PARTICULATE MATTER AND PHOTO-OXIDANTS IN CITY ENVIRONMENT

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Abstract
We carried out a monitoring of the atmospheric air in the city of Dobrich, Bulgaria, with a mobile station for imission control, equipped with automatic monitors for particulate matter – 10 (PM_{10}) and ozone, 1998 – 2002 years. We observed seven points: city background, transport-related, industry-related, housing-related, the outskirts, and meteorological conditions in the ground level. Everywhere very high concentrations of PM_{10} were registered. In the central city station the mean annual concentrations in 2000 reached 1.9 times over the utmost permissible concentrations (UPC), and in 2001 – 2.8 times. 76.9 to 100% of the maximal concentrations (MC) exceeded the UPC (highest one - 532 $\mu g/cm^3$, exceeding the UPC 7,1 times). In the industrial point the mean daily concentrations (MDC) exceeded the standard 1.5 times. In the transport point 23,5 % of the MC exceeded the standard 2.5 times, and in the housing station – 2.6 times. In 2000 the ozone levels exceeded the UPC in the transport station - MDC in summer exceeded the UPC 1.5 times and 45.8% of the MC exceeded the standards (highest value – 204.5 $\mu g/m^3$). The presence of high ozone concentrations during summer and wind velocity under 1m/sec indicates a photochemical smog in the region of intensive traffic.

Introduction

Particulate matter and photo-oxidants are basic atmospheric air pollutants. PM10 (diameter of a particle under 10 μm) exerts negative effect on population's health, which is determined by their capability to enter the upper respiratory tract and to irritate the skin and exposed mucous membranes. At PM10 concentrations under 100 $\mu g/m^3$ (MDC = mean daily concentration) the number of hospitalizations because of respiratory and cardio-vascular diseases grows, and there is a change in the mortality index (2–4,7). That is why WHO does not recommend the use of short-term standards for exposure. The long-term exposure to low PM10 levels correlates with shorter duration of life. Apart from this, at concentration of PM2.5 of 20 $\mu g/m^3$ and of PM10 of 30$\mu g/m^3$ there is an increase in the morbidity with bronchitis among children and adults (5,8). Photo-oxidants, representatives of the secondary atmospheric air pollutants, include ozone, nitrogen dioxide, hydrogen peroxide, substances of the type of peroxy-acetyl-nitrate, possible other types of organic peroxides and hydroxide compounds. These substances can be measured separately in different ways, but determined as a total, are expressed as ozone. The main sources of air pollution with photo-oxidants are car traffic and industry: oil-processing plants, power stations and other industrial plants, which emit reactive organic compounds and nitrogen oxides. The atmospheric pollution with photo-oxidants, which form the so-called photochemical smog, is a serious problem in cities of developed industry and intensive car traffic. The aim of the current research is to assess the PM10 and ozone levels in the atmospheric air of an ecologically polluted city in Bulgaria and to establish a program with proper measurements to improve the air quality.

