	98%

The measured concentrations from all three sites are generally similar, but the annual average concentration is highest at Sutton Bridge. This may be due to the influence of the background ozone in unpolluted air which affects Sutton Bridge for much of the year.

Table 3: Comparison of Nitric Oxide Statistics with DETR sites: August 1999-July 2000

NO	Sutton Bridge	Lincoln	Norwich	Wicken Fen
Max 15-min mean	165ppb	720ppb	364ppb	114ppb
99.9%ile 15-min mean	92ppb	659ppb	235ppb	84ppb
Max hourly mean	142ppb	649ppb	322ppb	104ppb
Max 8-hourly mean	62ppb	521ppb	204ppb	68ppb
Max 24-hourly mean	38ppb	364ppb	110ppb	53ppb
99% daily max. 24hr mean	28ppb	306ppb	72ppb	34ppb
Mean	2ppb	114ppb	7ppb	3ppb
Data capture	99%	38%	97%	90%

Although NO is not regarded as a significant pollutant (it has no recognised adverse affects on human health), it does provide an indication of influence by combustion processes. Urban sites show higher NO concentrations, often due to road traffic. Rural sites show lower levels, as any NO present is oxidised to NO_2 in the atmosphere.

Table 4: Comparison of Nitrogen Dioxide Statistics with DETR sites: August 1999-July 2000

NO_2	Sutton Bridge	Lincoln	Norwich	Wicken Fen
Max 15-min mean	121ppb	149ppb	125ppb	35ppb
99.9%ile 15-min mean	38ppb	130ppb	59ppb	31ppb
Max hourly mean	44ppb	111ppb	79ppb	33ppb
98%ile hourly mean	28ppb	90ppb	32ppb	23ppb
Max 8-hourly mean	34ppb	96ppb	46ppb	27ppb
Max 24-hourly mean	29ppb	72ppb	34ppb	22ppb
99% daily max 24 hourly mean	27ppb	64ppb	29ppb	21ppb
Mean	9ppb	36ppb	13ppb	7ppb
Data capture	99%	38%	97%	89%

The NO_2 concentrations measured at Sutton Bridge are similar to those measured at Wicken Fen, with the exception of the peak 15-minute average. Sutton Bridge is a semi-rural site, and is likely to be influenced by local factors, eg traffic. Both Norwich and Lincoln show higher levels of NO_2; Lincoln is a roadside site and shows levels considerably higher than Sutton Bridge.

5 Conclusions

1. The maximum hourly mean NO_2 concentration measured at Sutton Bridge during the period 1 August 1999-31 July 2000 was 44ppb. This is well within the AQS limit of 105ppb and the EC Directive limit (also 105ppb).

2. The annual average NO_2 concentration measured was 9ppb. This is well within the AQS standard of 21ppb, and the proposed EC Daughter Directive (also 21ppb), to be met by 2010.

3. The existing EC Directive on NO_2 states that the 98th percentile of hourly means over the calendar year must not exceed 105ppb. In this survey, no hourly means exceeded this value, and the 98th percentile of hourly means was 28ppb. This indicates that the existing EC Directive is met at this site.

4. The NO_2 concentrations remained in the DETR "low" banding throughout the year.

5. O_3 concentrations exceeded the AQS objective daily maximum of running 8-hour means on 29 occasions during the period; the objective permits only 10 such exceedences.

6. The EC Population Information Threshold for hourly average O_3 concentration was exceeded four times (4 hourly averages above 90ppb), with the maximum hourly concentration being 93ppb.

7. The O_3 concentrations were "high" as defined by DETR banding for four hourly averages during the period.

6 References

1. The Air Quality Strategy.for England, Scotland, Wales and Northern Ireland. January 2000. ISBN 0-10-145482
2. EC Directive 85/203/EEC on Nitrogen Dioxide
3. Council Directive 96/62/EC on Ambient Air Quality Assessment and Management
4. Council Directive 1999/30/EC relating to limit values for SO_2, NO_2, NO_x, particulate matter and lead in ambient air

Appendices

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Appendix 1
Location of Monitoring Site

Appendix 2
Summary of Data from Sutton Bridge

Appendix 3
Relevant Air Quality Standards and Guidelines

Nitrogen Dioxide

Guideline Set By	Description	Criteria Based On	Value / ppb (μgm^{-3})
UK Government	LOW Air Pollution		< 150 (287)
- Air Pollution Bandings	MODERATE Air Pollution	1-hour mean	150 - 299 (287 - 572)
	HIGH Air Pollution		300 - 399 (573 - 763)
	V HIGH Air Pollution		>= 400 (764)
- The Air Quality Strategy(1)	Objective for Dec. 31st 2005	1-hour mean	105 (200) not to be exceeded more than 18 times per calendar year
	Objective for Dec. 31st 2005	Annual mean	21 (40)
European Community(2)	Limit Value	Calendar year of data: 98%ile of hourly means.	104.6 (200)
	Guide Value	98%ile of hourly means.	70.6 (135)
	Guide Value	50%ile of hourly means.	26.2 (50)
Daughter Directive(3)	Limit Value	1 hour mean	105 (200) not to be exceeded more than 18 times per calendar year
	Limit Value	Calendar year annual mean	21 (40)
	Limit Value (NO_x)	Calendar year annual mean	16 (30)
World Health Organisation(4) **(Revised Guidelines)**	Health Guideline	1-hour mean	110 (200)
	Health Guideline	Annual mean	21 (40)
United Nations Economic Commission for Europe	Vegetation Guideline	Annual mean	15 (29)

(1) The Air Quality Strategy.for England, Scotland, Wales and Northern Ireland. January 2000. ISBN 0-10-145482-1
(2) Council Directive 85/203/EEC
(3) Council Directive 1999/30/EC
(4) Conversions between $\mu g\, m^{-3}$ and ppb given by WHO

Ozone

Guideline Set By	Description	Criteria Based On	Value / ppb (μgm^{-3})
UK Government	LOW Air Pollution	Running 8-hour and 1-hour mean	< 50 (100)
- Air Pollution Bandings	MODERATE Air Pollution	Running 8-hour or 1-hour mean	50 - 89 (100 - 179)
	HIGH Air Pollution	1-hour mean	90 - 179 (180 - 359)
	V HIGH Air Pollution	1-hour mean	>= 180 (360)
- The Air Quality Strategy[1]	Objective for Dec. 31st 2005	Daily maximum running 8-hour mean	50 (100) not to be exceeded more than 10 times per calendar year
European Community[9]	Population Information Threshold	1-hour mean	90 (180)
	Population Warning Value	1-hour mean	180 (360)
	Health Protection Threshold	Fixed 8-hour means (hours 1-8, 9-16, 17-0, 13-20)	55 (110)
	Vegetation Protection Threshold	1-hour mean	100 (200)
	Vegetation Protection Threshold	24 hours (daily mean)	32 (65)
World Health Organisation[4] **(Revised Guidelines)**	Health Guideline	Running 8-hour mean	60 (120)
United Nations Economic Commission for Europe	Vegetation Guideline	Growing Season[10] mean	25 (50)
	Vegetation Guideline	1-hour mean	75 (150)
	Vegetation Guideline	Running 8-hour mean	30 (60)

(9) Council Directive 92/72/EEC
(10) Growing season is defined as April to September for WHO guidelines, but is daytime (0900-1500) April to September for UNECE

Appendix 4
Wind Speed, Direction and Pollution Roses at Sutton Bridge