Athens Institute for Education and Research
ATINER

ATINER's Conference Paper Series
ENV2017-2302

Study of $PM_{2.5}$ and PM_{10} Mass Concentration in Korça City

Raimonda Totoni
Head
Polytechnic University of Tirana
Albania

Edlira Baraj
Lecturer
Polytechnic University of Tirana
Albania

Vanela Gjeca
Head
National Environmental Agency
Albania

Gjystina Fusha
Air Expert
National Environmental Agency
Albania

An Introduction to ATINER's Conference Paper Series

ATINER started to publish this conference papers series in 2012. It includes only the papers submitted for publication after they were presented at one of the conferences organized by our Institute every year. This paper has been peer reviewed by at least two academic members of ATINER.

Dr. Gregory T. Papanikos
President
Athens Institute for Education and Research

This paper should be cited as follows:

Totoni, R., Baraj, E., Gjeca, V. and Fusha, G. (2017). **"Study of $PM_{2.5}$ and PM_{10} Mass Concentration in Korça City",** Athens: ATINER'S Conference Paper Series, No: **ENV2017-2302.**

Athens Institute for Education and Research
8 Valaoritou Street, Kolonaki, 10671 Athens, Greece
Tel: + 30 210 3634210 Fax: + 30 210 3634209 Email: info@atiner.gr URL: www.atiner.gr
URL Conference Papers Series: www.atiner.gr/papers.htm
Printed in Athens, Greece by the Athens Institute for Education and Research.
ISSN: 2241-2891
13/11/2017

Study of $PM_{2.5}$ and PM_{10} Mass Concentration in Korça City

Raimonda Totoni

Edlira Baraj

Vanela Gjeca

Gjystina Fusha

Abstract

The monitoring data of particulate matter ($PM_{2.5}$ and PM_{10}) mass concentration in Korça city are presented and analyzed in this paper. During the study period (January- December 2014) the mean concentration of $PM_{2.5}$ and PM_{10} were found to be 24.8μg/m^3 and 37.9 μg/m^3 respectively. The results show clear variation of these two fractions, in seasonal average mass concentration. The higher $PM_{2.5}$ and PM_{10} mean concentration belongs to winter, reaching respectively 54.8μg/m^3 and 61.9μg/m^3. Minimum of $PM_{2.5}$ and PM_{10} mean values of 9.2 μg/m^3 and 28.2 μg/m^3 occurred during the summer season. December seems to be most polluted month by PM fractions, presenting a mean value of 79.9μg/m^3 for PM_{10} and 70μg/m^3 for $PM_{2.5}$. Both values are higher than EU daily limit value and WHO AQG, indicating for an unhealthy air quality. The annual mean ratio of $PM_{2.5}$ /PM10 was 0.61±0.24. During the cold months the average ratio of $PM_{2.5}$ /PM_{10} results 0.89 against 0.32 in the summer season. The high proportions of $PM_{2.5}$ within PM_{10} values demonstrate that fine particles are the greatest contributor to PM air pollution during the winter and suggest that anthropogenic sources have a major influence on such pollution. The high level of PM fractions during winter period can be explained by the extensive use of wood in this city, primarily for heating purposes.

Keywords: Air quality, Korça, Particulate matter.

.

Introduction

Korça is one of the main towns in Albania and the major urban centre in Southeast Albania. Situated at 869m above sea level, it is bordered to the East with Greece and to the North with FYROM. Korça has a Mediterranean continental climate, with cold winters and a sharp increase in temperature during the summer. The hottest month is August, while January is the coldest. The average precipitation is 710 mm/year. The driest month is June, with an average of 38 mm of precipitation. November is the month with more precipitations, averaging at 108 mm. The most common winds are those of North and Southwest direction. During the winter the temperature often goes lower than 0^oC. On average, seasonal temperature ranges from -3.2ºC to + 26.8ºC. According to 2011 National Census data, Korça city has 51 683 inhabitants. It is the sixth largest city in Albania.

Regionally, Korça economy is based at agricultural development. In the city, there are other major businesses, which mainly include developments at sectors, such as: civil construction and production of construction materials, food and garments, alongside with IT and services. Considering the investments made in culture and heritage conservation together with touristic attractions offered inside the city and on surroundings, tourism is becoming even more important.

Over the last years several important projects are implemented in Korça city, mainly on infrastructure sector. The rehabilitation of drinking water network, rehabilitation of sewage system and the construction of Urban Wastewater Treatment Plant, the construction of a regional sanitary landfill, reconstruction of the roads, are some of the most important interventions carried out, which undoubtedly have had positive impact in improvement of life and of environmental quality. Therefore, Korça can be considered a "success story" regarding its environmental status.

The purpose of this study has been the assessment of urban air pollution from particulate matter in Korça city. Monitoring data of PM_{10} and $PM_{2.5}$ mass concentration during year 2014, their monthly and seasonal variability, as well as the factors that influence particulate matter pollution in Korça city, are presented and discussed.

Literature Review

Good air quality is a prerequisite for human health and well-being of humans and ecosystems. Polluted air has a significant impact on human health, particularly in urbanized areas. Many urban activities (e.g., traffic, combustion processes, industrial processes, agriculture, waste management) are accompanied by emission of several dangerous compounds into air, causing elevated concentration of pollutants. The concentration of air pollutants varies depending on the magnitude and the distribution of emission sources, on meteorological factors and the local topography (Manahan, 2010).

It is well known that air pollution cause adverse effects on human health and is a major environmental health problem affecting everyone in developed and developing countries. The human exposure to air pollutants contributes to increased morbidity and mortality. In terms of harm to human health, the most problematic pollutants are estimated to be PM, ground-level O_3 and NO_2 (EEA, 2015). Air pollutants can harm ecological resources, including water quality, soils, plants, and animals. Air pollutants are also considered to cause Climate Change to Earth. The most harmful air pollutants in terms of damage to ecosystems are O_3, ammonia (NH_3) and NO_x (EEA, 2015).

Air pollutants may be transported or formed over long distances; and they may affect large areas. Local and national emissions of air pollutants may thus have implication at regional and global scale (WHO, 2006b).

Particulate Matter (PM) is one of the six criteria pollutants, and the most important in terms of adverse effects on human health. In this context, particularly in the recent years, the particulate matter is subject of extensive research. Particulate matter is the term used for a mixture of solid particles and liquid droplets suspended in the air. These particles can either have natural or anthropogenic sources. Urban particulate matter originates from a variety of stationary and mobile sources and can be directly emitted or can be formed in atmosphere when gaseous pollutants such as SO_2 and NO_x react to form fine particles. Car engine combustion accounts for the significant contribution in urban particulate matter load (Fraser et al., 2003; Fuzzi et al., 2015).

