For a cleaner environment, healthier today and tomorrow for Croatian citizens

A Modern Air Quality Measurement and Control System for Protecting Human Health and the Environment

Expansion and Modernisation of the National Network for Continuous Air Quality Monitoring

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AIRQ: A Modern Air Quality Measurement and Control System for Protecting Human Health and the Environment

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AIRQ

Expansion and Modernisation of the National Network for Continuous Air Quality Monitoring

Beneficiary:
Croatian Meteorological and Hydrological Service

DHMZ

Project Partner:
Institute for Medical Research and Occupational Health

Institut za medicinska istraživanja i medicinu rada

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More information on EU funds can be found on the website of the Ministry of Regional Development and EU Funds: www.strukturnifondovi.hr

Branka Ivančan-Picek, PhD

Director-General, Croatian Meteorological and Hydrological Service (DHMZ)

The largest modernisation in DHMZ history ends this year. Modernising the meteorological, hydrological and air quality monitoring networks is important to Croatia's transformation into a climate-neutral community. In implementing the AIRQ project in partnership with the Institute for Medical Research and Occupational Health, we have shown our active commitment to protecting the health of our fellow citizens and preserving the environment. The project has established a comprehensive air quality measurement and control system, ensuring 100 % coverage and acquisition of real-time air quality data on the Croatian territory where inhabitants live. The ability to diagnose air quality conditions has been improved, including the basis for making projections, determining the origin of pollution, and implementing appropriate measures to protect and improve air quality. The results of the AIRQ project set the conditions for healthier and cleaner air for the present and future generations.

Jadranka Škevin-Sović

AIRQ Project Leader, Head of the Air Quality Sector, Croatian Meteorological and Hydrological Service (DHMZ)

The project has built and modernised 24 air quality monitoring stations across Croatia. The equipment at the DHMZ Chemical and Calibration Laboratory has been modernised and replaced, as well as the equipment at the IMI chemical laboratory with instruments necessary for analysing precipitation, particulate matter and air samples and to ensure traceability and measurement quality. The computer infrastructure at the DHMZ has been upgraded, as well as the model for estimating ground concentrations of pollutants in areas of Croatia where there are no measuring stations. AIRQ has provided additional information on air quality so that more effective measures can be adopted for a better and healthier life for all of us.

Gordana Pehnec, PhD

Project Coordinator, Institute for Medical Research and Occupational Health (IMI)

The project provides equipment for physicochemical analyses of particulate matter at national network stations for permanent air quality monitoring. The modern equipment will facilitate measuring the chemical composition of particulate matter in line with the EU legal framework and provide the latest insight into their impact on health and the environment. Increasing the number of stations where PM_{10} and $PM_{2.5}$ particulate matter are measured offers greater insight into their spatial and temporal distribution, as well as relevant information on the exposure of Croatian citizens.

Modernisation of 18 existing and construction of 6 new stations

for monitoring air quality has enabled AIRQ to double the relevant data coverage on air quality in terms of the number of inhabitants, especially in urban areas.

AIRQ has improved the computer model

for assessing ground-level concentrations of pollutants in regions of Croatia not equipped with measuring stations.

AIRQ has modernised the equipment at the DHMZ chemical laboratory

used for analysing precipitation and the air, equipment at the IMI chemical laboratory used for analysing airborne particles and equipment at the DHMZ calibration laboratory for ensuring precise air quality measurements.

AIRQ has upgraded the DHMZ computer infrastructure

enabling greater availability of air quality information and timely notification of the public and state institutions.

