AEAT/ENV/R/0594 Issue 1

PM10 Particle Monitoring in Sutton Bridge

A report produced for South Holland District Council

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Title	PM10 Particle Monitoring in Sutton Bridge
Customer	South Holland District Council
Customer reference	
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File reference	ED47064
Report number	AEAT/ENV/R/0594
Report status	Issue 1

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Summary of Report

AEA Technology Environment has carried out a 6-month survey of airborne PM_{10} particulate matter at Petts Lane in Sutton Bridge, between October 2000 and March 2001. The purpose of this was to establish whether ship loading operations at Port Sutton Bridge were having an impact on local air quality due to fine dust. The local authority, South Holland District Council (SHDC), is obliged to carry out this assessment as part of the air quality review and assessment required by The Environment Act 1995.

The data obtained from this site are compared with data from the Westmere school site, currently operated by South Holland District Council. Wind direction measurements were made at both sites to help identify whether any high concentrations measured may have resulted from port operations. Some data on cargo handling at the port were available, but this was insufficient to establish if port activities contributed to elevated particle concentrations.

The results obtained show that peak concentrations were substantially higher at Petts Lane, although average concentrations at the two sites were more equal. The maximum daily average of 50μg m^{-3} (gravimetric) as defined by the Department of Environment, Transport and the Regions (DETR, now DEFRA) Air Quality Strategy was exceeded on 8 days at Petts Lane in the 6-month period, compared with 3 at Westmere School. Note that 35 daily averages higher than 50μg m^{-3} are allowed under these regulations. Many urban areas of the UK do exceed this figure.

The concentrations measured at Petts Lane were, on average, slightly higher from the direction of the port area, but this does not conclusively prove port operations were the source. Samples from both sites were sent for analysis, and both showed traffic (particularly diesel) as the predominant source, with other materials also present at the Petts Lane site. These may be present as a result of agricultural activity.

Contents

1 Introduction

AEA Technology Environment has carried out a six-month monitoring programme for PM_{10} particulate matter at Sutton Bridge, Lincolnshire. The monitoring equipment was located at Petts Lane, close to the cargo handling facilities at Port Sutton Bridge. It is possible that the handling of some cargoes may give rise to dust emissions, and the monitoring programme was undertaken to permit South Holland District Council to carry out their obligations under the Air Quality Regulations 2000[1]. The site was operated from September 2000 to April 2001. PM_{10} particulate matter mainly consists of particles with a mean diameter of 10μm (10^{-6}m).

The data from the Petts Lane site are compared here to the PM_{10} data obtained from the automatic monitoring site at Westmere School. A sample of dust from each of the sites has been examined to determine if the composition of the dust collected is similar at each site.

2 Description of Monitoring Site

2.1 LOCATION OF SITE

The analyser was installed in a mobile laboratory parked by the side of the road near the entrance to the port area. The grid reference is TF48351: 22462; a map is given in Appendix 1. The site was equipped with sensors for wind speed and direction, and a telephone line to transmit data to AEA Technology Environment's central computer facility at Culham, Oxfordshire.

Monitoring site at Petts Lane

2.2 MEASUREMENT METHOD

The analyser used at Petts Lane was a Rupprecht & Patashnick TEOM 1400AB. This analyser is in common use throughout the DETR urban air pollution monitoring network, and is identical to that purchased by SHDC for the Westmere School site. The TEOM (tapered element oscillating microbalance) measures airborne particle dust concentrations by sucking air through a glassfibre filter, which oscillates at an accurately known frequency. As dust collects on the filter, this causes the mass of the filter to increase, and the vibration frequency changes. This change is detected by sensitive electronics, which calculate the mass concentration in the atmosphere using the air flowrate through the analyser.

The data were collected daily by AEA Technology Environment staff, and were screened for analyser faults by trained staff to ensure reliable operation of the equipment. The data capture achieved was 94%; some data were lost due to analyser problems which were found to have occurred during periods when communications with the site failed.

Significant problems were encountered with the wind speed measured. However, as these data are used only to reject direction data during periods of low wind speed (less than 0.5ms^{-1}), surrogate wind speed data from Westmere School have been used. Some icing of the direction sensor also occurred during the period, and the wind direction data for these periods has been lost.