The capacity of particulate matter to produce adverse health effects in humans depends on its deposition in the respiratory tract. Commonly used indicators describing PM that are relevant to health refer to the mass concentration of particles with a diameter of less than 10 µm (PM_{10}) and of particles with a diameter of less than 2.5 µm ($PM_{2.5}$). These particles correspond to the inhalable particles that are small enough to penetrate the thoracic region of the respiratory system.

A great number of studies have documented the adverse effects of airborne particulate matter to public health on a global scale, not only in highly polluted environments (WHO, 2006a; WHO, 2013). The health effects of inhalable PM are due to exposure over both the short term and long term and include the lung dysfunction, increased frequency of respiratory symptoms, increases in morbidity and mortality from cardiovascular and respiratory diseases and from lung cancer (Dockery et al., 1993; Pope et al., 1995; Pope et al., 2006; Anderson et al., 2012; Brook et al., 2010). People with pre-existing heart and lung disease, children and elderly are the population subgroups most sensitive to PM exposure impacts (WHO, 2006a; WHO, 2006b).

The long-term exposure to current ambient PM concentrations may lead to a significant reduction in life expectancy by up to a few years , primarily due to increased cardio-pulmonary and lung cancer mortality (Brunekreef, 1997). Numerous health studies suggest that fine particles ($PM_{2.5}$) arising mainly from man-made sources are more toxic than larger sized particles (Schwartz et al., 1996; Hoek et al., 2002, Pope et al., 2002; Franklin et al., 2007). Referring to EEA Report on air quality in Europe, it has been estimated that exposure to $PM_{2.5}$ concentrations in outdoor air in 2013, was responsible for about 467 000 premature deaths originating from long-term exposure over 41 countries in Europe (EEA, 2016).

Epidemiological studies on large populations have been unable to identify a threshold concentration below which ambient PM has no effect on health. Adverse health effects due to PM exposure have already been observed at PM concentrations slightly above background levels, i.e. 3–5 μg/ m^3 (WHO, 2006a).

The rapid changes on economic and social structure in Albania, after years ’90 were associated with important changes on pollution sources and on the structure of air pollution. Before ’90, the industry was the major pollution source of urban air. Due to very low number of vehicles in that period, emission of pollutants by road traffic was insignificant. The situation is currently reversed, higher pollutants emission occurs as a result of immense increase of vehicular transport, whilst industrial emission is low because of the limited industrial activities.

Several projects financed by EU have supported the establishment of an air monitoring network in the country, which includes major municipalities, such as Tirana, Elbasan, Durrës, Fier, Vlora, Shkodra, Korça. Monitoring is carried out for six key indicators of air quality (NO_2, SO_2, O_3, Pb, CO, PM_{10}) and monitoring data are published in the Annual Environmental Reports and in the web site of National Environmental Agency, which is responsible for environmental monitoring in Albania. NEA is conducting monitoring of urban air quality, for which Public Health Institution is also contracted.

As a candidate country, Albania is approximating its legal framework in environmental areas, including air control and monitoring, with the EU legislation. The CoM Decision “On air quality norms” determines 66μg/m^3 and 150μg/m^3 as 24 hourly average limit values for $PM_{2.5}$ and PM_{10}, respectively, whilst the annual average limit values are 15μg/m^3 for $PM_{2.5}$ and 60μg/m^3 for PM_{10} (CoM, 2003).

Air quality monitoring data and studies carried out in the last decades have indicated that particulate matter, less than 10 and 2.5 microns in diameter, (PM_{10} and $PM_{2.5}$) are the most problematic ones, for air quality in Albanian cities (AEF, 2008-2011; NEA, 2012-2014; ECAT, 2008, Totoni et al, 2001; Totoni et al., 2014). Referring to the air quality, the most polluted city remains Albanian capital, where in last decade the levels of particulate matter and NO_2 have often overcome the long-term and short-term limits defined by Albanian standards and EC Directives. The other main Albanian cities have also gone beyond the legal limit of PM_{10}.

A downward trend is observed, however, during the last years, in PM levels in urban air of Tirana and other main Albanian cities. Measures undertaken to control and monitor the air pollution sources together with infrastructural works and developments, have contributed on such improvements (Totoni et al., 2012; Damo and Icka, 2014).

Methodology

The particulate matter monitoring data for this study were obtained from the National Agency of Environment. Measurements have been carried out in Korça city at regular basis, in the period January - December 2014. Samples have been collected every hour, at about 3.5 m above ground level, in the schoolyard of high school "Raqi Qirinxhi", with geographical coordinates 40°37'32" and 20° 46'50". The sampling area is mainly a residential area and the monitoring station is classified as urban station. The concentrations of PM_{10} and $PM_{2.5}$ were continuously monitored using GRIMM EDM 180 Aerosol Spectrometer device. The instrument is used for continuous measurements of particles in air, detecting light scattered from airborne particles. The air, to be analyzed, was drawn into the unit via an internal volume-controlled pump at a rate of 1.2 l /min. The equivalence of this method is in accordance with EN 12341 standards for the determination of PM_{10} and $PM_{2.5}$ mass concentration of suspended particulate matter.

Statistical assessments to compare seasonal variations have been performed by using one-way ANOVA test. All mathematical and statistical computations were made using Minitab 16 and Microsoft Office Excel 2007.

Results and Discussion

The Table 1 presents the overall statistic of measured concentrations for $PM_{2.5}$ and PM_{10} in Korça city during the year 2014.

Table 1. *Summery Statistics of $PM_{2.5}$ and PM_{10} Mass Concentrations (µg/m^3) during Year 2014 in Korça City*

Parameters		$PM_{2.5}$	PM_{10}
Number of monitoring days		280	280
Arithmetic mean		24.84	37.89
Standard Deviation		26.84	30.94
Minimum concentration		0.57	4.53
Maximum concentration		202.98	226.32
Percentiles	10%	6.12	13.05
	90%	53.70	73.15

Means of monthly values for $PM_{2.5}$ and PM_{10} are presented in Tables 2 and 3 respectively. The tables show also the minimum and maximum 24-hour concentration values and the number of the days when PM concentrations exceed the short-term limit values set by EU Directive and WHO Guidelines.

