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ZERO STATE OF AIR QUALITY IN THE AREA OF FUTURE FACTORY R-S SILICON IN MRKONJIĆ GRAD

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ABSTRACT

Air quality measurement was conducted in the vicinity of the industrial plot that belongs to RS Silicon LLC Mrkonjić Grad where a plant for the production of the silicon metal is constructed, during the period January – December 2015; this air quality measurement comprised the immissions concentrations of CO, SO_2, NO_2 and total suspended particles (TSP), while simultaneously measuring wind speed and direction.

The factory for Si-metal production will generate direct and indirect environmental impacts, especially on air. Generally, the largest environmental impact during operation of the factory will be reflected in the emission of a large quantity of waste gases. This document shows air pollution measurement results which represent the zero state, it is to say a basis for further assessment of air quality after the commissioning of subject factory.

Key words: *factory "R-S Silicon", air quality, emission, immission, limit value*

INTRODUCTION

Construction of the silica metal factory named R-S Silicon, with an annual production capacity of 15,210 ton of Si-metal, was planned in the village of Bjelajce, municipality of Mrkonjić Grad. The position of subject location is between the R-412 regional road, Mrkonjić Grad – Crna Rijeka and the water course Crna rijeka, in the territory of the former auto-transporting company, Udarnik. Individual residential facilities - rural households, are situated around the location. At a distance of about 200 m, southwest of the location border,"Branko Ćopić" Elementary School is situated.

The planned factory for the silicon metal production, at subject location in Bjelajce, can have negative environmental impacts, due to expected emissions of waste gases, unless adequate measures for the mitigation of emissions and environmental protection are forseen and implemented. The most significant potential emissions into the environment from subject plant for the silicon metal production are dominantly related to the processes of melting in an electric arc furnace, and to the process of crushing and classification of the metal in separation [1]. The silicon metal production process also comprises the emissions of dust and waste flue gases that are dominantly generated as a product of the quartz melting process, with the addition of carbon materials (wood chips, wood charcoal, charcoal with a low percentage of ash), and emissions of dust when crushing and classifying the silicon metal in separation into commercial granulations [2]. As a product of the quartz melting process in electric arc

furnaces is generated fine SiO_2-dust, as well as characteristic waste flue gases (CO_2, SO_2,NOx, CO, VOC, PAH) [3].

Identified sources of the emission of dust and waste gases in the air, in the territory of subject location, is the R-412 regional road, section Crna rijeka – Mrkonjić Grad, which is also the only communication in wider area. There were also identified two plants whose primary activity is wood processing, and one workshop whose activity is stone processing; thus they represent sources of dust and noise.
The municipality of Mrkonjić Grad has no indicators that could help establish the real state of air pollution, because no air quality monitoring was established. For this reason it was necessary to conduct certain air quality tests in the area where this factory for the silicon metal production named R-S Silicon is being constructed. These data will provide a real status of air quality prior to the construction and commissioning of subject factory, it is to say a zero state.

DETERMINATION OF AIRQUALITY ZERO STATE IN THE AREA OF THE FUTURE FACTORY R-S SILICON

For the assessment of air quality at the location of RS Silicon LLC Mrkonjić Grad construction site in the period January – December 2015 with a mobile station equipped with analysers for the measurement of polluting substances in air, once a month (twelve times per year) the immission concentration of air polluters were measured, as follow:

- total suspended particles - TSP,
- carbon monoxide - CO,
- sulphur dioxide - SO_2,
- nitrogen dioxide - NO_2.

Measurement of micro meteorological parameters implied the registration of the wind speed and direction.

Coordinates of measuring locations are 44° 26' 21" N and 17° 09' 10" E (figure 1).

