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Estimation of particulate matter concentrations in selected centres around Shkodra Lake

F.Mandija

Department of Physics, University "Luigj Gurakuqi", Sheshi 2 prilli, Shkoder, (ALBANIA)

E-mail : f_mandija@yahoo.com

ABSTRACT

Lake of Shkodra as the largest lake in the Balkan Peninsula forms a relatively complex ecosystem. One of the most important indicators of this ecosystem is also the quality of air. Air quality can be estimated based on several viewpoints, using physical or chemical parameters. In this study, the work is based on estimation of particulate matter concentrations in the air. Particulate matter is one of the most important physical parameters influencing air quality. There are selected three main locations in the measurement campaign; urban center of Shkodra city and the tourist center Shirokë. There are monitored PM-s mass concentrations in these centers, and then there are obtained conclusions about emission sources and transport mechanisms, controlling the concentrations of particulate matter in our study.

PM_x concentrations in both locations are near the thresholds of international recommendations. This fact signifies the necessity of initiation of more profound studies on reducing of emission rate of particulate matter in the city of Shkodra.

KEYWORDS

Air quality;
PM concentrations;
Shkodra Lake.

INTRODUCTION

Atmospheric particles originate from a variety of sources and possess a range of physical and chemical properties. Collectively, particulate pollution is often referred to as total suspended particulates (TSP). Fine particulates less than 10 and 2.5 microns in size are referred to as PM_{10} and $PM_{2.5}$, respectively[1,2]. These have the most significant impact on human health because they can penetrate deep into the lungs. PM_x emissions are a key health concern with estimated economic damage costs much higher than for other pollutants[3].

Atmospheric particulate matter (PM) affects climate, environment, visibility and health through a great variety of processes. PM can be classified by size into PM_{10} and $PM_{2.5}$ whose median aerodynamic diameter less than 10 mm and 2.5 mm, respectively[4,5].

Wood smoke produces particles too small to be seen by the human eye, measuring 10 microns and smaller. Larger particles tend to settle out of the air quickly, and are less likely to affect public health. Particles 10 microns and smaller may be inhaled deep in the lungs, posing a threat to public health and visibility. Particles 2.5 microns and smaller, are of the highest concern for potential health effects[6].

Health impacts of air pollution vary based on the type of pollutant, length of exposure, and extent of interaction among pollutants. Fine particulate matter such

as PM_{10} poses a serious and direct threat to human health as the particles penetrate deep into lung tissue, conveying toxic substances.

The ubiquitous PM air pollution is likely to have a large overall impact on human health, even if the risks are relatively small[7]. There have recently been a large number of papers reporting quantitative estimations of the health impact of PM on health, as measured by the proportion of excess events that are attributable to PM exposures in the general population, mainly in industrialized countries[8].

Shkodra lake has many tourist centers around it. Nearest urban centers are the cities of Shkodra and Podgorica. To estimate the presence of particulate matter in this region, many papers are presented in scientific journals and international conferences[10].

MATHERIAL AND METHODS

This section consists of three main parts; site selection, measurement methods and instrumental setup.

Site selection

The selection of sites for PM monitoring is done based on their diversity of conditions. We have done measurements in different locations, for estimating PM_x concentrations near the Lake of Shkodra. There are selected several sites in the urban area of the city of Shkodra, and one site outside the city (Figure 1-2).

The sites in the city are located in the center of the city, near the main exit road of the city, and in the inner part of the city (about 55 m far from the main roads). Measurements in the first two sites of urban centers are done near the roads, while measurements at the third site were conducted to perform a clear picture of city background PM_x concentrations. Shkodra city is an urban center with about 120,000 inhabitants. In this center main PM_x sources are traffic and residential activities (like cooking, heating), commercial activities, etc.

Another site where we have conducted PM measurements is Shirokë. This is a rural area near the lake. Its air distance from the urban center of Shkodra is about 4.8 km. Main PM contributors in this area are residential activities and the transport mechanism for the urban center. Traffic plays a minor role in PM emission.