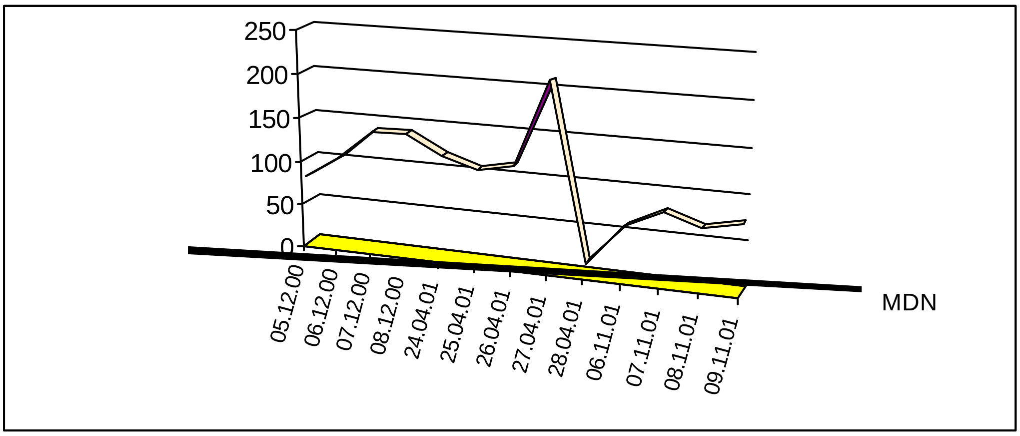
Method

An atmospheric air monitoring was carried out in the ecologically polluted town of Dobrich, Bulgaria. The main sources of air pollution are industry, energetics, car traffic and domestic heating. The emissions from the steam boilers of the industrial plants are basic sources of atmospheric air pollution. On the territory of Dobrich city the air quality is observed mainly via a mobile station for imission control, equipped with automatic monitors. PM10 and ozone levels were determined for 7 stations: city background station in the city center, transport-related station “KAT”, industrial-related station “Start”, 2 in-town stations “Trakya boulevard” and “Square Builder”, representative for the traffic influence, 2 stations in the living quarters “Balik” and “Sariiski” and one suburban background station “Pathway Building”. The samples were collected at the height of 2.5 m above the ground. The analyzer for PM10 measures the weight of dust-like particles on a filter carrier by β-rays absorption. A total of 809 samples of PM10 and 1656 ozone samples were analyzed. Parallel to this the background data about the meteorological conditions at the ground layer were observed: wind velocity and direction, atmospheric pressure, air temperature and humidity, sun radiation. The data for PM10 is for the period 2000-2002, and in most stations measurements are carried out only in 2002. The data about ozone are for a longer period 1998-2002. Final data was compared with the permitted norms, according to Regulations concerning the UPC (Upper permitted Concentration) for harmful substances in the atmospheric air.

Results and Discussion

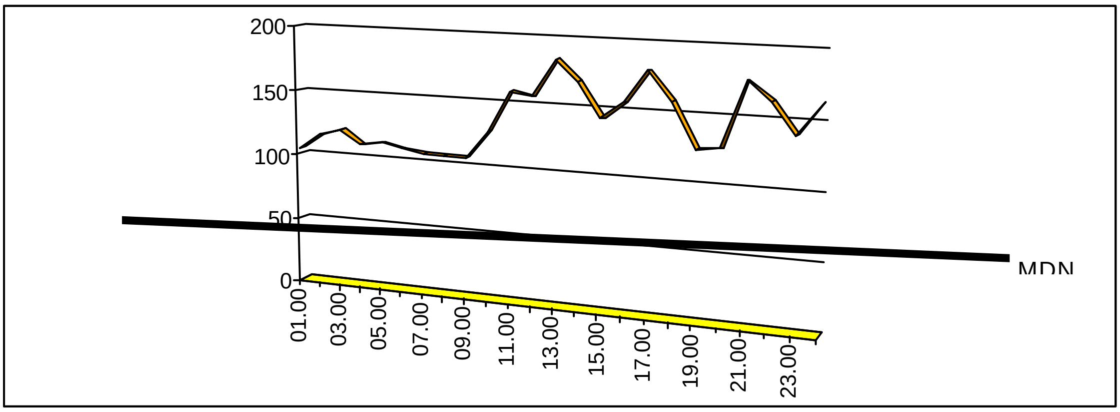
The results from the monitoring show that the PM10 concentrations are very high at all stations. In 2000 the mean day-and-night concentrations of PM10 at the station in the city center exceeded the established norm from 1.1 to 1.9 times, and in 2001 - up to 2.8 times (Fig.1).

Fig. 1 Mean daily concentrations of PM10 at the station in the center of the town (years 2000 - 2001), data in µg/m^3, MDN = mean daily norm (MDN=75µg/m^3)