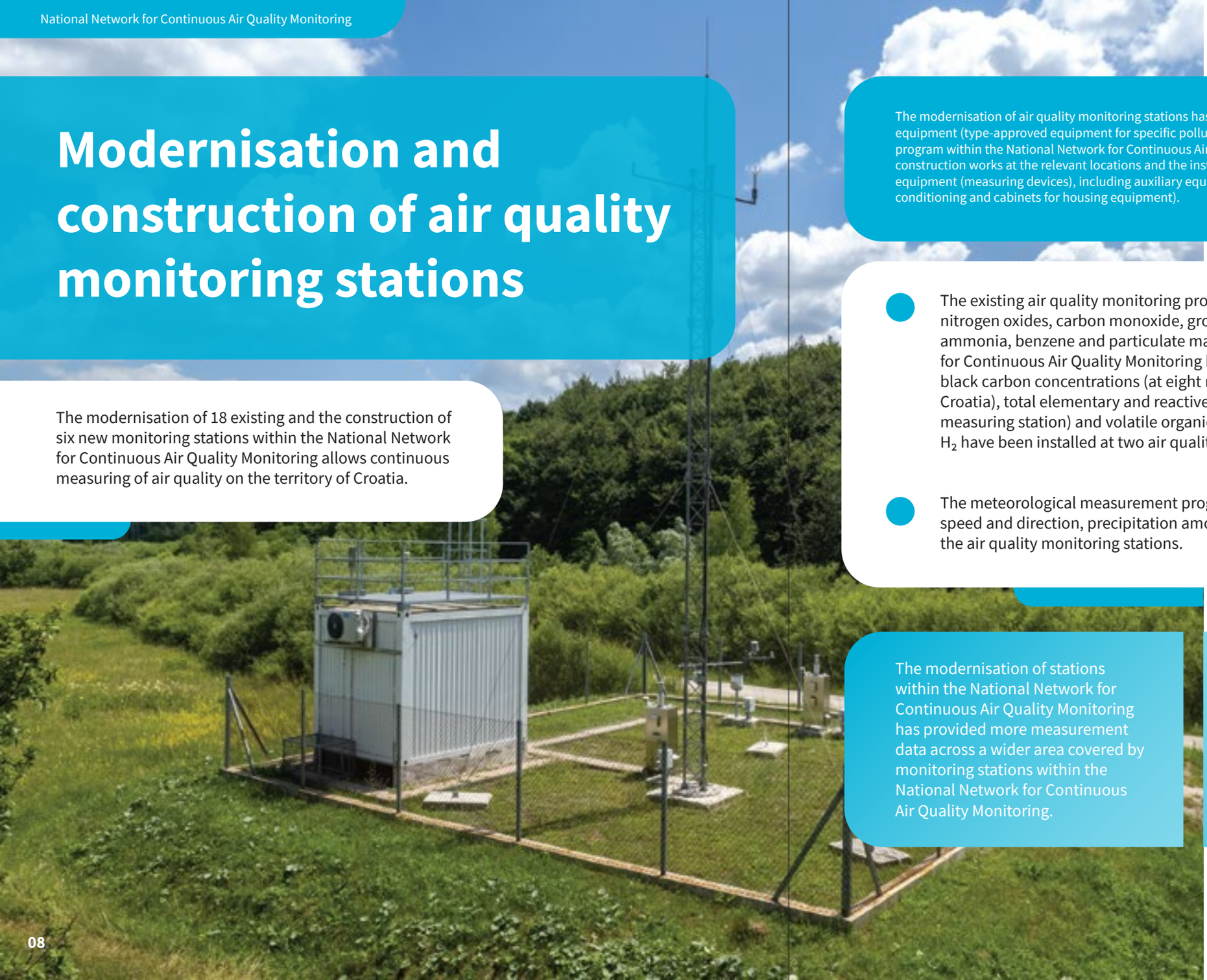
AIRQ has ensured support for implementing the Air Protection Act

and the development of sustainable strategies, key to the planning and implementation of measures for improving monitoring and reduction of pollutants that have a negative impact on the climate and people's health.

Clean air is our primal need, whereas polluting it knows no boundaries.

Modernisation and construction of air quality monitoring stations

The modernisation of 18 existing and the construction of six new monitoring stations within the National Network for Continuous Air Quality Monitoring allows continuous measuring of air quality on the territory of Croatia.



The modernisation of air quality monitoring stations has been made possible by procuring new measuring equipment (type-approved equipment for specific pollutants) and setting up six new stations for the monitoring program within the National Network for Continuous Air Quality Monitoring. This modernisation required construction works at the relevant locations and the installation of new containers for accommodating monitoring equipment (measuring devices), including auxiliary equipment (such as anti-theft and fire protection systems, air conditioning and cabinets for housing equipment).

- The existing air quality monitoring program (pollutants such as sulphur dioxide, nitrogen oxides, carbon monoxide, ground-level ozone, hydrogen sulphide, ammonia, benzene and particulate matter $PM_{10}/PM_{2.5}$) within the National Network for Continuous Air Quality Monitoring has been expanded by additionally measuring black carbon concentrations (at eight monitoring stations in different parts of Croatia), total elementary and reactive mercury (using an automatic method at one measuring station) and volatile organic compounds. Analyzers for CO, CO_2, CH_4, and H_2 have been installed at two air quality monitoring stations.