Figure 1 : Location of Shkodra Lake and populated centers of Shkodra city and Shiroke.

Analyzes methods

The PM monitoring campaign was realized during the autumn season, October 2010. We are focused mainly on fair weather measurement conditions, although the measurements are carried out also in rainy and foggy days. At each site there are done measurements for several days, and this process is repeated every month. A further step in measurement methods is also the analysis of measurement data. The use of Information Communication Technology (ICT) is one of the most important factors, influencing on our analysis process[11]. There are extracted more than 70,000 experimental values (PM concentrations). These data were collected in the memory card of the measurement instrument. After each measurement, in each site, we have downloaded these data into computer. Then these data are then analyzed by software like Microsoft Excel, Wolfram Mathematica

6.0, MATLAB R2010a, Origin 8, etc.

For measurements and data collection an Environmental Dust Monitor, model GRIMM EDM 107 is used, which enables simultaneous measurements of PM_1, $PM_{2.5}$ and PM_{10}. Measurement principle is light-scattering and the measurement range of this instrument is 0.25-32 μm. This size range is divided into 31 channels (number concentrations) for aerosol research, and in three PM modes for environmental purposes. Concentration range is $1\text{-}2 \cdot 10^6$ particles/liter. The time response of the instrument is 1 min, but it can be obtained hourly or daily averaged data. In the Figure 2 the EDM 107 instrument and also its case for outdoor monitoring is presented.

Figure 2 : Environmental dust monitor, GRIMM EDM 107.

RESULTS AND DISCUSSIONS

For the measurements during monitoring campaign on the above mentioned sites, there are obtained these parameters of PM concentrations; minimal, average, maximal, median, mode and standard deviation.

We have also obtained PM_x averaged values taken in the city of Shkodra (background PM_x concentrations) and rural center of Shirokë.

Measured PM_x concentration values during monitoring campaign are presented in the TABLES 1-3. Values in TABLES 1-4 are expressed in $\mu g/m^3$.

It is clearly seen that PM concentration in the city of Shkodra is greater than in rural area of Shirokë (except minimal values). The "surprising" result that minimal values are greater in the rural area can be justified by the fact that time interval during we have conducted measurements in Shirokë is only 5 hours, from 13^{oo} to 17^{oo} (obtaining about 300 values). In this interval is not achieved yet the lowest traffic and residential activities, and so the real minimal values in Shirokë must be much lower than the minimal values presented in TABLE 2.

TABLE 1 : PM_x concentrations in the Shkodra city (inner part).

	Minimal	Average	Maximal	Median	Mode	St.dev.
PM_1	13.25	27.13	63.08	23.00	14.90	15.60
$PM_{2.5}$	16.35	33.50	79.12	27.20	18.00	20.51
PM_{10}	38.03	69.52	140.6	60.10	45.20	36.33

TABLE 2 : PM_x concentrations in the Shkodra city (road side).

	Minimal	Average	Maximal	Median	Mode	St.dev.
PM_1	22.47	30.82	46.22	29.15	26.30	7.47
$PM_{2.5}$	26.98	38.56	70.83	30.45	29.70	13.67
PM_{10}	41.52	96.07	256.7	68.60	63.80	86.89

TABLE 3 : PM_x concentrations in the rural area of Shiroke.

	Minimal	Average	Maximal	Median	Mode	St.dev.
PM_1	6.52	7.03	7.49	7.00	7.50	0.43
$PM_{2.5}$	7.43	8.08	8.61	8.10	8.30	0.53
PM_{10}	9.46	10.97	12.67	10.95	11.10	2.13

We have also compared averaged PM concentrations in the city of Shkodra and Shirokë to WHO[1] recommendations for $PM_{2.5}$ and PM_{10} concentrations.

These comparisons are presented by the TABLE 4.

TABLE 4 : Comparisons of measured PM_x concentrations with international recommendations.

