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Short Communication

The use of image analysis for PM10 characterisation of volumetric air samples taken in Cardiff since 1956

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Abstract

This study investigates the size, composition and concentration of airborne particles. These features are examined from continuously recorded volumetric daily air samples, taken by Burkard and Hirst traps from the center of Cardiff City and samples from selected sites around Cardiff. The set of slides is unique as it dates from 1954 to the present day, and contains data, which precedes any other routine measurements of PM10.

Image analysis has not been used previously to examine PM10 from slides taken by Hirst-type traps, but it has been demonstrated as an important application in alternative projects. The advantages of being able to perform simple but tedious measurements quickly make it an important tool for this project. It can also measure a number of images simultaneously and quantify parameters that would otherwise have been based on qualitative subjective comparisons.

Environmental data including wind speeds, rain fall and temperature measurements are investigated to examine the influence on the temporal variation of the abundance and characteristics of airborne particulate matter. Confounding factors that may have impacts on cardiovascular and respiratory illness are being examined. These include data on aeroallergens (pollen and fungal spore counts), nitrogen oxide, sulphur dioxide, and carbon monoxide. The project will be extended to an analysis of the results in relation to health data.

Introduction

The increase of industry in the UK in the 1940s caused a number of severe smogs that continued to occur through the 1950s. The most significant incident featured in London, in 1952 and resulted in the premature deaths of 4,000 people (Ministry of Health, 1954). The episodes resulted in the UK Clean Air Acts in 1956 and 1968, which led to a reduction in urban pollution and the elimination of severe winter smogs. After the 1950s limited research took place until the 1980s when a re-emergence of research on particulates occurred due to the increased concern about pollution emissions from traffic.

Recent research has included epidemiologically based studies, investigating the links between air pollution and the incidence of cardiovascular and respiratory illness. These studies have demonstrated links of particulate air pollution with acute attacks of asthma and other respiratory diseases (Walters et al., 1994) and cardiovascular disease (Schwartz and Morris, 1995).

Current methods used to monitor the particulates are only able to measure their mass, so there are no routine data on the size, composition and concentration of particles in the air. Fresh evidence has implicated the size, composition and concentration of airborne particles as having the paramount effect on health, particularly the ultrafine fraction of particles (Quality of Urban Air Review Group, 1996).

This project aims to investigate the temporal variation of the abundance and characteristics of airborne

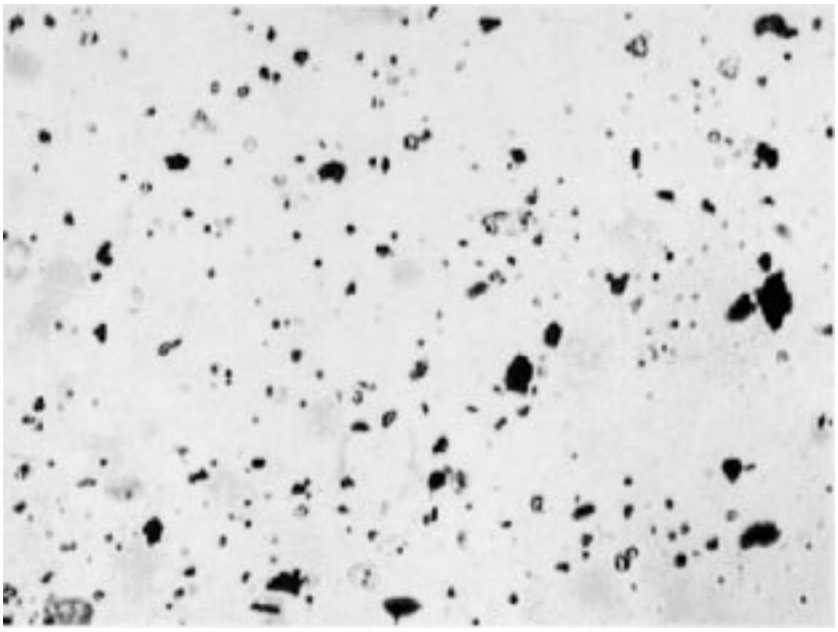

Figure 1. Actual Image obtained via microscope by IA.

particulate matter in Cardiff from 1956 to 1996. This possible variation is then analysed in relation to the patterns of weather, aeroallergens and other pollutants. This data will then be analysed against the incidence patterns of cardiovascular and respiratory diseases.