Although the use of TEOMs in the UK is commonplace, there is concern expressed by, amongst others, the Airborne Particles Expert Group (APEG) that this monitoring method does result in an under-read of particle concentrations of between 15 and 30 % at typical ambient concentrations. It is thought this occurs as a result of evaporation of volatile species (eg hydrocarbons) in the heated inlet of the analyser. There is a study by DETR underway at the time of writing to investigate this effect in more detail. The air quality objectives referred to in the DETR's Pollutant Specific Guidance[2] are based on the European reference method, which is a gravimetric method. It is therefore necessary to apply a "correction factor" when comparing TEOM measurements with the objectives. A constant factor of 1.3 is therefore applied to the measurements from this survey when comparing with the objectives. Measurements thus corrected in this report will therefore be referred to as μg m^{-3}, gravimetric.

The selection of the TEOM for monitoring particles is justified on the basis that the method is in widespread use in the UK (and other countries), and that short-term averages (15-minute) are easily obtainable using this method. Other options for measurement of PM_{10} include the beta-gauge analyser or the gravimetric sampler. Gravimetric methods are recognised as a reference method, but are less convenient to use, require filter conditioning and weighing, and only offer daily average concentrations at best. The beta-gauge analysers have not achieved widescale use in the UK at present, and the relationship between these and gravimetric measurements are not yet well established.

There are some other monitoring methods in existence, (eg optical devices) but these are generally unproven at this point in time.

3 Results and Discussion

3.1 PRESENTATION OF DATA

The results from the Petts Lane monitoring survey are given in Table 1.

Table 1: Summary of PM_{10} data from Petts Lane, Sutton Bridge

	AQS objective (to be achieved by Dec 2004)	PM_{10} concentration ($\mu g\ m^{-3}$, TEOM)	PM_{10} concentration ($\mu g\ m^{-3}$, grav.)
Maximum 15-minute average	-	446$\mu g\ m^{-3}$	580$\mu g\ m^{-3}$
Maximum hourly average	-	313$\mu g\ m^{-3}$	407$\mu g\ m^{-3}$
Max 8-hourly average	-	142$\mu g\ m^{-3}$	185$\mu g\ m^{-3}$
Max 24-hourly average[1]	50$\mu g\ m^{-3}$	62$\mu g\ m^{-3}$	81$\mu g\ m^{-3}$
Max daily average	-	62$\mu g\ m^{-3}$	81$\mu g\ m^{-3}$
6-month average[2]	40$\mu g\ m^{-3}$	18$\mu g\ m^{-3}$	23$\mu g\ m^{-3}$
No. daily means above AQS		-	8
Data capture	-	94%	-

1. Not to be exceeded more than 35 times per year.
2. 40$\mu g\ m^{-3}$ is the annual average concentration in the Air Quality Strategy; this is compared here to the 6-monthly average obtained from this programme.

3.2 COMPARISON WITH AIR QUALITY OBJECTIVES AND STANDARDS

The current air quality objectives, EC Directive limit and guide values and the DETR air quality bandings are given in Appendix 2. For PM_{10}, the gravimentric equivalent data in Table 1 are used to compare against the objectives. It can be seen that although the annual average of 40$\mu g\ m^{-3}$ was not exceeded, there were 8 24-hourly averages above the Air Quality Strategy objective of 50μgm^{-3} during the 6-month period of monitoring.

There were 130 hours in the DETR "moderate" air quality band; the remaining 3935 hours were in the "low" band.

A summary of the statistics, plus timeseries plots, are given in Appendix 3.

3.3 COMPARISON WITH OTHER MONITORING SITES

The data from the Petts Lane site are compared to the data from the same period from the Westmere School site. The data from these sites are summarised in Table 2.

The Westmere School site is located in the grounds of Westmere County primary school, approximately 1.5km south-west of the Petts Lane site. The site is operated by SHDC, with quality assurance & control services provided by AEA Technology Environment to protocols identical to those specified for the DETR urban monitoring network. The site, which also measures NO_2 and ozone, has been operated since 1998, although the TEOM analyser was only installed in September 2000.

