

Improving the Protection of Children Against Air Pollution Threats in Romania – The RokidAIR Project Approach and Future Perspectives

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This paper presents the approach used to develop the information chain required to reach the objectives of the EEA Grants' RokidAIR project in two Romanian cities i.e., Targoviste and Ploiesti. It describes the PM_{2.5} monitoring infrastructure and architecture to the web-based GIS platform, the early warning system and the decision support system, and finally, the linking of air pollution to health effects in children. In addition, it shows the analysis performance of the designed system to process the collected time series from various data sources using the benzene concentrations monitored in Ploiesti. Moreover, this paper suggests that biomarkers, mobile technologies, and Citizens' Observatories are potential perspectives to improve data coverage by the provision of near-real-time air quality maps, and provide personal exposure and health assessment results, enabling the citizens' engagement and behavioural change. This paper also addresses new fields in nature-based solutions to improve air quality, and studies on air pollution and its mental health effects in the urban areas of Romania.

Keywords: air pollution, benzene, descriptive statistics, health effects, decision support system, RokidAIR project

It is well documented that air pollution has negative health effects, and children's exposure to airborne pollutants is of special concern. According to the World Health Organisation (WHO) estimates, outdoor air pollution was responsible for the deaths of 3.7 million people under the age of 60 in 2012 [1]. One of the most problematic air pollutants in Europe in terms of human health is Particulate Matter (PM) [2]. The effects of PM on human health, which were widely studied in the last twenty years, include asthma, lung cancer and cardiovascular issues [3]. PM up to 10 micrometres in diameter (PM₁₀) is able to penetrate the bronchi. PM up to 2.5 micrometres (PM_{2.5}) can penetrate the lungs, while nanoparticles are able to pass through the lungs and enter the circulatory system [4]. In 2011, approximately 458,000 premature deaths were attributed to airborne PM in Europe [5].

Although there is consensus about the global scale of air pollution affecting the human life and the well-being of people, the problems remain [6]. For example, some common issues are inadequate air quality monitoring networks consisting of insufficient and inappropriately located, old and unreliable monitoring stations. There is a lack of up-to-date information on air quality levels with data published long after limit values have been exceeded and in complicated technical formats, which are difficult to be interpreted by citizens. Such problems are commonly occurring in countries located in Eastern Europe, including Romania [7].

In Romania, levels of outdoor air pollutants are lower today than in the past. However, in many urban areas, outdoor air pollution is still a concern [8]. Sedimentable dusts and suspended PM are the main air pollutants in Romania often exceeding the legal limits for various intervals of mediation. There are many residential areas under the permanent incidence of pollution, which determines high morbidity levels and numerous subclinical

symptoms especially in infants and small children [9]. At present, at the population level in Romania, research regarding the determination of differences in the health effects of PM with various chemical compositions originating from different sources is still at the beginning [10]. Moreover, studies focusing on children's exposure to air pollution and preventative actions to protect them in Romania, are required, but are still in the early phase [11].

The actual infrastructure of the Romanian air quality monitoring provides data only for a relatively limited portion of the residential areas [12]. Air quality monitoring should provide reliable and complete data for the specific characterization of the impact on residential areas focusing on vulnerable receptors at neighbourhood level (e.g., schools, kindergartens, maternities, hospitals, residential areas).

To address these issues, the EEA Grants' RokidAIR project (*Towards a better protection of children against air pollution threats in the urban areas of Romania*) aims to develop, test, validate, implement a PM_{2.5} monitoring system, and establish the environmental health knowledge base. The main objective of the RokidAIR is to protect the children against air pollution threats in Targoviste and Ploiesti, Romania, by providing information to citizens and authorities on PM_{2.5} emissions, i.e., air quality forecasts and early warnings [13, 14].

This paper describes the approach developed and implemented in the RokidAIR project, focusing on the methodology and implementation details, and expected products and services resulting from deploying the RokidAIR cyberinfrastructure. A case study that presents the capabilities of the web-based GIS geoportals for statistical processing of the reported benzene concentrations in Ploiesti between 2013 and 2014 from AirBase [15] and 2015 (raw data from National Network for Air Quality Monitoring (RNMCA)) was presented.

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Section 2 of this paper provides a brief overview of the concept and approach employed in RokidAIR from data collection to data dissemination; Section 3 discusses the methodology and implementation details; Section 4 highlights the expected products and services; and finally section 5 describes a case study on benzene time series analysis. The last section provides conclusions and details regarding the future work based on the results from the RokidAIR project.