	Shkodra		Shirokë	WHO	
	Inner part	Road-side		24-hour mean	Annual mean
$PM_{2.5}$	33.5	38.5	29.3	25	10
PM_{10}	69.5	96.1	47.7	50	20

Main PM_x sources in Shkodra city are traffic (vehicle emissions and resuspension dust, etc.), domestic activities (heating, cooking, etc), commercial activities (bars, hotels, etc).

Average PM values in the inner part of the city (55 m far from the main road) are much lower than PM values in the road-side measurements. The higher differences between these values are obtained especially in the case of larger aerosol modes.

Meanwhile main PM_x sources in Shirokë are almost the same as in Shkodra city, although their contributions are much lower, especially in largest PM modes. For both measurement sites (Shkodra and Shirokë),

there is another PM contributor; long-range transport, contributing especially in the lower PM mode (PM_1). But the last source influence more PM_1 concentrations in Shirokë than in Shkodër. This is because Shkodra city is the largest area source of particulate matter in the region of Shkodra Lake.

The overall results (averaged PM_x concentrations in $\mu g/m^3$) in two sites in Shkodra and in Shirokë are presented in Figure 3.

Let us discuss about the influence of the distance from the source to aerosol concentration on the measurement site. Traffic is the major source of aerosols in the near-road measurements. Traffic and combustion processes are the major sources for the measurements in the inner part of the city. Meanwhile combustion processes and long range transport for Shkodra city are the principal sources of aerosols on the measurements in Shiroka. Combustion processes emit primarily PM_1 and $PM_{2.5}$. Because aerosols of these modes constitute a stable background over the area of the city, we can exclude combustion processes form this analysis. Thus for measurement inside the city we have considered only for traffic.

The reduction of PM_{10} according to the distance from the source is calculated in this way:

$$R_{10} = \frac{\overline{PM_{10}}^{inner} - \overline{PM_{10}}^{Shiroke}}{distance\,(m)} = \frac{69.52 - 10.97}{9500} = 1.22 \quad (1)$$

PM_{10} reduction for the measurements in Shiroka, is determined using background concentrations in Shkodra city (measurements in the inner part of the city) and average concentrations in Shiroka.

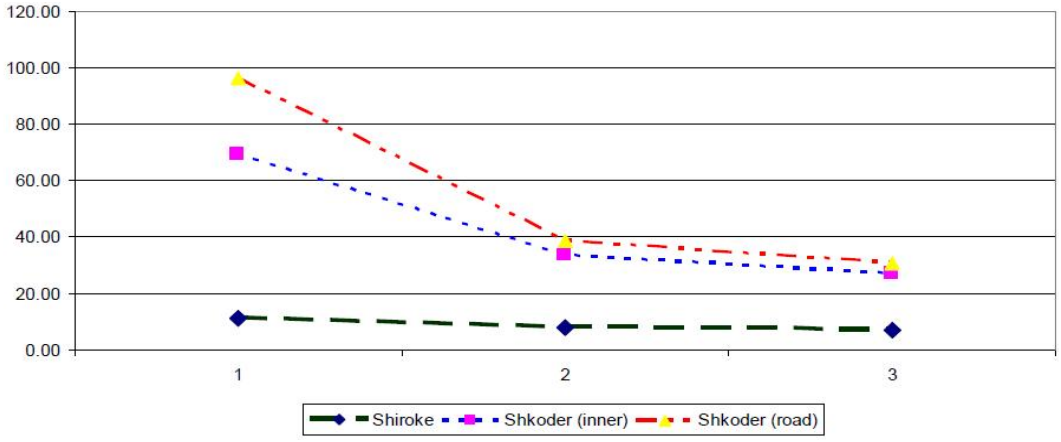

Figure 3 : Overall PM_x concentrations in measuring sites.

