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ESTIMATION OF PARTICULATE MATTER CONCENTRATIONS AT SOME POPULATED CENTERS AROUND SHKODRA LAKE USING SYNERGISTICALLY IN-SITU MEASUREMENTS AND REMOTE SENSING TECHNIQUES

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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 centre of Shkodra city and the tourist center Zogaj. 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 these areas. Despite of the in-situ measurements, our analyses are based also on the usage of the remote sensing techniques in order to evident more efficiently the types and the sources of aerosol in this region. PM-s 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.

1. INTRODUCTION

Atmospheric particles originate from a variety of sources and possess a range of physical and chemical properties [1]. 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 [2]. These have the most significant impact on human health because they can penetrate deep into the lungs [3]. PM emissions are a key health concern with estimated economic damage costs much higher than for other pollutants [4]. Atmospheric particulate matter (PM) affects climate, environment, visibility and health through a great variety of processes [5]. PM can be classified by size into PM_{10} and $PM_{2.5}$ with mass median aerodynamic diameter less than 10 mm and 2.5 mm, respectively [6]. The primary air quality concerns associated with forest management activities include road dust and smoke from wildfires and prescribed burning. The main air quality concern associated with this specific project would be the amount and concentration of particulate matter (PM) produced by proposed prescribed burning [7]. Wood smoke produces particles too small to be seen by the human eye, measuring 10 microns (one micron equals a millionth of a meter) 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 especially those problems related to the respiratory system [8]. 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. Many epidemiological studies have demonstrated the importance of air pollution as a risk factor and characterized dose-response relationships between health endpoints and pollutants [9]. The association between particulate matter (PM) and health is generally regarded as causal, and a no threshold linear relationship with, for example, mortality and hospital admission has been observed in several settings. The ubiquitous PM air pollution is likely to have a large overall impact on human health, even if risks are relatively small [10]. 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. Several monitoring campaigns are carried out in the region of Shkodra Lake and these results are presented in several conferences and peer review journals [11-15].

2. MATERIAL AND METHODS

This section consist on three main parts; site selection, measurement methods and instrumental setup.

2.1. Site selection

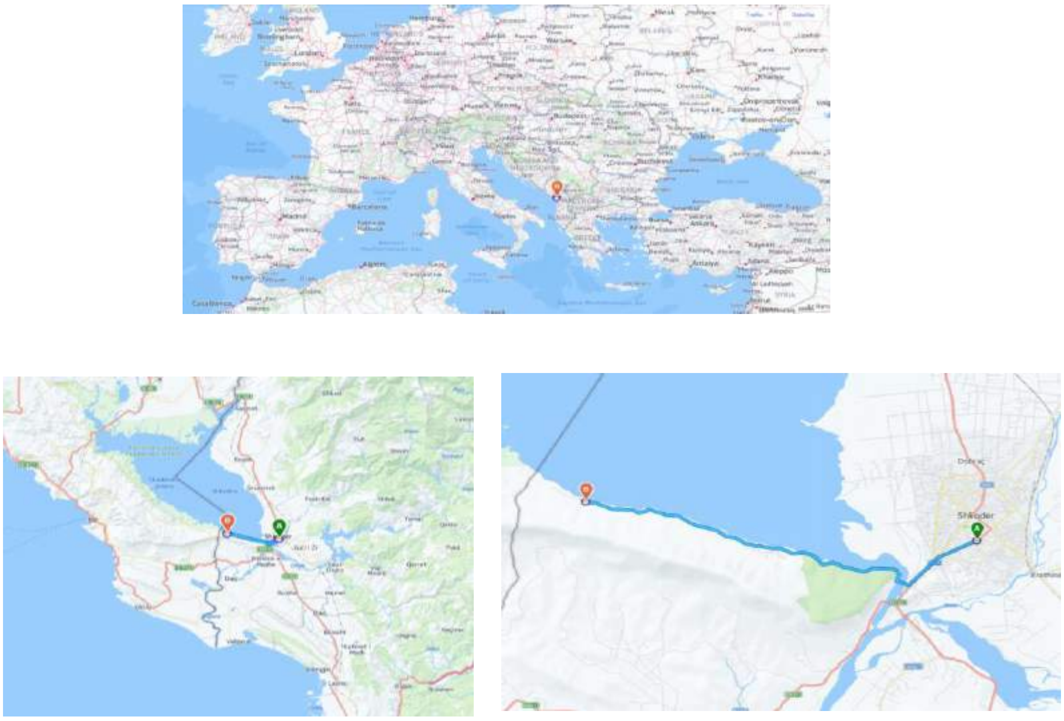
The selection of sites for PM monitoring is done based on their diversity of conditions. We have done measurements in different locations, for estimating PM concentrations near the Lake of Shkodra. There are selected several sites in the urban area of city of Shkodra, and one site outside the city. The sites inside the city are located in the center of the city, in 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 centre are done in near the roads, while measurements in the third site were conducted to perform a clear picture of city background PM concentrations. Shkodra city is a urban centre with about 120,000 inhabitants (fig. 1. a). In this center main PM sources are traffic and residential activities, like cooking, heating, etc.

