ISSN 1330-3651 (Print), ISSN 1848-6339 (Online)
UDC/UDK 502.36:504.3.054(497.11Smederevo)

# THE INFLUENCE OF "ZELEZARA SMEDEREVO" ON THE QUALITY OF THE ENVIRONMENT AND ITS ABILITY TO IMPROVE THROUGH THE MONITORING SYSTEM

*Slobodan Miladinović, Stevo Jaćimovski, Željko Nikač, Dalibor Kekić*

Original scientific paper

The uneven development and achieved degree of economy have negative consequences on the quality of the environment in Smederevo. The most endangered area is the industrial area of "Zelezara Smederevo" which directly threatens the city of Smederevo and a few settlements nearby, like Radinac, Ralja and Vranovo. Using a mathematical pattern the maximum low concentration of $SO_2$ exhausted from the blast furnace of "Zelezara Smederevo" was calculated. The data from health statistics about prescribed medicine, the structure of diseases and the current information about the degree of endangered environment were used to illustrate the cause and effect relation between health condition and the influence of certain pollutants existing in the environment.

***Keywords:*** *air pollution, ingredient concentration, the quality of air, Zelezara Smederevo*

## Utjecaj "Željezare Smederevo" na kvalitetu okoliša i mogućnost njezinog poboljšanja pomoću sustava nadzora

Izvorni znanstveni članak

Neujednačen razvoj i postignut stupanj ekonomije imaju negativne posljedice na kvalitetu okoliša u Smederevu. Najugroženije područje je industrijsko područje "Željezare Smederevo" koja izravno ugrožava grad Smederevo i nekoliko naselja u blizini, kao što su Radinac, Ralja i Vranovo. Uporabom matematičkog modela izračunata je maksimalna niska koncentracija $SO_2$ potekla iz visoke peći "Željezare Smederevo". Podaci iz zdravstvene statistike o propisanim lijekovima, strukturi bolesti i informacija o trenutačnom stupnju ugroženosti okoliša rabljene su za ilustraciju odnosa uzroka i posljedica između zdravstvenog stanja i utjecaja pojedinih onečišćujućih tvari koje postoje u okolišu.

***Ključne riječi:*** *kvaliteta zraka, onečišćenje zraka, sastojak koncentracije, Željezara Smederevo*

## 1 Introduction

City of Smederevo is in a mildly rolled lowland area of the southern edge of the Pannonian Basin, on far north-eastern part of Sumadija. The territory of Smederevo has an area of 481,7 $km^2$ and regionally belongs to the District of Podunavlje and Donje Veliko Pomoravlje. The area of the City of Smederevo consists of an urban settlement Smederevo and 27 rural and semi-urban settlements. With an average density of 229,6 inhabitants per $km^2$, Smederevo is one of the most densely populated cities in the Republic of Serbia. Existing conditions and environmental quality of the City of Smederevo and its environment are defined according to the results of measurements of environmental elements performed by authorized organization, existing planning documents, performed research studies, available technical and scientific literature, and direct insight into the situation on the field. Irregular development and achieved level of economic development had a negative impact on environmental quality in Smederevo. High concentration of population, industry and transport as well as agricultural production, caused the increased degree of degradation and pollution of land, air and water. The most endangered areas can be identified in industrial zone of Steel Plant in Smederevo, which directly threatens the City of Smederevo and its nearby villages, such as Radinac, Ralja and Vranovo, then the Smederevo industrial zone, which occupies an area of 260 hectares, where the majority of the industry (metal manufacturing and engineering industry) is placed, and which was built and developed without proper planning and environmental standards [1]. Ecologically, much endangered area is the river Ralja, where the Smederevo Steel Plant wastewater, without prior treatment, is released [2].

## 2 Air quality

The Smederevo Steel Plant is an industrial complex located 7 miles southeast of Smederevo on 350 hectares. It represents the most important part of Smederevo's development (74 % of total production and 97 % of exports) in the field of black metallurgy, manufacture of iron and steel. It is characterized by high techno-economic and spatial characteristics regarding water consumption, waste water discharges, power consumption, large-scale transport, with stressed production link in intra- regional (Republican) and trans-regional spatial dimension. In the same area there is a company named "Messer Tehnogas" which produces medical and specialty gases. This factory wields modern facilities and equipment in 8 cities of Serbia, of which the largest are in Smederevo and Nis. Specific types, large amount and production methods create major environmental pressure on all elements of the environment which contribute to the highest level of environmental hazard in this area. With the production of 2,2 million tons per year, over 70 billion $m^3$ of waste gases is emitted into the atmosphere (approximately 32 000 $m^3$ per ton of processed steel, or 8,2 million $m^3$ per hour). In the Smederevo Steel Plant 89 emitters are registered: 34 in Sintering Plant, 8 in Blast Furnace 1 and 2, 32 in Steelshop, 4 in Hot Strip Mill, 10 in Cold Rolling Mill and 1 in Power Plant [1]. Besides them, The Steel Plant has 5 ore and raw materials landfills which are specific contaminants, actually, surface emitters of large amounts of dust that pollutes the air of villages nearby. According to the Regulations on limit values of

emissions, of these 89 listed emitters, at 18 of them continuous measurements are required, at 55 of them individual measurements are required, while 10 emitters require no measuring emissions of pollutants. Until the year 2005 continual measurements had not been done in the Steel Plant but only individual measurements on individual emitters. Measurements were conducted by the Institute "1 Maj" from Nis. At the end of year 2005, "U. S. Steel Serbia" started the measurements in accordance with the Regulations on limit values of emissions, the method and terms of measuring and data recording. Measurement was carried out by the Department of Public Health "Pomoravlje" from Cuprija.

**Table 1** View of the emitters given by the Steel Plant units where the limit values of the emission of powder substances were exceeded (measurements were performed in September ÷ October 2010.

| Unit | Emitter | Emitter title | Purifier type | Measured values, $mg/m^3$ | Limit value of emission, $mg/m^3$ | Emitted quantities, kg/h |
|---|---|---|---|---|---|---|
| Sintering plant | E2-22 | Central stack | Battery cyclone Ven. scrubber | 71 ÷ 82 | 50 | 31 |
| | E2-25 | Dedusting freezer system | Scrubber | 100 ÷ 105 | 50 | 3 |
| | E2-27 | Electric filter No 2 | Electric filter | 87 ÷ 96 | 50 | 4 |
| | E2-28 | Cooling | Multi cyclone | 91 ÷ 98 | 50 | 36 |
| Blast Furnace 1 and 2 | E3-1 | Object No 2350 Exit No 3 | - | 94 ÷ 99 | 50 | 43 |
| Steel shop | E4-1 | Emitter of the Drier | Battery cyclone | 104 ÷ 112 | 50 | 1 |
| | E4-2 | Emitter of bunker dedusting | Battery cyclone | 138 ÷ 147 | 50 | 2 |
| | E4-3 | Emitter of desulphurization | - | 730 ÷ 810 | 50 | 40 |
| | E4-15 | Dedusting system of angle conveyor and reversible transport | Baggy filter | 132 ÷ 140 | 50 | 1 |
| Cold rolling mill | E6-7 | Emitter of continuous annealing line | - | 9,7 ÷ 11,3 | 5 | |

The amount of powder matter emitted into the atmosphere of the primary emission, calculated based on the gas flow through the flue is also large scale, not only on the emitter where the emission limit values were exceeded, but also on the other emitters. Additional air pollution, which comes from the powder matter, occurs by the so called secondary emission, during outpouring iron and steel, and cannot be measured. By activating Blast Furnace number 2 and parallel operation of both furnaces, there was significant excess of limit values of powder matter emission which is why existing filters built on the emitters do not provide the necessary air protection measures.

