

AN ASSESSMENT OF THE QUALITY OF THE ATMOSPHERIC AIR IN TWO INDUSTRIAL REGIONS IN BULGARIA

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Abstract

We prepared an assessment of the quality of the atmospheric air in two regions of developed chemical industry in Bulgaria – Devnya and Dimitrovgrad, 1996 – 2001 years. We carried out a monitoring of the air pollution in two permanent stations, by using automatic analyzers, and in 4 stations with active methods for sample taking. The following parameters were covered: SO₂, H₂S, aerosols of H₂SO₄, NO₂, NO, NH₃, CO, ozone, total suspended particles (TSP), particulate matter-10 and lead aerosols. The results were processed by the method of variation analysis. In Dimitrovgrad the registered mean annual concentrations of SO₂, H₂S and NO₂ were considerably high: levels of SO₂ reach 1,6 times over the utmost permissible concentrations (UPC), H₂S – 1,9 times, NO₂ – 4,1 times. In 2001 we observed a decrease in the pollution with SO₂ and NO₂. The concentration of particulate matter-10 was very high in Devnya reaching 3,9 times over the UPC. Levels of NH₃ were up to 6,2 times over the UPC, but decreased in 2001. In both regions permanently high levels of TSP were established. In Devnya there was a trend of increase of the pollution with aerosols of H₂SO₄, 1,2 times over the UPC. A program aiming to diminish the emissions is being established.

Introduction

According to the National plan for environmental health in Bulgaria, the towns of Devnya and Dimitrovgrad are defined as “hot spots” of high concentrations of atmospheric pollutants, harmful to the health and well-being of the local population. Devnya and Dimitrovgrad are regions of intensively developed chemical industry. There are plants for the production of nitrate and phosphate fertilizers, calcinated soda, chlorine and chlorous products, cement, as well as a stream power plant are located on the territory of the town of Devnya. There are analogous factories on the territory of the town of Dimitrovgrad – chemical plant mainly for nitrate and phosphae fertilizers, but also although in minimal quantities about 40 organic and inorganic products; a plant for cement production and a steam power station in the region of the plant, as well as another steam power station – Maritsa III. The problems of the “hot spots” are due mainly to the emissions of nitrate and sulphuric oxides, hydrogen sulphide, ammonia, total suspended dust and particulate matter (PM10). There are many studies done on the environmental health of the exposed population in the industrial regions of significant atmospheric air pollution. There is a correlation between atmospheric air pollution with sulphur dioxide, sulfur acid, dust, ammonia, nitrogenous dioxide and pulmonary diseases (acute and chronic bronchitis, asthma, acute infections of upper respiratory tract), cardiovascular diseases, haemopoetic disorders, as well as skin diseases and neoplasmas (1 – 6). The National system for observation, control and information on the environmental status in Bulgaria and the local systems for monitoring of the atmospheric air registered for a long period over the standard concentrations of the typical for the chemical regions pollutants. The aim of the current research is to provide an estimation of the quality of the atmospheric air for the period of years 1996 – 2001 in these two industrial regions and prepare a program to diminish the emissions to levels lower than the established standards for atmospheric air pollutants.