Figure 1. Location of the construction site

MEASURING INSTRUMENTS AND MEASUREMENT METHODS

Air pollution measurement at subject location was conducted with an automatic measurement station that is equipped with the following measuring instruments:

HORIBA APMA 360	s/n 909001
Analyser for measurement of carbon monoxide (CO)	
lower limit of detection:	0.05 ppm (2 sigma)
measurement method:	infrared spectroscopy (absorption) – BAS EN 14626

HORIBA APSA 350	s/n 107009
Analyser for measurement of the concentration of SO_2 (SO_x scrubber, CU-1 converter unit for measurement of H_2S)	
relative measurement uncertainty	7,80 %
lower limit of detection:	0.5 ppb (2 sigma)
measurement method:	UV fluorescence (BAS EN 14212)

HORIBA APNA 350E	s/n 564362085
Analyser for measurement of the concentration of NO , NO_2 , NOx	
Lower limit of detection:	0.5 ppb (2 sigma)
Measurement method:	Chemiluminescence (BAS EN 14211)

FH 62 I-N	
Analyser for measurement of total suspended particles	
Lower limit of detection:	1.0 $\mu g/m^3$ (2 sigma)
Measurement method:	absorption of β^- rays BAS EN 12341

NETZ “ALCYON”	
Three-dimensional anemometer for wind speed/direction	
Measurement area:	0-30 m/s
Lower limit of detection:	0.1 m/s (2 sigma)
Measurement method:	optoelectronic

LEGAL PROVISIONS ON AIR QUALITY

Air quality categories are established according to the level of pollution, starting from the prescribed limit and tolerance values, defined by the Regulation on air quality values [4], and based on the results of measurement. If a tolerance value was not prescribed for some polluting substance, its limit values is considered as its tolerance value. Air quality categories are established once a year for the previous calendar year.

The provisions defined by Article 21 of the Air Protection Act (RS Official Gazette, No. 124/11) establish the following categories of air quality:

a) first category – clean or insignificantly polluted air, where limit values were not exceeded for any polluting substance

b) second category – moderately polluted air, where limit values were exceeded for one or several polluting substances, but tolerance values were not exceeded for any polluting substances

c) third category - excessively polluted air, where tolerance values were exceeded for one or several polluting substances [5]

Regulation on air quality values (RS Official Gazette, No.124/12) establishes air quality values with the aim of managing air quality in the territory of the Republic of Srpska. According to the mentioned regulation [4] air quality values represent numerical values of the limit values of air polluting substances levels, both lower and upper limit of air quality assessment, critical levels, tolerance limits and tolerance values, target values and long-term goals for air polluting substances, concentrations hazardous to human health and concentrations of which the public is notified. Air quality values referred to in this regulation are air quality requirements for a planning period, in accordance with this regulation. Limit values of air polluting substances level, which are prescribed by this regulation [4] must not be exceeded once they have been reached. A deadline for achieving the limit values of polluting substances that were analysed in this paper (sulphur dioxide, nitrogen dioxide, suspended particles (PM_{10}) and carbon monoxide) is 1 January 2021. In accordance with this target, tolerance limit decreases by equal annual percentage as of 1 January 2015, and every 12 months afterwards, so that 0 % is to be reached by 1 January 2021 [4].

Limit and tolerance values and tolerance limits for sulphur dioxide, nitrogen dioxide, suspended particles (PM_{10}) and carbon monoxide are given in the table 1. Concentrations of sulphur dioxide and nitrogen dioxide which are hazardous to human health are given in the table 2. Maximum permissible concentration for the protection of human health in case of dedicated measurement for total suspended particles is given in the table 3.

Table 1. Limit values, tolerance values and tolerance limits

Polluting substance	Period of averaging	Limit value	Tolerance limit	Tolerance value
SO_2	1 hour	350 µg/m³(remark 1)	107 µg/m³	457 µg/m³
SO_2	24 hours	125 µg/m³(remark 2)	-	125 µg/m³
SO_2	Calendar year	50 µg/m³	-	50 µg/m³
NO_2	1 hour	150 µg/m³(remark 3)	54 µg/m³	204 µg/m³
NO_2	24 hours	85 µg/m³	29 µg/m³	114 µg/m³
NO_2	Calendar year	40 µg/m³	14 µg/m³	54 µg/m³
PM_{10}	24 hours	50 µg/m³(remark 4)	18 µg/m³	68 µg/m³
PM_{10}	Calendar year	40 µg/m³	6 µg/m³	46 µg/m³
CO	8 hours	10 mg/m³	4 mg/m³	14 mg/m³
CO	24 hours	5 mg/m³	4 mg/m³	9 mg/m³
CO	Calendar year	3 mg/m³	-	3 mg/m³