Table 2. *Monthly Average Mass Concentrations (μg/m^3) of $PM_{2.5}$ during Year 2014 in Korça City*

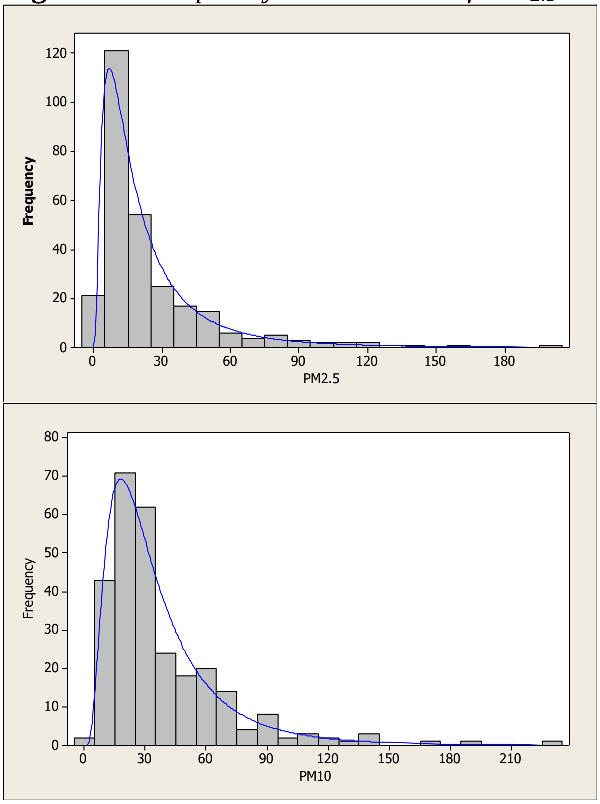
Month	Nr. of monitoring days	Mean concentration	Minimal concentration	Maximal concentration	Nr. of days with $PM_{2.5}$>25μg/m^3
January	16	54.0	17.67	109.81	11
February	17	27.86	12.70	53.67	11
March	31	25.70	11.03	94.05	9
April	29	15.69	5.30	26.01	1
May	30	7.64	1.27	16.36	0
Jun	21	8.51	0.57	14.15	0
July	31	7.40	0.68	13.79	0
August	31	11.60	3.77	22.34	0
September	7	8.49	5.42	13.96	0
October	15	19.50	8.79	37.99	3
November	21	40.32	15.88	59.41	19
December	31	69.97	10.85	202.98	30

Table 3. *Monthly Average Mass Concentrations (μg/m^3) of PM_{10} during Year 2014 in Korça City*

Month	Nr. of monitoring days	Mean concentration (μg/m^3)	Minimal concentration	Maximal concentration	Nr. of days with PM_{10}>50μg/m^3
January	16	58.45	19.68	139.39	8
February	17	32.26	19.86	56.45	1
March	31	31.97	7.63	80.57	3
April	29	20.66	8.83	29.86	0
May	30	13.15	4.53	26.48	0
Jun	21	20.52	5.67	43.39	0
July	31	24.18	4.94	67.33	3
August	31	39.17	14.11	93.08	6
September	7	26.84	17.44	60.37	1
October	15	41.24	13.08	89.73	6
November	21	69.72	36.49	135.35	16
December	31	79.85	12.11	226.32	21

As it is seen from the information presented in the above tables the concentrations of PM_{10} and $PM_{2.5}$ during year 2014 in urban area of Korça vary widely, which is expressed also in the high values of standard deviations. Frequency distribution of 24-hours mean concentrations for $PM_{2.5}$ and PM_{10} (n=280) is presented in Figure 1. The histogram indicates that the distribution is much close to a log-normal distribution.

Figure 1. *Frequency Distribution of $PM_{2.5}$ and PM_{10} 24-hours Means*



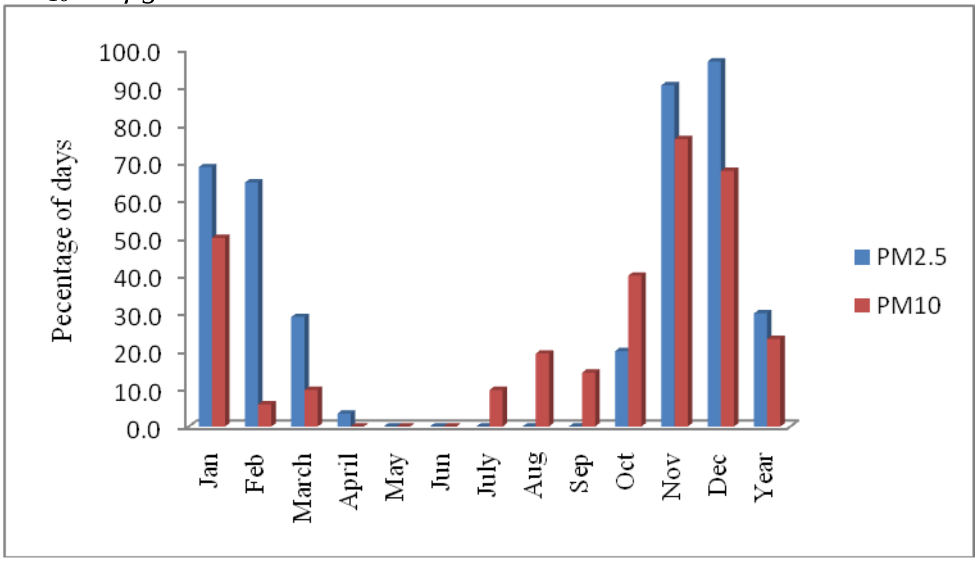
The annual mean concentration results to be 24.84μg/m^3 for $PM_{2.5}$ and 37.89μg/m^3 for PM_{10}. These values meet the annual limit values set by EU Ambient Air Quality Directive for $PM_{2.5}$ and PM_{10} (respectively 25 μg/m^3 and 40 μg/m^3), but are obviously higher compared to stricter values of WHO AQG guideline for $PM_{2.5}$ annual mean (10 μg/m^3) and PM_{10} annual mean (25 μg/m^3). The results obtained for particulate matter mass concentrations in Korça city are similar with those reported from recent studies performed in other European countries. Across Europe the annual averages of PM_{10} varied from 5 to 54μg/m^{3}and for $PM_{2.5}$ ranged between 3 and 35μg/m^3, increasing when moving from rural and natural background to urban background sites (Fuzzi et al., 2015).