RokidAIR concept and approach

RokidAIR is a three-year project funded by European Economic Area (EEA) Grants (<http://www.rokidair.ro/en>). It has been built upon the concept of improving urban air quality monitoring activities in Targoviste (73,964 permanent residents) and Ploiesti (197,542 permanent residents), Romania. RokidAIR aims to provide synthesized information concerning the $PM_{2.5}$ levels and its effects on children's health, an air quality forecast and a Decision Support System (DSS) that will raise awareness of the citizens on air quality, changing their common behaviour (fig. 1). To prove the concept and to realize its objective, $PM_{2.5}$ monitoring campaigns were performed using calibrated portable systems to determine $PM_{2.5}$ levels. The monitoring network prototype was developed resulting eight micro-stations that will be deployed in the envisaged monitoring points in the final phase of the project.

The RokidAIR concept and associated approach are based on the following: data/information sources, data fusion/integration and data/information access. RokidAIR enables the collection of air quality related data from publicly available sources and contributions from the RokidAIR monitoring system. These relational data sources include:

- historical levels of air pollutants database: from Airbase EIONET pollutant database recorded by eight stations located in two studied areas [9, 16];
- current levels of air pollution database: from the dedicated website of RNMCA (www.calitateair.ro) [15, 16];
- $PM_{2.5}$ monitoring and $PM_{2.5}$ database: recorded from RokidAIR sequential monitoring campaigns and continuous time series from the eight micro-stations [16];
- meteorological parameters database recorded at Targoviste (153750) and Ploiesti (153770) WMO stations (e.g., air temperature, wind speed and direction, relative humidity and precipitations - daily average values) [16];
- medical database includes number of wheezing episodes, number of asthma attacks (with hospitalization), response to inhalation medication, medication controller (yes/no), eosinophil count (normal value = 1-3%), serum level of Immunoglobulin E (IgE) (normal value < 60 units/

ml), and residential address and school/kindergarten address of the children [16];

- receptor database includes information regarding the address of kindergartens, schools, and paediatric hospitals, number of children, age groups, number of sensitive children, and indoor $PM_{2.5}$ levels [16].

The pollutants' data, meteorological data and medical data are pre-processed, stored into a relational database, and analysed with the RokidAIR web-based GIS functions [16]. Furthermore, the RokidAIR analysis system integrates an Artificial Intelligence (AI)-based forecasting module, a fusion algorithm for merging air quality information from the sources described above to provide value-added information on air quality forecast, air quality Early Warning System (EWS) and DSS to the public (fig. 1). The air quality early warning messages are designed to be sent out to those registered users via their emails and/or mobile phones.

Methodologies and Implementation

In the first step, a database with existent data for the envisaged urban areas was required to be developed to accomplish the goal of developing an air quality monitoring and forecasting system for urban environment and health management. Based on the database (e.g., pollutant emissions, meteorological data, topography, and number of children with respiratory illnesses), and modelling scenarios, critical areas (CAs) have been identified (fig. 1). In these CAs, sequential monitoring campaigns were performed to determine the $PM_{2.5}$ levels. Figure 2 illustrates the RokidAIR implementation phases (<http://www.rokidair.ro/en>). They include the following:

- preliminary studies of pollutant loads in the studied areas, ranking of CAs and system's prototyping and design;
- development of the monitoring system and infrastructure consisting of micro-station's sensors/hardware, the management system of the database, and the tools for geospatial analysis, pollutants' correlation and AI forecasting;
- testing and validation of the $PM_{2.5}$ monitoring system including adjacent data communication and processing infrastructure;
- promoting the RokidAIR system to be used by relevant stakeholders.

The current $PM_{2.5}$ levels were collected from the RNMCA website (www.calitateair.ro). The monitoring campaigns were performed in 12 sampling points in Ploiesti, and 10 points in Targoviste, respectively. All data were stored in the RokidAIR web-based GIS server. In the RokidAIR web-based GIS, the georeferenced layers allowed the spatiotemporal characterization of vulnerable areas in each city through the application of geospatial analysis. Medical