Regulation on air quality values („RS Official Gazette".no.124/12)
Remark 1: must not be exceeded more than 24 times in one calendar year.
Remark 2: must not be exceeded more than 3 times in one calendar year.
Remark 3: must not be exceeded more than 18 times in one calendar year.
Remark 4: must not be exceeded more than 35 times in one calendar year.

Table 2. Concentrations of sulphur dioxide and nitrogen dioxide, which are hazardous to human health

Polluting substance	Concentration hazardous to human health
Sulphur dioxide	500 µg/m³
Nitrogen dioxide	400 µg/m³

Regulation on air quality values („RS Official Gazette" No. 124/12)

Table 3. Maximum permissible concentration for the protection of human health in case of dedicated measurement for Total suspended particles

Period of averaging	Maximum permissible value
One day	250 µg/m³
Calendar year	90 µg/m³

Concentrations hazardous to human health are measured during three consecutive hours at locations representative for the quality of air in an area not less than 100 km^2, or in a zone or agglomerations, if their area is smaller.

MEASUREMENT RESULTS

A mobile station equipped with analysers for the measurement of air polluting substances was used every month in the period January – December 2015 at the location of RS Silicon LLC Mrkonjić Grad construction site to conduct a one-day measurement of the immission concentrations of polluting substances, as follow: total suspended particles, CO, SO_2 and NO_2, with a simultaneous measurement of wind speed and direction.

Wind direction is conditioned by seasons and terrain configuration, and geographic location of the very area where the measurement was conducted. During the observed period several directions of wind were registered; out of these the most dominant were winds from the direction of south and southwest, and occasionally from the direction of northwest. Measured wind speeds during the observed period ranged in interval 0.3 - 6.5 m/s.

With regard to the measured values of carbon monoxide (CO), we can notice that the highest averaged daily immission concentration of 32.6 µg/m^3, measured in December, is multiple times lower than the prescribed limit value of 5 mg/m^3 (5000 µg/m^3) (figure 2).