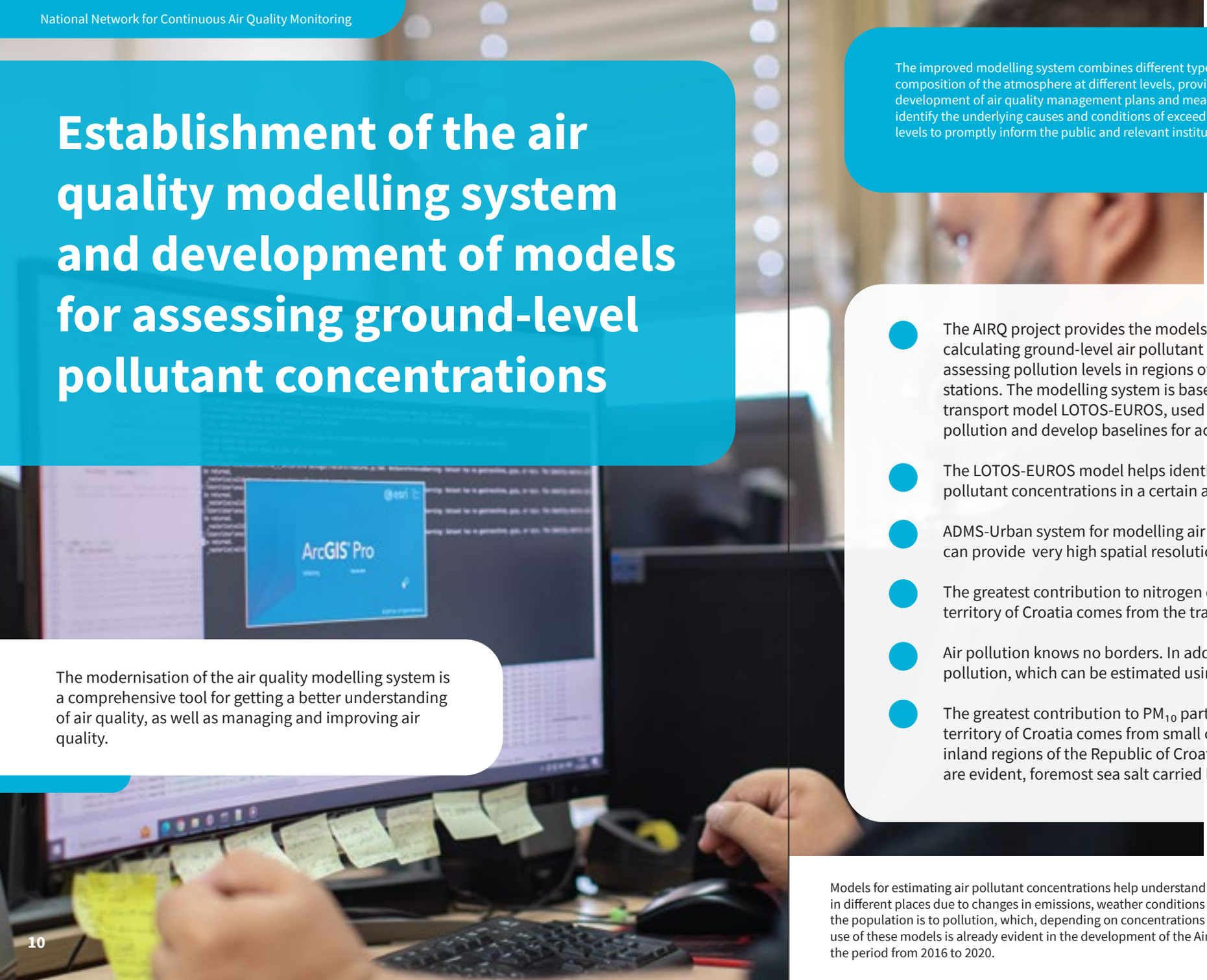
- The meteorological measurement program (air temperature, relative humidity, wind speed and direction, precipitation amount, and air pressure) has been modernised at the air quality monitoring stations.

The modernisation of stations within the National Network for Continuous Air Quality Monitoring has provided more measurement data across a wider area covered by monitoring stations within the National Network for Continuous Air Quality Monitoring.

