Investigation of the Influence of Meteorological Parameters on PM10 Levels in Antalya Turkey

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Abstract

Antalya is the fifth populated city with a downtown population of over 1 million and is located on Mediterranean coast of southwestern Turkey. Even though main sources of income are agricultural and tourism activities, there is a complaint about air pollution in the downtown area especially in winter. There is only one air quality monitoring station that is operated by Ministry of Environment and Civilization. Data gathered from this station showed that wind direction and wind speed were important parameters for the pollutant dispersion. In addition to that inversion played an important role to control the dispersion of pollutants by isolating some parts of the city from wind.

Key words: Eastern Mediterranean, particulate matter, meteorological parameters

1. Introduction

Antalya is a nested city composed of history, agriculture, tourism and trade. Antalyahas highest population growth rate in Turkey for the last five years and therefore there is a rapid growth of the city.Antalya's rapid growth adversely affects air quality in the city. Especially in the winter evenings between 18:00 and 22:00, elevated particulate matter concentrations are observed. The main reason of this increased PM10 level was speculated as the use of various fossil fuels for heating purposes in houses and in greenhouses. Even some of these fossil fuels were approved by Local Environment Board and inspected by Antalya Metropolitan Municipality, there were some comments made for the convenience of the rest of the fuels used in the city. In this topic, several news were made in written and visual media and air quality in Antalya was emphasized as low [1-3].

In this respect, reasons of high PM concentrations were needed to be investigated in region. In this study, as a startup, the influence of local meteorology on particulate matter pollution in Antalya is discussed.

2. Materials and Method

2.1. Antalya and thesampling site

Downtown Antalya is located on the Mediterranean coast of southwestern Turkey. The location of Antalya and the sampling site is given in Figure 1. Mediterranean coast is located on the south

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of Antalya. High mountains over 3000 m occupy west and northwest Antalya. Mount Mazı divides the downtown into two sub-regions: west Antalya and east Antalya. West Antalya is mainly formed of commercial and residential buildings. There are two important factories in the region: ferrochrome factory and cement factory. Besides, there are three industrial estates located in the area. West, north and east of west Antalya is surrounded by mountains. Therefore, west Antalya is more like a closed box. On the other hand, commercial, agricultural and residential areas dominate in the east Antalya. Airport is the most important stationary source in this region.

Figure 1. Antalya and location of sampling site

The data used in this study is obtained from an air quality monitoring station in Antalya. The monitoring station is operated by Ministry of Environment and Civilization. The sampling site is in the residential district of east Antalya. There are very few commercial houses in the close proximity of the station. Monitoring station is approximately 2 km from Mediterranean Sea coast.

As in all air monitoring stations of Ministry of Environment and Civilization, the PM10 monitoring in the station is carried out with beta gauge samplers with PM10 pre-impactor. In these samplers, air is drawn into the inlet and deflected downwards into the acceleration jet of the pre-impactor unit. The pre-impactor allows the passage ofthe particles with aerodynamic diameter less than 10μm. After passing the inlet, particles are deposited on a glass fibre filter tape. Emitted low level of beta rays from a source passes through the part of the filter tape where particles are being deposited. The increase of particle of particles collected on the tape causes a lower beta-ray measurement in the measuring chamber. A compensation chamber receives an equal portion of the beta-ray and is used as a reference by comparing the sample measurement in the measuring chamber with transmitted radiation through a compensation chamber foil that exhibits the same absorptivity as clean filter tape. As particles collect on the filter, the differential reading changes, and the signal is converted by an onboard computer to PM10 concentrations. By measuring the accumulated mass of particles on the tape and the volumetric flow rate of air through the instrument, the instrument can calculate the mass concentration of particles in the ambient air [4]. The temporal resolution in these devices may be down to seconds to days depending on the operating system. However, in air quality monitoring stations, the Ministry of Environment and Civilization takes hourly samples.

Antalya air quality monitoring station was put into operation in January 2008. In this study,hourly and daily averaged PM10 concentrations in between January 2008 to April 2014 obtained from the web site of Ministry of Environment and Civilization were used [5].

2.2. Meteorological data

Meteorological parameters used in this study were obtained from Turkish State Meteorological Service. The data was obtained from meteorological station located approximately 2.5 km west of the air quality monitoring station. The meteorological parameters discussed in this study include hourly wind speed andwind direction.