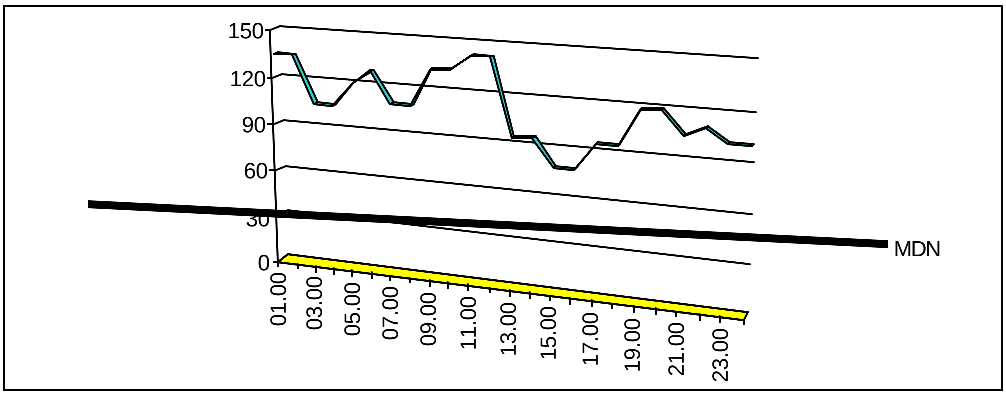
In 2000 from 76.9 to 100 % îf the maximal PM10 concentrations exceeded MDN. The highest MC reached 203 µg/m^3 and exceeded the norm 2.7 times. In 2001 from 25 to 75 % from the MC exceeded MDN but here higher maximal levels of PM10 were registered – up to 532 µg/m^3 and thus exceeded the norm 7.1 times. In the transport station “KAT” the MDC of PM10 that exceeded the norm were registered only in 2000 – from 1.3 tî 2.1 times over the norm, and in 2001 the concentrations were much lower – from 21.2 tî 33.0 µg/m^3. In the year 2000 75 tî 100 % of the maximal PM10 concentrations exceeded MDN, with values that varied from 1.8 tî 11.2 x UPC. In 2001 the number of overexceedings is less – 8.3 tî 15.4 % of the MC exceeded the norm up to 1.7 times. In the industrial station “Start” the MDC of PM10 in 2002 varied: from values under the UPN (Upper Permitted Norm) up to 112.7 µg/m^3, with the highest concentration exceeding the norm 1.5 times. From 30.4 to 41.7 % îf the maximal short-term PM10 concentrations exceeded the MDN and reached up to 5.2 times over the established day-and-night norm. In the city station “Trakya”, representative for the influence of transport, the MDC of PM10 in 2002 were under the norm – from 41.7 tî 63.6 µg/m^3, but from 12.5 to 23.5 % îf the MC exceeded MDN and the highest MC of PM10 reached up to 214.8 µg/m^3, exceeding the UPN 2.9 times. In the living quarter “Balik” the MDC of PM10 are low – from 38.3 to 55.4 µg/m^3, but 8.3 to 16.7 % of the maximal single concentrations exceeded MDN, which exceeding was from 1.9 tî 2.6 times. In the suburban background station “Pathway building” the MDC of PM10 were under the established norm. However the maximal levels were high and from 4.2 tî 16.7 % îf the short-term concentrations exceeded MDN – up to 2.6 times. Only in the living quarter “Sariiski” the mean day-and-night and maximal single PM10 concentrations did not exceed the established norm of 75 µg/m^3. The results show that over the norm maximal single PM10 concentrations were registered in almost all stations and that PM10 is a basic source of atmospheric air pollution in the city of Dobrich. The presented data is for different periods of the year and the high concentrations of PM10 during different seasons proved the influence of fuel sources (industrial and domestic) and car traffic. The seasonal dynamics in the atmospheric air pollution with PM10 is most obvious in the central part of the city, as only here there is data for the both seasons (Fig.1). The MDC of PM10 were much higher in summer – up to 211 $\mu g/m^3$ in comparison to winter – up to 81,2 $\mu g/m^3$. In summer the registered MC were much high – up to 532 $\mu g/m^3$, and in winter the MC reached up to 230 $\mu g/m^3$. This seasonal correlation is related to the PM10 emissions from the car traffic during the warm period in the central part of the city, because of the increased car traffic in summer. The day-and-night distribution of concentrations during the cold period is presented in Fig. 2.

Fig.2 Daily fluctuations in the concentrations of PM10 in the center of the town, 7th December, 2000, data in µg/m3



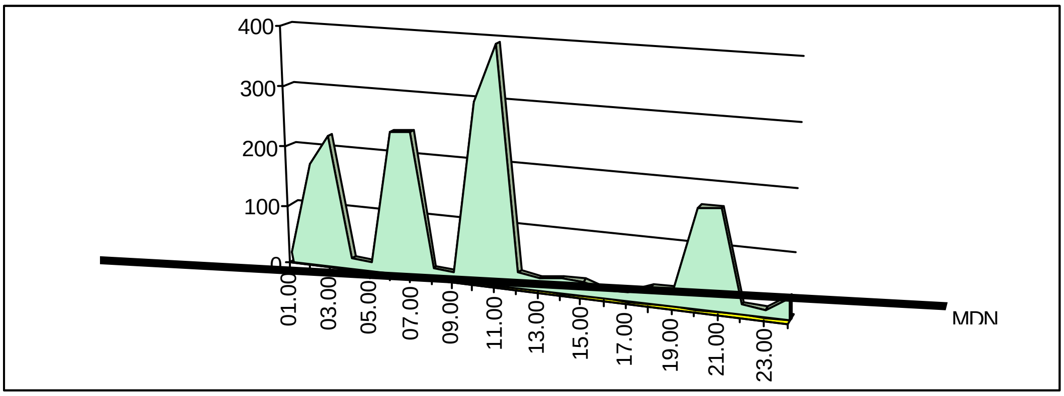
The results show that during the entire day the concentrations were extremely high with an acme around lunchtime – 183 $\mu g/m^3$, and in 5 p.m. – 179 $\mu g/m^3$ è 9 p.m.– 176 $\mu g/m^3$. The rest of the time the hourly concentrations varied from 105 tî 168,5$\mu g/m^3$. The data proved car traffic and domestic heating in the cold period in the city center as main sources of PM10 emissions. In the transport station "KAT" the hourly concentrations were also entirely over the norm. In summer the greatest increase of concentrations was observed after 8a.m. with an acme at 11 a.m. – 142 $\mu g/m^3$, followed by a gradual decrease, but still over the norm until 4p.m., after that the concentrations raised again up to 118 $\mu g/m^3$ (Fig .3).

