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Real-time particle mass measurement in the environment

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Zurich Abstract – K Earnshaw

Ambient Particulate Pollution Surveys

Introduction

The issue of local particulate pollution within an urban area requires a data collection system that can be rapidly utilised to develop a screening facility on which to make judgements. With rapid data capture of measurement location and pollution concentration possible, local authorities and environmental consultants can examine pollution hotspots. This information helps both traffic management and local planning.

Gathering Profiles

A Pollution Survey can utilise standard equipment to collect data for a pre-defined area. Surveys can be carried out on foot and/or in a vehicle. In practice a combination of the two is required for built-up areas or parts of a town that has already limited access. (Most modern towns have pedestrian and bus-only areas that produce their own pollution profiles.) The maps in the presentation indicate particle concentration against location in a particular city. The survey captured a profile of the streets in and around a coastal city in the UK, bounded by a motorway to the north. These and other measurements have shown that pollution is not necessarily linked to vehicle speed or time of day.

Depending upon weather conditions quite detailed information can be collected during a single day of measurement.

Packaged Measurement Systems

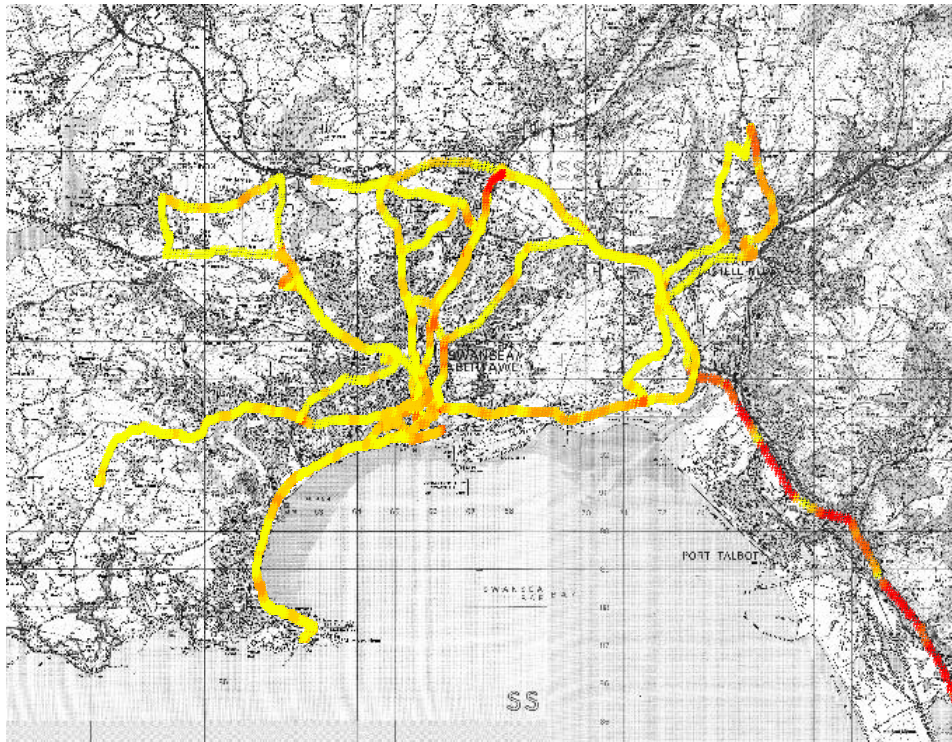
The equipment required for the measurements includes a Quartz Crystal Microbalance (QCM) for particle mass, and a Global Positioning Satellite (GPS) sensor. For very heavily polluted sampling areas a Sample Conditioning System with a Pumping Station may be required as shown. By using a CAN interface installed in the QCM, data from other measurement devices such as NO_x and CO monitors can be incorporated in the combined data report. The entire QCM system is compact enough to be fitted into cars as part of a long-term study and the basic units can be carried around an area. In addition the QCM is capable of being placed on a passenger seat sampling inside the vehicle as a method of assessing driver exposure to respirable particulates.

Report Delivery

The collected data from all the measurement devices, including the GPS, is combined in the Quartz Crystal Microbalance during the measurement period and later downloaded onto PC in *Excel* format for analysis and archiving. Many software packages are available which will incorporate the pollution concentration and location with a map of the surveyed area.