Air quality measurement data will facilitate performing statistical analyses of air quality measurements for quality assessments and ensure expert analyses and the study of atmospheric processes in the outside air.

Establishment of the air quality modelling system and development of models for assessing ground-level pollutant concentrations

The modernisation of the air quality modelling system is a comprehensive tool for getting a better understanding of air quality, as well as managing and improving air quality.



The improved modelling system combines different types of numerical analyses and forecasts of the chemical composition of the atmosphere at different levels, providing precise data for different purposes, such as the development of air quality management plans and measures, with the aim of improving air quality. It helps identify the underlying causes and conditions of exceeding stipulated target values, as well as forecast pollution levels to promptly inform the public and relevant institutions and thus protect the health of citizens.

- The AIRQ project provides the models (LOTOS_EUROS and ADMS-Urban) for calculating ground-level air pollutant concentrations to ensure data acquisition for assessing pollution levels in regions of Croatia where there are no monitoring stations. The modelling system is based on the internationally recognised chemical transport model LOTOS-EUROS, used in Europe and the world to estimate air pollution and develop baselines for action plans.
- The LOTOS-EUROS model helps identify which emission source mostly contributes to pollutant concentrations in a certain area.
- ADMS-Urban system for modelling air quality, given detailed emission information, can provide very high spatial resolution concentration maps.
- The greatest contribution to nitrogen dioxide concentrations in the outside air in the territory of Croatia comes from the transport sector, small combustion and industry.
- Air pollution knows no borders. In addition to local, there are also transboundary air pollution, which can be estimated using modelling.
- The greatest contribution to PM_{10} particle concentrations in the outside air on the territory of Croatia comes from small combustion, especially in densely populated inland regions of the Republic of Croatia. In coastal areas, effects from natural sources are evident, foremost sea salt carried by the wind.

Models for estimating air pollutant concentrations help understand how pollution concentrations change over time in different places due to changes in emissions, weather conditions and the climate. They help assess how exposed the population is to pollution, which, depending on concentrations and the duration, can affect people's health. The use of these models is already evident in the development of the Air Quality Assessment in the Republic of Croatia in the period from 2016 to 2020.

Modern laboratory equipment for analysing the chemical composition of the atmosphere, aerosols and precipitation

Integrating new devices into the DHMZ and IMI chemical laboratories has led to better laboratory analytical capacities for tracking air quality and precipitation.

Equipping laboratories with modern instruments has been an important factor in the comprehensive air quality control system to meet European and national criteria for protecting people's health and the environment.

DHMZ chemical laboratory

The laboratory was founded in 1965 and performs activities related to the precipitation and air quality at 20 stations – 14 at DHMZ meteorological stations and six within the National Network of Continuous Air Quality Monitoring. The meteorological stations at Putijarka and Zavižan are also EMEP stations.

The analysis methods used at the DHMZ Chemical Laboratory have been accredited according to standard HRN EN ISO/IEC 17025 since 2013.

Equipping the laboratory included procuring new devices and training experts in handling the devices to quantitatively and qualitatively analyse air and precipitation samples sourced from measuring stations.

Air and precipitation samples have also been procured, including sequential air samplers and large-volume air samplers, including wet-only and bulk precipitation samplers. The devices have been installed at six rural stations in the national network from which weekly and monthly precipitation and air samples arrive at the chemical laboratory. An analysis of these samples is conducted for the purpose of tracking the cross-border transmission of pollutants, sedimentation of pollution and calculating the critical environmental load.

Equipping the DHMZ chemical laboratory required procuring analytical instruments:

- **Gas chromatography-mass spectrometry (GC-MSMS):** used to quantitatively determine polycyclic aromatic hydrocarbons from precipitation and air samples
- **Ionic chromatography (IC):** used to quantitatively identify the major ions in samples of precipitation and inorganic components from precipitation and air samples

As well as laboratory equipment:

- Device for automated extraction of precipitation samples
- Device for automated extraction of solid samples
- Centrifuge, shakers, washer for laboratory vessels, climate chambers, driers, ultrasonic baths, laboratory refrigerators

What are polycyclic aromatic hydrocarbons or PAHs?

Polycyclic aromatic hydrocarbons or PAHs (Trademark Act).

PAHs are a group of compounds with two or more benzene rings. They are found in car exhaust fumes, formed during forest fires, volcanic eruptions, insufficient combustion of wood, and industrial processes. PAHs can pollute water, air and soil.