2. Materials and methods

2.1 *Microscope slides*

This project is investigating the characteristics of airborne particles including the abundance, size, shape, and the degree of aggregation. These features are examined from a set of microscope slides of volumetric daily air samples taken by Hirst-type air samplers. The samples are from a continuous record in Cardiff City center and from short term sampling at selected sites around Cardiff. These slides are unique worldwide as they date from 1956 to 1996, and contain data which precedes any other measurements of PM10 (Particulate Matter less than 10 μm in diameter). The whole slide set cannot be examined due to the vast quantity of slides available, so the structured sampling of slides will be implemented based on epidemic years (e.g. influenza), availability of health data and incomplete sets of annual data from 1956.

2.2 *Image analysis*

Image analysis has not been used previously to examine PM10 from slides taken by Hirst-type traps, but it has been demonstrated as an important application in alternative projects (Houghton, 1992). Image Analysis is a system that employs a computer to obtain information from an image via the extraction of quantitative geometric and densitometric data. It can perform simple but tedious measurements quickly making it an important tool for this project and also gives a qualitative subjective comparison. The system used for this project is the Aequitas IA System developed by Dynamic Data Links Ltd., UK.

The first stage of the process is to start a specially designed macro, where a series of commands are grouped together as a single command to accomplish a task automatically, and speed up the process. The first stage of the macro is to capture the image (Figure 1). This covers the conversion of the image into an electronic signal suitable for digital processing and storage. The optimisation of the picture during this stage makes ensuing computation uncomplicated, rapid, and more accurate. It is also important to check that the focusing of the microscope is accurate, to ensure a flat field, so the edges of the field are in focus when the center is.

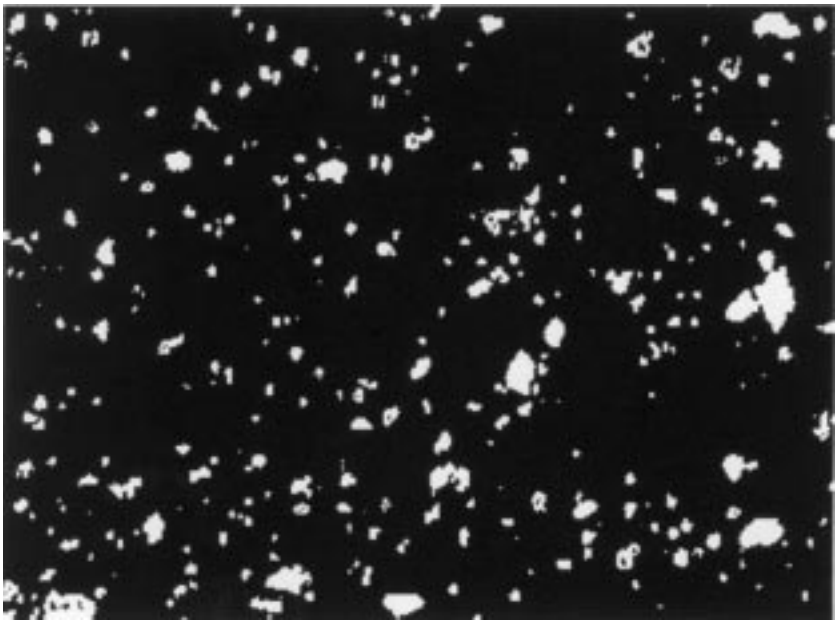

Figure 2. Correct Binary Threshold Image by IA.

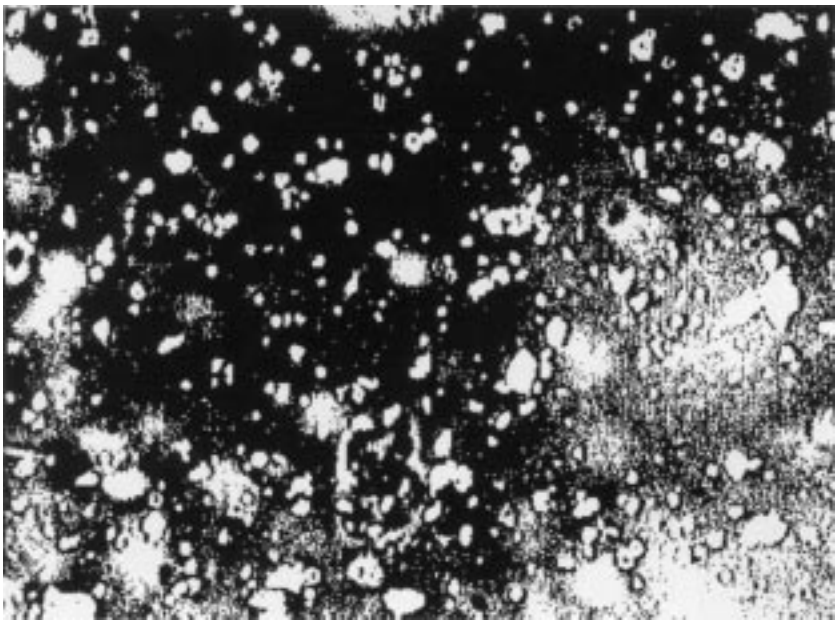

Figure 3. The binary image where the threshold limit has been set too high.