3. Results and Discussion

3.1. General characteristics of the data

The yearly average and median values of PM10 concentrations in Antalya together with national European Union PM10 limit values were given in Figure 2. Decreasing trend in the annual PM10 concentrations was observed. The annual PM10 values were well below the national standards. However, theywere above the EU limit values. As indicated in Turkish national air quality guidelines, after 2019, the concentration limits stated in EU directives will be valid in Turkey as well. This figure clearly demonstrates that even though there is an improvement in the PM10 levels in the city, the PM10 concentrations are still needed to be decreased.

Seasonal PM10 concentrations were calculated. In winter (October-March) and in summer (April-September), the median PM10 concentrations were found as 61 $\mu g/m^3$ and 46 $\mu g/m^3$, respectively. Mann-Whitney W test was conducted to compare the medians. The P value was found as 0. Since P value was less than 0.05,there was a statistically significant difference between the medians at the 95.0% confidence level. Thus, winter season PM10 concentration is statistically higher than summer PM10 concentration. Further discussions about reasons of differences in seasonal concentrations will be made in following sections.

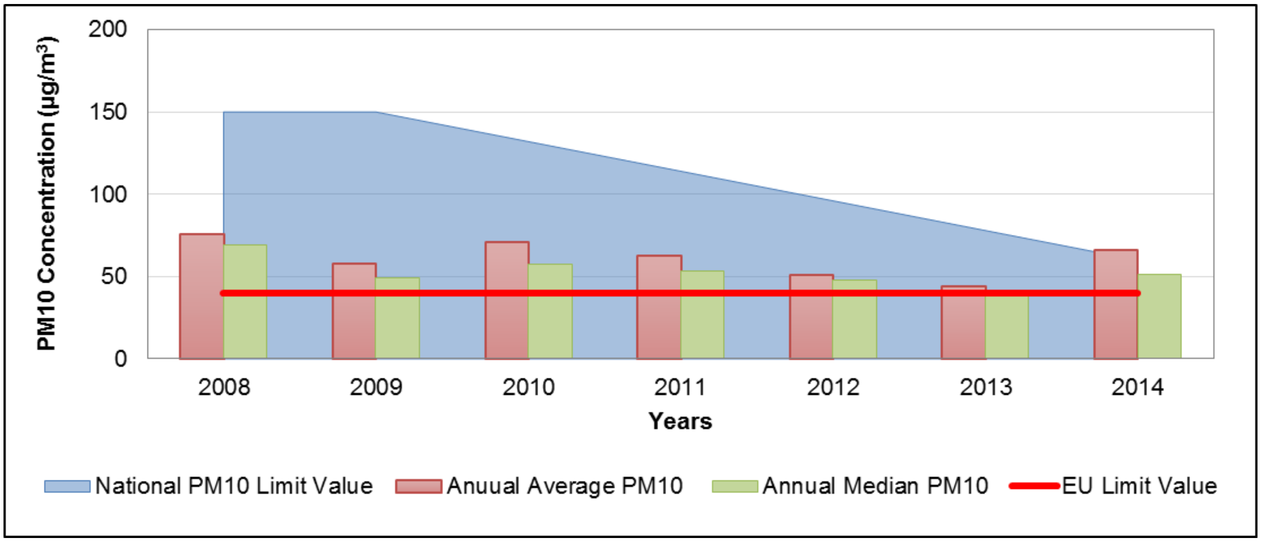

Figure 2. Annual average and median PM10 values in Antalya

The seasonal background concentrations and median values are calculated to see the influence of non-continuous sources. In both seasons, background PM10 concentration of 42 µg/m^3 was found. In winter and in summer, 19 µg/m^3 and 4 µg/m^3 of additional non-continuous sources were determined, respectively. This indicates that approximately one third of the PM10 concentration in winter was due to non-continuous sources. There could be many reasons for this. The most important candidate for this source is fossil fuel combustion for space heating. The other reasons could be meteorological parameters such as variation in wind speed and wind direction, decrease in mixing height or combination of all. 4 µg/m^3 of additional non-continuous source in summer season might be due to long range transport of particulate matter.

Weekday-weekend PM10 concentrations were calculated. On weekdays and weekends, median PM10 concentrations were found as 51 µg/m^{3}and 49 µg/m^3, respectively. Mann-Whitney W test was conducted to compare the medians. The P value was found greater than 0.05. Hence, there was not a statistically significant difference between the medians at the 95.0% confidence level. This was expected as the residents of Antalya mainly work on agriculture and tourism. The emissions from these branches of economic activities do not vary between weekend and weekday.