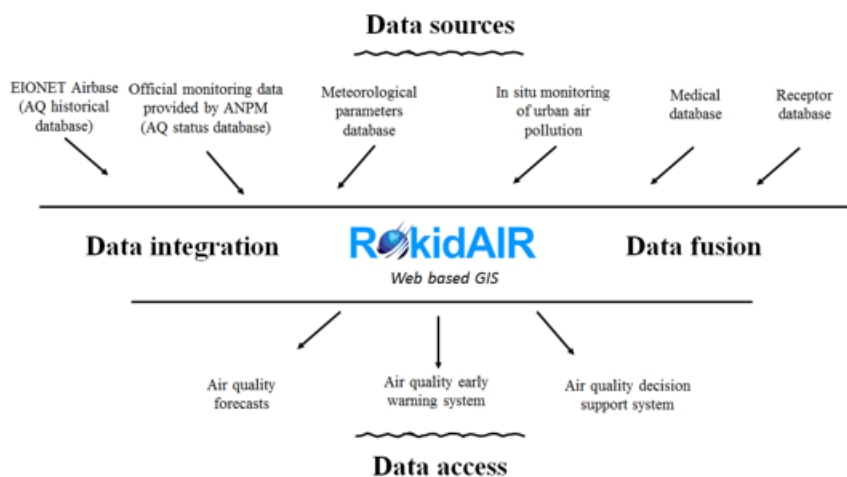


Fig. 1. Components of the RokidAIR analysis system (AQ: air quality; ANPM: Romanian National Environmental Protection Agency)

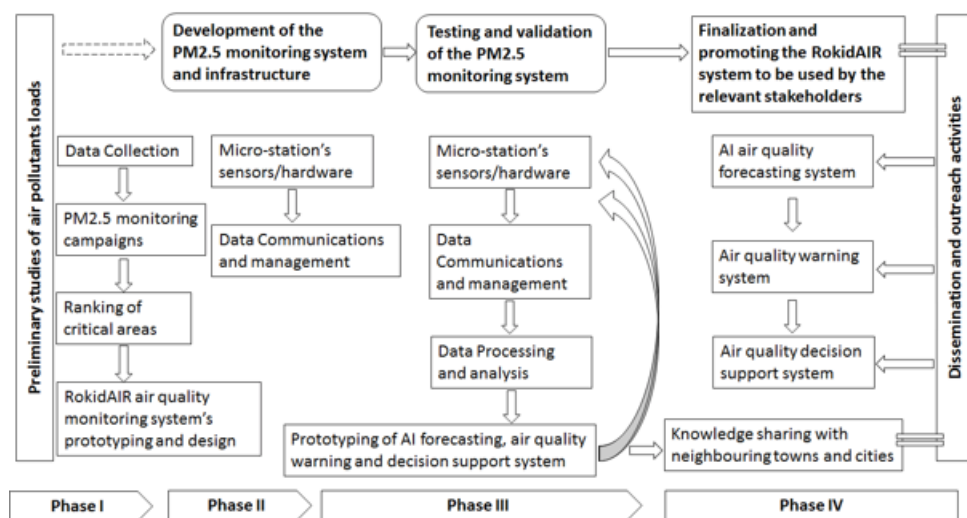


Fig. 2. RokidAIR implementation phases and tasks in each phase

database and receptor database were supplemented with specific information to identify the CAs that are under a major $PM_{2.5}$ impact [17, 26]. The subsequent ranking of the CAs allowed the selection of the locations for the deployment of the micro-stations in Phase II. The measurements from the micro-stations are stored on a RokidAIR GIS server as well.

In phase II, an intelligent $PM_{2.5}$ continuous monitoring system was developed to monitor the $PM_{2.5}$ fraction, the air temperature, the relative humidity, and the atmospheric pressure. The connection between the PM micro-stations and the main server was established using the GSM/GPRS protocol (Global System for Mobile communication/ General Packet Radio Service). In Phase III, the micro-stations, which aim to monitor the various components of the $PM_{2.5}$ were tested, and calibrated, and will be installed at the eight pre-defined CAs (fig. 3). The calibration was performed using a Leckel SEQ 47/50 Sequential Gravimetric Sampler according to the current measurements standards. Figure 4 illustrates the data acquisition diagram of the RokidAIR $PM_{2.5}$ micro-stations monitoring system.

Furthermore, in Phase III, the developed relational database was used in statistical/AI models to establish the relationships between air quality, meteorology and health effects. The same database was used for the development and testing of the air quality forecasts, early warning and decision support system [18]. In Phase IV, the RokidAIR system, including DSS, EWS and forecasting modules will be finalized and presented to the public and other stakeholders at national and international levels.