Fig.3 Day and night fluctuations in the concentration of PM10, station "KAT", 15th August 2000, data in $\mu g/m^3$.



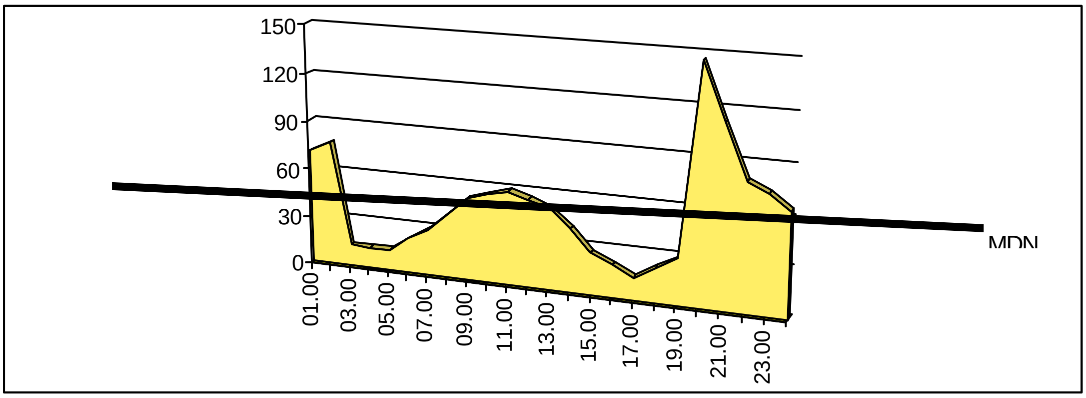
The results prove the influence of car traffic emissions on air pollution with PM10 in this transport-related station in summer, because of increase in car traffic. The emissions of dust particles are caused from direct emissions of gases from vehicles, worned out tyres and repeated suspension of dust on the pathway. In the industrial station "Start" the MC were also much higher during day and night hours. Data from 03.11.2002 showed that the highest concentrations were registered around 11 a.m. – 391 $\mu g/m^3$, as well as in night: at 2 a.m. – 171,3 $\mu g/m^3$, at 3a.m. – 220 $\mu g/m^3$, in the morning hours: at 6 a.m. – 237 $\mu g/m^3$, at 7 a.m. – 239 $\mu g/m^3$, and in night hours: 8 p.m. – 162,8 $\mu g/m^3$, 9 p.m. – 165 $\mu g/m^3$ (Fig. 4).

Fig.4 Day and night fluctuations in the concentrations of PM10, station "Start", 3rd November 2002, data in $\mu g/m^3$.



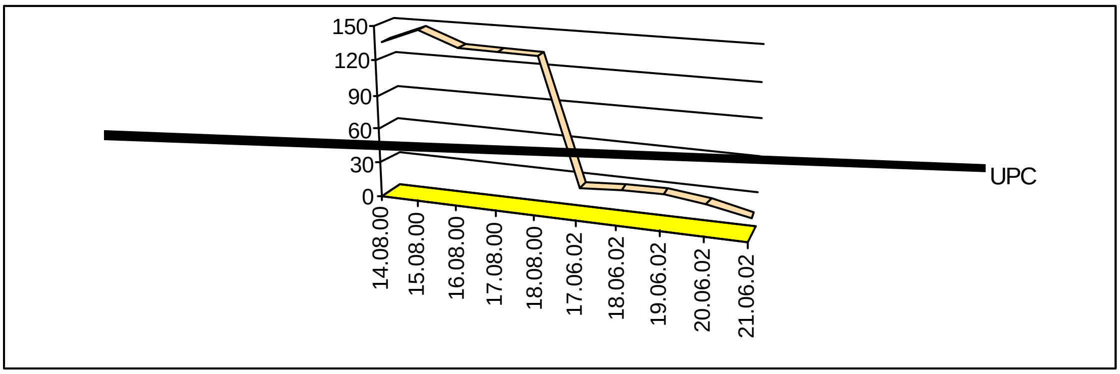
In this industrial-related station the air pollution with PM10 is mainly from fuel processes, industrial sources and car traffic. In the living quarter "Balik" the hourly concentrations were also under the UPN in winter – until 6 p.m. – from 14 to 58 µg/m^3 and suddenly increased with acme at 8 p.m. – 145 µg/m^3. Until 10 p.m. the maximal concentrations were over MDN + ÄÎ and under the norm towards 12p.m. (Fig. 5).