The major ions in precipitation and inorganic components which we track in the air

Inorganic components in the air are:

sulphur dioxide SO_2
ammonia NH_3
sulphates SO_4^{2-}
nitrates NO_3^-
chlorides Cl^-
ammonium NH_4^+
sodium Na^+
potassium K^+
calcium Ca^{2+}
magnesium Mg^{2+}

The major ions in precipitation are:

sulphates SO_4^{2-}
nitrates NO_3^-
chlorides Cl^-
ammonium NH_4^+
sodium Na^+
potassium K^+
calcium Ca^{2+}
magnesium Mg^{2+}

IMI Chemical Laboratory

The IMI chemical laboratory operates within the Environmental Hygiene Unit, which has been engaged in outdoor air research for more than 60 years and has been accredited according to HRN EN ISO/IEC 17025 since 2010.

The chemical laboratory conducts sampling and physicochemical analyses of PM_{10} and $PM_{2.5}$ and the equivalence of non-referential methods for determining the mass concentrations of PM_{10} and $PM_{2.5}$.

What is airborne particular matter?

Airborne particulate matter or PM are very tiny particles invisible to the naked eye that float in the air. It contains a complex mixture of various solids and liquids, some harmful to human health or the environment. The number after the PM designation (e.g., PM_{10} and $PM_{2.5}$) indicates their size, i.e., diameter in micrometres (μm). The smaller the particles, the smaller the diameter, and the more dangerous they are to health due to their ability to penetrate the respiratory system more easily and deeply. The sources of these particles are natural (e.g., forest fires, desert sand, soil particles, marine aerosols) and human (e.g., industrial processes, burning fossil fuels, transport).

The analysis results are used for:

- Assessing air quality (categorisation)
- Assessing a possible increase in pollution levels
- Facilitating analyses of the distribution of pollution sources
- Modelling
- Gaining a better understanding of atmospheric airborne particles

Modern equipment ensures the proper monitoring of a large number of chemical substances in the air compared to current possibilities, providing more effective measurements, a better air quality management system, and the implementation of a legislative framework for air and environmental protection for the benefit of each individual and society as a whole.

New equipment at the IMI chemical laboratory includes:

- **Inductively coupled plasma mass spectrometry (ICP-MS)** is used for identifying metals in PM_{10} airborne particulate matter.
- **X-ray fluorescence (XRF) spectrometry** enables the simultaneous identification of a larger number of chemical elements in airborne particulate matter.
- **High-performance liquid chromatograph** is used for identifying polycyclic aromatic hydrocarbons (PAHs) in airborne particulate matter.
- **Organic carbon and elemental carbon analyser**
  Organic and elemental carbon is determined in $PM_{2.5}$ particles.
- **Ionic chromatography for determining molecular markers of organic carbon**
  Molecular markers of organic carbon are sugar anhydrides where its presence in airborne particulate matter indicates the burning of biomass.
- **Dual-channel ion chromatography equipped with a mass spectrometer and conductometric detector**
  It is used for determining inorganic compounds in airborne particular matter Cl^-, NO_3^-, SO_4^{2-}, Na^+, NH_4^+, K^+, Mg^{2+} i Ca^{2+}. ions.

Determining the chemical composition of airborne particulate matter is essential in terms of public health. It also provides valuable data for assessing the main sources of air pollution from airborne particulate matter, which is important for plans to improve air quality.

Equipping the DHMZ calibration laboratory to ensure traceability and proper air quality measurements

Acquiring homogenous and reliable data on air quality requires the regular calibration of all measuring devices and ensuring measuring traceability according to international standards.

Equipping the DHMZ calibration laboratory through the procurement and modernisation of instruments and measuring equipment necessary for calibrating air quality measuring devices and related measuring quantities ensures the traceability of measurements according to reference standards. The technical foundation of the laboratory consists of analysers and instruments procured by the project.

DHMZ calibration laboratory

The Calibration Laboratory Department establishes, calibrates, maintains, continuously develops and modernises the DHMZ standard base, ensuring the traceability of DHMZ measurements to national and international standards and SI systems. On 22 October 2020, the Calibration Laboratory Department was included in the database of the International Bureau of Weights and Measures (BIPM). Thus, the calibration laboratory confirmed its status as a state standard for ground-level ozone concentration, and the DHMZ gained global recognition for the calibration of scales with the highest accuracy standard for this parameter.