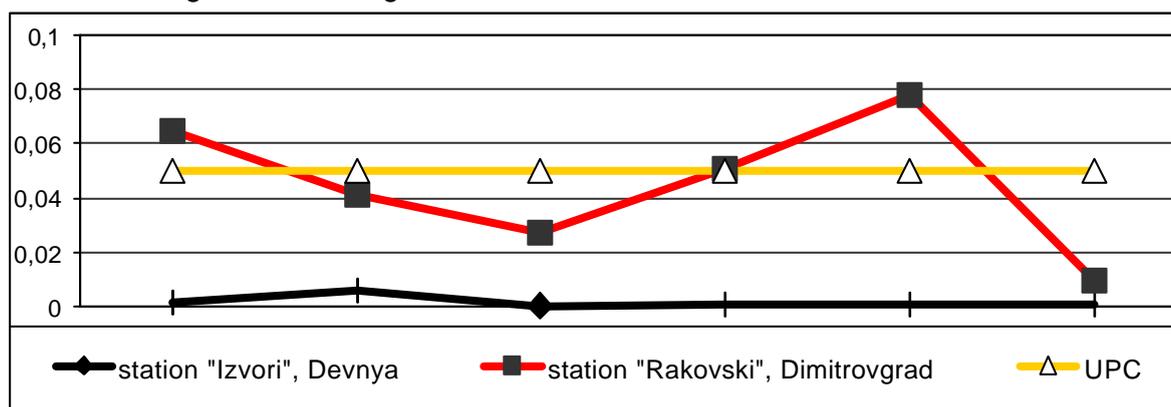
Methods

The monitoring of the atmospheric air in Devnya and Dimitrovgrad was carried out in 2 permanent automatic stations of the National system for air monitoring and in 4 stations using active methods for samples collection and standardized methods for analysis of the local monitoring system. The automatic station "Izvori" in Devnya is located in the center of the town nearby one of the biggest industrial sources of pollutants – the cement plant. The automatic station "Rakovski" in Dimitrovgrad is located at about 3 km from the chemical factory for fertilizers. The stations of the local air monitoring system are located as follows: in Devnya – station "Povelyanovo" is the nearest to the plant for nitrate and phosphate fertilizers, station "Devnya" is located at 5 km from the industrial objects on the territory of the town. In Dimitrovgrad the station "Prolet" is in the central part of the town at about 2 km from the chemical factory and at about 5 km from the cement plant. The station "Mariino" is located in the west part of the city. It stands at 1 km from the cement plant and at 6 km from the steam power station Maritsa III. The permanent automatic stations are equipped with measuring and registering apparatus of the "SFI" firm, France. They are built as stationary-informational measurement stations, working 24 hours. They have automatic gas analyzers "Monitor Labs" for incessant control of the atmospheric air, from which data is showed every minute and is equalized every hour. Samples are collected at the height of 2,5 m from the ground. The study was carried out from year 1996 to 2001, and registered the following indices, included in the National and local monitoring systems: SO₂, H₂S, aerosols of sulfur acid, NO₂, NO, NH₃, CO, ozone, TSP, PM₁₀ and lead aerosols. We also observed the background data in the ground stratum: wind velocity and direction, air temperature and humidity, atmospheric pressure and sun radiation. The results were processed by the method of variation analysis.

Results and Discussion

The results from the atmospheric air monitoring in the automatic stations showed that the SO₂ pollution in Dimitrovgrad is significantly higher in comparison with that in Devnya. The mean yearly concentrations of SO₂ in 1996 reached 1.3 times over the upper permitted concentrations (UPC), and in 2000 – up to 1.6 x UPC. In 1998 and 2001 there was a decreasing trend with lowest levels in 2001- 0,0095 mg/m³ (Fig. 1).