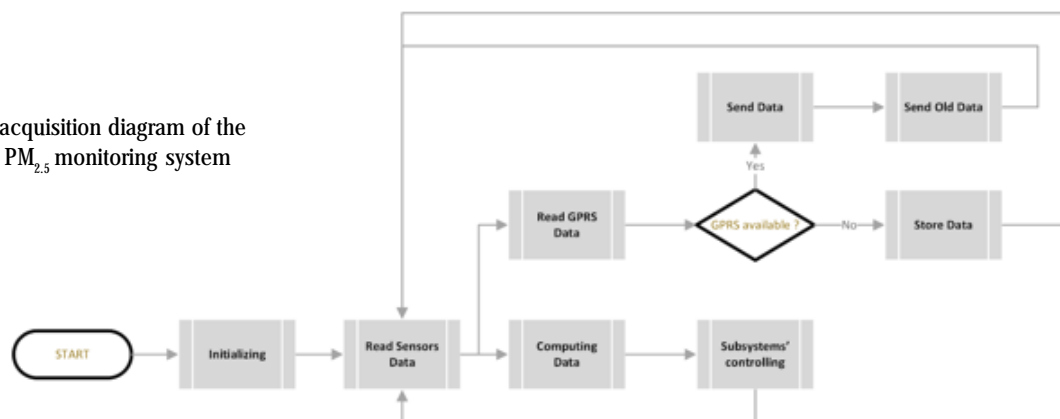


Fig.3. Inter-comparison tests for $PM_{2.5}$ monitors calibration performed in Bucharest (left and right - two RokidAIR $PM_{2.5}$ micro-stations; centre - a Leckel SEQ 47/50 Sequential Gravimetric Sampler provided by NILU).

Products and Services

Considering the end user's health protection needs, the main products and services provided by the RokidAIR project (fig. 5) are as follows: i) $PM_{2.5}$ thematic maps; ii) RokidAIR web-based GIS database with specific analysis and modelling functions; iii) $PM_{2.5}$ monitoring system consisting of both static micro-stations and portable instruments; iv) RokidAIR AI model for $PM_{2.5}$ forecasts – functional prototype based on AI techniques that will allow the prediction of $PM_{2.5}$ at multi-locational scale; v) RokidAIR DSS – a decisional support system that establishes a link between the contamination levels stored in databases and the children's health threats providing expert messages to the end-user segment; vi) RokidAIR web-based early warning system; and vii) major findings regarding the

Fig.4. Data acquisition diagram of the RokidAIR $PM_{2.5}$ monitoring system



children's respiratory diseases in relation to the urban air pollution in Targoviste and Ploiesti cities, Romania.

The web-based GIS database will be accessible directly via the webpage of the project by various interested users, e.g., researchers, parents, teachers, family medics, etc. Moreover, the data should also be useful for other stakeholders such as decision makers from the local authorities. The information from the RokidAIR system will provide urban-scale PM_{2.5} air quality mapping enabling the management and control of air pollution in cities to a much finer spatial resolution. The air quality forecast will provide benefits to the local public, and the early warning message will be sent to those who have registered as users via e-mails and SMS providing support for children's health protection under the impacts of air quality stressors and pressures.

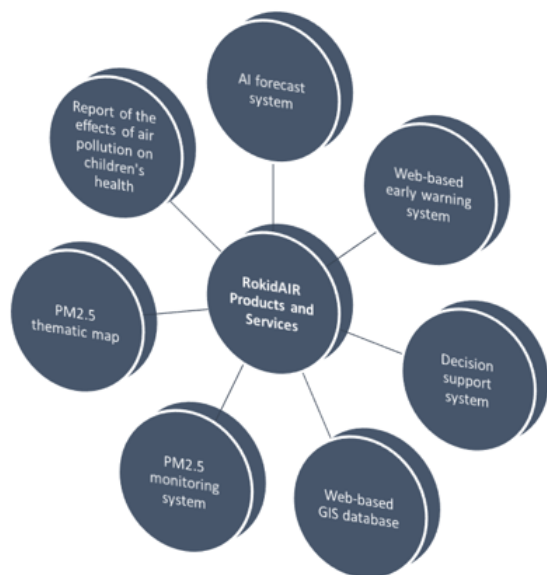


Fig.5. RokidAIR products and services (AI: artificial intelligence)

Case Study - capabilities of the RokidAIR web-based GIS geoportal for statistical processing of the benzene concentrations monitored in Ploiesti city

Due to the oil industries emission sources, the air from Ploiesti city contains benzene and other aromatic compounds (e.g., toluene, o-xylene, ethylbenzene, m- and

p-xylene compounds). In Ploiesti city, there are five RNMCA stations that monitor benzene concentrations from surrounding air, i.e., three in the city (PH-1, PH-2, and PH-5) and two in suburbs (PH-3 and PH-4).