Reference air pollutant analysers validate the etalon system to generate a precisely set concentration of air pollutants measured by the analyser being calibrated.

Analyser ensured through the AIRQ project	Onečišćujuća tvar
analyser	ozone
analyser	sulfur diokside SO_2
analyser	nitrogen oxides NO, NO_2
analyser	carbon monoxide CO
analyser VOC	aromatic hydrocarbons: benzene, toluene, ethylbenzene, xylene (o,m,p)
analyser VOC C2-C6	volatile organic compounds (VOC)

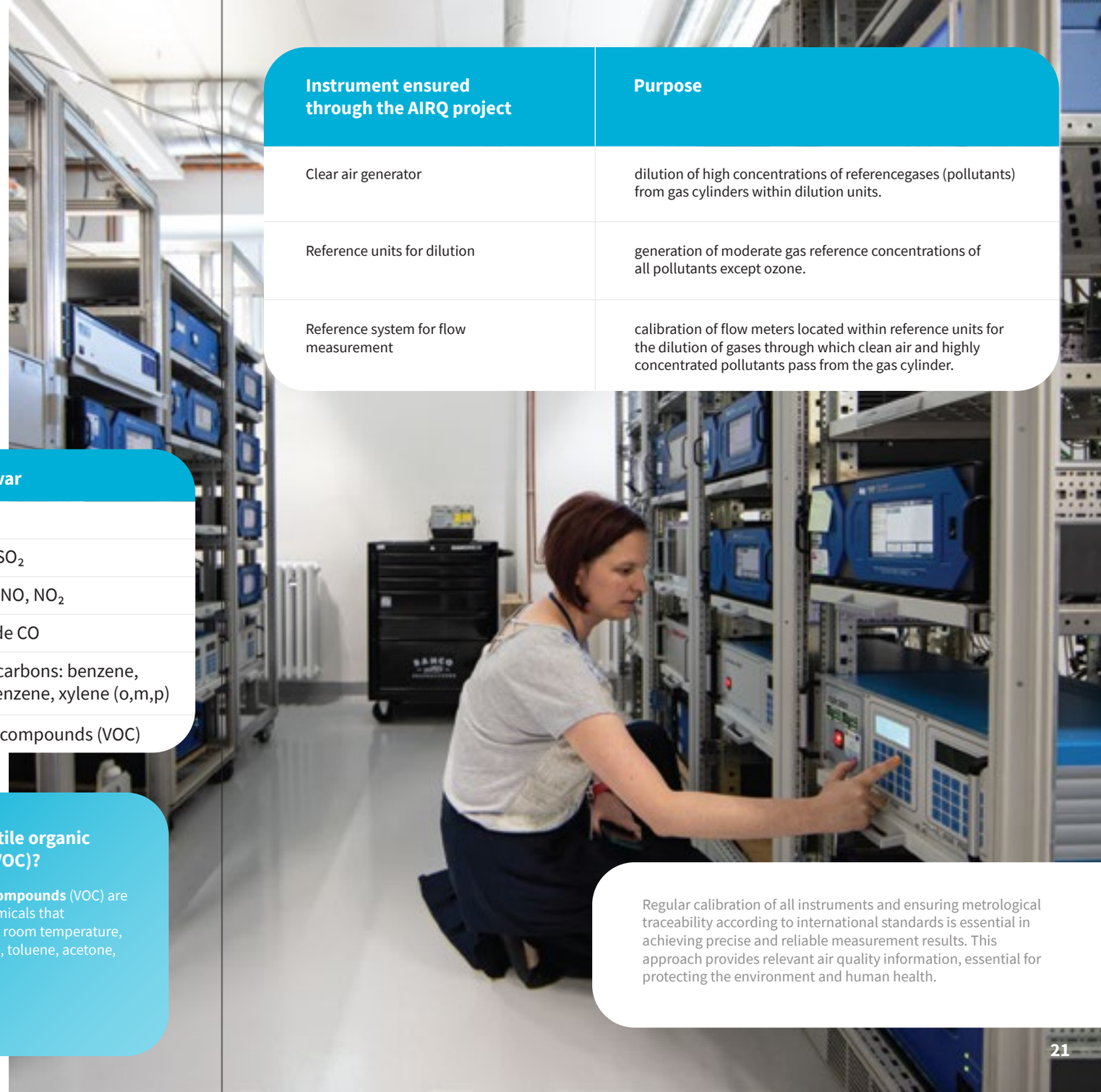
What are aromatic hydrocarbons?

