15th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2011, Prague, Czech Republic, 12-18 September 2011

# MONITORING OF AIR QUALITY IN ZENICA VALLEY

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## ABSTRACT
*This paper presents the results of measurements of air pollution in the town of Zenica for period 2006 – 2010. Measurement parameters are sulfur dioxide ($SO_2$), TSP (total suspended particles), and the content of lead and cadmium in the TSP by fixed measurement points. Give a somewhat more detailed results of the measurements for 2010 mobile station of the University in Zenica in measuring point Tetovo near the steel mills Arcelor Mittal for the parameters: sulfur dioxide, $SO_2$, and PM10 (particule of matter). Presents the results of measurements are analyzed and evaluated in relation to the standardized values of the parameters of air quality in terms of average and high values of concentrations of certain pollutants under the regulations of the Federation of Bosnia and Herzegovina (FB&H). The results clearly show the trend of the impairment of the quality of air concentrations of $SO_2$, and $PM_{10}$, but for the first year the active measurements exceed the annual average, as well as the parameters of high concentrations, adding to the situation, the high value of the TSP in the earlier period, due to many years of active presence of the basic industries , and due to the geometry of Zenica valley and meteorological parameters, favoring the creation of temperature inversions.*
**Keywords:** sulfur diokside ($SO_2$), particle of mater ($PM_{10}$), total suspended particles (TSP), measurment points, air quality, air monitoring.

## 1. INTRODUCTION
At the beginning of the third millennium, the air quality in urban areas in Europe, due to growing industrialization, receive special attention. In industrial zones, the problem of air pollution is much higher, especially in areas with a developed base industries such as ironworks [1].
Research and monitoring air quality in urban and industrial areas is one of the first steps towards a solution, in most countries of the world, present problems of air pollution. The study and monitoring of air quality aims to control and reduction of harmful substances in it [2].
For monitoring the air quality in particular attracted the attention of $SO_2$, $PM_{10}$, and the content of heavy metals (Pb, Cd, Zn) and other pollutants. In the deep Zenica valley over 118 years shall be primary and secondary metallurgical production at substantially the burning of brown coal with high sulfur content. In this valley, present adverse conditions for the maintenance of air quality due to high emissions of $SO_2$, dust with a high content of heavy metals and organic matter, and because of the unfavorable terrain. Sulphur dioxide ($SO_2$) is a traditional atmospheric pollutants, and monitoring of its concentration of particular interest to characterize the air quality which says the World Health Organization (WHO, 2000). $SO_2$ is one of the major polluters of the environment and is mainly derived from oxidation of sulfur compounds [1,3]. Therefore, a longer period of $SO_2$ measured at several fixed points, while the last two years and a mobile automatic monitoring stations.
Suspended particles $PM_{10}$ (Particel of matter, d <10 microns) and $PM_{2,5}$ are one of the most important atmospheric pollutants that adversely affect human health, with exposure to these particles cause respiratory and cardiovascular diseases and increased mortality in humans [1]. The measurement of

these particles in the air began in the last two years using the mobile monitoring station, while for many years before the present measurements of total suspended particles (TSP) and the content of lead (Pb) and cadmium (Cd) in the TSP, and the sedimentary dust and the contents of individual heavy metals (Pb, Cd, Zn ..) in the sedimentary dust at several locations in Zenica valley [3].
During the period of 2006-2010 years were carried out continuous measurements of air pollution in Zenica on fixed measuring points (measuring equipment of the Institute "Kemal Kapetanovic" of the Zenica University), and periodic measurements were made at different locations and time intervals mobile automatic measuring stations: University of Zenica, DvokuPro Sarajevo and Zenica-Doboj Canton. Mobile measuring station of the University were carried out continuous measurements in 2010 at location in Tetovo.

## 2. RESULTS OF AIR QUALITY MEASURMENT

During the period in 2006 - 2010 was conducted on the continuous measurements of $SO_2$ on three points: Institut, Crkvice and Tetovo, as shown in Figure 1 [3]. During the follow-up in 2006 not only resulted in exceeding the annual limit value 90 µg/m3 of air [3,4]. 98 - percentile ($C_{98}$ = 240 µg/m3, according to the regulations of the Federation of Bosnia and Herzegovina - FBiH) for all years of measurement is exceeded for almost all points. This shows that the air quality in terms of monitoring $SO_2$ disrupted continuously over recent years, and that the maximum daily values of the 98-percentile point of excess, which gives the load air pollutants over a number of days within a 24-hour monitoring.