The International Agency for Research on Cancer has classified benzene in Group 1 concerning the carcinogenic effect to humans. Benzene is a highly volatile organic compound (VOC), and exposure occurs mostly through direct inhalation [19]. Human activities using petroleum lead to increased exposure to benzene that has a concentration in crude petroleum at levels up to 4 g/L [19]. These activities include processing of petroleum products, and use in industrial and consumer products, as a component of petrol (gasoline). Ploiesti city is the centre of the Romanian oil industry being the only city in Europe surrounded by four refineries. Numerous companies operate in industries related to this branch. Consequently, the presence of benzene in petrol can result in widespread emissions to the urban environment of Ploiesti. There is no specific guideline value available for benzene concentration in the air. Benzene is carcinogenic to humans, and no safe level of exposure can be recommended. For general guidance, WHO recommended that the concentrations of airborne benzene associated with an excess lifetime risk of leukaemia of 10⁻⁴, 10⁻⁵ and 10⁻⁶ are 17, 1.7 and 0.17 µg/m³, respectively [20].

We used the RokidAIR geoportal functions to analyse the time series of benzene collected in the databases. The latest reports included in AirBase contain the time series from 2013 and 2014 recorded at PH-2 station, located in the centre of Ploiesti. Figure 6 shows the hourly-measured concentrations with higher values occurring during cold months.

A statistical significant difference ($t = 26.9$; $p < 0.001$; 95% CI (0.81–0.94)) was found between the means of 2013 (2.42 µg m⁻³) and 2014 (1.63 µg m⁻³). Compared to the WHO guidance, the recorded concentrations in the centre of Ploiesti have increased potential to cause health risks for those people who live in the area. Table 1 presents the descriptive statistical indicators ($n = 8205$). The maximum values were 36.46 µg m⁻³ in 2013 and 47.72 µg m⁻³ in 2014.

The time series recorded in 2015 (not validated data) shows that only two stations (PH-2 and PH-4) provided sufficient data for analysis, and the results indicated that

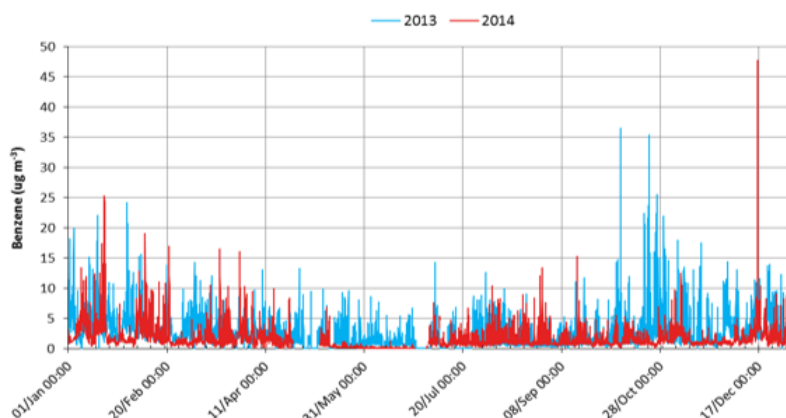


Fig. 6. Benzene time series analysis at PH-2 station between 2013 and 2014 (validated data collected from AirBase database) - hourly measurements, in Ploiesti, Romania

Table 1

STATISTICAL INDICATORS OF BENZENE TIME SERIES ANALYSIS, AT PH-2 STATION BETWEEN 2013 AND 2014 (VALIDATED DATA COLLECTED FROM AIRBASE) - HOURLY MEASUREMENTS (VALID $n = 8205$), IN PLOIESTI, ROMANIA

Year	Range	Minimum	Maximum	Mean		Std. Deviation	Variance	Skewness		Kurtosis	
				Statistic	Std. Error			Statistic	Std. Error	Statistic	Std. Error
2013	36.46	0.00	36.46	2.42	0.027	2.60	6.77	2.92	0.026	15.86	0.052
2014	47.72	0.00	47.72	1.63	0.021	1.90	3.61	5.09	0.027	62.53	0.054