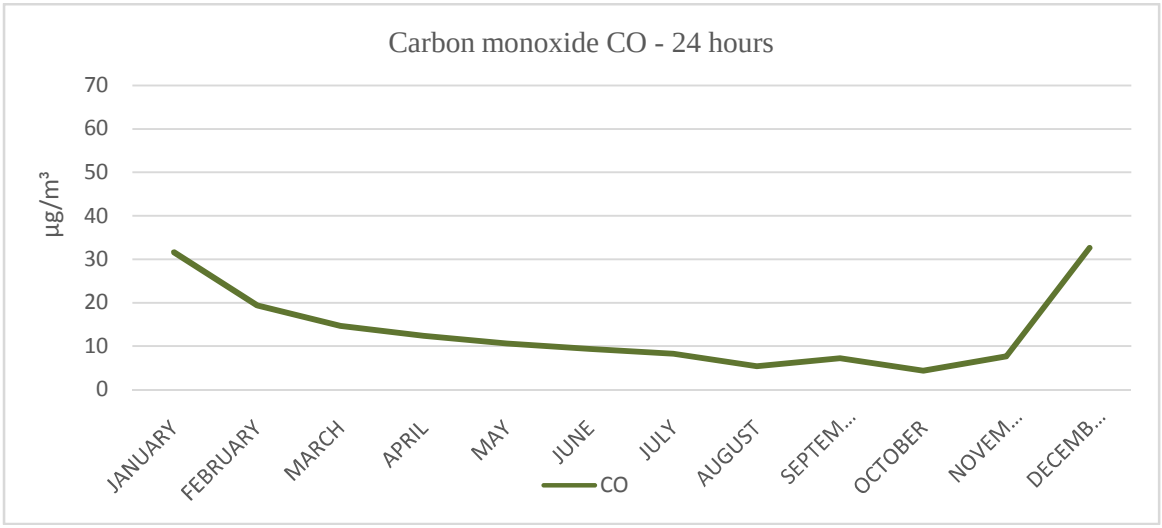

Figure 2. Overview of daily concentrations of carbon monoxide (CO) in the year 2015 according to the data from the mobile station for air pollution measurement

In an eight-hour measuring interval, the highest immission concentrations of CO of 58.3 µg/m^3 were also measured in December and are much lower than the limit value of 10000 µg/m^3 (figure 3). The highest 1h concentration of carbon monoxide in the air of 113 µg/m^3 was registered also in the month of December, and the lowest 1h concentration was recorded in May and October, as low as 15 µg/m^3.

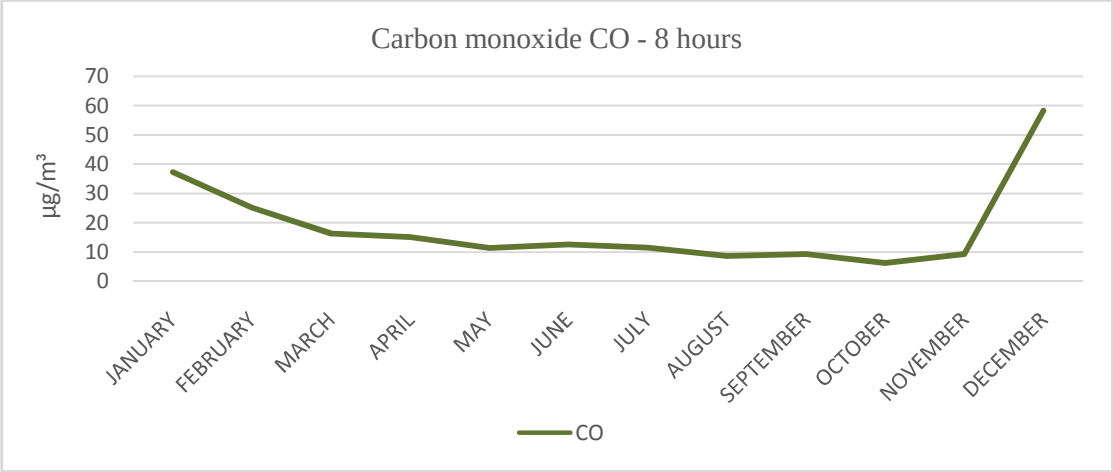

Figure 3. Overview of 8-hour concentrations of carbon monoxide (CO) in the year 2015

Averaged daily concentration of total suspended particles in the air at the observed location ranged between 21.6 µg/m^3, as measured in February, and 250.0 µg/m^3, measured in the month of November (figure 4), which reached the maximum permissible value for the protection of health in case of dedicated measurements prescribed by the Regulation on air quality values [4].

