

AIR QUALITY MONITORING IN JIU VALLEY

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DOI: 10.2478/minrv-2021-0026

Abstract: *The paper presents air quality monitoring in Jiu Valley, which is carried out at HD-5 Vulcan monitoring station, starting with March 2010, allowing the obtaining of useful data for the rapid identification of polluted areas and for taking strategic decisions by competent factors and tactics to combat and prevent pollution. After highlighting the pollution sources in Jiu Valley, we present both the evolution of hourly and / or daily values of pollutants recorded at the automatic HD-Vulcan air quality monitoring station during 2020: SO₂, NO₂, CO, gravimetric PM₁₀, Pb, Cd and Ni, but also the evolution of air quality for quality indicators, monitored in Hunedoara County (including Jiu Valley, at HD-5 station), during 2010-2020.*

Taking into account the average annual values of pollutants recorded in 2020 at HD-5 Vulcan station, the paper calculates air quality indices for each pollutant and then indicates air quality throughout Jiu Valley in 2020, establishing that air quality is good in this area, with a very low level of pollution and no effect on humans, ecosystems and materials.

Keywords: *monitoring, air quality, Jiu Valley*

1. Introduction

The study of air pollution has become increasingly important due to phenomena that are produced directly, by concentrating polluting gases in certain regions of the globe, or indirectly by phenomena such as acid rain, photochemical smog, ozone depletion. Currently, the space-time distribution of these pollutants is monitored by various methods and techniques. The magnitude and complexity of pollution phenomena today require the study by relatively cheap and non-invasive methods, which can lead to the carrying out of remote determinations that are accurate in quantifying sources of pollution on large areas and relatively small areas.

A particularly important role in maintaining ecological balances is played by the activity of environmental quality control or monitoring of environmental components, in that it provides useful information to decision makers on the degree of pollution, the health of the population, their dynamics under the influence of anthropic activities, trends, evolution of environmental quality.

Currently in Romania the environmental quality monitoring system [1] is organized on life subsystems. The basic data from the field and laboratory measurements performed within each subsystem are stored in a unitary base built at the Research - Development Institute for Environmental Engineering. The data are sorted by name, are aligned as a way of presentation and units of measurement to national and international standards, and after their statistical processing are transmitted to international databases.

This paper is part of a larger research on the effects of mine closure in the Jiu Valley on the environment. Here we wanted to present the quality of one of the environmental components, namely air after 2010, when due to restructuring / refurbishment in the energy sector (mines, preparation plants, thermal power plant) and adjacent ones there is an improvement in the quality of the environment, in general, that of air in particular.

Following the completion of the county air quality monitoring network with the HD-5 Vulcan station, the opportunity was created to continuously analyze the air quality in the Jiu Valley, although it cannot specify the contribution of the mining units' activities to the air quality status in this area.

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As according to the negotiations between Romania and the European Commission, all mining units in the Jiu Valley must be closed by 2032 [2], it would result that an approach like the one described above would not make sense.

It is wanted to show that the energy activities (mines and thermal power plant) carried out in the Jiu Valley do not contribute significantly on the quality of the environment if money is invested for refurbishments and prevention measures as in some cases (Coroiești preparation plant, Paroseni thermal power plant).

The above is also supported by a series of research / studies over time that have shown that the impact of anthropogenic activities (including energy) in the Jiu Valley on the environment is within acceptable limits[3].

2. General data on the Jiu Valley mining basin

2.1. Geographical location

Jiu Valley mining basin, located in southwestern Romania, between 45°17' - 45°22' north latitude and 20°13' - 20°33' east longitude and located along the Southern Carpathians, is the gateway to the National Park. Retezat to other Carpathian destinations, being surrounded by mountains from the Parâng group and the Retezat group. It is morphologically constituted as a narrow and deep depression, one of the few found in the Southern Carpathians. It has the shape of a triangular, asymmetrical syncline, oriented in the ENE-VSV direction, with the peak in the west and the base in the east, with a length of 46 km and a width between 2-9 km, with the maximum at the confluence of the East Jiu with Jiu West and covering 137.6 km (Figure 1).



Figure 1. Geographic located of Jiu Valley mining basin [1]

Jiu Valley (figure 2) runs along the two sources of the Jiu, which practically divide the depression into two plateaus:

a) Petroșani plateau, to the east, crossed by the Eastern Jiu passing through the settlements, Cimpa, Lonea, Petroșani, Livezeni, to which Jieț and Bănița belong.

b) Vulcan plateau, to the west crossed by the West Jiu which passes through the settlements of Câmpu lui Neag, Uricani, Bărbăteni, Lupeni, Paroseni, Vulcan, Coroiești, Iscroni, to which Crividia, Dealu Babii and Aninoasa belong.

The bottom of this depression is relatively high (556 m at the confluence of the two Jiu, 800 m to the eastern and western edges) thus forming a high intra-mountain depression that explains its relatively cold climate. Jiu Valley is a micro-region made up of three municipalities: Petroșani, Lupeni, Vulcan and three cities: Petrila, Uricani, Aninoasa, with a total population of 120,734 inhabitants (2011 census). The connection

to Transylvania is ensured by means of a Petroșani - Simeria and DN 66A railway line, a road that intends to be extended by connecting with Băile Herculane, and with Oltenia by the Petroșani-Tg.Jiu railway and DN 67A.

Access to the mining perimeters is provided by normal or narrow DNs and railways. It is considered that the transport infrastructure at the mining perimeters currently ensures the transport and circulation capacities to the mines from Jiu Valley.



Figure 2. Location and positioning of localities in the Jiu Valley mining basin [3]

2.2. Basin hydrography

The hydrographic network [3] of the basin is mainly represented by two rivers:

- *East Jiu*, with a route of approximately 28 km, has its springs on the southern slope of the Șureanu Mountains, its main tributaries being Jieț, Taia, Răscoala, Bănița.

- *West Jiu*, which springs from the Scorota glacial circus and has a length of 51 km, its main tributaries being the Buta, Lazărul, Toplița, Valea de Pești, Mierleasa, Braia, Sohodol and Baleia streams. To these are added numerous streams and torrents that flow from the slopes of the mountains and join near the town of Iscroni, after which it enters the Livezeni- Bumbești gorge.

The hydrographic network of the Jiu River is very developed in the sector that crosses the mountainous area of the upper course of the Jiu. The density of the hydrographic network is 1.2 km / km², being considered very dense. All the flowing waters originating in the Vâlcan Mountains are tributary to the Jiu River, directly or indirectly. Jiu River has an area of 10,070 km² and a length of 331 km.

2.3. Climate

The climate is temperate-continental, with weak influences of the Mediterranean currents. The climate is harsh, but not excessive, winters are not frosty, summers are generally cool.