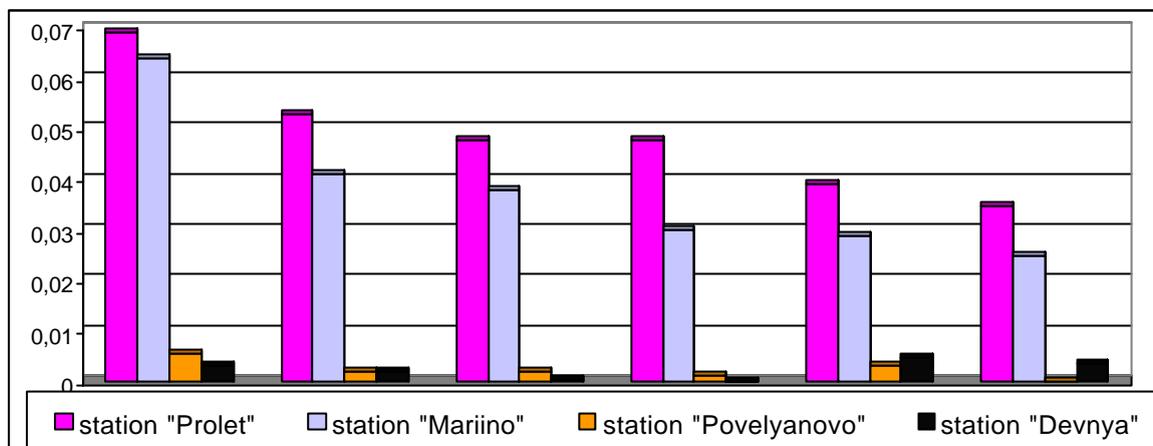
Fig 1. Atmospheric air pollution with SO₂ at stations from the National system for monitoring, UPC = 0,05 mg/m³, data in mg/m³



The concentrations of SO₂ in Devnya were extremely low for the same period and varied from 0,00053 to 0,0014 mg/m³ (UPC = 0,05 mg/m³). The increase in the concentrations of sulfur dioxide in the atmospheric air in Dimitrovgrad is statistically reliable in comparison to that in Devnya, and the differences are of high statistical significance (0,001 ≤ P ≤ 0,05). The data for SO₂ in the stations for manual collection of samples was identical. In 1996 the concentrations of SO₂ in "Prolet" station in Dimitrovgrad reached up to 1.4 UPC, and at station "Mariino", Dimitrovgrad – up to 1.3 x UPC. After which there was a gradual decrease of the mean yearly concentrations and after the year 1998 they were under the hygienic

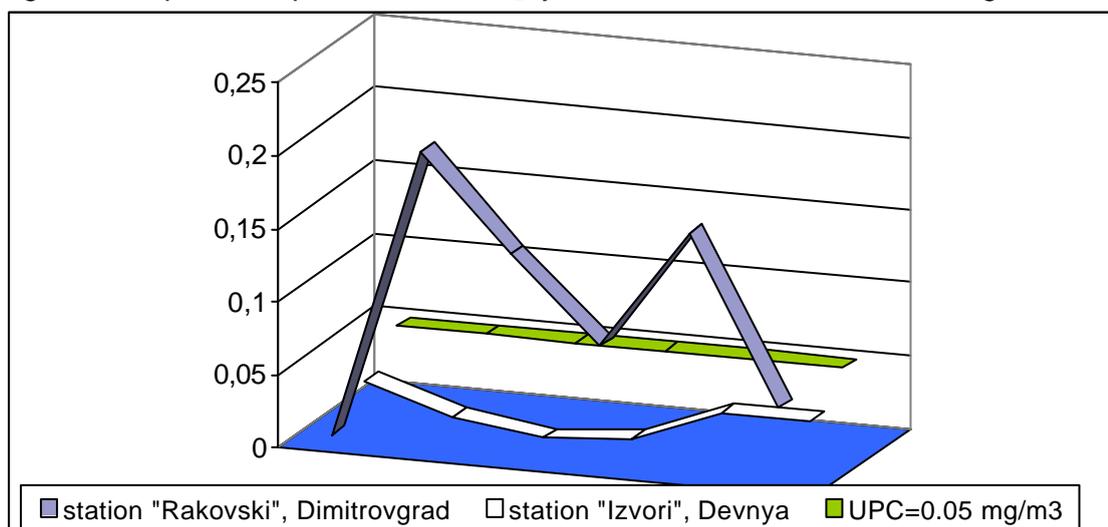
norm. In 2001 the levels were 0.035 mg/m^3 for the first station and 0.025 mg/m^3 for the second one (Fig. 2).

