Particulate matter assessment in the context of health impact study in Abu Dhabi (United Arab Emirates)

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A project dealing with the quantitative assessment and chemical characterisation of particulate matter (PM) in Abu Dhabi started in early 2009. By measuring PM in two size categories, respirable and fine particles, an estimation of the natural background fraction and the anthropogenic contribution shall be made. Ten monitoring stations, which are distributed over the Abu Dhabi Emirate, are the basis for the Abu Dhabi (AD) air quality monitoring programme. Intensive particle measurements at three of the sites involve continuous monitoring of PM10 and PM2.5 and daily filter samples. There are indications for a large regional contribution for both PM10 and PM2.5 at all three stations. The fundamentals and objectives of the project and first results are presented here.

Situation

Abu Dhabi is the biggest of the United Arab Emirates, which are located on the Arabian Peninsula. The rapid economic growth of the emirates over the most recent decades as a result of oil extraction was connected with increasing emissions from the transportation, power and industrial sectors, leading to a degradation of the air quality situation. As in most urban regions in the world, PM10 and NO_2 levels are the biggest problems in AD. However, due to its location in the desert, Abu Dhabi also has a relatively high, naturally occurring, level of particulate matter in the ambient air.

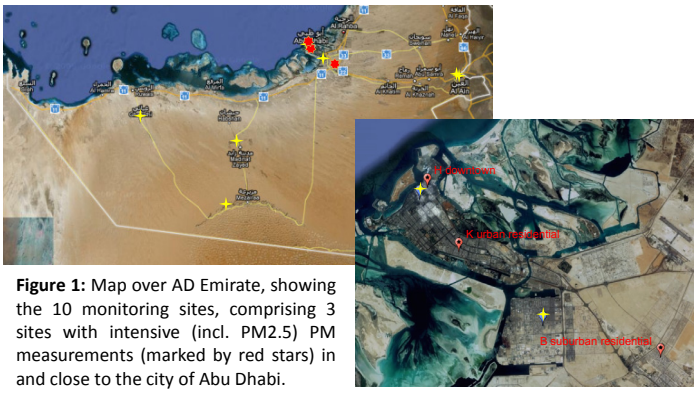

Figure 1: Map over AD Emirate, showing the 10 monitoring sites, comprising 3 sites with intensive (incl. PM2.5) PM measurements (marked by red stars) in and close to the city of Abu Dhabi.

Particle Health Effects

The adverse health effects of particulate matter are undoubted today. However, which particles pose the greatest threat to health is subject of discussion. Even though PM10 mass is the internationally recognised parameter to legislatively control the particulate matter content in ambient air, from the health effect point of view, PM2.5 mass concentrations are considered to be more relevant (e.g. Pope and Dockery, 2006). Particles indicated by PM2.5 remain suspended in air for longer periods of time and can be breathed more deeply into the lungs than larger particles. Apart from the size, the chemical composition of a particle is crucial for its health impact.

Due to health considerations, PM10 air quality standards (see table) are set, but they differ in different regions of the world. The high natural PM background in Abu Dhabi may be the reason for a somewhat higher limit value here.

Table: Air Quality Standards (AQS) for particulate matter in Europe, USA and the Abu Dhabi Emirate (24 h / annual limits, in µg/m³).

	WHO AQG [a]	EU AQS	USA NAAQS	AD AQS
PM10	50 / 20	50 / 40 [b]	150 / (50) [d]	150 / –
PM2.5	25 / 10	– / 25 [c]	35 / 15	– / –

[a] Air Quality Guideline (WHO, 2006); [b] EC-Directive 99/30/EC, annual limit changes as from 2010: 50 / 20 µg/m³; [c] EU target value, CAFE-directive, limit value coming into force in 2015; [d] 2006 revision of US National Ambient Air Quality Standards revoked annual PM10 standard

Instrumentation

Ten air quality monitoring stations are operative in the Abu Dhabi Emirate. PM10* is measured at all stations; PM2.5* is additionally measured at three of them, which are located in and close to AD City (Figure 1). Daily filter samples are taken at different sites in succession with a sequential sampler, which is moved after a period of four weeks in each case.

Methodology

To figure out the significance of the frequent PM10 exceedances in Abu Dhabi, it is necessary to know the origin of the particles, their size class and composition. This information is expected from the mass ratio method. The mass ratio PM2.5/PM10 gives an indication for the relative importance of natural and anthropogenic sources to particulate matter. The additional chemical speciation of the PM2.5 filter samples will give more insight into possible health impacts of particulate matter at AD sites. PTFE-filters will be analysed for inorganic ions and elemental composition, whereas the analysis of quartz filters will give information about carbonaceous species. The elements can be interpreted as source specific markers, e.g. Zn (tyre wear), Cu, Fe, Sb, Sn (brake wear), V (fuel combustion), Ni (heavy oil combustion), whereas Al, Si, Ca, Ti, Mn, Fe, Sr, K, Mg are crustal elements. Air mass origin and meteorological conditions have to be considered as well in the analysis.

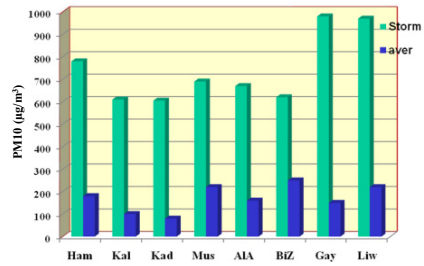

Figure 2: Average PM10 concentrations at 8 AD sites and levels during dust storm (3 March 2009).

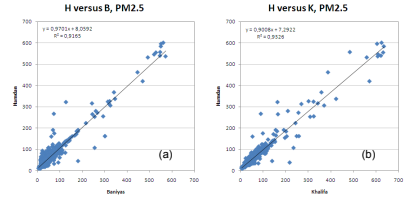

Figure 3: Scatter plots of PM2.5 mass concentrations (µg/m³) from a downtown street site (H) and **(a)** a suburban residential (B), **(b)** an urban residential (K) site.

First Results

High average PM10 levels are found at Abu Dhabi sites (blue bars in Figure 2). The levels at a regional background site (Liw) are as high as at an industrial site (Mus). The chemical speciation of the PM is required to assess possible health impacts. During dust storm events, PM10 concentrations can exceed 1000 µg/m³.

A comparison of hourly PM2.5 concentrations from three urban AD sites is shown in Figure 3. Very high correlations between all sites were found, although the sites were assumed to be influenced by different sources. The uniform PM2.5 distribution indicates that not only PM10, but also PM2.5 poses a regional problem

Summary and Conclusions

- Presentation of project and objectives
- Only preliminary results to date
- PM10 exceedances at remote and city sites
- Large regional contribution also found for PM2.5

References

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* Beta attenuation method in both cases.

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