An examination of PM daily mean concentrations highlights that the violations of short-term limit values are considerable both for $PM_{2.5}$ and PM_{10}. Thus, of 280 monitoring days, concentrations above PM_{10} daily limit value (50 μg/m^3), have been observed in 65 days (or in 23.2% of the total), while this limit cannot be exceeded by more than 35 days in a year (EC, 2008). Regarding $PM_{2.5}$, the values exceeding the allowed standard of AQG guideline for $PM_{2.5}$ daily mean have been detected in 84 days or in 30% of monitoring days. These data show that in more than a quarter of the year 2014 the inhabitants of Korça city were exposed to particulate matter concentrations that exceeded EU air quality daily limit value and WHO AQG for protection of human health.

It has to be emphasized that the major part of exceeded values belongs to cold months, particularly to January, February, November and December (Figure 2). During these months, only in a very limited number of days,

$PM_{2.5}$ and PM_{10} concentrations observed, are below daily limit values for such PM fractions. Most of the days are been characterized by concentrations that noticeably overpass the norms. The main factor that contributes to this high particulate matter pollution seems to be the anthropogenic emissions from residential heating. It is estimated that in some areas, the combustion of wood and other biomass fuels can be an important source of particulate air pollution, the resulting combustion particles being largely in the fine ($PM_{2.5}$) mode (WHO, 2006a).

Figure 2. *Percentage of Days with Concentration of $PM_{2.5}$>25µg/m^3 and of PM_{10}>50µg/m^3*



Referring to Albanian norms, the annual average value of PM_{10}, is significantly below the limit, whilst for $PM_{2.5}$ is 1.66 times higher. 24-hour concentration of $PM_{2.5}$ exceeded the daily limit of 66µg/m^3 in 7.1% of monitoring days, whilst PM_{10} daily concentrations were above 150µg/m^3 in three of monitoring days.

Monthly and Seasonal Variation in Mass Concentration of $PM_{2.5}$ and PM_{10}

Figure 3 presents the monthly average mass concentrations of $PM_{2.5}$ and PM_{10}. Trends for these two PM sizes are similar. Peak monthly values for average mass concentrations of $PM_{2.5}$ and PM_{10} appeared in December, reaching 69.79µg/m^3 and 79.95µg/m^3 respectively. During this month it is registered also the highest daily mass concentration both for $PM_{2.5}$ (202.98µg/m^3) and PM_{10} (226.32µg/m^3), which strongly exceeded the daily limit values of 25µg/m^3 and 50µg/m^3, respectively, defined by WHO AQG and EU Directive. The above limits values have been more evident for $PM_{2.5}$, daily mean concentration of which met the daily limit value of 25µg/m^3 only in one day, while in 30 other days of the month, the concentrations were from 1.2 to 8.1 times higher.

The lowest value for average mass concentrations of $PM_{2.5}$ were in July and reached 7.40µg/m^3, while May was the month with lowest monthly average concentration of PM_{10} (13.15µg/m3). During all this month the daily average mass concentrations obtained for $PM_{2.5}$ as well for PM_{10} were totally well below the daily limit values. The December monthly average concentrations were respectively 9.1 times ($PM_{2.5}$) and 6.1 times (PM_{10}) higher than May monthly average concentrations.

Figure 3. *The Monthly Average Mass Concentrations (µg/m^3) of $PM_{2.5}$ and PM_{10}*

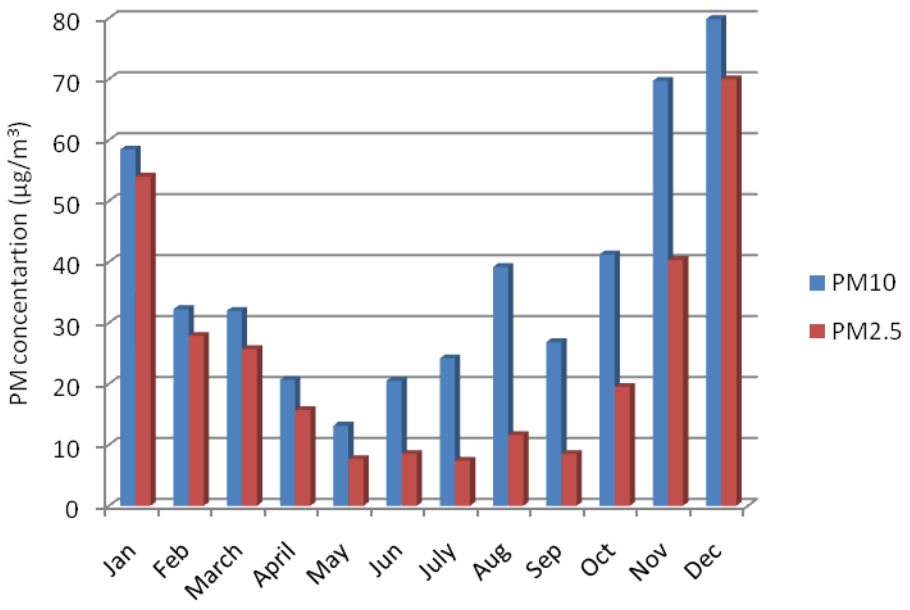
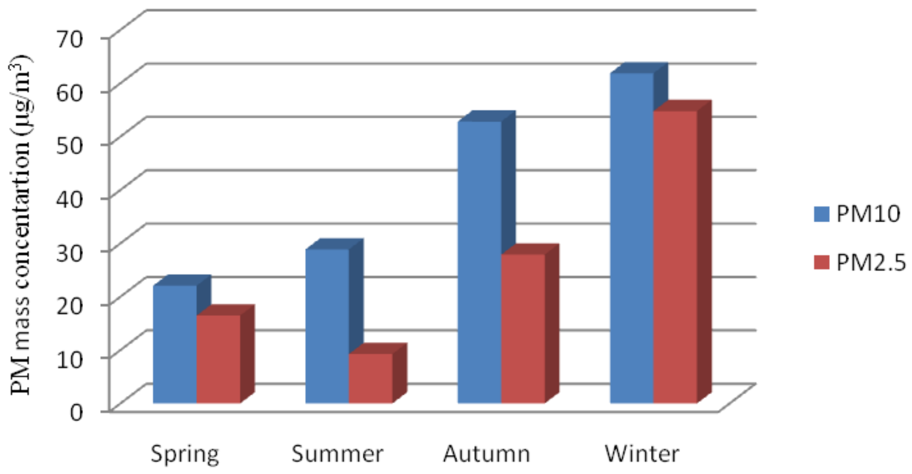


Figure 4, which presents the seasonal average mass concentration of $PM_{2.5}$ and PM_{10} indicates clear variations between seasons concerning air particulate matter pollution in Korça city. The seasons were demarcated as spring (March to May), summer (June to August), fall (September to November) and winter (December to February). Highest average mass concentration of $PM_{2.5}$ and PM_{10} concentration occurred in winter and reached 54.79µg/m^3 and 61.86µg/m^3 respectively. The lowest average mass concentration of $PM_{2.5}$ belongs to summer (9.25µg/m^3), whilst the spring is the season with lowest average mass concentration of PM_{10} (22.05µg/m^3).