The average multiannual air *temperature* is 7.5°C, the average monthly temperatures vary from a maximum in July of 17.2°C to a minimum in January of -3.8°C. Annually, the number of days with temperatures above 0°C is 193 days, and below 0°C is 172 days, representing the average of the values registered at Petroșani and Parâng stations.

Rainfall is the main source of river supply in the basin. Depending on the exposure of the slopes, the amounts of precipitation and their annual distribution are different. Thus, the northern slopes benefit from higher quantities, due to the western circulation, and the southern slopes of the mountains in the basin register small amounts of precipitation due to the phoenix circulation. High floods that cause floods are caused by rainfall exceeding 40-50 mm at short intervals (three to four per year).

In the cold season, precipitation is in the form of snow, which will serve as a water reservoir for the period from early spring when its melting triggers large spring waters. The largest snow reserve accumulates in the mountainous area of the basin, while in the extra-Carpathian area its thickness and duration will gradually decrease towards the confluence. The duration of the snow layer depends on the low amount and the maintenance of the air and soil temperature below 0°C, the snow remaining over 100 days a year in the mountain area.

In summer, during clear nights and with low local traffic, the development of radiative processes leads to cooling of the air above the slopes and increasing its density contributing to its movement to the lower part of the valley where it forms the "cold lake", which stagnates on the bottom of the depression throughout the night and disappears after sunrise.

An influential aspect, the phenomenon of thermal inversion, is the nebulosity. In winter, the cloud layers invade the low, depressed forms, allowing the establishment of a normal gradient at 800 m altitude from the cloudy ceiling that favors the formation of a layer with reverse temperature.

In the annual regime of relative humidity, the air is found, a main maximum in December (93%) when the air temperature is low, and the main minimum is recorded in March-April (77%).

The wind regime is normal, without excess intensity or duration, without danger to the forest vegetation, finding that when they intensify, in combination with snow and soil moistened by precipitation, due to the concentration of air currents due to the terrain, they can produce isolated fallings. During the summer, storms can occur, most often accompanied by hail, being short-lived. In the Petroșani depression, the predominant winds are the wind that blows from the northeast to the south and that causes the temperature to drop and the snow to blizzard, followed by the warm winds from the southeast.

2.4. Flora and fauna

The flora and fauna of Jiu Valley have elements that are part of it a tourist attraction. In the mountains predominate the coniferous forests, among the most common are those of spruce, but also pine, bison (*pinus cembra*), juniper, yew. Oak and beech forests are common, housing many birds and are home to many animals, such as hares, wolves, foxes, wild boars, deer, bears, black goats, bearded eagles, a species found only in the Retezat Mountains.

Jiu Valley still has a rich fauna whose spread is favored by the presence of forests. However, anthropogenic interventions - through the exploitation of forests or deforestation in order to expand meadows and cultivated areas, construction of forest roads, layout of mining operations, tailings storage, construction of cottages and holiday homes, have partly reduced the area of some species.

3. Sources of air pollution in the Jiu Valley

3.1. Mines

The main sources of air pollution, caused by mining activities, are: thermal power plants serving mining units, mining stations on the surface of the mines, activities on the surface of the mines and tailings dumps. They release sulfur and nitrogen oxides, suspended dust, soot and carbon dioxide into the atmosphere, affecting in particular the surrounding areas [4].

Measurements in the vicinity of thermal power plants (which ran on coal or LPG) revealed exceedances of the allowable concentrations of SO₂, (emissions) due to the relatively high sulfur content in the coal used by these plants (e.g. Lonea: 5 -6%, Vulcan: 1-4%, Lupeni: 1-4.5%, an average of about 3%) [1, 3, 5].

Fan stations discharge the vitiated air from the underground, air whose composition includes some harmful gases (CH₄, H₂S, CO, HCl) and mineral suspensions. Although there are no established rules on the maximum concentration of CH₄ released into the atmosphere, a more rigorous monitoring of the amounts of methane released into the atmosphere is required, given that methane is a gas that contributes significantly to the greenhouse effect.

Surface activities that involve sorting, transporting, unloading, loading coal and tailings also generate significant amounts of suspended dust, sedimentary dust and sometimes gases. These undirected (uncontrolled) emissions are dispersed in the mining perimeter and in the neighboring (inhabited) areas by air currents.

Appreciable amounts of suspended dust are generated by the scalding activity, to which is added a quantity of gases resulting from the ignition of the scalded material. In the last period of time, the phenomenon of self-ignition of tailings dumps no longer manifests itself with the same magnitude as in the past, the mines taking a series of measures to limit these outbreaks.

It is particularly difficult to establish to what extent mining activities contribute to air pollution in the Jiu Valley, but based on previous studies it can be said that they contribute about 60-65%.

3.2. *Paroşeni Thermal Power Plant*

The operation of the Paroşeni Thermal Power Plant involves the burning of coal, which implicitly means the evacuation into the atmosphere of quantities of suspensions and noxious substances resulting from the combustion of coal.

The chemical analyzes, performed on the coals from the Jiu Valley, highlighted a high sulfur content in their composition, the direct result being that of removing a large amount of SO₂ into the atmosphere [3].

The main pollutants produced by Paroşeni Thermal Power Plant are: carbon monoxide and dioxide (CO and CO₂), dust (fly ash, unburned coal particles, slag), sulfur oxides (SO₂ and SO₃), nitrogen oxides (NO and NO₂), small amounts of tar, hydrocarbons, soot, sulphates and organic acids [6].

3.3. *Road transport*

Vehicles are a major source of air pollution in urban areas.

There are currently no restrictions on the access of heavy vehicles on the main arteries. They are, for the most part, old and do not comply with the euro rules on emissions. As for personal cars, their number is constantly growing. The biggest problems are raised by cars older than 10 years that also do not comply with the rules on emissions of air pollutants. Car traffic also contributes to the load of the atmosphere with solid suspensions, especially during periods of rainfall deficit.

3.4. *Agriculture and stock raising*

Due to the configuration of the wild relief of Jiu Valley, it can be said that the agriculture of this area was and still is a subsistence focused on obtaining the strict necessities of potatoes, corn, fruits and vegetables, being an activity of local importance. The significant occupation of the rural population, surrounded by Jiu Valley, is, since ancient times, the breeding of animals, respectively cattle and sheep.

It can be appreciated that this sector of activity has an almost insignificant influence on air pollution.

Individual households that use fossil fuels (coal, methane gas, wood and to a lesser extent diesel), for the production of heating, cooking, production of domestic hot water, are also responsible for air pollution in Jiu Valley. This can be easily noticed in the evening and at night, especially if fog is present. The air has a specific smell, due to the pollutants present, in high concentrations, it becomes difficult to breathe, for sensitive people, or who suffer from various ailments, and the visibility sometimes decreases to a few tens of meters.