Table 2: Comparison of Petts Lane data with Westmere School data: October 2000-March 2001

	Petts Lane		Westmere School	
	PM_{10} (TEOM)	PM_{10} (grav.)	PM_{10} (TEOM)	PM_{10} (grav.)
Maximum 15-minute average	446μg m^{-3}	580μg m^{-3}	127μg m^{-3}	165μg m^{-3}
Maximum hourly average	313μg m^{-3}	407μg m^{-3}	100μg m^{-3}	130μg m^{-3}
Max 8-hourly average	142μg m^{-3}	185μg m^{-3}	71μg m^{-3}	92μg m^{-3}
Max 24-hourly average[1]	62μg m^{-3}	81μg m^{-3}	60μg m^{-3}	78μg m^{-3}
Max daily average	62μg m^{-3}	81μg m^{-3}	59μg m^{-3}	77μg m^{-3}
6-month average[2]	18μg m^{-3}	23μg m^{-3}	14μg m^{-3}	18μg m^{-3}
No. daily means above AQS	-	8	-	3
Data capture	-	94%	-	94%

1. Not to be exceeded more than 35 times per year.
2. 40μg m^{-3} is the annual average concentration in the AQS; this is compared here to the 6-monthly average obtained from this programme.

It can be seen that peak PM_{10} concentrations are substantially higher at Petts Lane than at Westmere School, but longer-term averages are much more similar.

3.4 POLLUTION EPISODES

There were several brief periods of elevated PM_{10} concentration observed at the Petts Lane site which were not observed at Westmere School, particularly in late November-early December and again from mid-January and early February.

3.5 CHARACTERISATION OF PARTICULATE SAMPLES

In order to establish whether the composition of particulate material collected at thePetts Lane and Westmere School sites were significantly different, TEOM filters from early March were sent to AEA Technology's Materials Characterisation Services for qualitative analysis by scanning electron microscopy (SEM) and energy dispersive X-ray analysis (EDX).

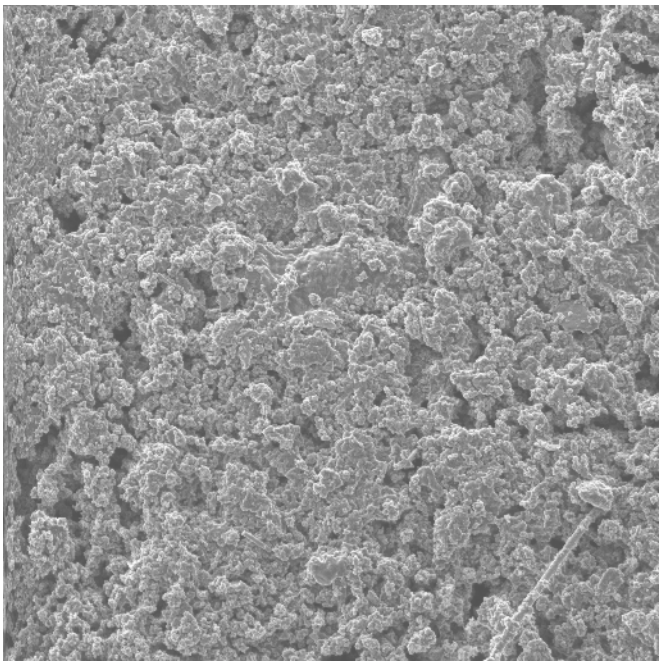
The particles from both sites were very small (less than 1μm) and were characteristic of diesel exhaust emissions. These are small particles of carbon held together by an oily matrix, as a result of incomplete combustion.