Figure 4. *The Seasonal Average Mass Concentrations (μg/m^3) of $PM_{2.5}$ and PM_{10}*



When statistical comparisons were performed using one-way ANOVA test, a significant differentiation results between four seasons, for both, $PM_{2.5}$ and PM_{10} (Table 4).

Table 4. *One-way ANOVA for $PM_{2.5}$ and PM_{10} in Four Seasons*

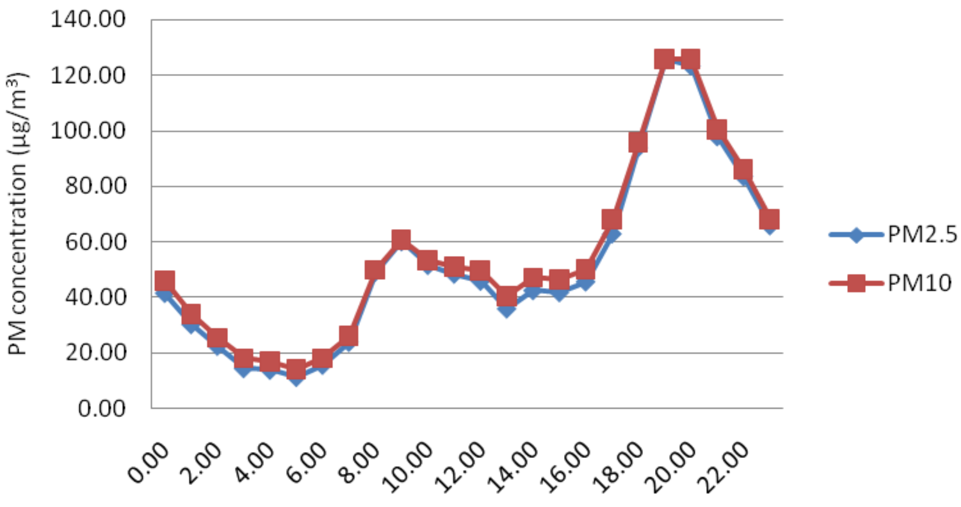
Parameter	$F_{(0.95)}$ -value	Significance level	Degree of freedom
$PM_{2.5}$	65.77	0.000	279
PM_{10}	36.22	0.000	279

If monitoring data are grouped according two periods: the cold period (October- March) and warm period (April-September), the differences in the average values calculated for the $PM_{2.5}$ and PM_{10} are even more noticeable. Distinction between the periods appears not only on the average levels of $PM_{2.5}$ and PM_{10}, but at the same time in the number of the days with concentration of $PM_{2.5}$>25μg/m^3 and of PM_{10}>50 μg/m^3. During the cold period the $PM_{2.5}$ and PM_{10} average concentrations were 42.55μg/m^3 and 53.69μg/m^3 respectively and the percentage of the days with PM mass concentration above daily limit values was 61% for $PM_{2.5}$ and 42% for PM_{10}. These high levels of PM measured in Korça city, as well as the high percentage of days on which limit values were exceeded indicate the constancy of air pollution with this pollutant during cold season. During the warm period the $PM_{2.5}$ average concentration was 10.14μg/m^3 and among monitoring days there was only a day with $PM_{2.5}$ daily concentration above 25μg/m^3. Average concentration of PM_{10} during warm period was 23.9μg/m^3 and the days with mean concentration above 50μg/m^3 constituted only 7% of the monitoring days.

The high concentrations of PM in urban area of Korça during cold season may be explained by extensive use of wood for heating purpose in this city. The meteorological condition, such as wind intensity and direction, temperature inversion and precipitation should have also impacted in high particulate matter content in air. It is well known the contribution of residential emission to ambient air pollution and especially as emitter of carbonaceous aerosols, which are formed by the incomplete combustion of fossil fuel and biomass in cooking and heating devices. The observation performed within international network EMEP (European Monitoring and Evaluation Program) concluded that the most of EMEP sites show a maximum level in black carbon during winter both in $PM_{2.5}$ and PM_{10}, due to high emission from residential heating and stagnant meteorological conditions (Tørseth et al., 2012).

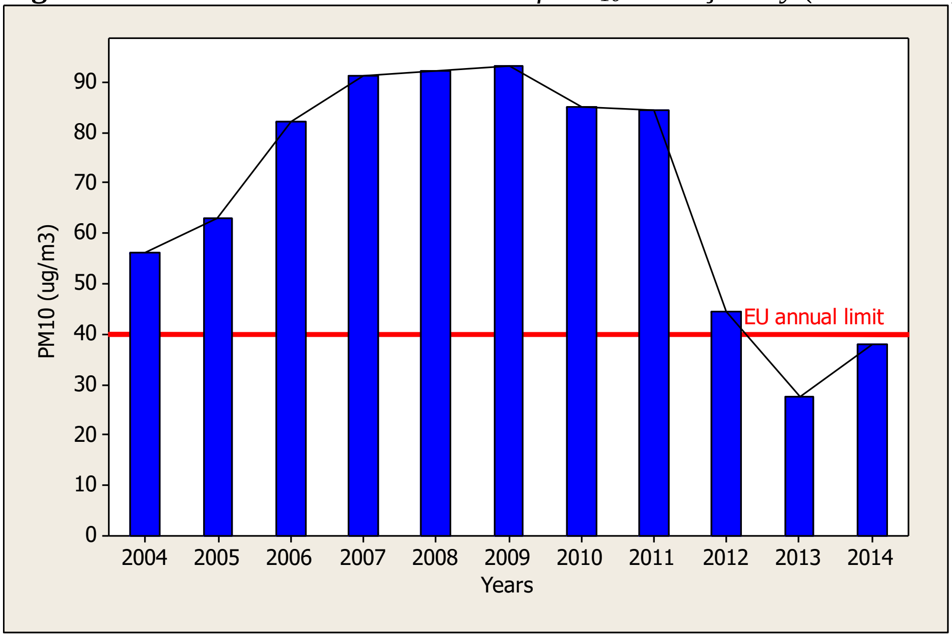
A detailed analysis of 1-hourly concentration levels of PM in air enables to estimate the trends in variation of PM concentrations over the day. During cold days, it is obvious the fluctuation in a wide range of PM levels, with peak concentrations in the hours of evening and with minimum concentrations in the early hours of the morning (Figure 5). This trend can be explained by the fact that, in the evening, due to low temperatures, the heating becomes more intense and, consequently, the emission into the air of the PM from wood burning increases. Another factor that may negatively influence in atmospheric particles pollution could be low height of chimneys from individual dwellings in Korça city, which are generally small buildings of 2-3 floors. Therefore in stagnant meteorological conditions, pollution emitted from these numerous chimneys remains settled around, avoiding long-range dispersion.