Overview of Data

Swansea - Particulate Survey



Swansea evening data file.txt

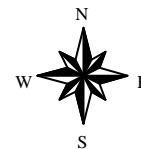
0 - 10
10 - 20
20 - 30
30 - 40
40 - 61

Swansea mid day data file.txt

0 - 10
10 - 20
20 - 30
30 - 40
40-60

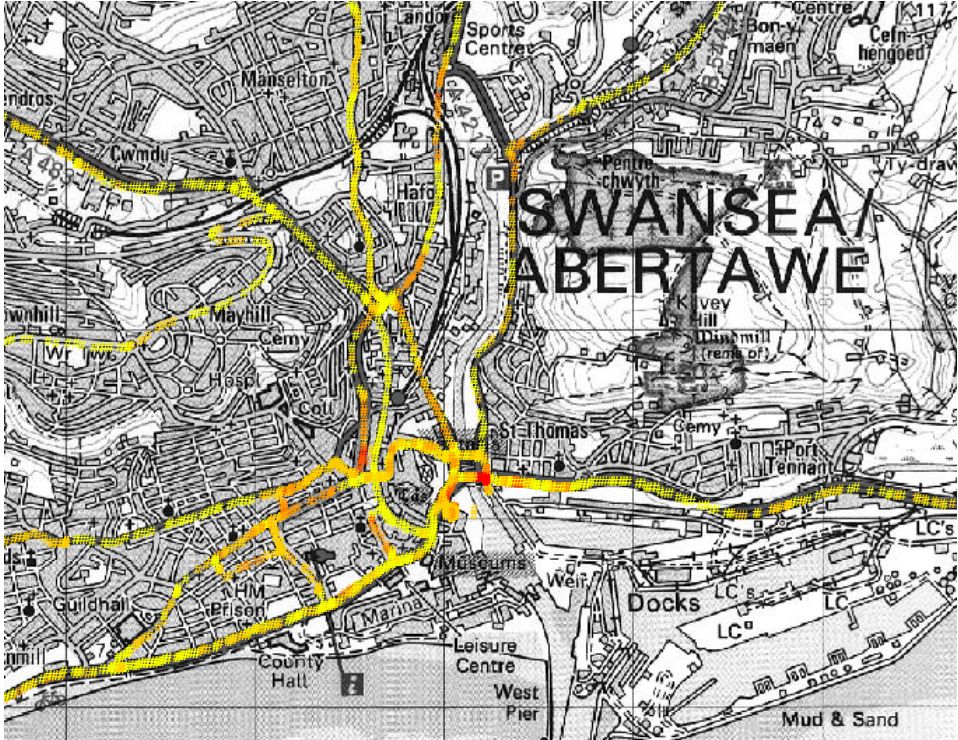
Swansea - banbury data file.txt

0 - 10
10 - 20
20 - 30
30 - 40
>40



Particle Concentrations for Swansea Area. Note highest levels are found on the M4 leading into Swansea. Variations in particle concentrations in Swansea are shown in more detail in the following illustrations.

