Investigation of Failures and Vulnerabilities in Road Traffic Air Quality Management System during 2020 Pandemics

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Abstract. Air deterioration and high toxicity affects life quality and longevity. Most important is pollution and toxicity impact upon health and disease management. Air born sicknesses and health problems are a permanent challenge for air dependent life-forms. Lately have been recorded manifestations and a complex phenomenology of air partially transferred pathogenic agents. The air quality is subject to investigation in order to provide a better management of the pollution control system. Pollution is a major contributor to air quality deterioration and to health problem multiplication. Present day pandemic is thought to be partially transmitted through air and by direct contact. Low air quality may be a serious contributing factor to sickness promotion. Air pollution due to road traffic and livestock is one such factor. The main objective of the paper is to investigate some important failures and vulnerabilities recorded in the road traffic air quality monitoring system during 2020 pandemics in our country and in Cluj. Thus, the evolution of chemical composition has been put under the spot of scientific investigation. Failures and weak points have been acknowledged and considered for improvement. At least twelve significant system failures and multiple vulnerabilities have been recorded due to sensor faults and unit malfunction. Social lockdown reduced all pollutants, but some units failed to indicate it properly.

1. Introduction
Air Quality Management System is implemented and operational by some years now, but its failures and vulnerabilities must be investigated in order to support the proper adjustments for technical and economic optimisations. Directive 2004/107 / EC, 2008/50 / EC, Decision 2011/850 / EC and Directive (EU) 2015/1480 are defining the terms, rules, reference methods, data validation and location points in ambient air quality investigation. Air quality is very important for life development. Many air-born diseases are reported nowadays [1], [2], [3]. High toxicity of the ambient air and the chemical stress are causal factors for many of the current health problems [4]. Benzene compounds (generated by road traffic and by fuel distribution networks), nitric oxides and CO₂ are toxic for human health [5], [6], [7].

Some developments and applied protocols have been realized in order to improve the air quality control and pollutant emissions management in relation with the road traffic and transportation field [8]. These contributions outline the road traffic pollution upon pathologic developments [9]. Some pollutants like particulate matter may be contained by using exhaust after-treatment systems [7], [10]. Fuel and oil combustion, evaporation and spill represent the cause for the environmental pollution and toxicity [10], [11]. Electronics [13] and mathematical modelling of the operational process from internal combustion engines [14], [15] constitutes basic support for pollution management. Improving efficiency regarding fuel consumption and energy transformation depends mostly upon the management system [16]. The electronic engine control [13] or the operational management system [16] facilitate, for both
compression ignited and for spark ignition engines [15], in the same time improved performances and lower fuel consumption with reduced pollutant emissions in ambient air [16], [17].

Figure 1 highlights the measurements made by the European Space Agency during the first three months of 2020 regarding the pollution with nitrogen dioxide during the COVID pandemics [18], showing the fact that road traffic lockdown in multiple countries have positively impacted the air quality. Reduction of road traffic values generates a reduction in pollutant emissions, as a following reasonable consequence, but there comes a justified question: may be measured correctly the pollutant trend? The present paper investigates the failures and vulnerabilities in road traffic air quality management system.

![Figure 1. Pollution high level in Italy first part of January 2020 (a) and March (b) same year [18].](image)

2. Applied investigation

Some of the most dangerous pollutants and air toxicity are generated by the road traffic, animal intensive factory farming, some industries and air transport [17], [18]. Main objective of the applied investigation consists in monitoring the actual values of pollutants recorded by four stations in Cluj-Napoca. These units (CJ1, CJ2, CJ3, CJ4) are positioned in central areas of the city, as they measure air quality.

Figure 2 presents the hardware infrastructure available for applied measurements and for pollutant data monitoring and investigation.