3.5. *Buildings*

Air pollution, with solid suspensions, is also due to various construction works, renovations and modifications of buildings, but these being temporary, are not a major source of pollution.

3.6. *Tourism*

Tourist activities can lead to a decrease in air quality. Thus, in the tourist season, when the traffic is at maximum levels, air pollution can occur, through exhaust gases produced by tourist cars and the large number of coaches.

The public food structures have a higher energy consumption and therefore there is a pollution produced by the thermal power plants, which serve the tourist resorts.

3.7. *Other activities*

The industrial and commercial units operating in Jiu Valley contribute to air pollution, even if with a much more modest share. The sources of pollution are related to the activity of drying the crumbs and heating the oil, respectively the bitumen, at the asphalt mixture preparation station. The handling of aggregates and binders at the concrete and mortar preparation station is another source.

4. Methods and apparatus for measuring/determining air quality

4.1. Air quality indicators and indices

Air quality indicators and indices ensure the communication of environmental information, noticing differences from the normal state or expected values, identifying the evolution of processes, substantiating decisions, developing forecasts and strategies, evaluating the success of environmental policies and informing the public. They focus on a few features that are considered relevant and for which data are available [7].

The most common and simplest method of using air quality indicators and indices involves comparing the values obtained from monitoring with maximum permissible values known as maximum permissible concentrations, limit values, maximum permissible limits or thresholds set by legislation based on scientific knowledge, in order to avoid, prevent or reduce harmful effects on human health or the environment; the limit values refer to a given period (1 hour, 3 hours, 8 hours, 24 hours, 1 year) and represent a maximum value, which must not be exceeded [8].

Among the specific indicators for the assessment of air quality, for which these relevant values are established, are: nitrogen oxides, sulfur dioxide, carbon monoxide, suspended particles (PM₁₀, PM_{2.5}), volatile organic compounds (especially benzene), ammonia, ozone.

Air quality indices can be used to assess the degree of air pollution. One of the most used internationally is the Air Quality Index (AQI), which has many variants of calculation in different states. The index allows the assessment of the level of air pollution, the impact on the health of the population and natural ecosystems.

A first calculation of the AQI starts from the division of the noxious substances into two categories, depending on the ratio with the maximum allowed concentration and into four categories depending on the degree of danger. Following the ratio of the maximum permitted concentration, the US EPA (2001) delimits two categories:

- category I: noxious substances whose values do not exceed the MAC, the AQI being calculated according to the equation:

$$AQI = 100 \cdot (C / MAC) \quad (1)$$

where: C - the recorded Concentration of the noxious substance,

MAC - Maximum Allowable Concentrations for noxious substances.

- category II: noxious substances whose values exceed the MAC:

$$AQI = 100n \cdot (C / MAC) \quad (2)$$

where: n- coefficient that varies depending on the degree of danger of the noxious: 0.9-1.7.

n = 1,7- very dangerous toxins: ozone, chlorine, mercury, cadmium, benzene,

n = 1,3- dangerous toxins: hydrogen sulfide, nitrogen oxides, formaldehyde, styrene

n = 1 - moderately dangerous toxins: sulfur dioxide, soot, suspended particles

n = 0,9- slightly hazardous pollutants: carbon monoxide, aliphatic hydrocarbons, ammonia

The index is calculated for each nuisance, after which the global AQI value can be found as the arithmetic mean of all monitored noxious substances from all points taken in the assessment.

The values obtained refer to the interpretation Grid of the values in Table 1.

Table 1. Interpretation - Grid of air quality index values (after www.epa.gov 2012)

Air quality index	Quality air / pollution level	Effects on humans	Effects on ecosystems and materials
0-50 (green)	Good/very poor	No effects	No effects
51-100 (yellow)	Satisfactory/poor or moderate	No effects	Reduced effects
101-300 (orange)	Unsatisfactory/relatively high	Influence on the respiratory system cardiovascular	Moderate effects
301-500 (red)	Weak/high	Significant effects on the population	Strong effects
Over 500 (brown)	Very weak/very high	Strong effects on high surfaces	Very strong effects

4.2. Methods for determining air quality

Air quality is measured/determined by two methods [9], which complement each other:

- the gravimetric method, recognized as the most accurate method of measurement,
- the automatic method, which completes the index of the gravimetric method.

The gravimetric method involves the use of dust collection devices in which atmospheric air is aspirated. Every two weeks, 14 disposable filters are placed in the device. The filters are conditioned and weighed, in the laboratory, before and after the measurement, every two weeks. Based on the difference in mass of the filters, the concentration of dust remaining on the filters is calculated.

The automatic method of measuring air quality is an equivalent method to the gravimetric method. This consists in the use of automatic measuring devices, which constantly measure the level of dust and allow the current graphical representation, in the form of maps of impurities.

In the standards regarding the concentrations of air pollutants (National Air Quality Monitoring Network Directive EC), the standard stationary, sampled measurement methods are given. But real-time measurement methods are used in air monitoring stations.

The reference methods for the analysis of the main pollutants used by the Environment Agency are the following:

- *the ultraviolet fluorescence method* provided for in ISO / FDIS 10948 (draft standard) "Ambient air - determination of sulfur dioxide" - for the analysis of sulfur dioxide;
- *chemo-luminescence method*, provided for in ISO 7996/1985, "Ambient air - determination of the mass concentration of nitrogen oxides" - for the analysis of nitrogen dioxide and oxides of nitrogen;
- *UV photometric method* provided for in ISO 13964, VDI 2468, B1.6 - for ozone measurement and calibration of ozone instruments;
- *the non-dispersive infrared spectrometric method (NDIR)* provided for in ISO4224- for the measurement of carbon monoxide is the spectrometric method in
- *gravimetric method or atomic absorption spectrometry or inductively coupled plasma mass spectrometry (ICP-MS)* presented in EN12341 "Air quality - field test procedure to demonstrate the reference equivalence of methods for sampling the PM10 fraction from powders in suspension"- for the measurement and sampling of PM10.

4.3. Measurement methods and apparatus used

The methods of measuring the environmental parameters [7] can be direct (without requiring sampling and preconditioning steps) and by going through several steps. In the latter case, the following steps are used:

1. The place of collection must be determined in such a way that the sample is representative.
2. During the harvest, the meteorological conditions (temperature, pressure, air movement, presence or absence of clouds) will be noted.
3. The recommended harvest time is 30 minutes for measuring the current concentration and 24 h for the average daily concentration.
4. The volume of air collected varies depending on the estimated concentration and sensitivity of the method of analysis.
5. If necessary, the devices must be transported to the laboratory after harvest, provided that they do not change during transport.
6. For the determination of dust, the harvesting device must be packed during transport to avoid contamination (dusting).