**Table 2** Annual statistics of hourly values of polluting matters $SO_2$, $NO_2$ and suspended particles $PM_{10}$, between 1.1.2011 ÷ 31.12.2011 at the measuring point Radinac [3]

| Parameter | $SO_2$ $\mu g/m^3$ | $NO_2$ $\mu g/m^3$ | $PM_{10}$ $\mu g/m^3$ |
|---|---|---|---|
| **Annual statistics of daily values** | | | |
| Limit Values - *LV* | 125 | 85 | 50 |
| Minimum | 8,1 | 2,6 | 17,1 |
| Maximum | 131,8 | 53,1 | 354,8 |
| Number of days > *LV* | 1 | 0 | 255 |
| **Annual statistics of daily values** | | | |
| Limit Values - *LV* | 350 | 150 | |
| Minimum | 6,9 | 0,0 | 4,7 |
| Maximum | 602,9 | 132,9 | 1063,7 |
| Number of days > *LV* | 7 | 0 | |

Since 2007, three automatic analysers for monitoring air quality were placed in Smederevo, one in the centre of the town, and two nearby the Steel Plant (Radinac and Ralja). This is how the comprehensive study of the quality of environment and its impact on public health began.

**Table 3** Annual statistics of hourly values of polluting matters $SO_2$, $NO_2$ and suspended particles $PM_{10}$, between 1.1.2011 ÷ 31.12.2011 at the measuring point Ralja [3]

| Parameter | $SO_2$ $\mu g/m^3$ | $NO_2$ $\mu g/m^3$ | $PM_{10}$ $\mu g/m^3$ |
|---|---|---|---|
| **Annual statistics of daily values** | | | |
| Limit values - *LV* | 125 | 85 | 50 |
| Minimum | 9,1 | 3,9 | 16,2 |
| Maximum | 130,7 | 52,9 | 251,3 |
| Number of days > *LV* | 1 | 0 | 205 |
| **Annual statistics of daily values** | | | |
| Limit values - *LV* | 350 | 150 | |
| Minimum | 6,8 | 0,9 | 3,2 |
| Maximum | 618,0 | 131,1 | 1174,1 |
| Number of days > *LV* | 5 | 0 | |

Besides these listed pollution matters, there is most of the carbon monoxide (CO) in flue gases, about 25 000 tons. In waste gas there are about 10 000 tons of sulphur dioxide ($SO_2$) and approximately 1500 tons of nitrous oxide ($NO_x$). Waste gas contains dust, whose amount depends on the quality of raw material and production process. It was calculated that the production and processing of one ton of iron, produces about 100 ÷ 120 kg of dust, sludge and scale, which means that during the production of 2,2 million tons of iron, 200 000 tons of dust is released into the atmosphere every year. Besides the dust, in Blast Furnace gas, there is 30 % of carbon monoxide, which is burnt after the purifying on so called "fluyere" before going into the atmosphere. In year 2005,

the accident occurred due to no burning and an uncontrolled release into the atmosphere. How dangerous the situation was, can be illustrated by the fact that the CO concentration of 0,4 % in the air is practically fatal. Since then, the other "fluyere" for burning Blast Furnace gas was mounted. However, all emitters do not have multistage purification, because the waste gases are not used, but released into the atmosphere. If there is purification, its efficiency depends on the type of device and physical-chemical characteristics of dust particles. If their size is below 10 μm, existing device cannot segregate them. Such particles are coal dust particles. In the atmosphere, along with the waste gas, 7000 ÷ 10 000 tons of different physical and chemical composition of dust is emitted [1]. Besides those sources, in the Steel Plant there are six different landfills of raw materials and by-products. They represent specific particulate dust pollutants, so called linear surface sources. Raw material landfill (of ore, coke and limestone) is located right next to the houses of Radinac and Vranovo inhabitants. In times of huge pyramids of raw materials formation or their taking for the production process, especially in adverse weather conditions (weather with no rainfall during the Kosava- cold, very squally south-eastern wind found in Serbia and some nearby countries) heavy air pollution by dust particles that are larger in diameter occurs. A rapid deposition in the immediate vicinity of the village occurs, so residents do not even open the windows on their houses. Crops also suffer extensive damage which cannot be seen by direct observation. More than twenty years ago, the projects for reducing dust emissions from landfills by wetting or lime milk pouring were conceived, but none of those projects were ever realized.

Air control program identified the measuring points for measuring the content of heavy metals (lead, arsenic, cadmium, nickel, chromium, manganese and iron) in suspended particles $PM_{10}$, and content of polycyclic aromatic hydrocarbons (PAH) in suspended particles $PM_{10}$ (pyrene and benzo(a)pyrene). One measuring point is located in the centre of the Town of Smederevo, the other one in Ralja, nearby Smederevo Steel Plant. Measurements are done once a week by the City Institute of Public Health from Belgrade. Daily analysis of measurement results in observed one-year period, lead us to the following conclusion: average 24 hour concentration of total suspended particles of $PM_{10}$ exceeded the limit value (50 μg/m$^3$) in 23 of 114 measurements in total. The maximum recorded concentration was 22 μg/m$^3$ in November. Average 24-hour concentration of total suspended particles of $PM_{10}$ exceeded the tolerable value (75 μg/m$^3$) in 26 of 114 measurements in total. In suspended particles up to 10 μm ($PM_{10}$) the concentrations of benzo(a)pyrene (BaP) and heavy metals As, Cd, Hr, Mn and Pb were investigated. Concentrations exceeding BaP were registered in 55 measurements. Target value (TV) for tested heavy metals were exceeded for Arsenic (As) in 24 measurements and Nickel (Ni) in 10 measurements. Other heavy metals for which the prescribed target value exists were within the values or below them. High values of benzo(a)pyrene were observed during the heating season (October ÷ March), and in the period from April to October these values were significantly lower and periodical. According to the reported results of measurements we have tried to present the exceeding of measuring parameters in the air in the city of Smederevo, for the period from November 2010 to December 2011 in Tab. 4.