Another site where we have conducted PM measurements is Zogaj (fig. 1. b). This is a rural area near the lake. Its air distance from the urban centre of Shkodra is about 9.5 km. main PM contributors in this area are residential activities and the transport mechanism for the urban centre. Traffic plays a minor role in PM emission.

2.2. Measurement methods

The period of PM monitoring was about six months, October-November 2009. We are focused mainly on fair weather measurement conditions, although the measurements are carried out also in rainy and foggy days. In each site there are done measurements for several days, and this process is repeated every month. Another step in measurement methods is also the analysis of measurement data. 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 Wolfram Mathematica 6.0, MATLAB R2010a, Origin 8, etc.

Another important method in our analysis is the remote sensing techniques. MODIS (Moderate Resolution Imaging Radio spectrometer) imagery as well as the forecast model like NAAPS (Navy Aerosol Analysis and Prediction System), are used to classify the aerosol types and their origins and pathways.



a) *b)*

Figure 1. Measurement sites; a) Shkodra city b) Zogaj rural site

2.3. Instrumental setup

For measurements and data collection there are used an environmental dust monitor, model GRIMM EDM 107, 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 in 31 channels for aerosol research, and in three PM modes for environmental purposes. Concentration range is $1\text{-}2 \cdot 10^6$ particles/liter. Time response of the instrument is 1 min, but it can be obtained hourly or daily averaged data. In the figure 3 there is presented the EDM 107 instrument and also its case for outdoor monitoring.

3. RESULTS AND DISCUSSIONS

3.1. In-situ measurements

For the measurements during monitoring campaign in the above mentioned sites, there are obtained these parameters of PM concentrations. We have extracted these results on averaged values taken in the city of Shkodra (background PM concentrations) and rural are of Zogaj. These PM concentration values are presented in the tables 1-2.

Table 1. PM (μgm^{-3}) results in the Shkodra city

	Average	Minimal	Maximal	Median	Mode	St. deviation
PM_1	44.2	6.8	160.7	32.3	10.2	33.6
$PM_{2.5}$	48.3	8.5	175.5	35.6	29.0	36.6
PM_{10}	71.9	11.3	293.8	51.7	24.2	54.7

Table 2. PM (μgm^{-3}) results in the rural area of Zogaj

	Average	Minimal	Maximal	Median	Mode	St. deviation
PM_1	25.2	20.0	42.1	24.6	24.8	2.88
$PM_{2.5}$	29.3	22.4	82.2	28.1	27.3	4.92
PM_{10}	47.6	28.6	416.3	39.7	39.3	34.15

It is clearly seen that PM concentration in the city of Shkodra are greater than in rural area of Zogaj, except minimal values. The 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 Zogaj is only 5 hours, from 13^{oo} to 18^{oo} (obtaining only 300 values). In this interval is not achieved yet the lowest traffic and residential activities, and so the real minimal values in Zogaj must be much lower than the minimal values presented in table 2. The ratios among their PM_1, $PM_{2.5}$ and PM_{10} average values were 1.75, 1.65 and 1.51 respectively.

We have also compared averaged PM concentrations in the city of Shkodra and Zogaj with WHO[1] recommendations for $PM_{2.5}$ and PM_{10} concentrations. These comparisons are presented by the table 3. The data on the table 3 indicate that the $PM_{2.5}$ and PM_{10} in Shkoder and Zogaj exceed the WHO recommendations. Anyway the situation in Zogaj is less preoccupant than in Shkodra urban centre. The average values of $PM_{2.5}$ in Zogaj exceed the WHO thresholds by 17.2% while PM_{10} is 4.6% lower than the limit. On the other hand, $PM_{2.5}$ and PM_{10} in Shkodra urban centre exceed the limits by 1.7 and 2.2 times respectively. This

[1] WHO - World Health Organization

result gives a critical indication about the real state of air pollution in urban centre of Shkodra city.