The instruments and devices available for taking atmospheric samples may fall into two categories, depending on the method of measurement:

A. Automatic air monitoring stations are equipped with continuous air collection devices, direct reading instruments that provide real-time data on the level of pollution.

B. For samples to be analyzed in laboratory instruments are special containers (glass, Teflon, steel), pumps and filters (for the collection of suspended particles) and sorbents deposited in tubes, columns, filters, or cartridges.

The installation used for passive sampling is equipped with an absorbent (fig. 3). The duration of sampling varies between a few weeks and a few months.

In order to take active air, in addition to the absorbent material, an air suction pump is also used to remove the air (fig. 4).

In both cases, the sorbent materials are transferred to the laboratory for sample preparation and measurement. The collection of air samples is based on physical or chemical processes.

The physical processes involved in sampling may differ, depending on the type of compounds of interest such as: gaseous and non-volatile compounds are collected on the basis of absorption / adsorption, absorption is followed by desorption, with solvents or heat.

Chemical processes use substrates treated with different chemical reagents or are based on derivatization. This consists in the chemical transformation of the pollutants of interest, in compounds with new properties, more suitable for detection systems. The chemical transformation step is then followed by physical processes to bring the samples into a measurable form.

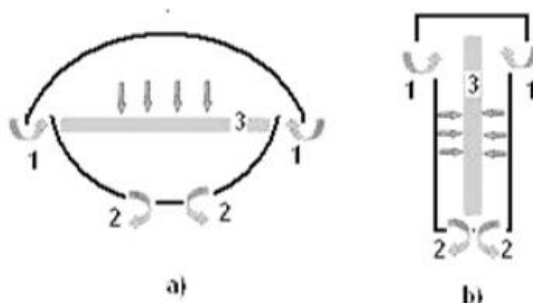


Figure 3. Passive air sampling: a) planar system; b) axial system;
1- air inlet; 2- air intake; 3- sorption material [9]

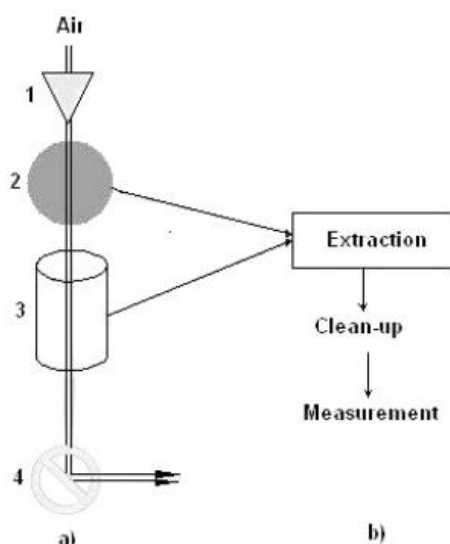


Figure 4. Active air sampling: a) sampling: 1- sample entry; 2- filter; 3- sorption material;
4- suction pump; b) preparation and measurement of samples [7]

The spectrometer is an instrument used to measure spectra. Optical spectrometers, in particular, analyze the intensity of light as a function of wavelength or frequency.

Shimadzu Scientific Instruments firm produces a wide range of spectrometers. The RF-5301 spectrofluorophotometer has a special sensitivity based on the optical system that includes a holographic network, a photomultiplier and a digital signal processing. It is a special tool dedicated to air monitoring. Scanning a spectrum reaches 5500 nm/min. Preset wavelengths can be entered because the monochromator does not reduce this speed (it scans the spectrum at 20,000 nm/min). The wavelength band is 220-750 nm, and can be extended up to 900 nm. The width of a peak is 1.5 nm.

The signal/noise ratio is very good due to the negative reaction in the electronic circuit.

Portable systems must also be considered.

5. Monitoring the air quality in Jiu Valley

5.1. Monitoring stations in Hunedoara county

The air quality monitoring system is a subsystem of the general environmental monitoring system. Air quality monitoring involves a series of actions, observation and quantitative and qualitative measurement of air condition indicators. The monitoring system makes it possible to obtain useful data for the rapid identification of polluted areas and for taking strategic and tactical decisions to combat and prevent pollution.

Among the main objectives of a monitoring system can be listed:

- Monitoring the air quality in relation to pre-established norms and standards and triggering the alarm, in case of accidental/systematic overtaking, of the norms.
- Identification of pollution sources.
- Establish background pollution and pollution trends.
- Environmental impact assessment of various pollutants.
- Assessment of microclimate change under the influence of pollution.
- Validation of analytical and empirical models of air pollutant dispersion.

In accordance with EU Directive 2008/50/EC, as amended by Directive 2015/1480, the air monitoring parameters are: SO₂, CO, O₃, Pb, As, Cd, Ni, Benzene, NO₂, PM₁₀ with different assessment thresholds and with limit values (table 2) [9].

Table 2. Limit values for the protection of human health of atmospheric air quality (cf. Law no. 104/2011)

Pollutant	Criterion	Mediation period	Value	U.M.	Number of annual overruns allowed (if any)
Sulphur dioxide, SO ₂	Limit value	1h	350	µg/m ³	24
	Limit value	24h	125		3
	Warning threshold	3h consecutive	500		Not applicable
Carbon monoxide, CO	Limit value	Maximum daily average value per 8h	10	mg/m ³	Not applicable
Ozone, O ₃	Target value	Maximum daily average value per 8h	120	µg/m ³	25 days/calendar year, averaged over 3 years
	Information threshold	1h	180		-
	Warning threshold	1h	240		Not applicable
Lead, Pb	Limit value	Calendar year	0.5	µg/m ³	Not applicable
Arsen.As	Target value	Calendar year	6	ng//m ³	Not applicable
Cadmium, Cd	Target value	Calendar year	5	ng//m ³	Not applicable
Nickel,Ni	Valoare țintă	Calendar year	20	ng//m ³	Not applicable
Benzene	Limit value	Calendar year	5	µg/m ³	Not applicable
Nitrogen dioxide, NO ₂	Limit value	1h	200	µg/m ³	18
	Limit value	Calendar year	40		Not applicable
	Target value	3h consecutive	400		Not applicable
Suspended particles, PM ₁₀	Limit value	1 day	50	µg/m ³	35
	Limit value	Calendar year	40		Not applicable

In addition to the air quality indicators interviewed in the monitoring stations, other compounds of interest for air quality can be determined, especially for research-based monitoring, such as: inorganic gases (NO_x, SO₂, SO₃, CO₂, CO, O₃); volatile organic compounds (VOCs) or inorganic substances; non-volatile organic compounds absorbed on solid particles (organic pollutants, persistent -POP); water-soluble atmospheric compounds, such as organic anions (NO₃⁻, NO₂⁻, S₂⁻, Cl⁻), organic anions (formate, acetate) and metal cations.