**Table 4** Monthly average concentrations of heavy metals in suspended particles $PM_{10}$ in 2011, for measuring point "Centar za kulturu" in Smederevo (City Institute of Public Health from Belgrade).

| Month | As ng/m$^3$ | Cd ng/m$^3$ | Cr ng/m$^3$ | Fe ng/m$^3$ | Mn ng/m$^3$ | Ni ng/m$^3$ | Pb ng/m$^3$ |
|---|---|---|---|---|---|---|---|
| I | 5,4 | 0,7 | 12,2 | 1240,2 | 14,3 | 19,5 | 24,4 |
| II | **9,4** | 0,6 | 8,9 | 687,4 | 12,2 | 16,3 | 20,0 |
| III | 5,5 | 0,5 | 7,1 | 697 | 16,2 | 12,5 | 12,6 |
| IV | **9,4** | 0,6 | 12,6 | 687,4 | 12,2 | 16,3 | 20,0 |
| V | 3,7 | 0,6 | 4,6 | 2043,9 | 32,9 | 4,9 | 21,5 |
| VI | 1,2 | 0,1 | 5,6 | 1573,2 | 29,4 | 5,5 | 9,9 |
| VII | 2,1 | 0,3 | 2,6 | 1700,6 | 28,7 | 8,7 | 18,4 |
| VIII | 1,4 | 0,3 | 3,7 | 1493,7 | 46,7 | 3,8 | 6,6 |
| IX | 1,5 | 0,3 | 3,5 | 1958,7 | 32,1 | 3,0 | 14,8 |
| X | 5,7 | 2,9 | 4,2 | 770,9 | 41,8 | 12,6 | 30,3 |
| XI | **10,0** | 0,6 | 2,1 | 654,0 | 16,8 | 14,9 | 21,8 |
| XII | **6,5** | 0,4 | 4,2 | 1114,1 | 15,7 | 23,2 | 13,6 |
| • Value above the limit | | | | | | | |

**Table 5** Monthly average concentrations of benzo(a)pyrene and suspended particles of $PM_{10}$ in 2011, for measuring point "Centar za kulturu" in Smederevo (City Institute of Public Health from Belgrade).

| Month | benzo(a)pyrene ng/m$^3$ | $PM_{10}$ μg/m$^3$ |
|---|---|---|
| I | **3,9** | **50,4** |
| II | **6,4** | **95,6** |
| III | **3,1** | **72,1** |
| IV | 0,2 | 33,8 |
| V | 0,2 | 40,3 |
| VI | 0,3 | 38,2 |
| VII | 0,3 | 31 |
| VIII | 0,1 | 39,9 |
| IX | 0,4 | 49,3 |
| X | **5,3** | **65,0** |
| XI | **9,8** | **126,4** |
| XII | **7,5** | **98,7** |
| • Value above the limit | | |

**Table 6** Exceeding the measuring parameters in the air in the City of Smederevo for the period from November 2010 to December 2011

| Parameter | $PM_{10}$ | | BaP | As | Ni | Total number of measurement |
|---|---|---|---|---|---|---|
| | *LV* | *TV* | *LV* | *VT* | *VT* | |
| % over *LV* | 21,92 % | 22,80 % | 48,24 % | 21,05 % | 8,77 % | 114 |
| Limit values | 50 μg/m$^3$ | 75 μg/m$^3$ | 1,0 ng/m$^3$ | 6,0 ng/m$^3$ | 20,0 ng/m$^3$ | |
| *LV* - Limit value, *TV* - Tolerant value, *VT* - Value target | | | | | | |

The percentage of exceeding limit and tolerant values for suspended particles matter $PM_{10}$, benzo(a)pyrene and heavy metals in suspended particles up to 10 μm, exceeds the prescribed values given in the Regulation on the conditions for monitoring and requirements of air quality ("Official Gazette of Republic of Serbia", No. 11/2010 and 75/2010).

Average 24 hour concentration of suspended particles of $PM_{10}$, exceeded the limit value of 50 μg/m$^3$,) in over 42,98 % of measurements. The concentration of benzo(a)pyrene was over limit value of 1 μg/m$^3$ in 48,24

% of the measurement. Arsenic concentrations exceeded the target value in 21,05 % of measurements, and target values for Nickel are exceeded in 8,77 % of measurements. According to recommendations of World Health Organization, exceeding of these parameters in the ambient air must not be more than 10 % for measurement period of one year. The obtained values of pollutants in the City of Smederevo show that the air quality is more threatened during the winter period, while some parameters such as suspended particles threaten the air quality through the whole year. The consequences of polluted air also are the "acid rains" falling down even up to nine months a year. In addition to these factors, a pier located in the city core near the Smederevo Fortress also has an adverse effect on air quality. In this area, the coast has been in the function of trade in goods, building materials, metallurgical material (ore and coke), grains, fertilizers, liquid fuels and others. Annual ship loading and unloading is approximately 800 and these ships carry million tons of goods. Pollution occurs as a result of material transport and transport equipment [4].

If we assume that the total quantity of gas and dust emissions was retained in the space of the City of Smederevo and evenly disposed, in one year the entire surface up to a height of 150 meters would be found in the exhaust gas and dust, so all residents would have to breathe only gas and dust. However, fortunately for the inhabitants, the advantages of geographical position and movement of the atmosphere, the emitted gas and dust spread out in much larger space, which significantly reduces the percentage of pollutants. By the Wind rose analysis we can conclude that the south and south-east wind, formally known as the Kosava, predominates in Smederevo. The prevailing circulation of air masses in the north south direction is the result of orographic factors, actually spreading from the Velika Morava valley. Since the Steel Plant is southeast of Smederevo, such movements of air masses present mitigating circumstances, especially if we know that the Kosava is a winter wind, and we pointed out that gas emissions are increased in winter. Movements of air depression and anticyclones across Pannonia and northern parts of Velika Morava, slightly reduce air pollution in Smederevo. Nevertheless, we can say, based on all those things, that the air in Smederevo is a third category, excessively polluted air.

## 3 Calculation model for maximum concentrations of air pollution

Determining the condition of air pollution by applying a mathematical model of distribution of air pollution allows the simulation of spreading of harmful substances for different assumed emission intensities in known topological, urban and meteorological situation. Using a mathematical model one can get the real picture of the events related to the dispersion of pollutants, which can be used as a basis for assessing the potential risks and resolving technical protection systems. Sulphur dioxide is an obligatory component of air pollution, especially in urban areas. It is a product of fossil and other fuels combustion, especially those rich in sulphur. It also occurs in the processing of mineral ores that contain sulphur in their composition (in obtaining iron and other metals which contain sulphide compounds). During the work, we tried using a mathematical model to calculate the distribution of $SO_2$ in case of the Smederevo Steel Plant, actually Blast Furnace as an emitter, in the well-known topological and meteorological situation. Using this model, we assume that all the air pollution is emitted from the furnace chimney and we have calculated at which distance from the chimney of the forge is the maximum concentration of $SO_2$ and what is its value. The procedure for finding ground concentrations of harmful gaseous substances, listed in this section, is part of the standards which are used in engineering practice during the facility designing with emissions of harmful substances. The goal of the standard is that for the appropriate installed power (and other characteristics of the source) the emissions of harmful gases and their accordance with the legislation are estimated. The procedure is performed in accordance with the empirical and theoretical models used in the field of air pollution [5].

