22 The completely automated MARGA system for monitoring air quality

Why does air quality need to be monitored?

One of the most serious cases of air pollution occurred during the Great London Smog of December 1952. Because of the particular meteorological conditions and the especially cold temperatures for the time of year that accompanied them, inhabitants burnt increasing amounts of coal, in order to keep their homes warm. Because this coal was of poor quality, large quantities of SO_2 were emitted into the foggy city air, so the concentration of SO_2 at peak times rose to up to 0.69 ppm (1.83 mg/m^3)[1].

Although the winter smog – a mixture of fog and smoke/waste gases – only hung over the city for four days in total, 12,000 people died during this time and in the weeks that followed as a direct consequence of this air pollution, most of them from respiratory illnesses. The smog, with its serious effects, was the inducement to draw up the «Clean Air Act», a piece of legislation containing measures to reduce air pollution, which was passed by the British Parliament in 1956 and remained in force until 1964.

Application report

Measuring station for air quality monitoring: among the analyzers installed in this portable building is a MARGA system, which can be operated fully automatically over an extended period of time.

The air pollution described above is certainly an extreme example, but one should not forget that the present air pollution still has serious implications for the environment and our health. Research into and understanding of the effects of air pollution and air constituents on climate and our health are of great importance. Air pollution is not caused solely by gaseous compounds, but also by aerosols and particulate matter (PM). These extremely fine particles enter the lungs and damage them; from there, ultrafine particles can spread throughout the body by way of the blood cells and lead to inflammation symptoms. Although these risks are being discussed and researched actively around the world, it is still not known which compounds exactly lead to damage. Consequently, there is a great need for more specific measurement data and data from long-term measurements. Fast measurement methods and real-time measurements of the concentrations of the chemical compounds in the ambient air are essential and should make it possible to understand the circumstances better.

Traditional measuring methods with weaknesses

A number of the rather traditional measuring methods used to analyze air are based on what are known as denuders (diffusion separators to separate out gases) and filters. The measurement systems equipped with denuders and filters draw in air, and gases are absorbed on a coating of absorber on the inner walls of the denuder. Aerosols or particulate matter, by contrast, pass through the denuder before being collected by filters. This sampling normally takes place over a prolonged period (typically a day or longer), before the systems are returned to the laboratory for the actual analysis.

Although it is possible to obtain a good overview of the air constituents with the traditional measuring methods, there are a few serious drawbacks. The most significant drawback is the averaging of the data. The analysis results from the laboratory only indicate the average concentration of the particular compound over the sampling period. Because the sampling typically takes a day or longer, it is impossible to make any specific comments about the different concentrations at various times during the day.

Another drawback is the handling of the denuders and filters. There are numerous manual steps, which need to be performed very conscientiously, in order to prevent any contamination.

Furthermore, the analyses are time-consuming and gases and aerosols cannot be determined simultaneously in systems with a traditional setup.

[1] Mortality and Morbidity during the London Fog of December 1952. Reports on Public Health and Medical Subjects No. 95. London, Ministry of Health, 1954.

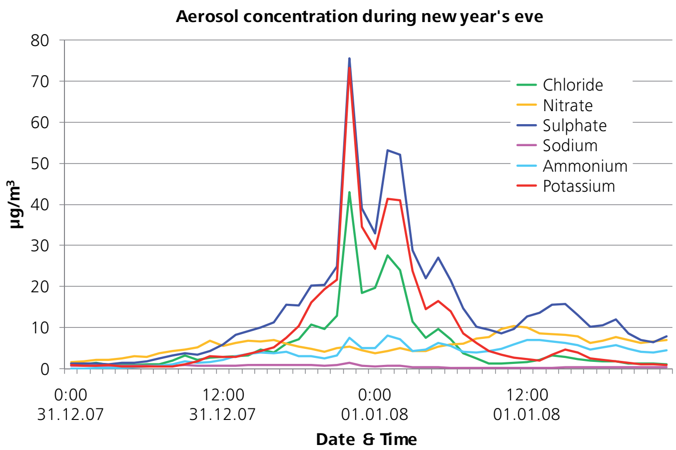
The MARGA system at a glance. On the top shelf of the unit is the box with the air inlet, the diffusion separator and the steam-jet aerosol collector as well as some peristaltic pumps to convey the auxiliary reagents. The box on the middle shelf contains the sample introduction system, the two ion chromatographs for determination of anions and cations as well as a built-in computer with hinged display. The bottom shelf accommodates the storage containers for the eluents, standards, etc., as well as an uninterruptable power supply (UPS) and a vacuum pump.