Agency for Environmental Protection, Hunedoara, by Contract no. 84 / 11.01. 2006, concluded between the Ministry of Environment and Water Management and DAMAT Italia, in association with ORION SRL Italia and ORION EUROPE Romania, based on the framework loan agreement between Romania and the Council of Europe Development Bank, on the financing of the *Project for the prevention of natural disasters flood monitoring and air pollution*, received 4 automatic air quality monitoring stations, distributed as follows: 2 monitoring stations for Deva, 1 monitoring station for Hunedoara and 1 monitoring station for Călan. Following the completion of the national monitoring network air quality, through Contract no. 436/2007, an automatic station was received for the Municipality of Vulcan, which was put into operation, starting with March 2010 (figure 5) [10].



Figure 5. Location of monitoring stations in Hunedoara county [10].

5.2. Synthesis of data from HD-5 Vulcan air quality monitoring station [10].

Figures 6-14 show the evolution of the hourly and or daily values recorded at the automatic HD-Vulcan monitoring station of air quality during 2020 of pollutants: SO₂, NO₂, CO, gravimetric PM₁₀, Pb, Cd and Ni.

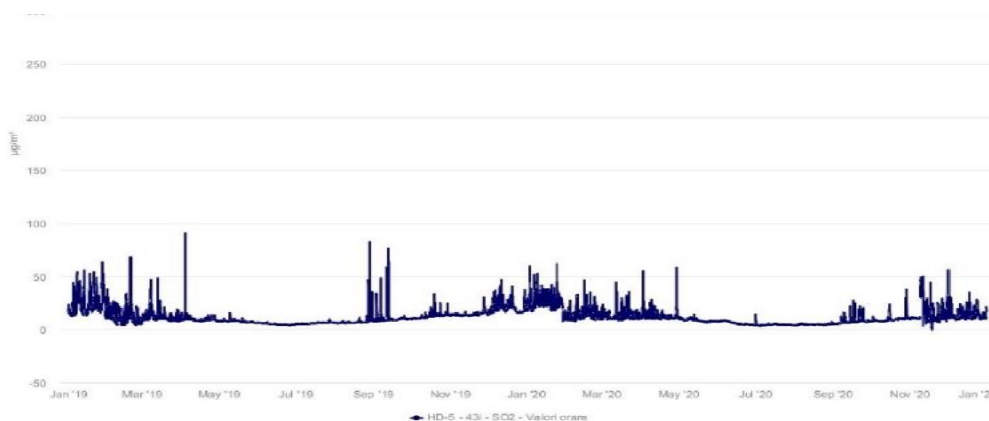


Figure 6. Evolution of *hourly* values of sulphur dioxide, SO₂, in 2020

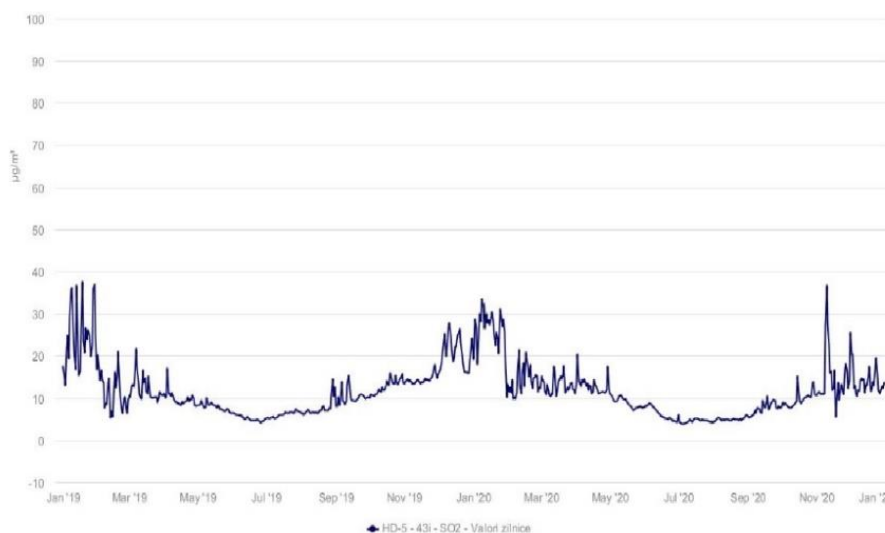


Figure 7. Evolution of *daily* values of sulphur dioxide, SO₂, in 2020

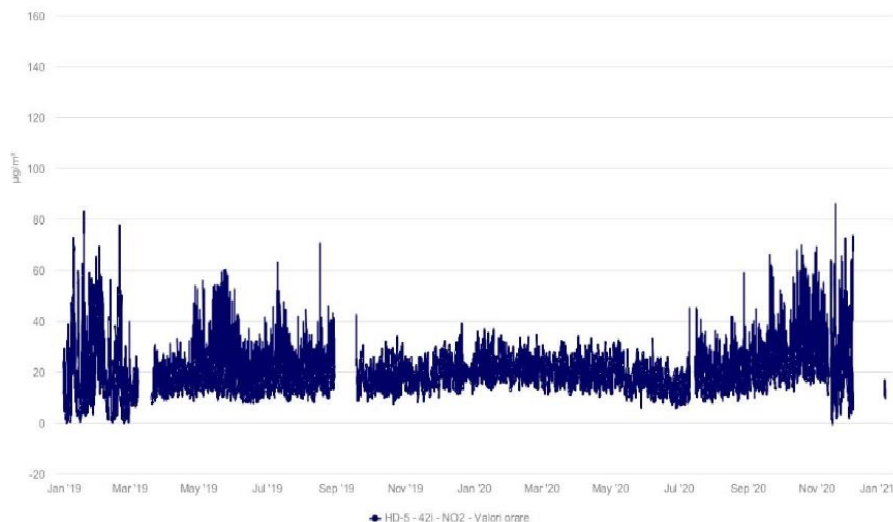


Figure 8. Evolution of *hourly* values of nitrogen dioxide, NO₂, in 2020

In 2020, the nitrogen dioxide indicator did not exceed the alert threshold of 400 µg/m³, recorded for 3 consecutive hours, nor did it exceed the value, annual limit of 40 µg/m³/year, provided in Law no. 104/2011, on ambient air quality.