The maximum value of ground-level concentrations of pollutants in (mg/m$^3$) in the case of the exhaust of gaseous substances from a single point source with a round opening, in the event of adverse weather conditions, at the distance $x_M$ (m) from the source is:

$$c_M = \frac{A \cdot M \cdot F \cdot m \cdot n \cdot \eta}{H^2 \sqrt[3]{V_1 \cdot \Delta T}}, \tag{1}$$

where $A$ is a coefficient which depends on the temperature stratification of the atmosphere; $F$ is a dimensionless factor, which reflects the speed of deposition of pollutants in the atmosphere; $M$ (g/s) is the mass of ejected harmful substances into the atmosphere per unit of time, $m$ and $n$ are the coefficients characterizing the conditions of the release of harmful substances from the opening of the source; $H$ (m) is the height of the source of pollutants above the earth's surface, $\eta$ is a dimensionless factor which characterizes the influence of terrain on harmful substances spreading, $\Delta T$ (°C) is the temperature difference between the gas mixture coming from the source and the ambient air temperature; $V_1$ (m$^3$/s) gases expense determined by the formula

$$V_1 = \frac{\pi \cdot D^2}{4} v_0, \tag{2}$$

where $D$ (m) is diameter of opening at the source, $v_0$ (m/s) average speed discharge of harmful substances in the gaseous form from opening at the source.

$$f = 1000 \cdot \frac{v_0^2 \cdot D}{H^2 \cdot \Delta T}, \tag{3}$$

$$v_M = 0{,}65 \cdot \sqrt[3]{\frac{V_1 \cdot \Delta T}{H}}. \tag{4}$$

Dangerous wind speed $u_M$ (m/s) at the central stack level which gives the highest value of ground concentration of harmful matter is:

$$u_M = v_M \cdot (1 + 0{,}12 \cdot \sqrt{f}); v_M > 2, \quad (5)$$

$$v'_M = 1{,}3 \cdot \frac{v_0 \cdot D}{H}, \quad (6)$$

$$f_e = 800 \cdot v'^3_M, \quad (7)$$

$$m = \frac{1}{0{,}67 + 0{,}1 \cdot \sqrt{f} + 0{,}34 \cdot \sqrt[3]{f}}; f < 100, \quad (8)$$

$$n = 1; v_M \geq 2, \quad (9)$$

$$x_M = \frac{5 - F}{4} \cdot d \cdot H, \quad (10)$$

$$d = 7 \cdot \sqrt{v_M} \cdot (1 + 0{,}28 \cdot \sqrt[3]{f_e}); v_M > 2. \quad (11)$$

The maximum value of the concentration of harmful substances in bad weather conditions at wind speed $u$ (m/s) is:

$$c_{Mu} \cdot r \cdot c_M, \quad (12)$$

where

$$r = 0{,}67 \cdot \frac{u}{u_M} + 1{,}67 \cdot \left(\frac{u}{u_M}\right)^2 - 1{,}34 \cdot \left(\frac{u}{u_M}\right)^3; \frac{u}{u_M} \leq 1. \quad (13)$$

Dimensionless

$$x_{Mu} = p \cdot x_M; p = 3; \frac{u}{u_M} \leq 0{,}25. \quad (14)$$

is the distance at which at wind speed $u$ (m/s) ground concentrations of harmful substances have the highest value; $p$ is a dimensionless parameter. Measured gas concentrations applied to time period of 24 hours after emission from the stack.

The Smederevo Steel Plant stack height is 150,2 m, the width of the stack at the top is 6,5 m. Steel Plant is located 7 miles southeast of Smederevo. Average height above the sea level of the city territory is 120,7 m; the lowest point has a height of 69 m, and the highest has 273 m. Adopted values of the parameters required for the calculation of the maximum ground concentration of $SO_2$ and the corresponding distances are:

$$A = 160; F = 1; H = 30{,}5\,\text{m}; \Delta T = 15\,^\circ\text{C};$$
$$\eta = 1; v_0 = 5\,\text{m/s}; M = 26{,}83\,\text{g/s}.$$

Using Eqs. (1) ÷ (14) we find that the maximum ground concentrations of $SO_2$ $c_M$ = 0,139 mg/m$^3$ and it is located at a distance $x_M$ = 2992 m from the source. Since the most frequent wind is south wind at the average speed of about 2,6 m/s, then we can say that the concentration of $SO_2$ $c_{Mu}$ = 0,0147 mg/m$^3$ and it is realized at the distance of $x_{Mu}$ = 8979 m from the source.
For Arsenic is obtained:

$$A = 160; F = 2; H = 30{,}5\,\text{m}; \Delta T = 150\,^\circ\text{C};$$
$$\eta = 1; v_0 = 5\ \text{m/s}; M = 1{,}79 \times 10^{-6}\,\text{g/s}$$
$$c_M = 18{,}54\,\text{ng/m}^3; x_M = 5984\,\text{m};$$
$$c_{Mu} = 1{,}96\,\text{ng/m}^3; x_{Mu} = 17\,952\,\text{m}.$$

According to the Regulations on limit values, emission measuring methods, criteria for establishing the monitoring points and data records (Official Gazette of the Republic of Serbia, No. 54/92, 30/00 and 19/2006) permitted emission limit of sulphur dioxide is 0,15 mg/m$^3$, and Arsenic 6 ng/m$^3$.

Based on the theoretical calculation of sulphur dioxide emission limit values and permitted emission limits, we can conclude that Steel Plant with its emissions of $SO_2$ in normal weather conditions is mostly near or below limits for sulphur dioxide emissions.

Systematic measurements of air quality in the measuring point "High School" in Smederevo, was performed by the Department of Public Health Pozarevac. At this measuring point, 24-hour measurements of sulphur dioxide, nitrogen dioxide, soot and sediment substances, where heavy metals were determined, were performed in 2011. The choice of measuring point, sampling, and methods used for identification of pollutants were created in accordance with the Law on Air Protection ("Official Gazette of the Republic of Serbia", No. 36/2009) and with the Decree on conditions and requirements for monitoring of air quality ("Official Gazette of the Republic of Serbia "No. 11/2010 and 75/2010).

Evaluation of air quality, at High school in Smederevo, based on automatic monitoring may be performed on the basis of the adopted criteria for quality evaluation based on domestic regulation, which takes into account the frequency of exceeding of LVI and determination of **temporary air quality index**.