Figure 5. *The Hourly Average Mass Concentration of $PM_{2.5}$ and PM_{10} during January*



Available monitoring data allow us to assess the trends in particulate matter air pollution in Korça city over the years. Figure 6 presents the annual means variation of PM_{10} levels for a ten years period, based on officially reported data. As the monitoring of $PM_{2.5}$ has been carried out only the last years, a trend in $PM_{2.5}$ concentration variation along the years cannot be determined.

Figure 6. *Annual Mean Concentrations of PM_{10}in Korça City (2004-2014)*



Between 2004 and 2009 there was an upward trend in PM_{10} levels, while after year 2011 the PM_{10} values were obviously decreased, resulting to the levels that are below EU annual limits values of 40µg/m^3. The period 2007-2011, when higher annual concentration of PM_{10} are observed, corresponds to years of intensive infrastructure rehabilitation working in Korça city. After this period, the improvements in infrastructure have also resulted in a better air quality regarding particulate matter pollution.

Relations between $PM_{2.5}$ and PM_{10}

The correlation between $PM_{2.5}$ and PM_{10} is presented in Figure 7. The correlation coefficient is 0.906, showing a significant covariance between $PM_{2.5}$ and PM_{10}. Good correlation between $PM_{2.5}$ and PM_{10} are demonstrated by different studies at each individual site, indicating that meteorology has a significant role in controlling PM levels and that fine and coarse particles sources might co-vary (Van Dingenen et al., 2004).

The average $PM_{2.5}/PM_{10}$ ratio in urban Korça area during year 2014 was 0.61, ranging from 0.32 in summer to 0.89 in winter (Figure 8). According to literature the ratio of $PM_{2.5}$ to PM_{10} varies from site to site, ranging between 0.5 and 0.9 (Putaud et al., 2010; Tørseth et al., 2012; Van Dingenen et al., 2004). It is worth mentioning that although the PM concentrations in spring compared to winter were decreased by about three time, the ratio $PM_{2.5}/PM_{10}$, continued to be quite high (0.75). These high proportions of $PM_{2.5}$ to PM_{10} demonstrate that in both seasons, fine particles remains the greatest contributor to PM air pollution and suggest that anthropogenic sources, such as wood combustion and traffic, have a major influence on such pollution. In contrast to winter and spring, in summer the ratio is apparently lower, suggesting that during this season the coarse particles are the main fraction of PM_{10} content in urban air of Korça. The coarse particles usually contain earth crust materials and fugitive dust from roads and industry. In this season the wood combustion, as primary source of fine particles pollution is not present, therefore leaving the traffic emission as the main contributor. In autumn, the $PM_{2.5}/PM_{10}$ rate resulted 0.53, showing that $PM_{2.5}$ and coarse particles ($PM_{2.5\text{-}10}$) contribute similar fraction to PM_{10}.

Figure 7. *Correlation between $PM_{2.5}$ and PM_{10} Average Concentrations*

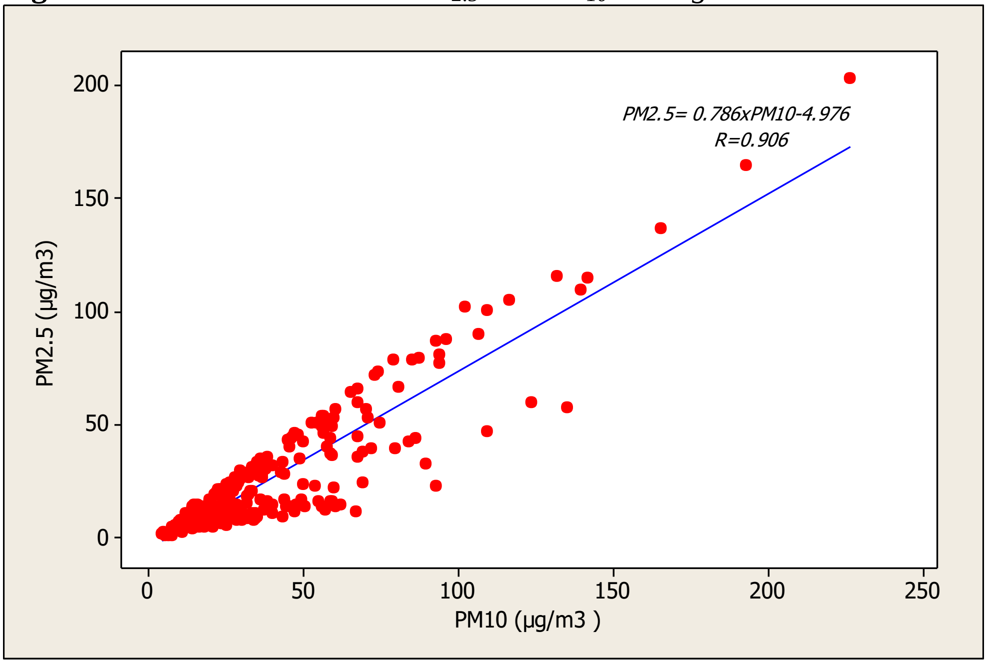
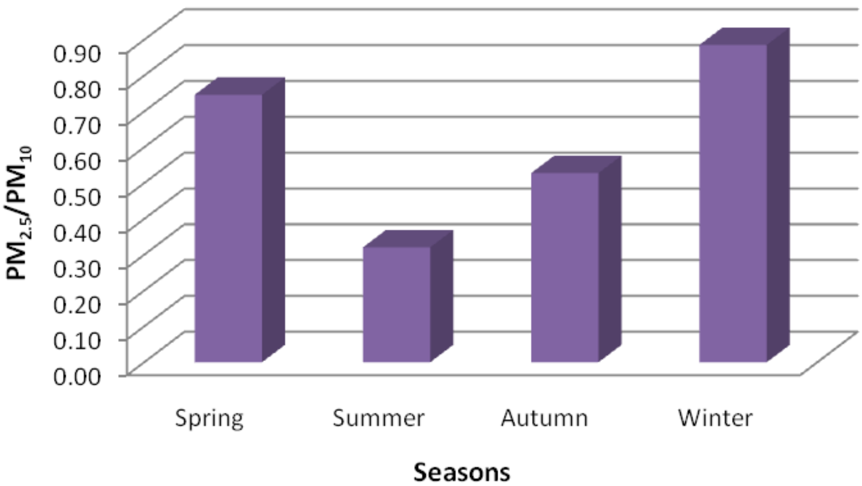