Aromatic hydrocarbons or ARENS form a special group of cyclic hydrocarbons due to their characteristic structure and properties. The first aromatic hydrocarbons were isolated from aromatic resins, from where they got their name (aroma in Greek means fragrant herb).

What are volatile organic compounds (VOC)?

Volatile organic compounds (VOC) are carbon-based chemicals that evaporate easily at room temperature, e.g., formaldehyde, toluene, acetone, and ethyl alcohol.

Instrument ensured through the AIRQ project	Purpose
Clear air generator	dilution of high concentrations of referencegases (pollutants) from gas cylinders within dilution units.
Reference units for dilution	generation of moderate gas reference concentrations of all pollutants except ozone.
Reference system for flow measurement	calibration of flow meters located within reference units for the dilution of gases through which clean air and highly concentrated pollutants pass from the gas cylinder.



Regular calibration of all instruments and ensuring metrological traceability according to international standards is essential in achieving precise and reliable measurement results. This approach provides relevant air quality information, essential for protecting the environment and human health.

Upgrading the DHMZ computer infrastructure

The procurement and commissioning of the BullSequana XH2000 supercomputer has significantly increased computing capacities, allowing for faster forecasting, analysis and processing of measurement data.

The AIRQ project also allowed upgrading the DHMZ computer infrastructure to improve the availability of information on air quality and provide prompt and comprehensive information to the public and national institutions.

In addition to the supercomputer, AIRQ has ensured the procurement of two other essential components of the DHMZ IT system:

1. Upgrading the IT infrastructure by expanding the data storage and archiving system and the construction of a new backup system
2. Efficient and flexible management of the infrastructure and equipment using a virtual environment

Procuring computer equipment and upgrading the DHMZ infrastructure results in even more support for its primary activity, ensuring quality, prompt and reliable meteorological and hydrological information, analysis of air quality information and warnings of hazardous phenomena. Meteorological, hydrological and air quality information is used in making strategic decisions in society and various branches of the economy, food production, protection of human life and the environment that are increasingly exposed to disaster risks.

How does implementing the AiRQ project affect the quality of life for each of us?

- AIRQ has established a comprehensive system for measuring and controlling air quality in Croatia to protect the environment and human health. It implies protecting the health of all our fellow citizens but also helping to protect health-impaired persons, the ecosystem with support for efficient and sustainable agriculture and economic development, and necessary support in adapting to climate changes we witness every day.

- AIRQ has doubled the proportion of the Croatian population covered by relevant data on air quality in urban areas. It was achieved by building six new stations (Osijek-2, Zagreb-4, Omišalj on the island of Krk, Split-2, Split-3, Dubrovnik) and the modernisation of 18 existing stations for continuous air quality monitoring (Kopački rit, Osijek-1, Slavonski Brod-1, Kutina-1, Sisak-1, Zagreb-1, Zagreb-2, Zagreb-3, Desinić, Parg, Višnjan, Pula, Rijeka-2, Plitvica Lakes, Vela straža on Dugi otok, Polača, Hum on Vis, Opuzen).

- AIRQ has facilitated the development of a computer model for estimating ground-level pollutant concentrations in areas where, in the past, no measurements have been taken.

- AIRQ has provided additional equipment to the DHMZ chemical laboratory for sampling and analysis of the chemical composition of precipitation and air, the IMI chemical laboratory for sampling and determining mass concentrations and analyses of the chemical composition of airborne particles, and the measurement laboratory for the calibration of air quality measuring devices and related measurement quantities to ensure the traceability of the respective measurements to international standards.

- AIRQ has helped upgrade the DHMZ computer infrastructure for faster and better availability of information on air quality and all other DHMZ services and for the purpose of promptly informing the public and national institutions.

- AIRQ has provided the necessary support in implementing the Air Protection Act (OG 127/19, 57/22) and the development of sustainable integrated strategies and projects. All this has been a prerequisite for the adequate assessment, planning and implementation of appropriate measures to improve monitoring programs and the introduction of measures against pollutants that affect the climate.

AIRQ

Clean air is our fundamental need.
There are no boundaries for air pollution.

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