Fig. 2. Atmospheric air pollution with SO_2 in two stations of the local monitoring system, years 1996 - 2001, data in mg/m^3 , stations 'Prolet' and 'Mariino', Dimitrovgrad; stations 'Povelyanovo' and 'Devnya', Devnya. UPC = 0.05 mg/m^3



In Devnya the levels of SO_2 in the atmospheric air were much lower. In the 'Povelyanovo' station for the entire period of observation they varied from $0,00022$ to $0,0057 \text{ mg/m}^3$, and in station 'Devnya' – from $0,00053$ to $0,0050 \text{ mg/m}^3$. The higher concentrations of SO_2 in Dimitrovgrad in the stations of active methods for collection of samples in comparison to these in Devnya are statistically reliable. The high levels of SO_2 in Dimitrovgrad makes it a typical air pollutant in this industrial region. Its main sources are the thermoelectric power station, which use brown coal of high sulfur content, as well as from the steam stations in the town, local steam boilers, domestic heating burning hard and liquid fuels of high sulfuric content. The data for NO_2 were also higher in Dimitrovgrad. The mean yearly NO_2 concentrations in the automatic station 'Rakovski' reached up to $4.1 \times \text{UPC}$ in 1997, and gradually decreased to $1.7 \times \text{UPC}$ in 1999. In 2000 there was an increase again up to $3.4 \times \text{UPC}$ and levels were slightly over the standards in 2001 – $1.1 \times \text{UPC}$ (Fig. 3).

Fig 3. Atmospheric air pollution with NO_2 , years 1996 - 2001, UPC = $0,05 \text{ mg/m}^3$

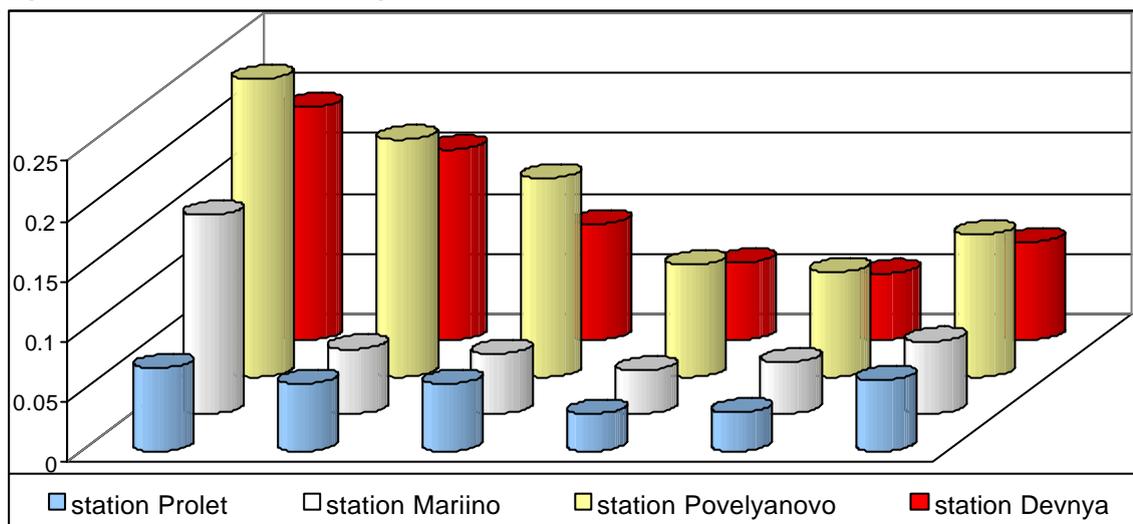


The concentrations of NO_2 in the automatic station 'Izvori' in Devnya were much lower and varied from $0,00038$ to $0,029 \text{ mg/m}^3$ (UPC = $0,05 \text{ mg/m}^3$). The concentrations of NO_2 in the stations for manual collection of samples in these two towns were entirely under the norm. Except for the year 1996, there are also statistically reliable higher levels of NO_2 in Dimitrovgrad in comparison to Devnya.