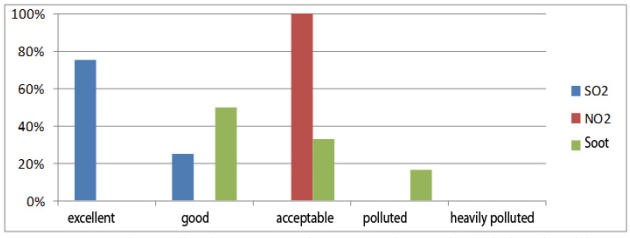


**Figure 1** Air quality in 2011 at the measuring point High school in Smederevo

## 4 The influence air quality on malignancy

During the 2011 by evaluation of average sulphur dioxide values, the air was excellent in 75 % of cases and good in 25 % of cases. In observed one-year period during only one day, twenty-four hour limit value and sulphur dioxide level tolerant value was exceeded. But the presence of $NO_2$ had completely different relations; the presence of this pollutant is completely within the range

44 ÷ 85 mg/m$^3$, actually acceptable by its quality, which means just below the pollution limit. During the 42 days in total, twenty-four hour limit value of nitrogen dioxide is exceeded, and in one day, twenty-four hour tolerance value is exceeded too. The *LVI* was exceeded each month, the highest one in February for 10 days. The presence of soot is increased in winter months when the values are above the *LVI*, from October to March, mainly because of the heating. In 50 % of cases, the presence of soot contributes that air pollution is at the pollution limit (33,33 %) or polluted (16,66 %) and 50 % of it is of good quality. During the 46 days in total, during the year, twenty-four hour limit value of soot level was exceeded, including 4 days when the twenty-four hours tolerant value was exceeded. Overdrafts are common in the winter period.

**Table 7** Results of automatic monitoring of air quality parameters at the measuring point Smederevo - High school during 2011 [6]

| | $SO_2$ / µg/m$^3$ | | | | $NO_2$ / µg/m$^3$ | | | | Soot / µg/m$^3$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month / Parameter | Number of measuring by day | Average value | Maximum daily value | *LVI* > 150 | Number of measuring | Average value | Maximum daily value | *LVI* > 85 | Number of measuring | Average value | Maximum daily value | Number of days above *LVI* > 50 |
| I | 31 | 42,5 | 96,0 | 0 | 31 | 55,3 | 94,0 | 1 | 31 | 42,4 | 126,0 | 10 |
| II | 28 | 46,2 | 111,0 | 0 | 28 | 72,8 | 105,0 | 10 | 28 | 56,1 | 204,0 | 8 |
| III | 31 | 43,1 | 131,0 | 0 | 31 | 63,8 | 95,0 | 4 | 31 | 31,2 | 127,0 | 4 |
| IV | 30 | 19,8 | 44,0 | 0 | 30 | 58,9 | 91,0 | 2 | 30 | 16,8 | 33,0 | 0 |
| V | 31 | 16,9 | 39,0 | 0 | 31 | 63,7 | 106,0 | 2 | 31 | 13,1 | 48,0 | 0 |
| VI | 30 | 15,2 | 57,0 | 0 | 30 | 66,6 | 98,0 | 5 | 30 | 10,8 | 20,0 | 0 |
| VII | 31 | 8,5 | 17,0 | 0 | 31 | 61,2 | 92,0 | 1 | 31 | 13,3 | 24,0 | 0 |
| VIII | 31 | 12,9 | 57,0 | 0 | 31 | 66,9 | 67,0 | 5 | 31 | 16,5 | 20,0 | 0 |
| IX | 30 | 14,8 | 51,0 | 0 | 30 | 70,4 | 120,0 | 8 | 30 | 17,8 | 41,0 | 0 |
| X | 31 | 23,6 | 64,0 | 0 | 31 | 48,2 | 89,0 | 1 | 31 | 30,8 | 99,0 | 5 |
| XI | 30 | 28,7 | 74,0 | 0 | 30 | 57,7 | 99,0 | 2 | 30 | 59,3 | 161,0 | 13 |
| XII | 31 | 35,2 | 79,0 | 0 | 30 | 50,9 | 178,0 | 1 | 31 | 34,3 | 90,0 | 6 |
| Year | - | 25,6 | 68,33 | 0 | - | 61,36 | 102,8 | 3,5 | - | 28,53 | 82,7 | 38,3 |

The connection between public health of the population and environmental conditions is not direct, because there are many other factors that affect human health. However, among many factors that determine the health status of the population, environmental factor is highly ranked, besides heritage and individual characteristics, lifestyle and the availability and effectiveness of health services. It is common thinking that the air quality in urban areas has a greater impact on the health of the population than other environmental factors, and that the ambient air pollutants represents one of the most important causes of health problems in general. According to the estimation of World Health Organization, each increase of 10 µg of fine particles in the air means that the risk of premature death increases from 11 % to 17 %. Numerous epidemiological studies clearly show that the air pollution as respiratory particles is related to increased morbidity and mortality from respiratory and cardiovascular diseases. The increase in certain diseases (cardiovascular diseases and hypertension, respiratory diseases, malignant diseases, infectious and parasitic diseases) can be the result of modern lifestyles, but also the result of environmental pollution. Carcinogenic effects of many contaminants were also determined. These are the polycyclic aromatic hydrocarbons, primarily the most widely benzopyrene, tetraethyl, asbestos, soot and carbon sediments. Some of them, such as lead compounds, change their ways of entering the body, because one can consume them through the soil and vegetation. CO, $NO_x$ and $SO_2$ and soot are "classic polluters", the most common measured pollutants, and both in the world and in our country, alone or together with the other pollutants they can cause serious health problems. The most important effect of these pollutants on health of the population is expressed in the respiratory tract. They affect the appearance of respiratory diseases and lead to changes in the pulmonary defence system. Besides respiratory diseases, the presence of these pollutants affects the decrease of immune system and the occurrence of cancer [7]. The reactions of people to the polluted air exposure, depends on the concentration level of the contamination matter, exposure time and persons current health condition, as well as the weather conditions. Certain segments of the population such as children, women at childbearing age, elderly and chronically ill persons, are more sensitive and they manifest symptoms of disease even at low concentrations of the pollutant in the air. Pollutants present in the ambient air, especially respirable particles (particulate matter - PM) because of their negative effects on human health, drew attention of experts, regulators and general public. The most recent researches of experts of the European Union warn that due to air pollution, life had lost at least 3,6 million people. Air pollution by suspended matter consists of very small particles in liquid or solid state of matter. Among them are especially important the ones that can reach the deepest parts of the lungs. These particles have a diameter less than 10 µm or in descriptive terms; their diameter is smaller than 1/7 thickness of a human hair. About 99 % of inhaled