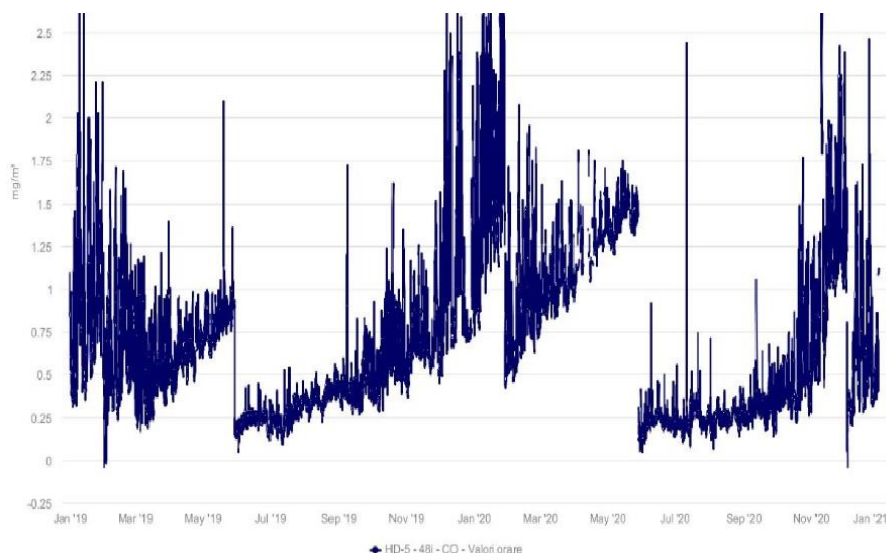


Figure 9. Evolution of *hourly* values of carbon monoxide, CO, in 2020



Figure 10. Evolution of *daily* values of carbon monoxide, CO, in 2020

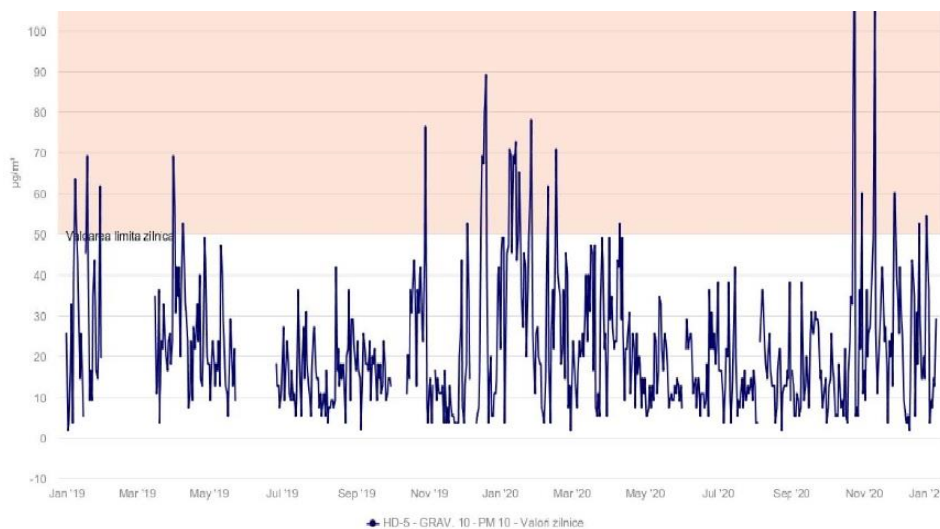


Figure 11. Evolution of *daily* values of suspended particles, PM₁₀, in 2020

At HD-5 station in Vulcan, 19 overruns were recorded at the PM₁₀ indicator (determined gravimetrically).