The main sources of air pollution with NO_2 are the emissions from the production of nitrate fertilizers in both cities - simple and stabilized ammonia saltpeter and liquid nitrate fertilizer

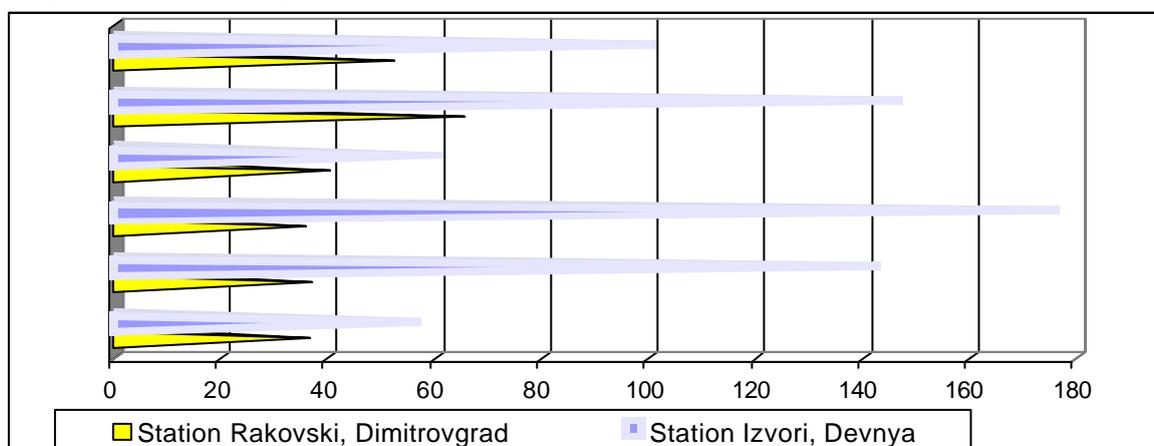
The H₂S pollution is much higher in Dimitrovgrad. In the two stations with active methods for collection of samples the mean yearly concentrations varied from 0,00024 tî 0,00173 mg/m³, while in Devnya the registered levels were around the zero (UPC = 0,008 mg/m³). In the automatic station in Dimitrovgrad the H₂S levels towards 2001 reached up to 1.9 x UPC. The concentrations of NH₃ were much higher and entirely over the norm for the observed period in Devnya. In the "Povelyanovo" station the NH₃ levels reached up to 6.2 x UPC in 1996, and in station "Devnya" –4.8 ò UPC. Gradually there was a decrease up to 3.3 x UPC in 1998 for the first station and 1.9 x UPC in the second one. In 2000 the levels were even much lower, but again over the standard –2.4 x UPC in "Povelyanovo" and 1.6 x UPC in "Devnya" (Fig. 4).

Fig. 4. Atmospheric air pollution with NH₃, years 1996 - 2001, data in mg/m³, stations "Prolet and Mariino", Dimitrovgrad, stations "Povelyanovo and Devnya", Devnya, UPC₁₉₉₆ = 0,04 mg/m³, UPC₁₉₉₇₋₂₀₀₁ = 0,05 mg/m³



The mean yearly concentrations of ammonia in Dimitrovgrad were much lower, about and under UPC (except for 1996). The higher ammonia levels in Devnya are due to the greater number of sources of emission: production of ammonia, stabilized ammonia saltpetre, liquid nitrate fertilizer, calcinated soda using Solvay's ammonia method. In Devnya the concentrations of PM₁₀ are also higher. In 1996 - 2001 they were over the standard and varied from 1.24 tî 3.9 x UPC. In Dimitrovgrad the levels were much lower and reached 1.4 x UPC in 2000. Towards 2001 the concentrations were slightly over the norm (Fig. 5).