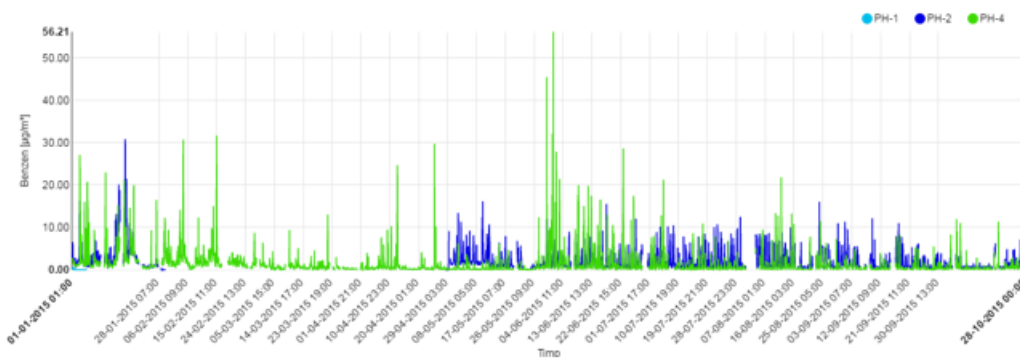


Fig.7. Benzene time series analysis at three RNMCA stations, i.e., PH-1, PH-2, and PH-4 in 2015 (raw data collected from <http://www.calitateair.ro>, the figure was drawn using the RokidAIR geoportal based upon the registered user's request)

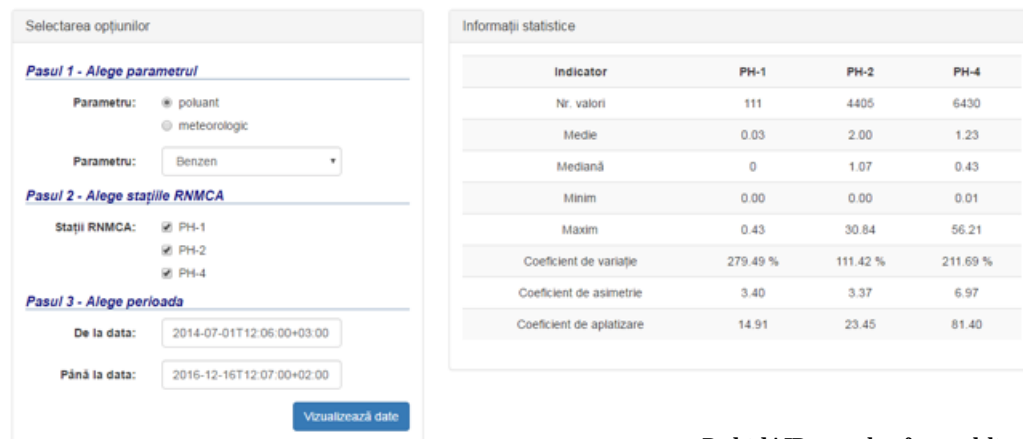


Fig.8. Screenshot for the benzene time series analysis via the RokidAIR geoportal at three RNMCA stations, i.e., PH-1, PH-2, and PH-4 in 2015 (raw data collected from <http://www.calitateair.ro>, indicators are: number of samples (n), average, median, minimum, maximum, coefficient of variation, skewness and kurtosis)

the benzene concentrations in 2015 are lower than the previous years (2013 and 2014). PH-4 is located outside Ploiesti near Brazi Refinery. Figure 7 shows the annual trends using hourly concentrations.

Figure 8 presents a screen capture from the RokidAIR geoportal showing the benzene time series analysis at three RNMCA stations, i.e., PH-1, PH-2, and PH-4 in 2015. The average value recorded at PH-2 station was higher than in previous years, but with lower maximum values compared to 2013 and 2014. Based on the reports and graphs generated by the RokidAIR geoportal, it can be concluded that benzene is a pollutant that is of highly concern in Ploiesti city. Concrete public health actions are required to reduce the exposure of population to benzene, i.e., avoiding outdoor activities when benzene rising concentrations are present.

Conclusions, Going Forward and New Perspectives

The RokidAIR project aims to improve urban air quality monitoring and forecasting activities in two Romanian cities i.e., Targoviste and Ploiesti. It has delimited the air pollution critical areas, performed $PM_{2.5}$ monitoring campaigns, established the web-based GIS database, analysed the $PM_{2.5}$ and its effects on children's health, and deployed one $PM_{2.5}$ micro-station in a special monitoring platform for air quality studies located in the Campus of Valahia University in Targoviste. Seven $PM_{2.5}$ micro-stations will be deployed after calibration by the end of February 2017 in the pre-defined locations.