Table 3. Comparisons of measured PM (μgm^{-3}) concentrations with international recommendation

	Shkodra	Zogaj	WHO	
			24 hour mean	annual mean
$PM_{2.5}$	42.3	29.3	25	10
PM_{10}	110.7	47.7	50	20

3.2. Remote sensing techniques

MODIS images on 9-Oct-10 are show in fig. 2. The average aerosol optical depth values AOD_550 nm, in the region of interest are of range 0.1. These values indicate a moderate situation of aerosol loading.

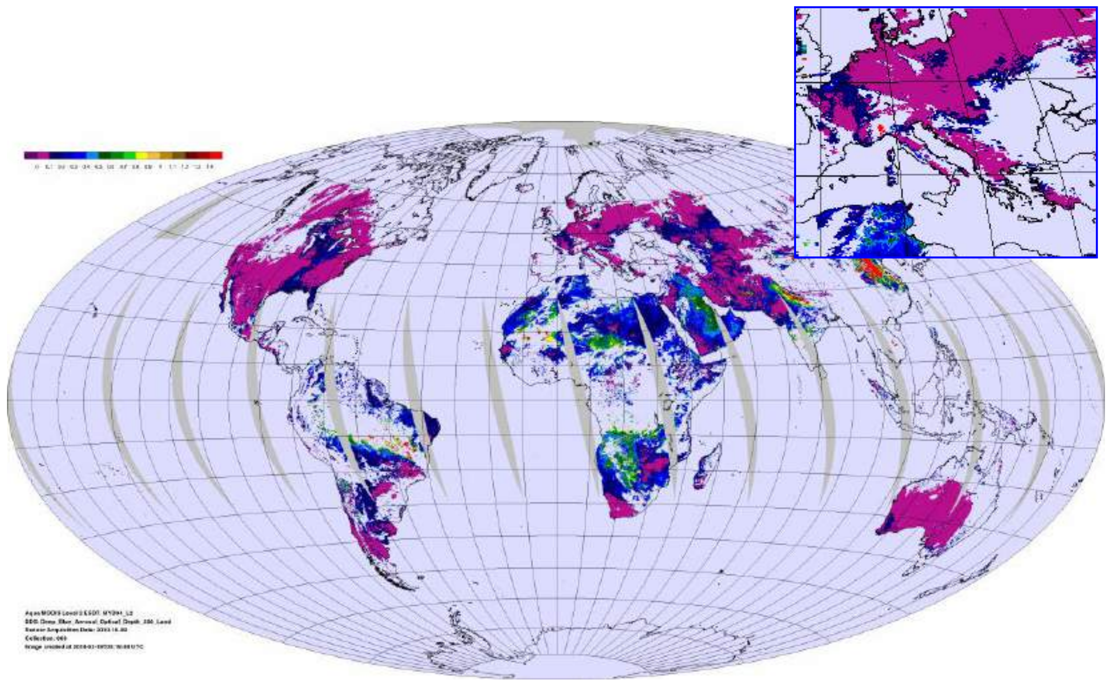


Figure 2. MODIS maps on AOD_550 nm values in a special case (09-Oct-10).

Time Averaged Maps of Aerosol Optical Depth 550 nm and Aerosol Angstrom Exponent 550/865 nm (Dark Target, Ocean-only) daily 1 deg. [MODIS-Terra MOD08_D3 v051] in the region of interest are presented in fig. 3.

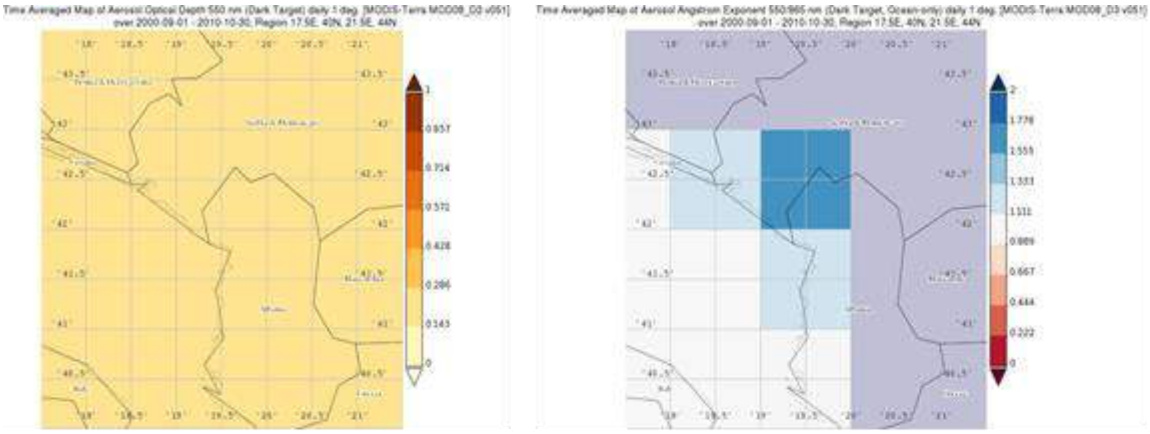


Figure 3. Time Averaged Maps of AOD_550 nm and AE_550/865 nm in the North Albania region.