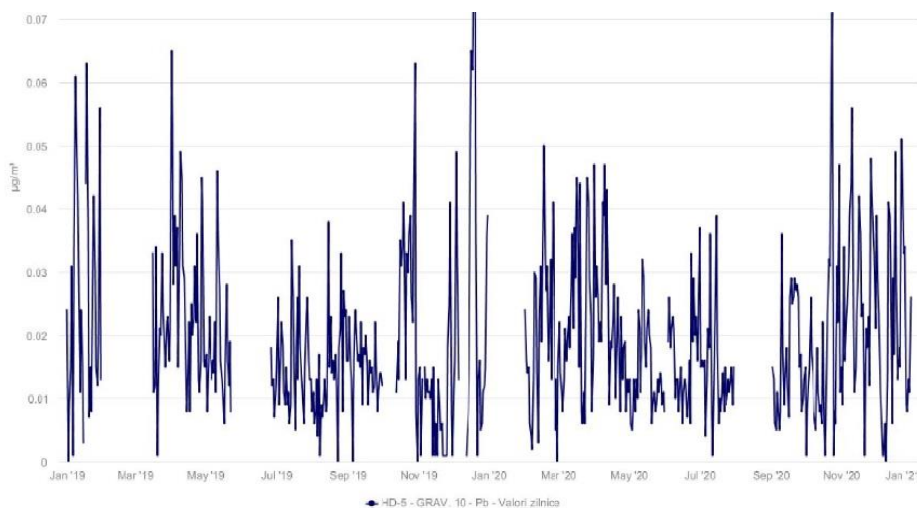


Figure 12. Evolution of *daily* values of lead, Pb, in 2020

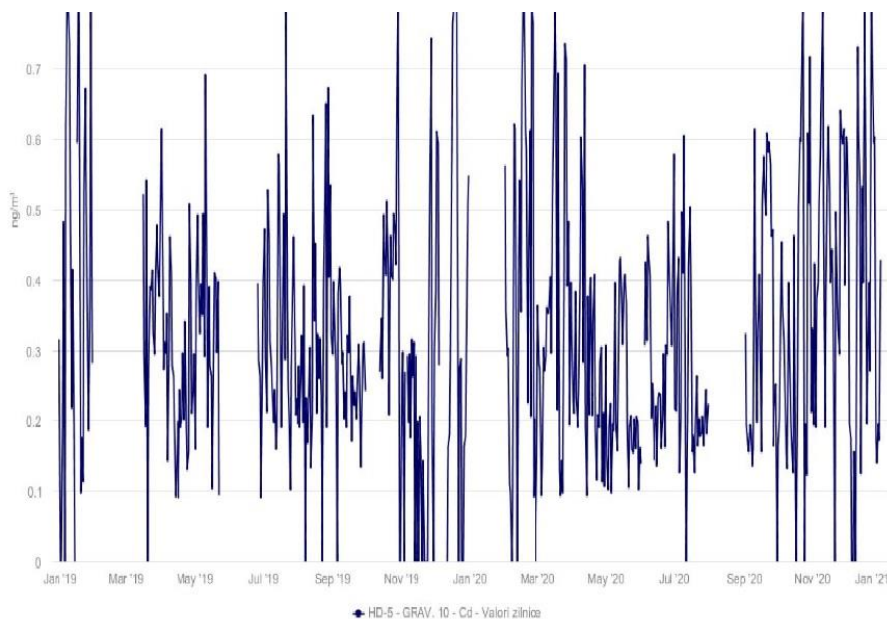


Figure 13. Evolution of *daily* values of cadmium, Cd, in 2020

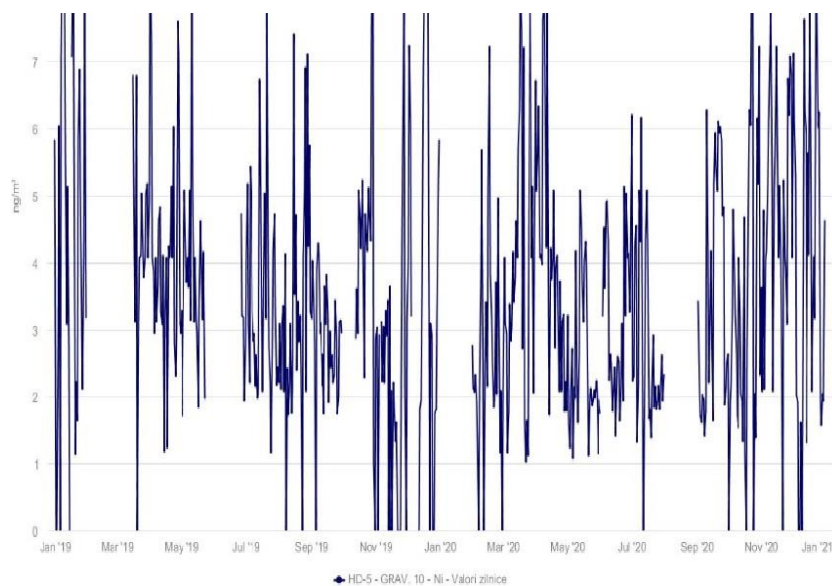


Figure 14. Evolution of *daily* values of nickel, Ni, in 2020

The evolution of air quality for quality indicators, monitored in Hunedoara County (including Jiu Valley, at HD-5 station), in the period 2010-2020, is presented graphically in Figures 15-18.

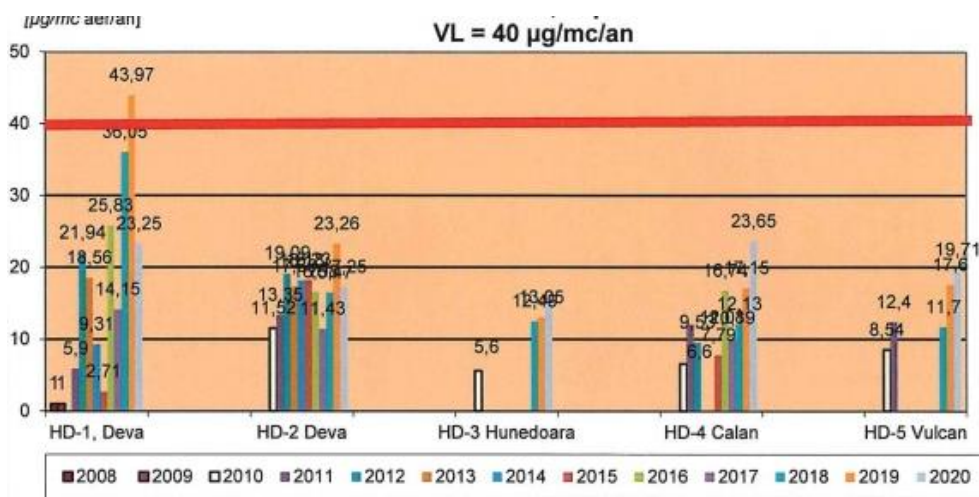


Figure 15. Average annual NO₂ values, in the period 2010-2020

As far as the nitrogen dioxide indicator is concerned, there are increases, compared to previous years, of the annual average values, at the following automatic monitoring stations: HD-3, HD-4, HD-5.

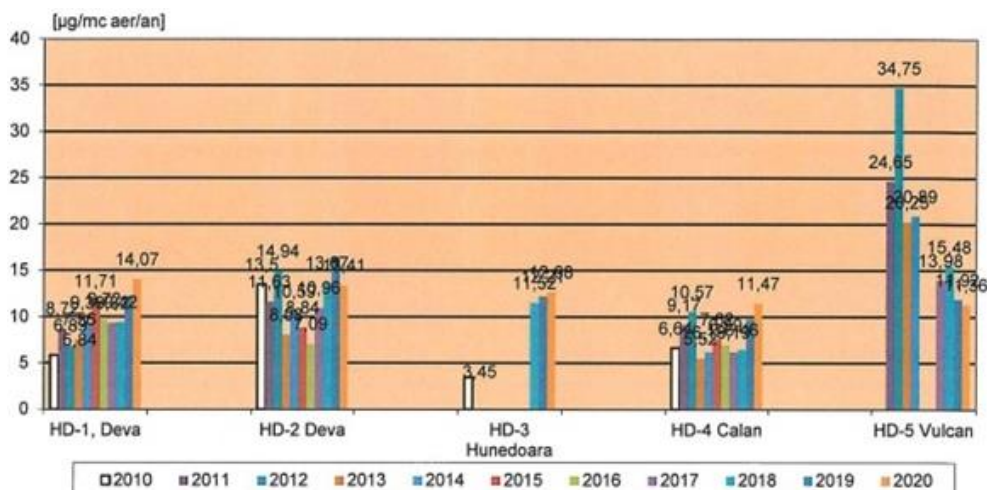


Figure 16. Average annual values of SO₂, in the period 2010-2020

As far as the sulphur dioxide indicator is concerned, there is an increasing trend of the annual average values, compared to previous years, at the following automatic monitoring stations: HD-1, HD-3, HD-4.