Figure 8. *Seasonal $PM_{2.5}/PM_{10}$ Ratio*



From the data presented and discussed above, it is clear that the pollution of air by particulate matter is a serious problem for the urban air quality in Korça city, mainly in cold months of the year. The high levels of air particulate matter and particularly the great proportion of fine particles originated from residential heating emission, undoubtedly poses a serious threat of the health and life quality of population. According to Naeher et al. (2007) the wood-burning particles should not be considered different from other combustion particles, regarding their health impacts. Exposure to particles from biomass combustion – most notably residential wood combustion – may be associated not only with respiratory, but also with cardiovascular health effects. There is evidence of an association between wood smoke exposure and health effects, including reduced resistance to infections, decreased lung function and asthma (Bølling et al., 2009).

Unfortunately, in Albania there are not relevant and systematic epidemiological studies to show the real air pollution impact on the public health. However, WHO have estimated that, in Albania, the outdoor air pollution causes 200 premature deaths/per year (WHO, 2008). The statistics of Albanian Ministry of Health show a systematic increasing of the hospital diseases due to respiratory and cardiovascular system problems (Totoni et al., 2014). Undoubtedly, $PM_{2.5}$ and PM_{10} air pollution has its own influence in this respect.

Conclusions

The monitoring data of PM mass concentrations in urban air of Korça city during year 2014 shows $PM_{2.5}$ and PM_{10} levels, that vary widely. The annual mean concentration results to be 24.84µg/m^3 for $PM_{2.5}$ and 37.89µg/m^3 for PM_{10}.These values meet the annual limit values set by EU Ambient Air Quality Directive for $PM_{2.5}$ and PM_{10}, but are higher compared to stricter values of WHO AQG guideline. An examination of PM daily mean concentrations highlights that the violations of short-term limit values are considerable both for $PM_{2.5}$ and PM_{10}.

Highest average mass concentration of $PM_{2.5}$ and PM_{10} concentration occurred in winter. The lowest average mass concentration of $PM_{2.5}$ belongs to summer, whilst the spring is the season with lowest average mass concentration of PM_{10}.

The high concentrations of PM in urban area of Korça during cold season may be explained by extensive use of wood for heating purpose in this city. The meteorological condition, such as wind intensity and direction, temperature inversion and precipitation should have also impacted in high particulate matter content in air.

The annual mean ratio of $PM_{2.5}$ /PM10 was 0.61±0.24. During the cold months the average ratio of $PM_{2.5}$ /PM10 resulted 0.89 against 0.32 in the summer season. These high proportions of $PM_{2.5}$ to PM_{10} in cold months demonstrate that fine particles are the greatest contributor to PM air pollution and suggest that wood combustion have a major influence on such pollution. In contrast to winter in summer the ratio is apparently lower, suggesting that during this season the coarse particles are the main fraction of PM_{10} content in urban air of Korça.

Although the measured concentrations of $PM_{2.5}$ and PM_{10} in Korça city during year 2014 were generally within or slightly above Albanian norms, considering the adverse impact that PM has to public health even at low levels, the air quality regarding particulate pollution is far of being healthy. In addition to this idea, we suggest that a review of Albanian standards in accordance with EU Directive on Ambient Air Quality is imperative.

References

AEF. 2008. State of Environment Report, 2005-2007. Agency of Environment and Forestry.

AEF. 2009. State of Environment Report, 2008. Agency of Environment and Forestry.

AEF. 2010. State of Environment Report, 2009. Agency of Environment and Forestry.

AEF. 2011. State of Environment Report, 2010. Agency of Environment and Forestry.

Anderson, G., Krall, J., Peng, R., and Bell, M. 2012. Is the relation between ozone and mortality confounded by chemical components of particulate matter? Analysis of 7 components in 57 US communities. *Am. J. Epidemiol.*176, 726-732.

Bølling, A. K., Pagels, J., Yttri, K., Barregard, L., Sallsten, G., Schwarze, P., and Boman, C. 2009. Health effects of residential wood smoke particles: the importance of combustion conditions and physicochemical particle properties. *Particle Fibre Toxicol*. 6, 29.

Brook, R., Rajagopalan, S., Pope, C., Brook, J., Bhatnagar, A., Diez-Roux, A., Holguin, F., Hong, Y., Luepker, R., Mittleman, M., Peters, A., Siscovick, D., Smith, S., Whitsel, L., and Kaufman, J. D. 2010. Particulate matter air pollution and cardiovascular disease. An update to the scientific statement from the American Heart Association. *Circulation*. 121, 2331-2378.

Brunekreef, B. 1997. Air pollution and life expectancy: is there a relation? *Occupational and environmental medicine,* 54. 781-784.

CoM (Council of Ministers). 2003. Decision of the Council of Ministers No. 803, date 4.12.2003 "On the approval of air quality norms". Official Journal, No. 101. December, 2003.

Damo R. and Icka P. 2014. A comparative study of ambient air quality status in major cities of Albania. *The Annals of Valahia University of Targoviste.* http://bit.ly/2Awzztn [Accessed on May 01, 2017].

Dockery, D. W., Pope, C. A., Xu, X., Spengler, J. D., Ware, J. H., Fay, M. E., Ferris, B. G., and Spizer, F. E. 1993. An association between air pollution and mortality in six US cities. *N Engl J Med*. 329, 1735-1759.

EC (European Commission). 2008. Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe.