![Figure 2. Cluj-Napoca Air Quality Management units distributed in the most populated areas [17]](image)

Definition of PM10 values by empirical polynomial model is presented as follows for CJ1 and CJ4:

\[
PM10(CJ1|CJ4) = (1.3 \ldots 2.4) \times 10^3 \times M_t^2 - (0.2 \ldots 0.4) \times M_t + 27, \tag{1}
\]

where \(PM10(CJ1|CJ4)\) is the \(PM_{10}\) estimated average value supported by a polynomial model in the investigated time period of 100 hours for the CJ1 & CJ4 stations; \(M_t\) – monitoring time.
Material and method used in applied research of the present investigation is outlined in table 1. Most significant failures were recorded by station CJ2 in monitoring nitric oxide compounds and derivates.

| Pollutant                  | Method                      | Station Unit | Chemical formula |
|----------------------------|-----------------------------|--------------|------------------|
| Benzene                    | SR EN 14662, part 1-3      | CJ1          | C6H6             |
| Ethylbenzene               | SR EN 14662                | CJ1          | C8H10            |
| Nitric oxides              | SR EN 14211                | CJ1, CJ2, CJ3, CJ4 | NO / NO₂        |
| Carbon monoxide            | SR EN 14626                | CJ1, CJ2, CJ3 | CO               |
| Ozone                      | SR EN 14625                | CJ2, CJ3, CJ4 | O₃               |
| Sulphur dioxide            | SR EN 14212                | CJ1, CJ2, CJ3, CJ4 | SO₂             |
| Polycyclic aromatic HC     | SR EN 15549                | CJ1, CJ2     | C₁₄H₁₀; ... C₃₂H₁₄; |
| Particulate matter         | EN 12341                   | CJ1, CJ4     | PM₁₀ and PM₂,₅  |

Most recorded failures during the investigation are based on individual specific posts or system failures. One of the investigated hypotheses is measuring sensors failures due to maintenance faults.

During the investigation presented in the present paper were recorded 12 significant failures of the Air Quality management system which support our conclusion on the importance of remote access and service implementation. An important vulnerability of the system is generated by the uneven type of the measurements. Some pollutants are not monitored on some stations due to the specific differences.

The individual failures shown in figure 3 and the multiple fault values in figure 4 were taken from air quality road traffic pollution management system. In the station unit CJ1 most failures were recorded with m, o, p-xilen emissions, but there were also considerable failures with benzene and some with NOₓ.

Definition of NOₓ average estimated values by an empirical polynomial model is represented as eq. (2):

\[
NO_x(CJ1|100h...28April...3May) = 6.1 \times 10^3 \times Mt - 1.53 \times Mt + 105.1,
\]  

where \( NO_x(CJ1|10h...28April...3May) \) is the NOₓ estimated average value calculated with a polynomial model on the 100 hours investigated time period; \( Mt \) – monitoring time.

In figures 5 to 14 are graphically represented the pollutants hourly recorded values on a 100 hours investigation period. Nitric oxides were specially studied on all the available stations in Cluj-Napoca city in order to properly investigate the failures and vulnerabilities of air quality monitoring units. The graphical representations allow a better study on the failures and vulnerabilities of the monitoring units.
3. Observations and conclusions

Both theoretical and the applied parts of the investigation have been realized successfully as planned. It was possible to show the real values which were recorded and monitored to outline the failures and vulnerabilities of the air quality system.

In the recorded set of values has been highlighted a decrease with an average of 45% of NO level starting from 28 April 2020 till 3rd of May 2020. Also, there was a reduction with 30% of NO2. The approaching weekend (1-3 May) and the low temperatures (6÷13°C), coupled with the imposed social lockdown measures contributed to overall reduction in pollution. The system failures must be further studied, and faults eliminated.
References

[1] Andrei L et al 2018 Analytic considerations regarding the link between air pollution with benzene and nasopharyngeal cancer (In Science and Engineering / Știință și Inginerie AGIR Press) DOI http://stiintasinginerie.ro/34-63

[2] Andrei L et al 2018 Contributions to research of CO2 emissions in environment pollution management and life (In Science and Engineering / Știință și Inginerie AGIR Press) DOI http://stiintasinginerie.ro/34-64