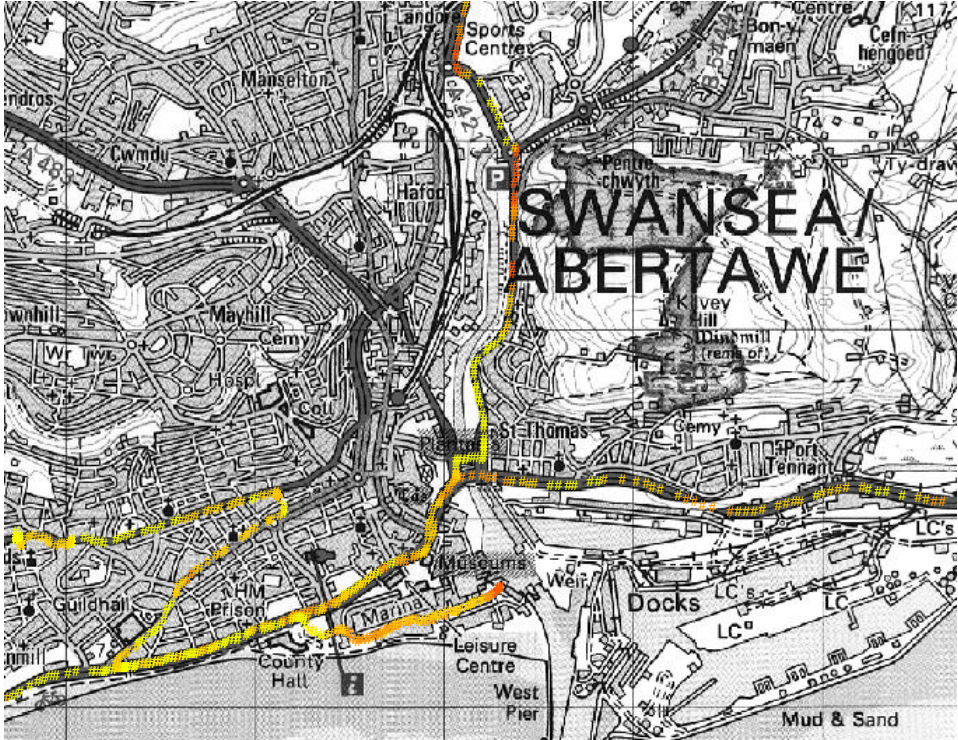
Swansea - Particulate Survey



Swansea mid day data file.txt
0-10
10-20
20-30
30-40
40-50



Swansea - Particulate Survey

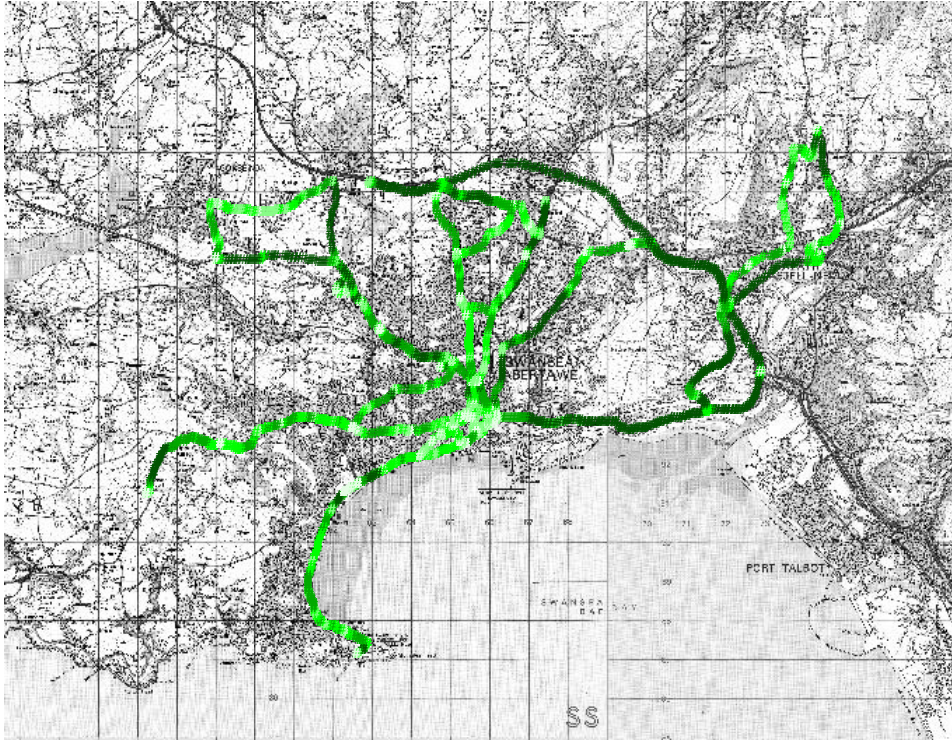


Swansea evening data file.txt
0 - 10
10 - 20
20 - 30
30 - 40
40 - 61

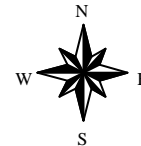


Particle Concentrations for Swansea Area.

Swansea - Particulate Survey



Swansea.mxd day0aa file.txt
0-10
10-20
20-30
30-40
>40



Vehicle Speed Measurements for Swansea Area..

Technical Data

Quartz Crystal Microbalance

Introduction

The most common dynamic instruments for particle mass monitoring have been the Beta Attenuation, and Tapered Element mass monitors (e.g. TEOM). Quartz crystal microbalances were popular in the 1970's and 80's, but because the sensor is easily overloaded with mass the TEOM and Beta devices became dominant for ambient PM₁₀ dust monitoring. However, with the current emphasis on ultrafine particles in the environment (e.g. those emitted from gasoline and diesel vehicles) in which the mass concentrations are typically much lower, and the drive is to make them lower still, the greater sensitivity of the quartz sensors makes this technique more suitable to modern applications. Since the 1980's a great deal of development work has been carried out to measure very low masses.

Quartz Crystal Microbalance

The Booker Systems' QCM devices dynamically determine the amount of aerosol particles deposited on a substrate from a known volume of air. A piezoelectric crystal is used as a sensitive microbalance. Electrostatic precipitation collects aerosol particles on the surface of the piezoelectric crystal. The crystal is excited in its natural frequency, which decreases with increasing mass load on its surface. Thus, the particulate mass collected on the crystal can be determined by measuring the change in the crystal's natural frequency. To ensure that particles are attracted and couple to the crystal surface a point-to-plane electrostatic precipitator is used. The collected mass on the crystal can be retained for further analysis or the crystal can be cleaned and replaced.

Features

- Traceable and precise mass measurement
- Very fast response with high sensitivity
- Designed to be used in workplace & ambient outdoor environments.
- Can be configured to respond to short high mass deposits or long term environmental sampling
- PC controlled option to provide audit trail
- Based on fundamental measuring science
- All critical parameters that affect the mass rates are measured.
- Easy to access crystal holder & crystal

Software

The QCM can be controlled by using supplied software based on a *Labview*¹ platform. The software allows the instrument to be configured against specific measurement requirements as well as providing graphical presentation of data. The recorded files can be exported to a range of spreadsheet programs. In addition the QCM can be used to accept data from other measurement or sample conditioning devices through its CAN interface so that the data can be collected into a single file for subsequent analysis.

Integration

By using the CAN interface, the QCM can report to or receive reports from a range of products. If a number of measurement devices produce analogue or serial outputs then the Booker Systems *Datalogger* can combine these output streams into a single report. The *Sample Conditioning System* will present a concentrated sample to the QCM in an accurately diluted form.

GPS Instrumentation

A wide range of instruments is available which can output location and other parameters to an external device. For automotive traffic pollution surveys the GPS data is logged by the QCM and incorporated with the mass measurement results. The positional information obtained from most GPS systems is sufficient to track and map recorded data against particular roads.

¹ *Labview* is a registered trademark of National Instruments Ltd.