The averaging was performed in the period 1-31 Oct 2010. The averaged map of AOD, indicate a moderate or high level of aerosol loading with $AOD_{550}>0.1$. Meanwhile the averaged AE map suggests that fine aerosol is dominant during this period. Their average values in the region of interest are in the range of 1.3 to 1.5.

NAAPS maps give an explanation of the type of these fine aerosols. One illustration case is presented in the first NAAPS map (fig. 4.). This map suggests that the fine aerosols are mainly sulfate. Anyway the NAAPS maps suggest that are not only fine aerosol present during this period. There are identified sporadic cases associated with dust intrusions (coarse aerosol). The second NAAPS map presented in fig. 4. show a case the dust intrusions from Saharan desert during this period.

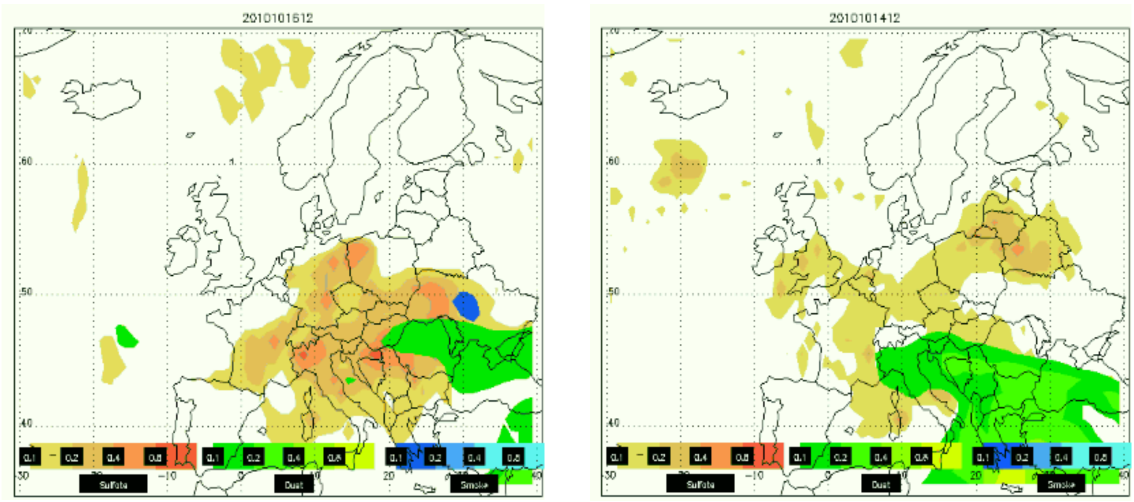


Figure 4. NAAPS maps of AOD_550 nm in the European area during two separate cases; 16-Oct-10 (fine mode contribution) and 14-Oct-10 (coarse mode contribution)

Anyway the lack of active/passive remote sensing measurements, like those provided by sun/star-photometers and lidar systems, increase the uncertainty of the obtained results, especially those related to column-integrated or vertical-resolved data on aerosol loads.

4. CONCLUSIONS

We have measured PM_1, $PM_{2.5}$ and PM_{10} concentrations in two main locations; urban centre of Shkodra city and rural are of Zogaj. Based on the in-situ measurement results it can be seen that all PM concentrations in Shkodra city exceed international limits, and more exactly limits recommended by WHO. In the rural area of Zogaj, which is also a tourist location of the Lake of Shkodra, the situation is better than in urban centre. PM 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 concentrations in the Shkodra Lake area influence directly on the quality of its water, loading it with particulate matter affecting at the same way the air quality in a residential and tourist site.

On the other hand, the AOD values obtained from satellite imagery provided by MODIS and forecast models like NAAPS indicate a moderate and high aerosol load. Average values on the Shkodra region during the investigated period are usually higher than 1.5 and often higher than 1.5. Meanwhile the AE values indicate the predominance of the fine mode aerosol. Anyway, some dust intrusions from Sahara desert are provided by the NAAPS model.

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