The elemental analysis provided by EDX shows dominant amounts of chlorine and sulphur on both filters, along with sodium and aluminium. Sodium and chlorine are probably due to sea salt (which may well contain other elements), and sulphur is present in many fuels[3]. The Petts Lane filter showed relatively higher levels of silicon, potassium, calcium, titanium, iron and zinc. Soil particles can contain significant levels of aluminium, titanium and silicon, and soot from combustion contains variable amounts of, amongst other elements, zinc. Whilst it is not possible to speculate further on the sources of these elements, the result shows that for the period in March during which these filters were exposed, the particle composition at the two sites were slightly different. It is probable that vehicle emissions will be the major source for Westmere School, but perhaps less so for Petts Lane, as there is very little traffic in the immediate area. Dust from fields is likely to affect measured PM_{10} concentrations at this rural site. Limited data are available on port activity over this period, but these were insufficient to establish whether these cargo movements affected local air quality.

The SEM images of typical areas of the filters are shown below:

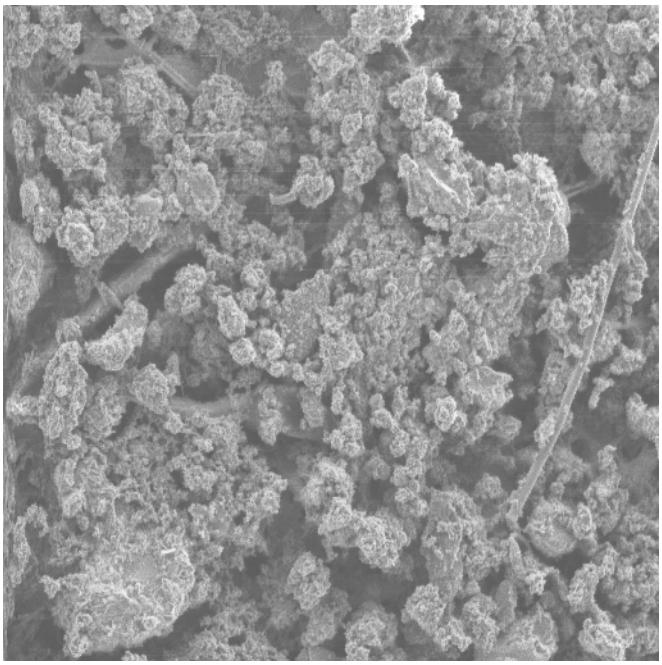
SEM Image of typical area of Westmere school filter

[x 2,000]



SEM Image of typical area of Petts Lane filter

[x 2,000]



4 Wind Direction and Measured Concentrations

Appendix 4 shows the average PM_{10} concentration measured in 16 direction sectors around the compass. Data are given for both Petts Lane and Westmere School.

The Petts Lane data shows slightly higher concentrations from the south-east, which may originate from the northern end of the port, but this is not conclusive. The Westmere School data shows influence from the south-east, which is likely to be due to sources within the town itself, and from the north-west. Levels from the direction of the port were generally lower.

5 References

1. The Air Quality (England) Regulations 2000, Statutory Instruments 2000 No. 928

2. Review and Assessment: Pollutant Specific Guidance, Part IV The Environment Act 1995, Local Air Quality Management LAQM.TG4(00) May 2000

3. Environmental Chemistry of the Elements, HJM Bowen 1979, ISBN 0-12-120450-2

Appendices

CONTENTS

Appendix 1
Location of Monitoring Site

Appendix 2
Air Quality Objectives and Standards

PM_{10} Particulate Matter

Guideline Set By	Description	Criteria Based On	Value / (μgm^{-3})
UK Government			
- Air Pollution Bandings	LOW Air Pollution	Running 24-hour mean (TEOM data)	< 50
	MODERATE Air Pollution		50 - 74
	HIGH Air Pollution		75 - 99
	V HIGH Air Pollution		>= 100
- The Air Quality Strategy[1]	Objective for Dec. 31st 2004	24 hours (daily mean) (Gravimetric data)	50 not to be exceeded more than 35 times per calendar year
	Objective for Dec. 31st 2004	Calendar year annual mean (Gravimetric data)	40
European Community Daughter Directive(	Limit Value	24 hours (daily mean) (Gravimetric data)	50 not to be exceeded more than 35 times per calendar year
	Limit Value	Calendar year annual mean (Gravimetric data)	40

Appendix 3
Summary of Data

Note: South Holland refers to Westmere School
Sutton Bridge refers to Petts Lane

Appendix 4
Pollution Roses