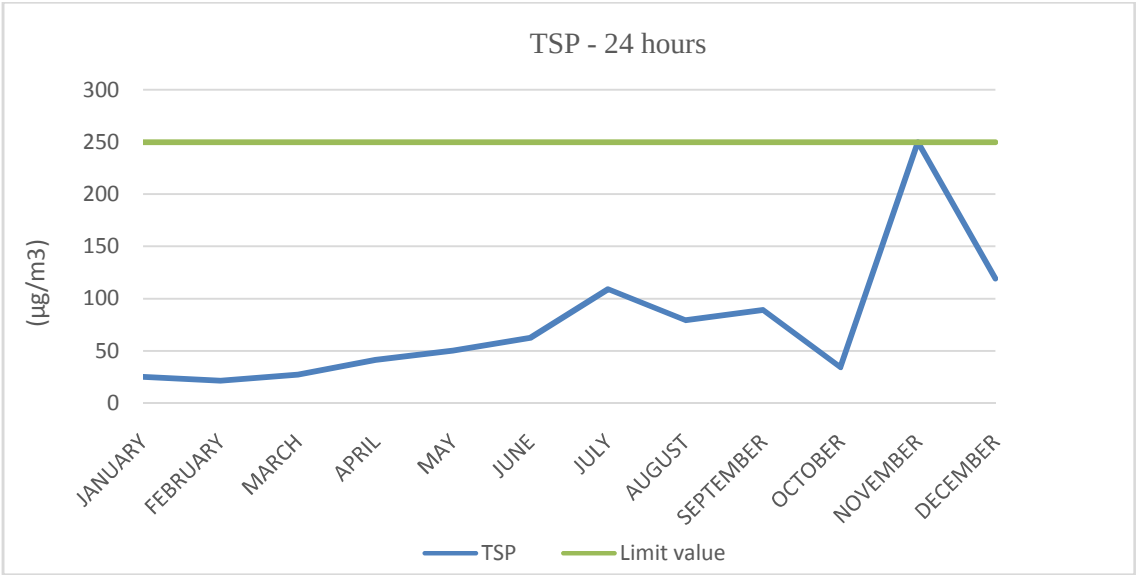

Figure 4. Overview of daily concentrations of total suspended particles in air in the year 2015

According to the data from the automatic air pollution measurement station in the first half of 2015, the highest hourly concentration of total suspended particles (TSP) in the air was registered in the month of June and amounted up to 141.0 µg/m^3. In the second half of the year, the hourly concentration of TSP reached much higher values, with a maximum in the month of November when it reached a value of 507 µg/m^3 (figure 5).

The highest average immission 24-hour concentration SO_2 in the observed measurement period January – December was measured in the month of November, when a value of 15.2 µg/m^3 was recorded, which is far below the limit value of 125 µg/m^3 (figure 6).

The highest one-hour concentration of SO_2 in the air at the selected construction site location was recorded in the month of September and amounted to 41 µg/m^3 (figure 7), which is far below the limit value of 350 µg/m^3, prescribed by the Regulation on air quality values [4].

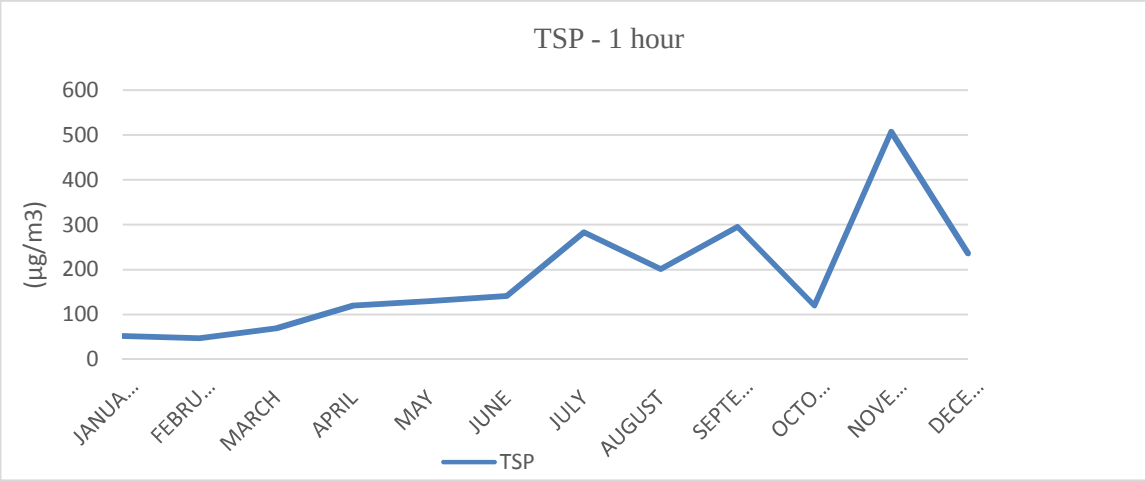

Figure 5. Overview of hourly concentrations of total suspended particles in air in the year 2015