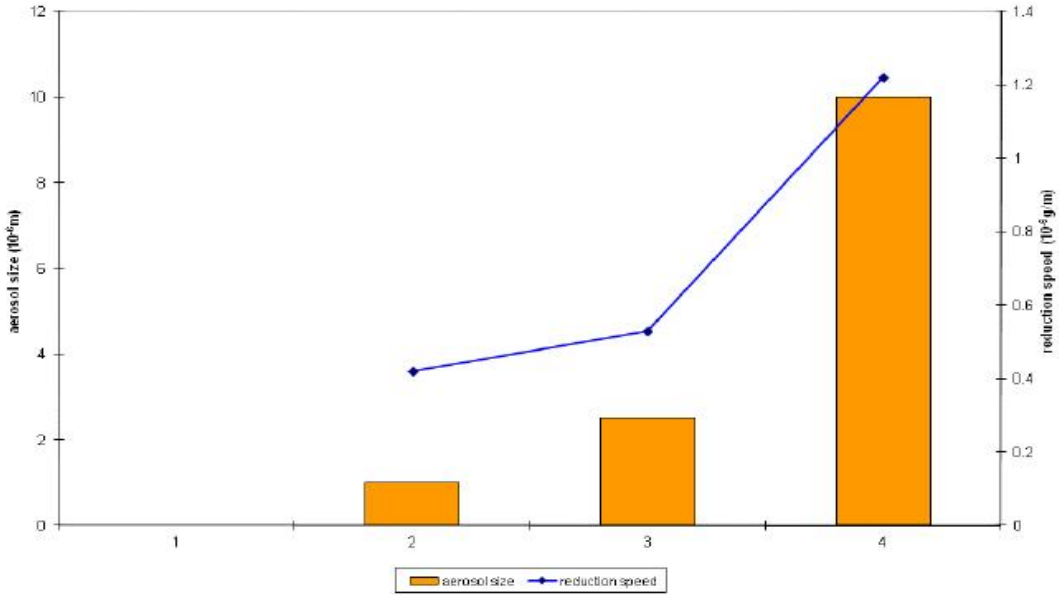

Figure 4 : Reduction speed of aerosol concentration vs aerodynamic size.

Let now discuss about other modes; PM_1 and $PM_{2.5}$. After calculations we obtain $R_{2.5} = 0.53$ and $R_1 = 0.42$. Thus the speed of reduction results related to aerosol size. Correlation coefficients among the values of speed reduction and aerosol sizes (1, 2.5 and 10 μm) is 0.99.

This situation is presented in Figure 4.

In Figure 4, the units in horizontal and vertical axes are μm and $\mu g/m^3$ respectively.

Figure 4 shows a clear positive relation between aerosol size and the reduction speed of their concentrations. So we can conclude that PM_1 and $PM_{2.5}$ sources in Shkodra city can influence also in their concentrations in Shhirokë or other areas near Shkodra Lake. Meanwhile PM_{10} sources in Shkodra city influence only in the area of the city.

CONCLUSIONS

PM concentrations play a direct effect on the quality of our living environment. We have measured PM_1, $PM_{2.5}$ and PM_{10} concentrations in two main locations; urban center of Shkodra city and rural area of Shirokë.

Based on the measurement results it can be seen that all PM_x concentrations in Shkodra city exceed international limits, and more exactly limits recommended by WHO. In the rural area of Shirokë, which is also a tourist location of the Lake of Shkodra, the situation is better than in urban centers. PM_x concentrations in this area are in the limits of WHO 24-hour limits, but it is a clearly excess of the annual limit for $PM_{2.5}$ and PM_{10} concentrations.

High PM_x concentrations in the Shkodra Lake area influence directly on the quality of its water, loading continuously it with particulate matter.

Reduction speed of aerosol concentrations according to the distance from the source, results positively correlated to aerosol aerodynamic size.

Thus it must be an important goal of all responsible authorities to regulate this situation, especially in tourist locations like Shirokë, etc. This would improve the quality of both air and water in the area of Lake of Shkodra.

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