suspended particles from the air are instantly eliminated from the body by exhalation, because they are mostly retained in the upper parts of the respiratory tract. The remaining 1 % of the particles are retained in the organism, come to the trachea and go to the lungs. Particles hazardous to human respiratory organs are those smaller than 10 μm. Such small particles have the tendency to deposit in the alveoli. Which part of the inhaled particles will remain in the respiratory tract and which depth they will reach before they deposit, depends on their size as the most important factor that determines the risk of inhalation of particles. If the particles reach the lungs, they slow down the exchange of oxygen and carbon dioxide, reducing breath. This leads to greater heart straining, which needs increased effort to compensate reduced oxygen intake. Usually, people who are sensitive to these harsh conditions suffer from respiratory diseases such as Emphysema, Bronchitis, Asthma and heart problems [8]. Particles, as well as the matters in liquid or gaseous state which are brought together with the absorbed or inhaled particles and which are toxic, contribute to the damage of organs, such as kidneys and liver. Although $PM_{10}$ attack the entire human population, population categories (children, pregnant women, the elderly and ill) are particularly endangered. Besides their contribution to health damage, $PM_{10}$ reduce visibility during the day because they create visible effects which are similar to mist, and often recognized as smog.

Not only long-term exposure studies fall within research on health effects of exposure to respirable particles. Even before the beginning of the studies on the health effects, air pollution and prolonged exposure, the studies were done on mortality related to ambient concentrations exposure to respirable particles during the same or during several previous days,. Based on the study implemented in 90 U.S. cities, it is determined that total mortality is increased by 0,27 % and cardiopulmonary mortality by 0,69 % with $PM_{10}$ concentration increase by 10 $\mu g/m^3$. In a broad European study, which is based on data from 29 cities, the estimated increase of total mortality was 0,6 % while the estimated increase of cardiovascular mortality was 0,76 % for $PM_{10}$ concentrations increase by 10 $\mu g/m^3$ [9].

According to the air quality which depends on sulphur dioxide, nitrogen oxides, carbon monoxide, soot, powder matter and other emissions, Smederevo is among ten most polluted cities in Serbia. The relation between the degree of environmental quality and the health of residents in the city area of Smederevo has not been studied thoroughly. Based on data from the health statistics on issued medicaments, disease structure and existing database of environmental threats, we attempted to find causal relationship. General picture of health condition and general disease symptoms can be related to the impact of certain pollutants recorded in the environment.

**Table 8** Movement of malignant disease in Smederevo and rural localities in 1997 ÷ 2011

| Settlement | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Smederevo | 89 | 77 | 49 | 111 | 221 | 205 | 186 | 151 | 271 | 248 | 260 | 260 | 235 | 250 | 278 |
| Mihajlovac | 5 | 2 | 4 | 11 | 16 | 8 | 14 | 4 | 11 | 7 | 5 | 10 | 12 | 12 | 4 |
| Skobalj | 2 | 2 | 1 | 2 | 10 | 2 | 6 | 5 | 5 | 7 | 1 | 9 | 12 | 6 | 5 |
| Vrbovac | - | - | 1 | - | 6 | - | 3 | 3 | 2 | 2 | 5 | 5 | 1 | 5 | 1 |
| Lipe | 4 | 6 | 4 | 4 | 20 | 11 | 8 | 5 | 9 | 6 | 5 | 8 | 6 | 13 | 4 |
| Osipaonica | 2 | - | 3 | 5 | 17 | 10 | 14 | 8 | 9 | 5 | 13 | 10 | 10 | 4 | 13 |
| Landol | - | 1 | - | - | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 1 |
| Vodanj | 2 | 1 | 1 | 2 | 9 | 4 | 6 | 3 | 4 | 1 | 9 | 3 | 4 | 4 | 5 |
| Radinac | 8 | 7 | 2 | 5 | 16 | 11 | 9 | 14 | 23 | 15 | 23 | 15 | 10 | 12 | 13 |
| Ralja | - | - | 2 | 1 | 2 | 2 | 1 | 2 | 4 | 4 | 6 | 4 | 6 | 3 | 4 |
| Vranovo | 2 | 1 | 2 | 5 | 12 | 7 | 9 | 6 | 4 | 5 | 9 | 6 | 10 | 7 | 8 |
| Dobri Do | 1 | 3 | 1 | 1 | 4 | 4 | - | 1 | 3 | 1 | 5 | 6 | 3 | 3 | 6 |
| Lugavčina | 2 | 2 | - | 4 | 6 | 10 | 8 | 9 | 11 | 6 | 8 | 13 | 7 | 6 | 10 |
| Seone | 2 | 1 | 1 | 1 | 3 | 2 | 4 | 3 | 0 | 2 | 4 | 5 | 2 | 4 | 2 |
| Vučak | 1 | - | 1 | 3 | 4 | 5 | 2 | 2 | 7 | 3 | 5 | 5 | 1 | 2 | 6 |
| Drugovac | 1 | 1 | 1 | 4 | 8 | 6 | 5 | 6 | 9 | 8 | 11 | 6 | 5 | 5 | 6 |
| Udovice | 3 | 1 | 1 | 2 | 6 | 4 | 4 | 3 | 3 | 4 | 2 | 7 | 3 | 4 | 8 |
| M. Krsna | 3 | 1 | 2 | 2 | 6 | 6 | 2 | 10 | 10 | 4 | 6 | 6 | 8 | 6 | 8 |
| Binovac | 1 | - | 1 | - | 6 | 1 | 2 | 2 | 4 | 0 | - | 1 | 3 | 2 | 2 |
| Šalinac | - | 1 | 2 | - | 3 | 4 | 1 | 1 | 1 | 1 | 5 | 2 | 1 | 2 | 3 |
| Suvodol | 2 | - | 2 | - | 1 | 5 | 3 | - | 5 | 3 | - | 6 | 4 | 3 | - |
| Saraorci | 1 | 3 | 1 | 1 | 7 | 5 | 6 | 3 | 6 | 6 | 10 | 3 | 7 | 6 | 4 |
| Petrijevo | - | 1 | - | 1 | 1 | 3 | - | 3 | 4 | 0 | 3 | 2 | 3 | 5 | - |
| M. Orašje | - | 1 | - | 2 | 3 | 1 | - | 1 | 3 | 0 | 4 | 1 | 1 | 3 | 2 |
| Kolari | - | 2 | - | 2 | 8 | 4 | 5 | 6 | 3 | 3 | 7 | 6 | 3 | 8 | 5 |
| Lunjevac | - | | 1 | 2 | 1 | 1 | 2 | 3 | 2 | 3 | 2 | 3 | 2 | | |
| Badljevica | 1 | 1 | - | - | 2 | - | - | 1 | 0 | 3 | | | 1 | 2 | 1 |
| Kulič | - | - | - | 1 | 1 | 4 | 3 | - | 0 | 0 | 1 | 1 | 1 | 2 | 1 |
| Total | 132 | 115 | 83 | 172 | 401 | 327 | 305 | 357 | 415 | 350 | 412 | 406 | 364 | 383 | 400 |
| Report of the Health Center "Sveti Luka" Hospital in Smederevo | | | | | | | | | | | | | | | |