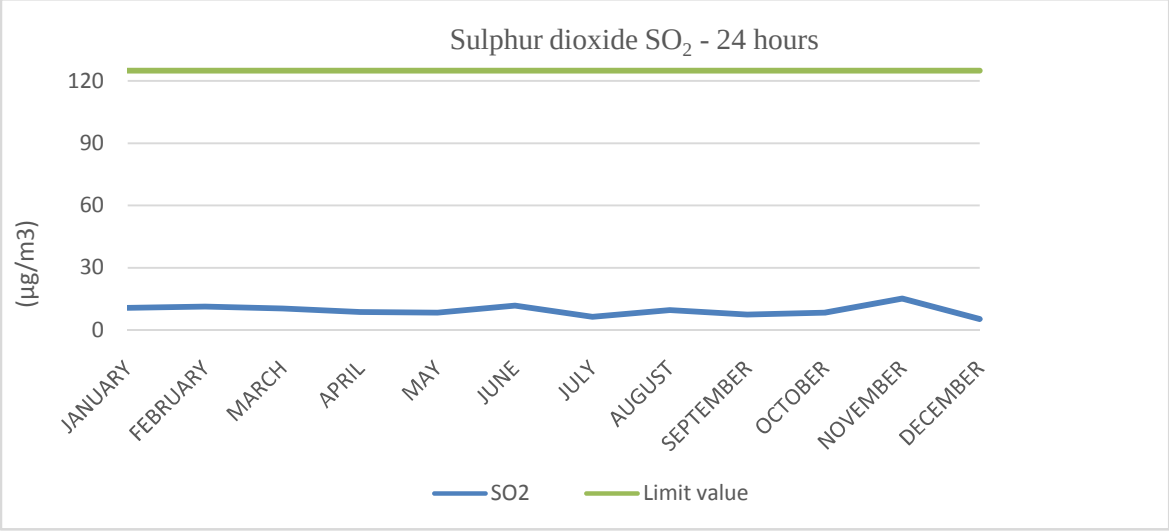

Figure 6. Overview of daily concentrations of sulphur dioxide (SO_2) in air in the year 2015

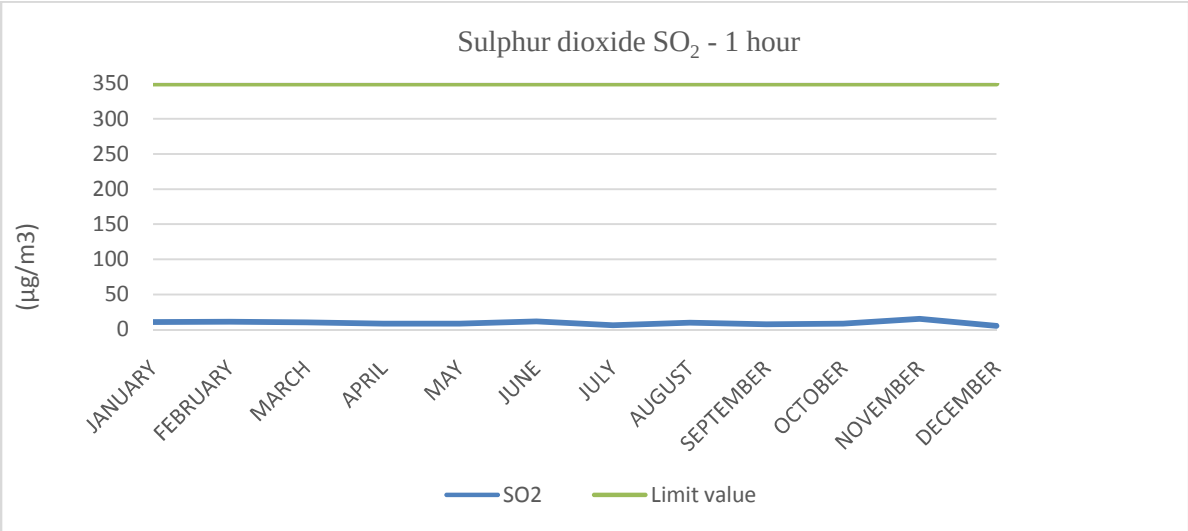

Figure 7. Overview of hourly concentrations of sulphur dioxide (SO_2) in air in the year 2015