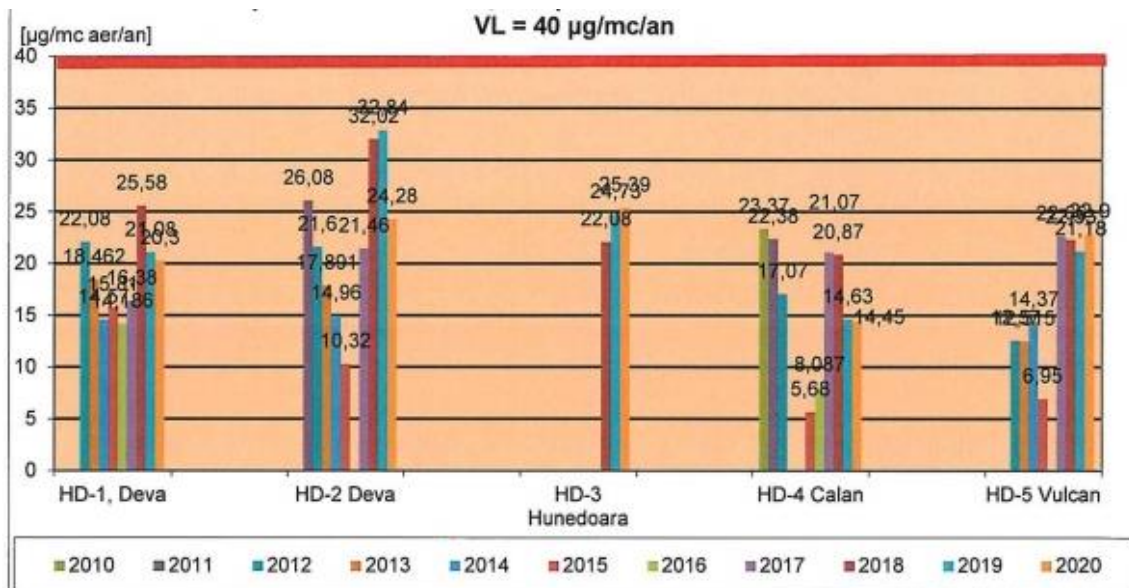


Figure 17. Average annual values of PM₁₀ (determined gravimetrically), in the period 2010-2020

As far as the indicator PM₁₀ (suspended particles) is concerned, there are slight increases compared to previous years, of the annual average values, at the automatic monitoring stations: HD-3, HD-5.

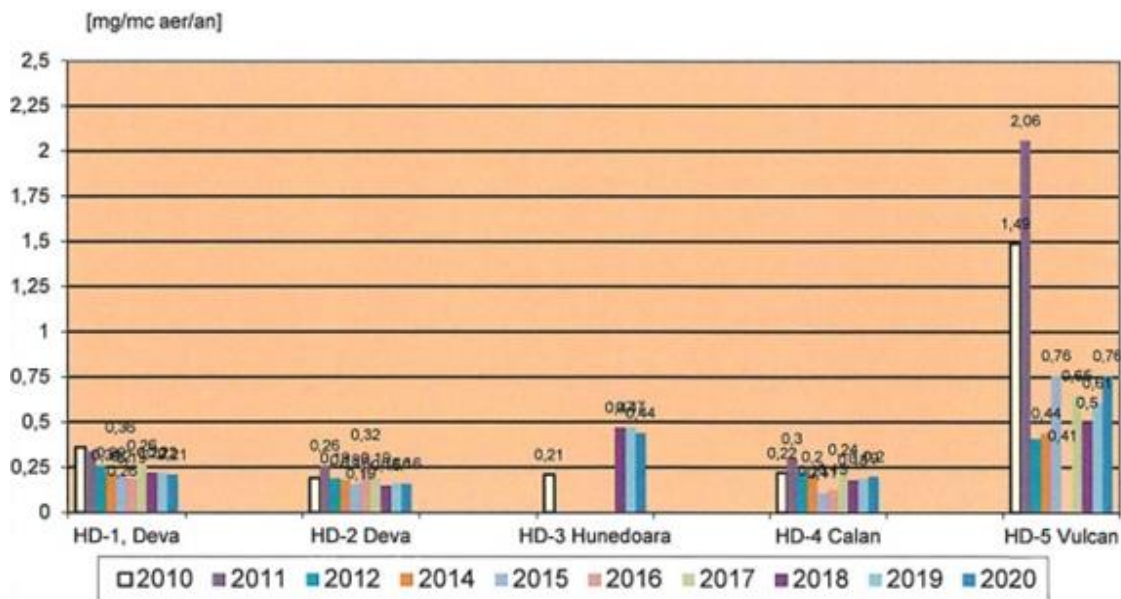


Figure 18. Average annual CO values, in the period 2010-2020

In the case of carbon monoxide, the trend of the annual average values, at most automatic monitoring stations in Hunedoara County, is decreasing in recent years, at HD-5 Vulcan station, showing an increase in 2020, compared to the previous year.

Taking into account the average annual values of pollutants recorded in 2020 at HD-5 Vulcan station (see Figures 15-18 and 6-14), Table 3 calculated the air quality indices for each pollutant in part and then the air quality index for the entire Jiu Valley in 2020, according to the equation (1), because for all pollutants/noxious the condition $C < MAC$ has been met.

Table 3. Air quality in Jiu Valley in 2020

Pollutant	U.M.	Registered concentration for pollutant, C	Maximum permissible concentration for pollutant, MAC	Air quality index, AQI
Sulphur dioxide, SO ₂	µg/m ³	11.36	125	9
Nitrogen dioxide, NO ₂	µg/m ³	19.71	40	49
Carbon monoxide, CO	mg/m ³	0.76	10	8
Suspended particles, PM ₁₀	µg/m ³	22.9	40	57
Lead, Pb	µg/m ³	0.019	0,5	4
Cadmium, Cd	ng/m ³	0.332	5	7
Nickel, Ni	ng/m ³	3.506	20	18
Air quality index in Jiu Valley in 2020				22

According to the Grid for interpreting the values of the air quality index (table 1) the air quality in 2020 for the Jiu Valley was AQI = 22, falling within the green zone (0-50) which means:

- Air quality: good;
- Pollution level: very low;
- Effects on humans: no effects;
- Effects on ecosystems and materials: no effects.

6. Conclusions

Making a comparison with the situation in the past, for the whole Jiu Valley, the quality of the environment is good, identifying aspects that have been improved in recent years.

Undoubtedly, the restructuring of the mining sector and the adjacent sectors has contributed to the improvement of the quality of the environment, consisting in the reduction of coal mining and preparation activities, construction of mining machinery and equipment, considered to have a major, negative impact, on the environment.

Taking into account the new status of Romania, as a member country, with full rights, the signed treaties and agreements as well as the new health provisions and WHO recommendations, monitoring air quality in urban areas become a mandatory activity, with implications not only locally, but also nationally and regionally.

The fact that Jiu Valley is an intra-mountain depression, with a high frequency of thermal inversion, a phenomenon that favors the retention of air pollutants near the ground, corroborated with the realities of the existence of areas where the production of heat, cooking and heating, is achieved based on the combustion of solid fuels, in individual installations, which are not provided with pollutant retention installations, there are periods of the year (autumn and winter) in which the values of the pollutants exceed the permitted limit (see diagrams in fig. 6-14), and the quality indices of some pollutants/noxious substances (NO₂, PM₁₀) are approaching or are in the yellow zone.

The local system for monitoring the quality of environmental factors, designed for Jiu Valley, is one that aims to use state-of-the-art modern equipment to perform measurements, while trying to reduce the likelihood of errors due to sampling, transport and analysis. In addition to the above, the use of modern equipment significantly reduces the time required to perform, analyze and process, store and transmit data, by using equipment, measuring machines and internal memory storing data devices, which subsequently can be easily downloaded to computers.

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Air Quality Report (in Romanian)



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