We analyzed health statistics of issued medicaments. "Apotekarska ustanova" supplies the City of Smederevo with medicaments and this institution has 14 pharmacies. Based on 5484 drug prescriptions, these pharmacies issued 1 080 491 medicaments in 2011. Our attention was focused on segregation of drugs used in the treatment of respiratory diseases: Emphysema, Bronchitis, Asthma, Lung cancer and infectious diseases. In collaboration with physicians and specialists for lung and respiratory organ treatment, we specifically marked antibiotics used in lung treatment and strengthening lung defence system, pumps that facilitate breathing to asthmatics and people suffering from obstructive bronchitis, drugs used to treat Lung cancer, Tuberculosis, allergies, cough medicines and fungal diseases. We also marked drugs used for pain which are used to soothe the pain related to Lung cancer in advanced stages. We found that 48 kinds of antibiotics with a total of 68 822 units were issued in 2011, which is 6,4 % of total issued drugs. 11 types of pumps are also issued with 17 216 units, commonly used by children and chronically ill persons. The total number of marked drugs used in the treatment of respiratory diseases is 123 600 which is more than 10 % of total issued drugs.

From the shown Tab. 8 one can see that the number of malignant diseases is on the rise. The increase since 2001 and its holding until 2011 is particularly significant. The number of patients is alarmingly increased almost three times. This situation cannot be fully explained by environmental pollution, but some facts can lead to the problem of the environment. As a matter of fact, the Smederevo Steel Plant, previously known as "Sartid", was privatized in 2003 by the American company U.S. Steel. The production beat every record and grew to the historic record of 2,2 million tons per year, and that was the first time that both Blast Furnaces worked together. Since then only one Blast Furnace has been in operation, and the other has been repaired. This production was inevitably reflected in increased environmental pollution of the surroundings, which certainly had an effect on the health of the population. From our previous representation of the environment one can see that almost all of the parameters endangering the environment were, in this period, over GVI. In this observed period, Radinac, a village in the Steel Plant neighbourhood, had the highest number of patients (183), which is clearly the result of environment violated at a large scale. Settlements located on Sumadija hills, more than 100 meters above the sea level, where the atmospheric circulation is much higher, had a significantly smaller number of ill people (dark lines) than the number of patients in the settlements located in the Velika Morava valley, below 100 m above sea level.

Data from Tab. 9 can also point to a causal relation of the quality of environment and growth of malignant diseases.

**Table 9** Malignant diseases according to location and sex in the City of Smederevo

| Malignant diseases | Age | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oral mouth pharynx | 00÷14 | *m* | 3 | 22 | 10 | 9 | 3 | 6 | 10 | 13 | 8 | 4 | 11 | 8 |
| | | *f* | 2 | 3 | 4 | | 3 | 0 | 2 | 4 | 3 | 2 | 5 | 1 |
| Gastrointestinal tract | 15÷29 | *m* | 14 | 46 | 39 | 44 | 24 | 39 | 38 | 33 | 42 | 28 | 28 | 19 |
| | | *f* | 10 | 33 | 36 | 25 | 20 | 25 | 12 | 26 | 19 | 22 | 22 | 23 |
| Respiratory system and thoracic cavity | 30÷39 | *m* | 13 | 106 | 76 | 73 | 59 | 82 | 82 | 89 | 71 | 63 | 75 | 89 |
| | | *f* | | 25 | 23 | 11 | 16 | 14 | 13 | 14 | 22 | 14 | 22 | 22 |
| Bones and joint cartilage | 40÷42 | *m* | | | 3 | | | | 1 | | 1 | | | 2 |
| | | *f* | | 1 | 1 | | | | | 1 | 1 | 1 | | |
| Melanoma and other skin cancers | 43÷44 | *m* | 20 | 20 | 19 | 27 | 30 | 22 | 21 | 22 | 31 | 22 | 27 | 34 |
| | | *f* | 11 | 18 | 20 | 10 | 15 | 26 | 32 | 33 | 28 | 25 | 32 | 31 |
| Lipoma | 45÷49 | *m* | 1 | 3 | | 2 | | 1 | 2 | | | 2 | | 1 |
| | | *f* | 1 | 3 | | | | 2 | 3 | 2 | | 2 | | |
| Breast cancer | 50 | *m* | 1 | 1 | | | 1 | | 1 | | | | | |
| | | *f* | 49 | 55 | 33 | 52 | 38 | 67 | 46 | 42 | 41 | 52 | 37 | 58 |
| Genital tumors | 51÷63 | *m* | 4 | 3 | 3 | 6 | 6 | 22 | 13 | 39 | 62 | 42 | 43 | 43 |
| | | *f* | 22 | 43 | 28 | 15 | 22 | 45 | 32 | 49 | 27 | 43 | 35 | 32 |
| Tumors of urinary system | 64÷68 | *m* | 6 | 5 | 7 | 6 | 1 | 25 | 13 | 14 | 20 | 13 | 17 | 17 |
| | | *f* | 1 | 1 | 2 | 2 | 3 | 8 | 2 | 7 | 4 | 7 | 6 | 5 |
| Eye, brain tumors | 69÷72 | *m* | 4 | 2 | 2 | 5 | 1 | 4 | 3 | 4 | 2 | 3 | 3 | 2 |
| | | *f* | | 1 | 2 | 4 | 3 | 2 | 4 | 1 | 2 | 2 | 1 | 1 |
| Endocrine glands tumors | 73÷80 | *m* | | 3 | 4 | 2 | 3 | 7 | 11 | 8 | 2 | 4 | 2 | 4 |
| | | *f* | | 1 | 7 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 12 | 4 |
| Tumors of the lymphoid, blood and related tissues | 81÷96 | *m* | 6 | 3 | 8 | 5 | 5 | 4 | 3 | 2 | 7 | 4 | 4 | |
| | | *f* | 4 | 4 | | 4 | 1 | 10 | 2 | 5 | 9 | 5 | 1 | |
| Total | | *m* | 72 | 213 | 171 | 179 | 133 | 212 | 198 | 224 | 246 | 185 | 210 | 223 |
| | | *f* | 100 | 188 | 156 | 126 | 124 | 203 | 152 | 188 | 160 | 179 | 173 | 177 |
| Total | *m + f* | | 172 | 401 | 327 | 305 | 257 | 415 | 350 | 412 | 406 | 364 | 383 | 400 |
| Report of the Health Center "Sveti Luka" Hospital in Smederevo | | | | | | | | | | | | | | |