Limit daily value for NO_2, which according to the Regulation on air quality values (RS Official Gazette, No.124/12) amounts to 85 µg/m^3, was not exceeded during the year 2015. Averaged daily concentration of NO_2 in the air at the observed location ranged between 4.3 µg/m^3, as measured in November, and 8.3 µg/m^3, measured in the month of Jun (figure 8).

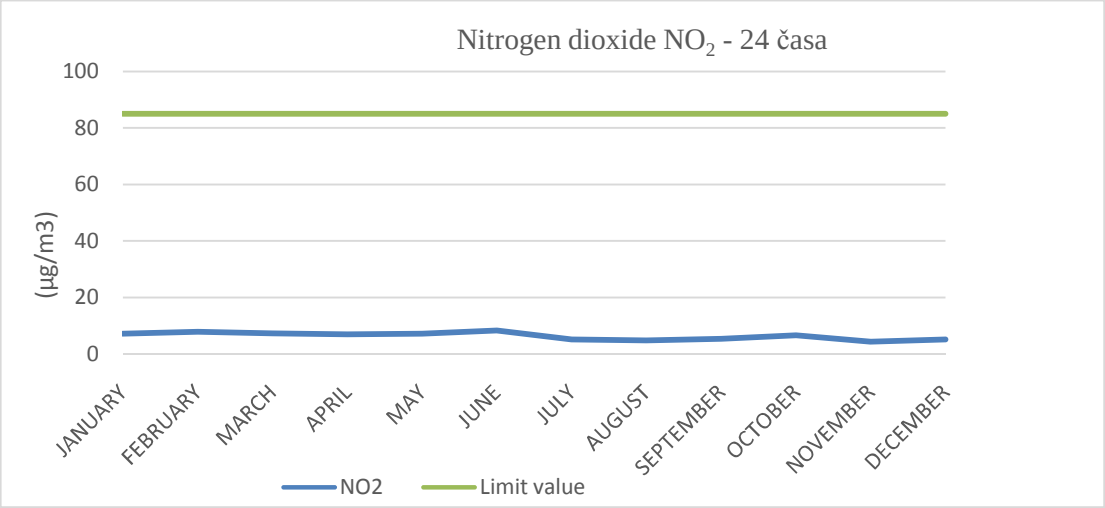

Figure 8. Overview of daily concentrations of nitrogen dioxide (NO_2) in air in the year 2015

The highest hourly immission concentration of NO_2 at the selected construction site location was recorded in September and October, and amounted to 20.0 µg/m^3, which is far below the prescribed limit value of 150 µg/m^3 (figure 9).