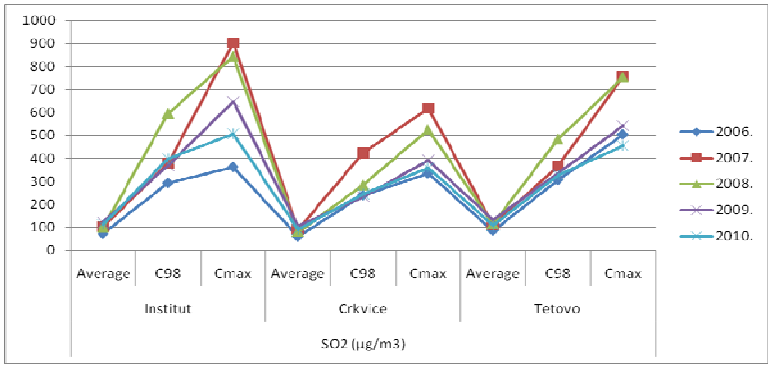


*Figure 1. Graphical display of measurements of $SO_2$ at three fixed measurement points [3].*

From the diagram shows that in all places (Tetovo, Institut and Crkvice) are almost identical to the movement of the curve by years and by statistical parameters, indicating the same trend of pollution at all measuring points. It further says, the consistency of meteorological parameters (although not continuously measured), which in this case does not differentiate sites with lower exposure to sulfur dioxide as pollutant.
The average content of TSP over the years did not exceed the standardized value of 150 µg/m$^3$ (Figure 2). High daily concentrations exceeded only in 2010 during which builds on the increased content of $PM_{10}$ concentrations, and the launch and continued operation of a plant of Arcelor Mittal with the end of 2008 [3].

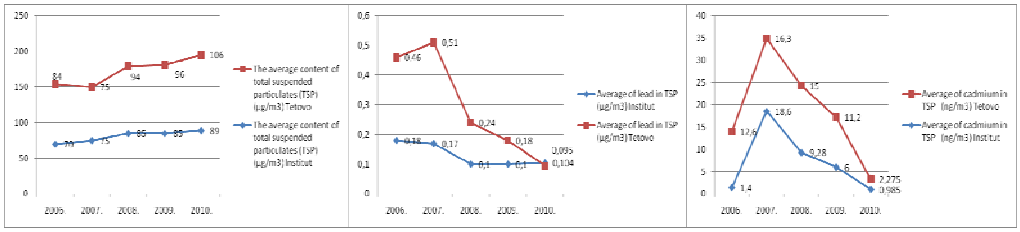


*Figure 2. Graphic display of measurement TSP and contents of Pb and Cd in the TSP at two fixed measuring points [3].*

Figure 2. shows that the average annual values have not been exceeded for lead content (2 μg/m3) and cadmium in ULC (40 ng/m3) [3,4]. The diagram clearly shows significantly higher concentration the measuring point Tetovo, due to the location of measuring stations near the metallurgical plant and equipment.

The first measure, which was conducted by the Sarajevo DvokutPro companies in the period 22-24. December 2008 mobile automatic monitoring stations within the Metallurgical Institute "Kemal Kapetanovic" in Zenica, shows a high average value of $SO_2$ (average: 289.11 and max. value: 699.11 μg/m$^3$) and $PM_{10}$ (average: 110.95 and max. value: 185.2 μg/m$^3$). Likewise, the second measurement, the phase shift of 50 days, completed in 12-23. February 2009 at the measuring point Tetovo, registered a very high concentration of $SO_2$ (average: 252.83 and max.vrijednsot: 927.85 μg/m$^3$) and $PM_{10}$ (average: 146.37 and max. value: 394.95 mg / m$^3$) [5].

Table 1. shows the summary results of measurements of air quality mobile automatic monitoring station at the location in Tetovo in 2010. $SO_2$ concentrations were higher than the average annual value of 90 μg/m$^3$, which means that the air pollution in Zenica valley [4,6]. With regard to particulate matter $PM_{10}$ average value of 67.16 μg/m$^3$ not be used for the evaluation of criteria for the annual average due to low volume measurements. Being in the third quarter of 100% achieved the level of valid test results and the average measured value particle of matter amounted to 54 μg/m$^3$, which indicates that it is permissible annual average particulate of matter of 50 μg/m$^3$ is exceeded in the period when the lowest air pollution flowing particles (not the heating season and the most favorable weather conditions). Although measurements are not made throughout the year in the required volume can be concluded that in Zenica excessive air pollution airborne PM10 particles [6].