ECAT. 2008. *Tirana Air Quality Report*. Environmental Center for Administration and Technology. Tirana.

EEA. 2015. Air Quality in Europe-2015 report. European Environment Agency. Copenhagen.

EEA. 2016. Air Quality in Europe-2016 report. European Environment Agency. Copenhagen.

Franklin, M., Zeka. A., and Schwartz, J. 2007. Association between $PM_{2.5}$ and all-cause and specific-cause mortality in 27 US communities. *J Expo Sci Environ Epidemiol*. 17(3). 279-287.

Fraser, M. P., Yue, Z. W., and Buzcu, B. 2003. Source apportionment of fine particulate matter in Houston, TX, using organic molecular markers. *Atmospheric Environment*. 37, 2117-2123.

Fuzzi, S., Baltensperger, U., Carslaw, S., Decesari, K., Denier van der Gon, H., Facchini, M. C., Fowler, D., Koren, I., Langford, B., Lohmann, U., Nemitz, E., Pandis, S., Riipinen, I., Rudich, Y., Schaap, M., Slowik, J. G., Spracklen, D. V., Vignati, E., Wild, M., Williams, M., and Gilardoet, S. 2015. Particulate matter, air quality and climate: lessons learned and future needs. *Atmos. Chem. Phys*., 15, 8217-8299.

Hoek G., Brunekreef B., Goldbohm S., Fischer P., van den Brandt PA. 2002. Association between mortality and indicators of traffic-related air pollution in the Netherlands: a cohort study. *Lancet*. Vol. 360 (9341), 1203-1209.

Manhan, Stainly E. 2010. Environmental Chemistry, 9th ed. Taylor & Francis Group.

Naeher, L., Brauer, M., Lipsett, M., Zelikoff, J., Simpson, C., Koenig, J., and Smith, K. 2007. Wood smoke health effects: A review. *Inhalation Toxicol*. 19, 67-106.

NEA. 2012. State of Environment Report, 2011. National Environmental Agency.

NEA. 2013. State of Environment Report, 2012. National Environmental Agency.

NEA. 2014. State of Environment Report, 2013. National Environmental Agency.

Pope, C. A., and Dockery, D. W. 2006. Health effects of fine particulate air pollution: Lines that connect. *Air & Waste Manage. Assoc.* 56, 709-742.

Pope, C. A., Thun, M. J., Namboodiri, M. M., Dockery, D.W., Evans, J. S., Speizer, F. E., Heath, J. C. W. 1995. Particulate air pollution as a predictor of mortality in a prospective study of U.S. adults. *Am J Respir Crit Care Med*. 151, 669-674.

Pope C. A., Burnett R. T., Thun M. J., Calle E. E., Krewski D., Ito K., and Thurston G. D. 2002. Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. *JAMA.* 287: 1132-1141.

Putaud, J., Van Dingenen, R., Alastuey, A., Bauer, H., Birmili, W., Cyrys, J., Flentje, H., Fuzzi, S., Gehrig, R., Hansson, H., Harrison, R., Herrmann, H., Hitzenberger, R., Huglin, C., Jones, A., Kasper-Giebl, A., Kiss, G., Kousa, A., Kuhlbusch, T., Loschau, G., Maenhaut, W., Molnar, A., Moreno, T., Pekkanen, J., Perrino, C., Pitz, M., Puxbaum, H., Querol, X., Rodriguez, S., Salma, I., Schwarz, J., Smolik, J., Schneider, J., Spindler, G., ten Brink, H., Tursic, J., Viana, M., Wiedensohler, A., and Raes, F. 2010. A European aerosol phenomenology - 3: Physical and chemical characteristics of particulate matter from 60 rural, urban, and kerbside sites across Europe. *Atmos. Environ. 44*(10), 1308-1320.

Schwartz J, Dockery D. W., Neas L. M. 1996. Is daily mortality associated specifically with fine particles? *J Air Waste Manag Asso*c 46, 927-939.

Tørseth, K., Aas, W., Breivik, K., Fjæraa, A. M., Fiebig, M.,Hjellbrekke, A. G., Lund Myhre, C., Solberg, S., and Yttri, K. E. 2012. Introduction to the European Monitoring and Evaluation Programme (EMEP) and observed atmospheric composition change during 1972-2009. *Atmos. Chem. Phys*. 12, 5447-5481.

Totoni (Lilo), R., and Cullaj, A. 2001. Assessment of Atmospheric pollution from Particulate Matter and Heavy Metals in Urban Environment of Tirana (Albania), *Asian Journal of Chemistry*.Vol 13, No. 1, 78-88.

Totoni (Lilo), R., Prifti, L. and Mulla, E. 2012. Particulate Matter pollution, a continuing problem in Tirana air quality: status and trends. *Asian Journal of Chemistry*. Vol. 24, No.6, 2674-2678.

Totoni (Lilo), R., Prifti, L., Lilo, S. 2014. A comparative study of air quality in two Albanian cities. In *Proceedings of the Medical Geography Symposium "Traditions and modernity in medical geography and disaster medicine"* (Sofia, Bulgaria, 25-26 October 2012). 54-61.

Van Dingenen, R., Raes, F., Putaud, J., Baltensperger, U., Charron, A., Facchini, M., Decesari, S., Fuzzi, S., Gehrig, R., Hansson, H., Harrison, R., Huglin, C., Jones, A., Laj, P., Lorbeer, G., Maenhaut, W., Palmgren, F., Querol, X., Rodriguez, S., Schneider, J., ten Brink, H., Tunved, P., Torseth, K., Wehner, B., Weingartner, E., Wiedensohler, A., and Wahlin, P. 2004. A European aerosol phenomenology-1: physical characteristics of particulate matter at kerbside, urban, rural and background sites in Europe. *Atmos. Environ*. 38, 2561-2577.

WHO. 2006a. Air quality guidelines. Global update 2005. Particulate matter, ozone, nitrogen, dioxide and sulfur dioxide. World Health Organization, Regional Office for Europe, Copenhagen.

WHO. 2006b. Health risks of particulate matter from long-range transboundary air pollution, World Health Organization., Regional Office for Europe, Copenhagen.

WHO. 2008. Country Profiles of Environmental Burden of Disease. World Health Organization. http://bit.ly/2AzMTxc. [Accessed 2017/05/09].

WHO. 2013. Review of evidence on health aspects of air pollution – REVIHAAP Project. Technical Report. World Health Organization, Regional Office for Europe, Copenhagen.