With the MARGA system for air quality monitoring (MARGA = **M**onitor for **A**e**R**osols & **G**ases in Ambient **A**ir) it is possible to analyze the gas and aerosol composition of the surrounding air practically simultaneously and continuously. MARGA is the result of a partnership between the Dutch Metrohm subsidiary Applikon Analytical and the Dutch Energy Research Center (ECN), the biggest research center for renewable energy in The Netherlands. Originally the system was developed by ECN. The analytical part of the measuring device consists of two Metrohm ion chromatographs for determining anions and cations.

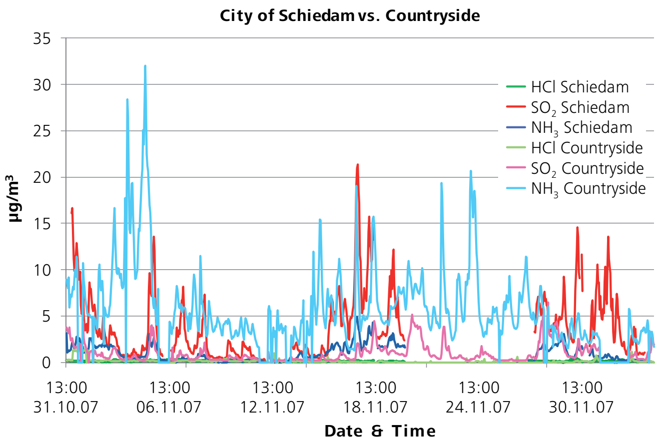
Air is sucked into the MARGA analyzer through a size-selective particle separator (e.g. cyclone). Thus the size of the particles for analysis can be limited, for example, to a diameter of less than 10 or 2.5 µm.

In the rotating diffusion separator, known as wet rotating denuder or WRD, a thin layer of water absorbs the gases from the air. Fully automatically, the solution with the absorbed gases is removed continuously from the WRD, collected, and then transferred to two ion chromatographs, where the concentrations of cations and anions are determined hourly. The quantity of water in the WRD is kept constant by a continuous flow of water. The air from the WRD, which is now free of gases, lands in a steam-jet aerosol collector (SJAC). There the particulate part of the aerosol is transferred to the liquid phase through the injection of steam. During this procedure, the aerosol particles in the supersaturated steam act as condensation nuclei, which grow constantly by absorbing water and, finally, are separated out mechanically in a glass spiral (cyclone). The resulting solution is collected and its anion and cation content determined hourly by means of two ion chromatographs.

The whole MARGA system operates autonomously and provides the detailed gas and aerosol concentrations every hour. New solutions only need to be added once a week. MARGA is therefore ideal for field use in remote regions.



Air pollution due to New Year's Eve fireworks in the Netherlands: aerosol concentrations of selected compounds.



One-month air quality monitoring with MARGA. Comparison of the concentrations of selected species between town and country.

Examples of some measurements with MARGA

Graph 1 shows the aerosol concentrations of a few selected compounds measured with MARGA on a New Year's Eve in the Netherlands. It can be seen clearly that the system has an extremely short response time; the concentration of some typical compounds increases as soon as it is legally permissible to let off fireworks.

MARGA is also ideal for collecting measurement data over several months. Graph 2 shows the results of one-month air quality monitoring at two different sites (town and country). The concentrations of almost all species are subject to sharp fluctuations at both sites. Differences between the two sites can also be seen; for example, in the rural area the concentration of NH_3 is much higher than in the town.

These two examples illustrate some of the advantages of the MARGA air quality monitoring system: hourly results, completely automated continuous operation, and simultaneous determination of the gas and aerosol composition of the surrounding air. MARGA has been used successfully for a few years now in Korea, the United Kingdom, the United States and the Netherlands, and more recently also in Finland and Germany. A long-term contract has also been signed with the U.S. Environmental Protection Agency (EPA), with the ultimate objective of equipping all its measuring stations in the Clean Air Status and Trends Network (CASTNET) with MARGA systems.

With the Particle Into Liquid Sampler (PILS) Metrohm offers you a second device for aerosol sampling. When it is coupled with Metrohm ion chromatographs, it is possible to determine the ionic composition of aerosols (particulate part) automatically. No additional sample preparation is required for this. Further information about PILS can be found in our new brochure «Analysis of Aerosols / PILS – IC» (document number 8.108.5006EN), which you can download from http://products.metrohm.com or obtain through your Metrohm representative.