*Tabela 1. Summary results of measurements for 2010 [6].*

| Pollutnat | Sampling period | Number of samples | The limit value for high values (μg/m$^3$) | The average measured value (μg/m$^3$) | The maximum value of the measured period (μg/m$^3$) | Number of exceedances of high values | Number of exceedances for $SO_2$ >500 μg/m$^3$ three and / or more consecutive hours |
|---|---|---|---|---|---|---|---|
| $SO_2$ | 1 sat | 7584 | 500 | 117,4 | 986,08 | 79 | 33 |
| $SO_2$ | 24 sata | 316 | 240 | 117,4 | 503,68 | 20 | - |
| LČ10 | 24 sata | 217 | 100 | 67,16 | 741,9 | 32 | - |

Table 2. shows the active period of measurement mobile automatic monitoring stations exceeded as the daily high (24-hourly) values in percentage, and they give The index for the statistical evaluation of the annual high concentrations (98$^{th}$ percentile, $C_{98}$). According to these results, the conclusion that both the analyzed pollutants ($SO_2$ and $PM_{10}$) on an annual basis, at least 7% of the active periods of measurements in Zenica valley, provided the trend of air pollution [6].

*Tabela 2. Active measurement period and exceeding the 2010 [6].*

| Pollutant | Measurement period / day (hours) | Active measurement period (%) | Exceedance (%) | $C_{98}$ (μg/m$^3$) |
|---|---|---|---|---|
| $SO_2$ | 365 (8760) | 86,5 | 6,32 | 301,48 |
| $PM_{10}$ | | 59,06 | 14,74 | 191,52 |

## 3. ANALYSIS OF RESULTS AND CONCLUSION

On the basis of results of measurements of daily average concentration of $SO_2$ at a fixed measuring stations (Institut, Crkvice i Tetovo) can be concluded that the wider area of Zenica, number of days exceeding the high concentration of 240 μg/m$^3$ is much higher than the maximum allowable exceeding 7 days during the calendar year.

Based on the results of measuring the concentration of airborne particles (TSP) at a fixed lid (Institute and Tetovo) can be concluded that at these locations, the number of days exceeding the high concentration of 350 μg/m$^3$ is rarely greater than the maximum permitted 7 days exceeded during the calendar year . It should be noted that the regulations of the Federation criteria for the assessment of air pollution with ULC very gently. In several EU countries there are no criteria air pollution ULC or the exercise of their measurements.

The content of heavy metals in the TSP does not exceed the limit values according to the regulations of the Federation. However, in EU countries, the content of heavy metals is not determined by the TSP, but the airborne $PM_{10}$ particles. Based on measurements by automatic monitoring stations in the considered period, the winter period is expressed frequently exceeding the prescribed threshold alarms for $SO_2$ (three or more hours of $SO_2$> 500 μg/m$^3$), that the daily averages of $SO_2$ greatly exceeded the allowed 24-hour exceedance of 500 μg/m$^3$ during the calendar year, and that the daily averages of concentrations of particulate matter $PM_{10}$ exceeded the allowed 7 days excess of 100 μg/m$^3$ during the calendar year.

Based on the presented results of measurements of concentrations of certain pollutants into the air, we can see that the trend of increasing air pollution at all points in the same period. In the days of high air pollution were unfavorable meteorological conditions (steady state of the atmosphere with a temperature inversion) for the dispersion of pollutants in Zenica valley. Previous studies have shown that in winter the days of stable atmospheric conditions with temperature inversion leads to a rapid increase of pollution in the deep valleys of central Bosnia (Sarajevo, Visoko, Kakanj, Zenica; available measurements), which is largely influenced by the occurrence of episodes of high air pollution . It is evident that the episodes of high air pollution days in Zenica in a stable state of the atmosphere with a temperature inversion repeated until the Ironworks in Zenica do not implement large projects to reduce air pollution. Likewise, in the days of stable weather situations can not be underestimated the impact of small boiler and secondary combustion air quality, due to its high content of sulfur and ash in Zenica coal [3,7].

Better and more complete picture impacts on air quality and air pollution in Zenica valley can be achieved by comprehensive monitoring and research programs in dominant sources and looking for correlations with measured air quality parameters. To obtain complete cross-section status and trends of air quality, and to define air quality management strategy, it is necessary to include the monitoring of meteorological parameters and other pollutants in the air and enrich the network of monitoring stations for air quality assessment.

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