3.2. Influence of wind direction on diurnal variation of PM10 levels

Winter, summer and yearly diurnal variation ofPM10 concentration were given in Figure 3. As depicted from the figure, PM10 concentrations showed bimodal distribution. This was an expected variation for a typical city. The first increase in the concentration was observed at 9:00 and the second increase was observed at 20:00. This bimodal distribution was due to motor vehicle emissions at rush hours.

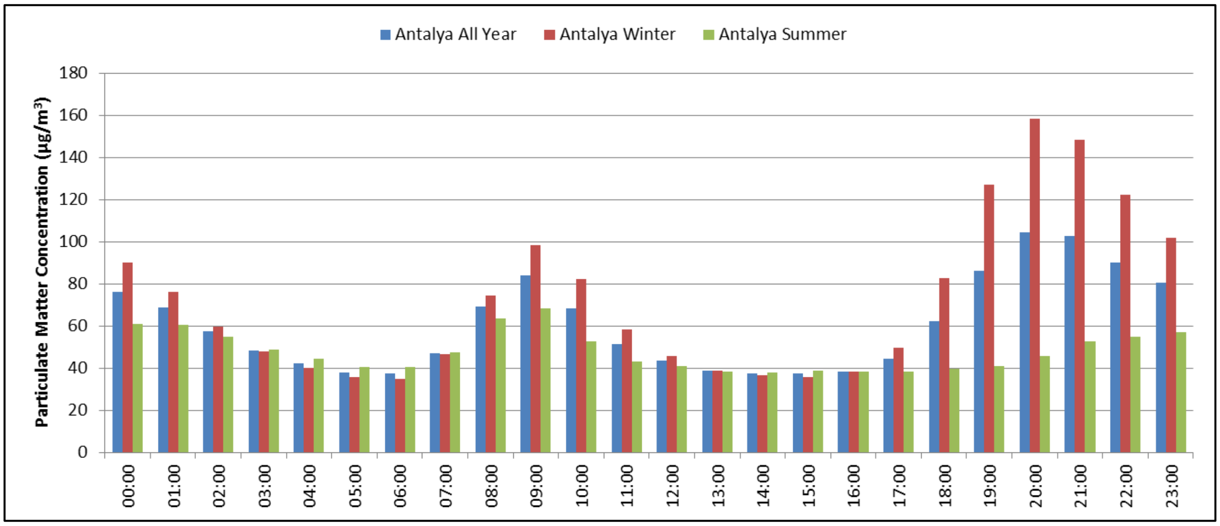

Figure 3. Winter, summer and yearly diurnal variation in PM10 concentrations

Especially during night rush hours, different PM10 variation was observed in winter than in summer. Hourly wind directions were inspected to understand the difference. Hourly wind roses between 18:00 and 21:00 were given in Figure 4. Between 18:00 and 21:00, northern winds dominate in winter. However, in summer, a significant portion of the wind blow southeast in 18:00 and 19:00. As depicted from Figure 1, Mediterranean Sea is located on the southeast of the monitoring station. Hence, this winds both carries clean air to the city and also dilutes the pollutants that were being emitted. This mechanism in the wind pattern decreases the concentration observed at 20:00 and 21:00, even the wind pattern in these two hours were the same.