Fig.5 Day and night fluctuations in the concentrations of PM10, at the station "Balik", 26th October 2002, data in µg/m^3.



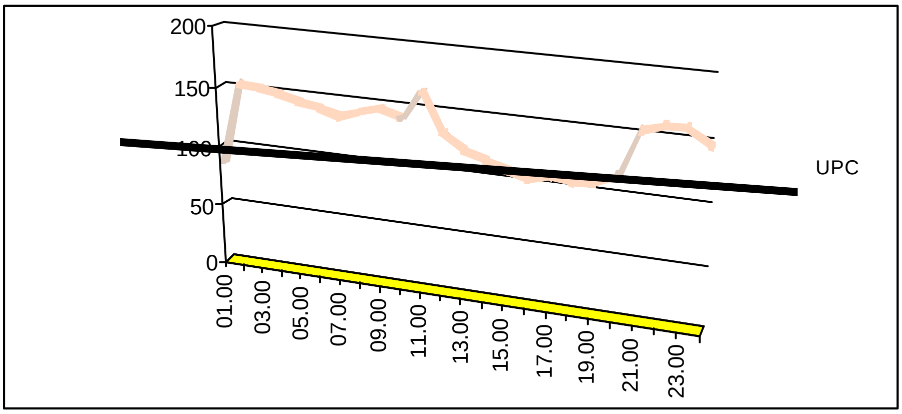
The defined correlation demonstrates the influence of emissions from the domestic heating (coal and wood) on the air pollution with PM10. The data about the secondary atmospheric pollutant ozone showed that the day-and-night concentrations in most stations from the National system for monitoring are under the UPN and are within the frames from 11 to 80.9 µg/m^3 (UPC = 100 µg/m^3). Station "KAT" is an exception, where the MDC of ozone in 2000 are much higher – from 132.5 to 147.2 µg/m^3 and exceeded the UPN 1.5 times (Fig. 6).

Fig.6 Mean daily ozone concentrations at the station "KAT" (years 2000 and 2002), data in µg/m3, UPC = 100 µg/m3



The maximal hourly concentrations are also high – 4.2 to 45.8 % from the maximal levels exceeded mean hourly levels = 160 µg/m^3, the highest MC reached up to 1.3 x UPN. At the comparison of this data with the high frequency of cases "shtil" (wind velocity under 1 m/s), which is typical for the city, especially in the summer of 2000 (wind velocity from 0.3 to 0.9 m/s). Thus we could assume the presence of a summer photochemical smog in the transport-related station "KAT". In this station the air is much polluted with reactive organic compounds, emitted from car traffic, nitrogen oxides, carbon monoxide which in the presence of ultraviolet sun radiation as a result of photochemical reactions transform into different secondary pollutants and ozone. This data is supported also by the day-and-night distribution of ozone concentrations in summer. The MC is significantly high during the entire day, but the short-term acmes were registered after 9 a.m. – up to 162.3 $\mu g/m^3$ (Fig. 7). The data proved the influence of emissions from car traffic (volatile organic compounds and nitrogen oxides) on the considerable air pollution with ozone.

Fig.7 Daily fluctuations in the ozone concentrations at the station "KAT", 16th August 2000, data in µg/m3, UPC = 160 µg/m3



The results from the monitoring presented ozone as a typical atmospheric air pollutant in Dobrich in summer in the region around the transport-related station "KAT". As a result of this research a program and measurements for decrease of the PM10 levels, a main air pollutant in the city, were established. There is a plan the car traffic to be moved around the city pathways, in order the emissions from PM10, nitrogen oxides and reactive organic compounds to be reduced.

Conclusion

The monitoring showed very high mean day-and-night and maximal short-term concentrations of PM10 in all stations in the city. PM10 is a main atmospheric air pollution in the city of Dobrich and the fuel sources (industrial and domestic) and car traffic cause the high levels. The over-exceeding pollution with ozone is observed only in the transport-related station in summer. The comparison of the high concentrations of ozone to the low wind velocity – under 1m/sec, demonstrates the availability of a photochemical smog in the region of intensive car traffic. A program aiming to decrease the PM10 levels and measurements to limit the car traffic in the boundaries of the city are established.

Publications

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