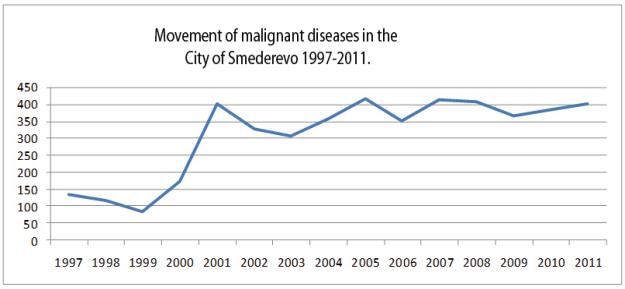


**Figure 2** Movement of malignant diseases in the City of Smederevo 1997 ÷ 2011

We can conclude that air pollution is directly related to respiratory and malignant diseases. In that sense, we can relate the large number of patients suffering from cancer of the respiratory system and thoracic cavity (1074), which represent 25,87 % of the total cancer patients. We notice considerably higher number of male patients (878) than women patients (196), which can be explained by working conditions in the Steel Plant. In production, where pollution is the highest, male labour force is mainly employed, while women mostly work in administration. If we add to that number the patients with cancer of the oral, mouth and pharynx (135), followed by melanoma and skin cancer (576), for which we can also assume that they are closely related to air pollution, this percentage is 43 %, which is nearly half of the patients. Carcinogenic effects of benzopirene, soot and carbon sediments, Arsenic heavy metal compounds, and nickel have great credit for the other malignant diseases such as tumours of endocrine glands, lymphoid and blood tissue. Arsenic concentration in the immediate vicinity of steelworks, in Ralja, reaches up to 18,54 ng/m$^3$, and nickel to 49,4 ng/m$^3$, which is almost twice of the allowable values. The effects of heavy metal pollution, which make up 1 % of the total pollution, include organ damages (kidney, liver, brain, etc.), brain damage and nervous system (seizures, mental retardation, behavioural problems, memory problems etc…), the heart and cardiovascular system (hypertension, heart failure) and so on. Mass of chronic non-communicable diseases (cardiovascular diseases, malignant tumours, obstructive lung disease, injuries, mental health disorders, etc.), for decades dominate the national pathology in Serbia [10].

## 5 Conclusion

Based on the reported values of substances that make up the quality of the environment, we can conclude that the City of Smederevo is a settlement with highly polluted environment. This conclusion especially applies to the polluted air, where the values of certain pollutants exceed limits several times. It is evident that there is a real risk of their seriously endangering human health. Without taking specific measures, we cannot expect significant improvement and enhancement of environmental quality. The main priority that would contribute to reducing air pollution by typical and polluting matters and their elimination from the air, is setting of air polluter cadastres in the city of Smederevo. In this way an insight can be provided into the air quality condition in the whole area at any time. This especially applies to the Smederevo Steel Plant, which is a dominant source of air pollution. Based on the cadastre one can make a meteorological diffusive model of pollution for the entire territory of the city, based on which the procedures in case of accidents and excessive pollution can be defined. Also, air protection from the harmful effects of pollutants is achieved through control over facilities and equipment which can contaminate the air and emission limitation is included to the limits stipulated by the Regulations on limit values, the method and terms of measuring and recording data, taking technological and other necessary measures for emissions reduction, as well as monitoring the impact of air pollution on human health and the environment. In order to improve the quality of the environment, additional measures such as the implementation of the project of gasification and central heating are needed. Existing boiler houses on liquid and solid fuels should be, in the future, converted in the boilers that use gas as a fuel. Diversion of transit and freight traffic on a circular road around the city would reduce air pollution in the city centre. This requires a study of the City and its vicinity transport mode, renewal, maintenance of existing and erection of new green spaces in the city and protection of low and medium green foliage of long growing period in the vicinity of major pollutants [11]. The city of Smederevo in its further development must rely on an ecological component and the general principle of sustainable development, because in this way it can be closer to the European standards, which can create opportunities and access to the EU funds and development loans.

## Acknowledgement

This paper is partly financed by the Ministry of Education and Science of Republic of Serbia, Projects TR 34019.

## 6 References

[1] Group of Authors Local Environmental Action Plan of the municipality of Smederevo. // Directorate of Construction, Urban Planning and Land, Smederevo, 2007, pp. 25-83.
[2] Gavrilovic, Lj.; Miladinović, S. Pollution of watercourses in the municipality of Smederevo and their protection. // Proceedings of the Faculty of Geography, University of Belgrade, Volume LVII. Belgrade, 2009, pp. 19-33.
[3] Agency for Environmental Protection. Results of automatic monitoring of air quality in the area of Smederevo, Belgrade, 2011.
[4] Report on the environmental situation in the city of Smederevo, The Assembly of Smederevo, 2012.
[5] Внуков, А. К. Защита атмосферы от выбросов энергообъектов: Справочник, Энергоатомиздат, Москва 1992, pp. 52-85.
[6] Department of Public Health Pozarevac: Results of automatic monitoring of air quality in the area of Smederevo. Požarevac, 2011.
[7] Jammes, Y.; Delpierre, S.; Delvolgo, M. J. Long-term exposure of adults to outdoor air pollution is associated with increased airway obstruction and higher prevalence of bronchial hyperresponsiveness. // Arch Environ Health, 53, 6(1998), pp. 372-377.
[8] Stojanovic, S.; Nikic, S. D. Exposure to air pollution and development of obstructive bronchitis. // Acta Medica Mediane, Vol 44 Institute of Public Health in Nis, Nis (2005), pp. 21-24.

[9] Health risks of heavy metals from long-range transboundary air pollution, WHO Regional Office for Europe, Copenhagen, 2007.
[10] Aleksic, I. Correlation between environmental and social aspects of sustainable development (poverty, health, education). // Template for discussion: Project "Sustainable Development Strategy in Serbia", Belgrade, 2006, pp. 3-13.
[11] A group of Author Spatial Plan of the city of Smederevo 2020. Strategic assessment of the environmental impact - report. // Directorate of Construction, Urban Planning and Land Smederevo - Department of Urban Planning, Smederevo, 2006, pp. 46-115.

**Authors' addresses**

***dr Slobodan Miladinović***
Academy of Criminalistic and Police Studies, Belgrade
Cara Dušana 196
11080 Zemun, Serbia
slobodan.miladinovic@kpa.edu.rs

***dr Stevo Jaćimovski***
Academy of Criminalistic and Police Studies, Belgrade
Cara Dušana 196
11080 Zemun, Serbia
stevo.jacimovski@kpoa.edu.rs

***prof. dr Željko Nikač***
Academy of Criminalistic and Police Studies, Belgrade
Cara Dušana 196
11080 Zemun, Serbia
zeljko.nikac@kpa.edu.rs

***dr Dalibor Kekić***
Academy of Criminalistic and Police Studies, Belgrade
Cara Dušana 196
11080 Zemun, Serbia
dalibor.kekic@kpa.edu.rs