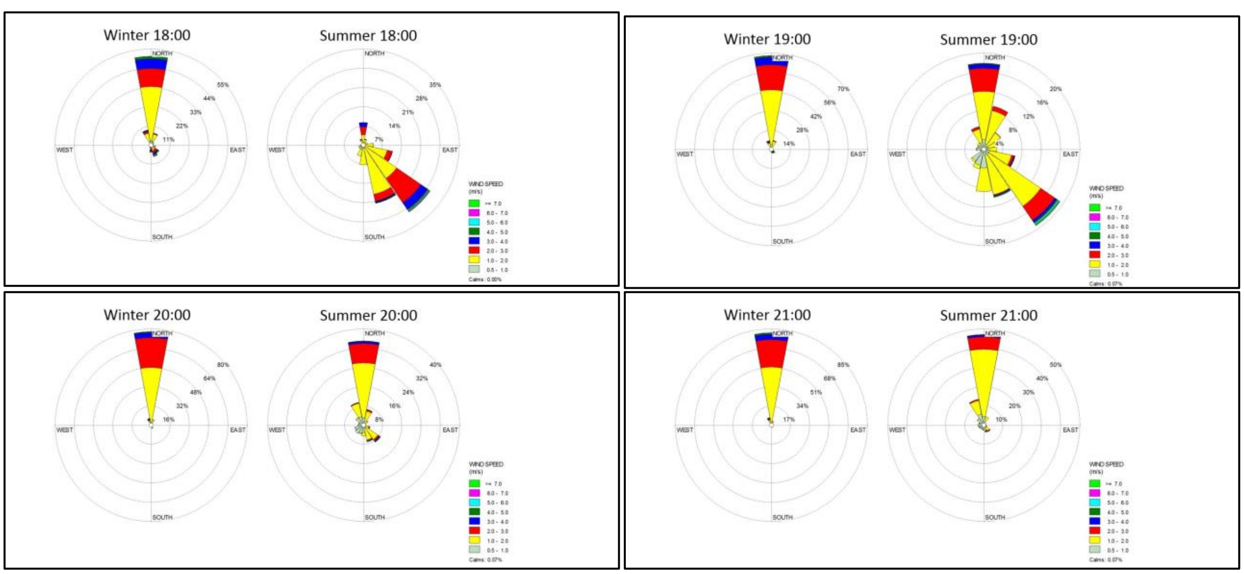

Figure 4. Hourly wind roses between 18:00 and 21:00 in summer and winter

Second key point in this variation is the inversion that decreases mixing height in winter. As the mixing height decreases, it is expected to observe higher concentrations. In winter season, inversion over Antalya is an important parameter on PM10 concentrations.

Thirdly, as stated earlier, in winter fossil fuel combustion for space heating seems to be an important parameter. Higher emissions during winter season yield higher concentrations after 18:00.

3.3. Influence of wind speed on PM10 levels

Wind speed is an important parameter supplying fresh air to the city. As wind speed increases, pollutant levels are expected to decrease. The wind speed vs PM10 concentration graph is given in Figure 5. The relation between PM10 concentration and wind speed consists of two parts. Up to 3 m/s of wind speed, PM10 concentrations do not show any specific variation. However, after wind speed of 3 m/s, PM10 concentrations start to decrease.

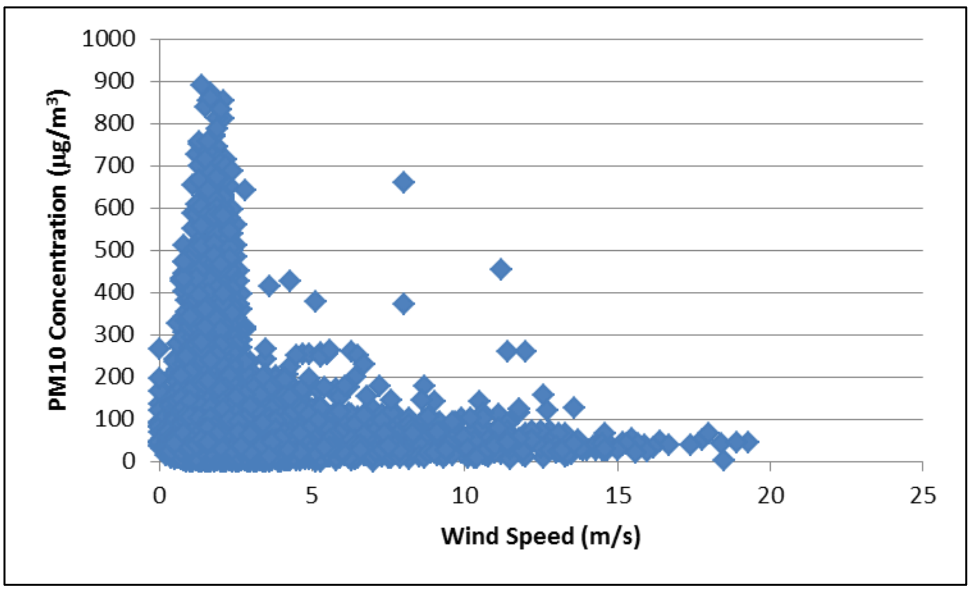

Figure 5. Wind speed vs PM10 concentration in Antalya

4. Conclusions

- PM10 concentration in Antalya is decreasing.
- In winter, 19 µg/m^3 of additional PM10 concentration was observed. This could be because of inversion, fossil fuel combustion and wind direction variation.
- Variation of wind direction, especially between 18:00 and 20:00, plays an important role in winter PM10 concentrations.
- Wind speed with a speed less than 3 m/s does not have a specific influence in PM10 concentration in Antalya.

Acknowledgements

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