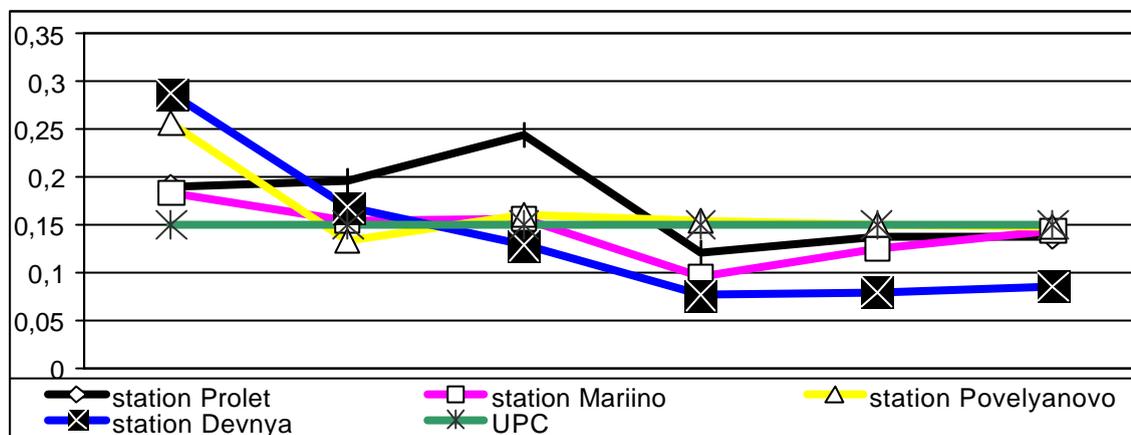
Fig. 5 Atmospheric air pollution with particulate matter - 10 (P10), years 1996 - 2001, data in µg/m³, UPC = 45 µg/m³



The high levels of P₁₀ in Devnya and partly in Dimitrovgrad were mainly due to burning processes, industrial sources and car traffic. In Devnya there was an intensive traffic of cargo vehicles, transporting on daily basis coal and coke from the sea port to the cement

plant, as well as basic raw materials for the fertilizers plant – phosphorite and apatite. In the 2 chemical regions there were permanently high levels of total suspended dust (size of a particle from 10 to 100 μm). In Devnya the concentrations varied from 0,076 to 0,287 mg/m^3 , and in Dimitrovgrad – from 0,095 to 0,244 mg/m^3 (UPC = 0,150 mg/m^3) (Fig. 6).

Fig. 6 Atmospheric air pollution with TSP, years 1996 - 2001, data in mg/m^3 , stations “Prolet and Mariino”, Dimitrovgrad, stations “Povelyanovo and Devnya”, Devnya, UPC = 0,150 mg/m^3



The rest of the pollutants nitrogen oxide, carbon monoxide, ozone and lead aerosols did not exceed the established norm. The concentrations of aerosoles of sulfur acid showed an ascending trend and slight increase in the industrial city of Devnya – up to 1.2 times over the UPC. As a result of the conducted research, a program was established that aims the decrease of emissions of pollutants of levels over the UPC and attainment of the permitted norms of harmful substances in the atmospheric air. The programs were accepted at program and municipality councils and after being financed will be on work.

Conclusions

The registered levels of sulfur dioxide, hydrogen sulfide and nitrogen dioxide were much higher than the upper permitted levels in the atmospheric air in Dimitrovgrad. The concentrations of sulfur dioxide reached up to 1.6 times over the UPC, of H_2S – up to 1.9 times over the UPC, and of NO_2 – up to 4.1 times over the UPC. The concentrations of particulate matter and ammonia were much higher in Devnya for the entire observational period of years 1996 – 2001 and reached up to 3.9 times over the upper permitted concentrations for PM_{10} and 6.2 times over the UPC for ammonia. In the two industrial regions the registered levels of total suspended dust were permanently high. A program for decrease of emissions and reaching the standards for harmful substances in the atmospheric air is established.

References

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