[3] Andrei L et al 2018 Contributions to the research of the relation between air pollution with nitric oxides and the impact upon environment and life (In Science and Engineering / Știință și Inginerie AGIR Press) DOI http://stiintasinginerie.ro/34-68

[4] Andrei L et al 2018 Research and reporting development of formic acid emissions in environment pollution management and life health (In Science and Engineering / Știință și Inginerie AGIR Press) eISSN 2359–828X DOI http://stiintasinginerie.ro/34-71

[5] Andrei L et al 2019 Applied Measurements and Instrumentation for Improving Diagnostic Devices and Systems in Metropolitan Polluted Environments with Nitric and Carbon Oxides (In Meditech, IFMBE Proceedings 71, Springer, Singapore) ISBN 978-981-13-6206-4 DOI https://doi.org/10.1007/978-981-13-6207-1_8

[6] Borza E V et al 2018 Research Concerning Fuel Economy Coefficient and Carbon Foot Print in Various Conditions for a City Compact Size Vehicle with Digital Control for a Green Solution and Method (In Burnete N., Varga B. (eds) Pr. of the 4th Inter. Congress of Automotive and Transport Engineering (AMMA 2018). Proceedings in Automotive Engineering. Springer, Cham) eISSN 978-3-319-94409-8 https://doi.org/10.1007/978-3-319-94409-8_22

[7] Borzan A I et al 2018 Research contributions through virtual modeling of an innovative particle filter for alternative application in automotive field using advanced engineering methods (In the 4th Inter. Congress of Automotive and Transport Engineering AMMA 2018) http://www.amma2018.ro/index.php/amma/2018/paper/view/28

[8] Cherecheș I A 2018 Researching the applied engineering protocol to implement a program for monitoring air quality management and carbon-footprint for future green vehicles in urban area (In the 4th Inter. Congress of Automotive and Transport Engineering AMMA 2018) http://www.amma2018.ro/index.php/amma/2018/paper/view/37

[9] Cherecheș I A et al 2017 Contributions to the applied research of effects from surrounding environment pollution due to road traffic upon eyes’ anatomy and pathology development (In Science and Engineering / Știință și Ing. AGIR Press) DOI http://stiintasinginerie.ro/32-85

[10] Jurchiș B M et al 2019 Experimental research on Diesel Particle Filter (DPF) in relation to the fuel type (In IOP Conf. Ser.: Mater. Sci. Eng, 568) 012027

[11] Marc C A et al 2010 Study of the automotive fuel and oil pollution influences upon some plants in different conditions (In CONAT, International congress on automotive and transport engineering, 27-29 October, 2010, Brașov, Romania, 3, CONAT20102030) ISSN 2069-0401 http://conat.ro/index.php/conat/2010/paper/view/305

[12] Marc C A et al 2010 Pollution influence of fuel used for engines on some plant species (In Acta Mecanica, 2, (3), Technical University of Cluj-Napoca, ISSN 2066-9577)

[13] Marincas C et al 2017 Contributions to the experimental research of electronic diesel control (EDC) module operation in relation with supply of the N47 engine from BMW 320d (E90) automobile (In Sci. and Eng. 31-82) eISSN 2359–828X http://stiintasinginerie.ro/31-82

[14] Mitran T et al 2018 The calculus of the technical-economic parameters of a SI direct inj. engine (In RoJAE 24 (3) 89-97) http://siar.ro/wp-content/uploads/2018/12/RoJAE-24-3.pdf#page=5

[15] Mitran T et al 2019 The calculus of the temperatures in the characteristic points of the gasoline direct injection engine cycle (In IOP Conf. Ser.: Mater. Sci. Eng, 568) 012073

[16] Moldovan A et al 2017 Experimental research of the management system from the Peugeot 4007 Sport utility veh. (In Sci. and Eng. 31-71) eISSN 2359–828X http://stiintasinginerie.ro/31-71

[17] *** 2020 AirQuality N.A.Q.M.N. (In: http://www.calitateaer.ro/ accessed 01 May 2020)

[18] *** 2020 How nature is thriving during COVID-19 (https://www.livelykindly.co/ accessed 04 May)