RokidAIR is currently within phase III (fig. 2) of testing and validation of the $PM_{2.5}$ monitoring system including adjacent data communication and processing infrastructure, and is expected to have the first major results of the AI air quality forecasting and early warning system by the end of February 2017. We expect to have the results and overall evaluation of the system by the end of March 2017. At that time, the full integration of products for AI air quality forecasting, EWS, DSS into web-based GIS will be realized and we expect to demonstrate the

RokidAIR results for public, decision makers and other stakeholders.

We believe that the RokidAIR approach may open new perspectives in monitoring and understanding of urban air pollution and its health effects. The RokidAIR products and services (fig. 5) can be further tested and applied in other towns and cities. To provide reliable and useful estimates of air quality to the public, to increase citizens' awareness, and to provide evident-based solutions to the policy makers, the following new perspectives applicable in Romania were identified, and suggested to be further studied:

i) Biomarkers for exposure to air pollution: to understand the association between air pollutants exposure and the development of respiratory problems resulting from the damage in the respiratory system [21]. Biomarker is a measurable indicator of the severity or presence of some diseases. It can be specific cells, molecules, or genes, gene products, enzymes, or hormones. Target groups can be both adults and children. The univariate and multivariate models are normally used to analyse the correlation between the air pollutants and its health effects. The use of biomarkers for evaluating the exposure to air pollution is in the early phase, worldwide.

ii) Citizen science and citizens' observatories: The impact of mobile technologies on the citizen science and citizens' observatories in the areas of air quality, environmental health and climate change, has the potential to improve the data coverage by the provision of near-real-time high-resolution data over urban areas [22, 23]. For example, with a high number of the low-cost static sensors in the area, using data fusion methodologies, a real time air quality map may be generated. One step further, a real time personal exposure trajectory can be provided as well either via a combination of a wearable low cost sensors and smartphones (i.e., sensor data combined with GPS time data), or a real time air quality map combined with a smartphone (i.e., air quality map combined with GPS data to estimate exposure along a given track). Moreover, from engagement and behaviour change aspects, citizen science and citizens' observatories activities enable air

quality problem visible, helps citizens to move from awareness to behaviour change, and the data may be used to affect policy making towards air quality improvements.

iii) Air pollution and its mental health effects: it is well known that air pollution is a contributor to physical diseases such as respiratory diseases, heart disease, stroke, high blood pressure, etc. There are few studies about the connection between mental health and air pollution among public [24]. There is potential to develop new research approaches to generate new knowledge about “how” and “to what extent” air pollution affects mental health.

v) Nature-based solutions to improve air quality in the cities: plants and green areas have air pollution reducing effects among many other benefits. However, nature-based solutions remain unused by many urban planners and policy makers when planning abatement strategies for air pollution control [25]. There is potential to develop new practical approaches to estimate the removal of air pollutants by urban vegetation, as well as the health effects and economic value. The outcomes can be used as policy support tools as well.

We conclude that the RokidAIR approach is a pioneer pilot that improves the urban air quality monitoring and forecasting activities in Romania. All data, the main stream of information and the expert advises and recommendations on the protection of children’s health against air pollution threats are formatted and stored on a dedicated geoportal that has potential to be further used, developed and integrated into new projects. The data packages aimed to be re-directed to the authorities for informational and triggering policy change purposes. Various stakeholders can use the RokidAIR approach, and its new perspectives can be further developed and tested in Romania to increase the citizens’ engagement on air quality and encourage behavioural change towards a cleaner air, and used by authorities to formulate air pollution mitigation policies and regulations.

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References

1. *** WHO., Ambient (outdoor) air quality and health, Fact sheet N°313, 2016.
- 2.*** EEA., Air quality in Europe – 2016 report, **28**, Publications Office of the European Union, Luxembourg, 2016, pp. 83.
3. DOCKERY, D.W., STONE, P.H., N. Eng. J. Med., **356**, No. 5, 2007, p. 511.
4. PEREZ, L., MEDINA RAMON, M., KUNZLI, N., ALASTUEY, A., PEY, J., PEREZ, N., GARCÍA, R., TOBIÁS, A., QUEROL, X., SUNYER, J., Environ. Sci. Technol., **43**, No. 13, 2009, p. 4707.
5. *** EEA., Air quality in Europe – 2014 report, **5**, Publications Office of the European Union, Luxembourg, 2014, pp. 80.
6. ANDREWS, A., The Clean Air Handbook: A practical guide to EU air quality law, Version 1.0, ClientEarth, London, 2015, pp.45.