The next stage is establishing the threshold of the sample, which is determined by eye. Thresholding is a process that analyses all tones and determines all those below a selected level are treated as black and those above as white, and hence termed background. Thresholding is a major consideration in measuring particles and obtaining a correct threshold can be difficult (Figure 2). There are various methods of thresholding but the simplest and the most common, which is used in this analysis is setting the binary image to superimpose the grey image, but if this is not done carefully the threshold may be set too high

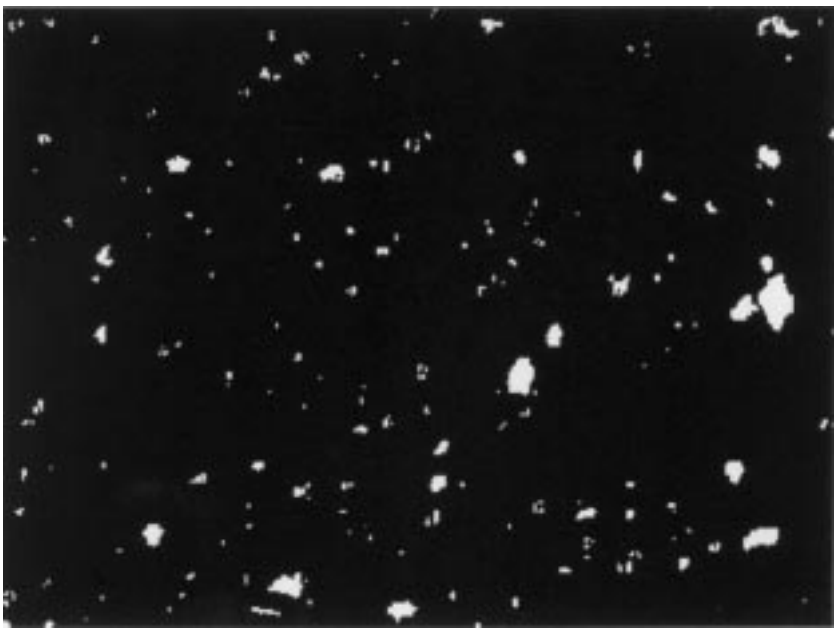

Figure 4. The binary image where the threshold limit has been set too low.

(Figure 3). Noise is a problem in a threshold too high, which spreads the grey level, and areas that are really separate may start to overlap. This results in an overcalculation of the number and measurements of the particles. The other difficulty is setting the threshold too low, which results in the undercalculation in the number of particles and their measurements (Figure 4). To overcome these problems the detection level is standardised and in some cases it may be possible to introduce a correction factor.

3. Analysis of results

The image analysis system can obtain a variety of results, which is dependent on what is defined as the area of interest (Table 1). These include analysis of the **region** (provides data on detected areas in the defined region of interest), **objects** (provides data for discrete detected objects in the defined region of interest) or **lines** (provides data on user defined lines). After the results are obtained, data can be classified, which is important as thousands of individual measurements can be difficult to interpret. For example, if data is classified, results may be better interpreted from graphical representation. Classification can also exclude unnecessary data, for example in the case of this project; particles that are too large can be excluded from the study. This projects also classifies data into groups, particles with a maximum diameter below 2.5 μm (ultra-fine particles), then 2.5–10.0 μm (fine particles) and finally those above 10 μm (Coarse particles). The data for the project is saved in an image database. This is a useful program as it allows the data to be stored together with the image analysed. In addition data is stored in Microsoft's Excel where all data is transferred directly to the program, via a macro, so it can be analysed statistically. The project will then analyse this data against environmental factors, mortality and hospital admissions of cardiovascular and respiratory illness in the Cardiff area.

Table 1. Areas of interest

Region	Objects	Line
Percentage Area Detected	Actual Area	Angles
Percentage Area Undetected	Average Intensity	Intercepts
Area Detected	Center of Gravity	Length
Area Undetected	Circularity	Profile
Histogram	Class Label	
	Enclosed Area	
	Maximum Diameter	
	Object Count	
	Object Edge	
	Orientation	
	Perimeter	

4. Conclusion

Hopefully this project will demonstrate that the technique is an effective application in the measurement of airborne particulate matter as image analysis has a number of major advantages. It can perform calculations much swifter than if performed manually. It executes the quantification of an image better than the human eye, and greater certainty can be attached to the quantitative results obtained, rather than those performed manually. The errors included in data are not normally as great compared to analysis by a non-automated procedure.

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