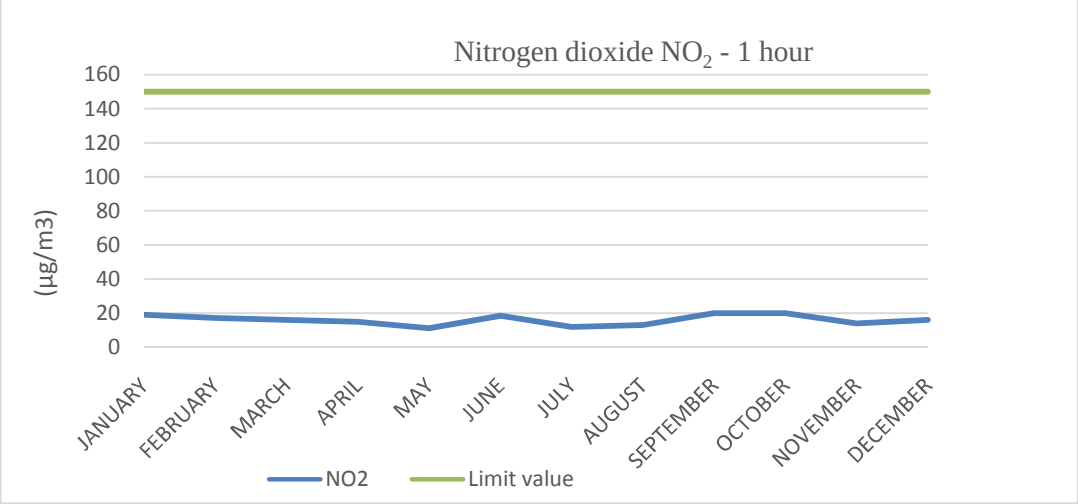

Figure 9. Overview of hourly concentrations of nitrogen dioxide (NO_2) in air in the year 2015

DISCUSSION

Results of the air quality measurement during 2015 at the location of RS Silicon construction site, in the village of Bjelajci, had shown that the air in this area is mostly loaded with total suspended particles. It should be stressed that the mentioned regulation [4] does not define limit values for total suspended particles (TSP), but for particles PM_{10} and $PM_{2.5,}$ and that for TSP was determined a maximum allowable concentration for the protection of human health in case of dedicated measurements. It is a fact that concentration of total suspended particles reached the maximum value allowed related to health in amount of 250.0 µg/m^3 in the mentioned twelve-month period, which was

recorded in the month of November. Concentration of deposition of particles/matter depends on the seasons; they are mostly increased in the autumn and winter months [6] due to increased consumption of fossil fuels and the weather. Particulate matters consist of a mixture of solid and liquid particles of organic and inorganic substances that are suspended in the air, and they, as complex mixtures have a very negative impact on human organism because they are inhaled and deposited in the respiratory system [7]. Particulate matters occur in the air in diverse forms and sizes, starting from a diameter of several millimetres to several microns [8]. Adversity of the impact on human health is inversely proportional to dimensions of suspended particles [9].

Since the silicon metal production process results in significant quantities of dust as a product of the quartz melting process, the addition of carbon substances (wooden chips, wooden charcoal, charcoal with a low percentage of ash), and that dust is emitted during the process of crushing and classifying the silicon metal in the separation to commercial granulations [2] it is necessary to provide continuous monitoring of the concentration of PM_{10} (particles with a diameter smaller than 10 μm) and $PM_{2.5}$ (with a diameter smaller than 2.5 μm), soot and total suspended particles and, if necessary, take measures for decreasing their concentration.

CONCLUSION

Prior to the construction, and commissioning of subject factory, the zero state of air quality around the factory was determined in order to have a realistic image of its impacts on air quality during the operation. The location at which the construction of this factory is planned is situated in rural area, in the village of Bjelajce, municipality of Mrkonjić Grad. A characteristic of this area is the absence of industrial polluters. The most significant sources of emissions at subject location is the R-412 regional road, section Mrkonjić Grad – Crna rijeka, and two plants whose primary activity is wood processing. Population mostly practise agriculture, mainly for their own needs. All this show that the environmental quality at subject location and its area is at a rather high level.

With the aim of establishing level of the air quality at the location of the planned factory, air quality was measured in the period January – December 2015 with a movable station equipped with analysers for the measurement of immission concentrations of polluting substances. The results of measurements had shown that all values of the measured air polluters were far below the limits of allowed values, except for a daily concentration of total suspended particles, which reached its highest value of 250.0 $\mu g/m^3$ in November. According to the Regulation on air quality values this value represents a maximum allowed value related to health in case of dedicated measurements. Sources of an increased emission of dust and waste gases are the mentioned regional road, local roads, plants whose primary activity is wood processing and individual furnaces of surrounding households.

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