7. *** WHO., Health effects of particulate matter: Policy implications for countries in Eastern Europe, Caucasus and central Asia, WHO Regional Office for Europe, Denmark, 2013, pp. 15.
8. IORDACHE, S., DUNEA, D., Environ. Eng. Manag. J., **12**, No. 4, 2013, p. 677.
9. *** EEA., AirBase: the European air quality database. November, **2016**.
10. STANEK, L.W., SACKS, J. D., DUTTON, S. J., DUBOIS, J-J. B., Atmos. Environ., **45**, No. 32, 2011, p. 5655.
11. DUNEA, D., IORDACHE, S., LIU, H.-Y., BOHLER, T., IANACHE, C., SAVU, T., A multi-criteria approach to evaluate impacts of particulate matter on children’s health in urban areas, In book of abstracts of 12th Urban Environment Symposium (12UES), 1-3 June 2015, Oslo, Norway, pp. 31.
12. BANICA, A., BOBRIC, D.E., BREABAN, I.G., Issues related to air quality monitoring in north-east region (Romania). In conference Proceedings of the 16th International Multidisciplinary Scientific GeoConference (SGEM 2016), June 28 - July 6, 2016, Book 4, **2**, p. 451.
13. DUNEA, D., IORDACHE, S., LIU, H.-Y., BØHLER, T., POHOATA, A., RADULESCU, C., Environ. Sci. Pollut. Res. Int., **23**, No. 15, 2016, p. 15395.
14. IORDACHE, S., LIU, H.-Y., BØHLER, T., DUNEA, D., DUMITRU, D., IANACHE, C., Public Perception Survey of Air Quality and Quality of Life in Urban Areas. In conference proceedings of the 7th LUMEN International Conference - Multidimensional Education & Professional Development. Ethical Values. (MEPDEV 2015), 12th-14th November, 2015, Targoviste, Romania. p. 269.
15. CALDARE, I., MUNTEA, C., GIURCA, I., NASTAC, C., Bulletin of the Transilvania University of Bra^oov CIBv, **6**, No. 55, Special Issue No. 1, p. 225.
16. DUNEA, D., IORDACHE, S., POHOATA, A., LUNGU, E., OPREA, M., SAVU, T., Bulletin. UASVM. Agriculture., **71**, No. 2, 2014, p. 205.
17. DUNEA, D., IORDACHE, S., POHOATA, A., Int. J. Environ. Res. Public Health., **13**, No. 12, 2016, p. 1246.
18. OPREA M., IANACHE C., MIHALACHE S.F., DRAGOMIR, E.G., DUNEA, D., IORDACHE, S., SAVU, T., On the development of an intelligent system for particulate matter air pollution monitoring, analysis and forecasting in urban regions. In conference proceedings of 19th International Conference on System Theory, Control and Computing (ICSTCC), 14-16 October, 2015, Sinaia, Romania, p. 711.
19. *** WHO., Exposure to benzene: A major public health concern, WHO Document Production Services, Geneva, 2000, pp. 4.
20. ** WHO., Air quality guideline for Europe, 2nd edition, **91**, WHO regional publications, Copenhagen, 2000, pp. 273.
21. SUHAIMI, N.F., JALALUDIN, J., BioMed. Res. Int., **2015**, 2015, p. 1.
22. LIU, H.-Y., KOBERNUS, M., BRODAY, D., BARTONOVA, A., Environ. Health., **13**, 2014, p. 107.
23. LIU, H.-Y., SKJETNE, E., KOBERNUS, M., Environ. Health., **12**, 2013, p. 93.
24. OUDIN, A., BRABACK, L., ASTRÖM D.O., STROMGREN, M., FORSBERG, B., BMJ. Open., **6**, 2016, p. e010004.
25. KABISCH, N., FRANTZESKAKI, N., PAULEIT, S., NAUMANN, S., DAVIS, M., ARTMANN, M., HAASE, D., KNAPP, S., KORN, H., STADLER, J., ZAUNBERGER, K., BONN, A., Ecol. Soc., **21**, No. 2, 2016, p. 39
26. SAVU, T., JUGRAVU, B.A., DUNEA, D., Rev. Chim. (Bucharest), **68**, no. 4, 2017, p. 796

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