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Research Paper

Modelling of Particle Matter Pollution in 2021 Autumn in Kosovo Region of Konya province, Turkey

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Abstract: Urban growth and energy consumption are directly related to air pollution; the growth in the number of vehicles and traffic on the avenues is the main cause of air deterioration. Energy consumption has a negative impact on the air, mainly in winter, where heaters are used more intensely. Likewise, air pollution can travel to places where there are no polluting sources. This global character has brought to the discussion the creation of global policies to combat pollution and find those who are responsible for its remediation. Particulate matter is part of the atmospheric pollutants and receives special attention due to its physical and chemical characteristics; they are liquid or solid, organic, or inorganic compounds that can have different shapes and be suspended in the air or not depending on their mass. From a medical point of view, particulate matter can cause health problems, primarily affecting the respiratory and circulatory systems. The objective of this study was to determine the level of pollution and distribution of particulate matter generated by vehicles and heating systems in the Selçuklu district of the city of Konya city. In the analysis PM concentration was performed at 11 temporary monitoring stations. Measurements were taken 5 times a day in 2 winter and summer periods of the year during the October month. The measurement data was modelled using Surf to generate maps of the distribution of particulate matter in the evaluation months. The results of the study show that the levels of particulate matter vary during the day. A high concentration is observed at 6 am and at 5 pm. Levels are reduced during that morning and afternoon interval. This phenomenon occurs due to the high circulation of vehicles. At a seasonal level, during the winter higher levels of concentration of particulate matter are recorded. The points with the highest level of concentration are in the east of the study area. In general, according to the air quality index, the air quality of the study area does not represent any risk to people's health. In the study it is recommended to carry out a scope to determine the nature of the PM pollution and their sources of origin.

Keywords: *Air quality, Surfer mapping, modelling, Particulate matter, health,*

Introduction

Industrialization, urbanization, population growth and accelerating energy consumption indirectly affect the level of atmospheric pollution. Air pollution: It can be defined as the deterioration of the chemical, physical or biological composition of the air we breathe. It occurs with the change of natural values when unwanted substances (pollutants) enter at levels that the environment cannot tolerate (Ezzati et al., 2004; Russell, 1974; Sarla, 2020). Air pollution is a phenomenon associated with the activities of today's societies. However, research shows that non-industrial agricultural activities contribute to air pollution in developing countries. Although the biggest source of pollution comes from human activities, another important source of pollution comes from natural ways. Volcano eruptions, decomposition of organic matter, transport of particulate matter with air currents, forest fires are some types of natural pollution (European Commission, 2010; Russell, 1974). This occurs in the lower atmosphere and is considered an environmental impact with a half-life of less than one day or more than one year. Affects locally, regionally, and globally at the geographical level; therefore, it is accepted as a public health problem and determinant of health (Buonanno & Hänninen, 2018; Seigneur, 2019).

Air pollutants are unwanted substances in solid, liquid, or gaseous form that are thought to cause illness in humans. Pollutant materials have several different physical or chemical properties changing on their ability to make toxic effects. Air pollutants can be emitted directly into the atmosphere or created in the atmosphere through chemical reactions (hydrolysis, oxidation or photochemical reactions) or physical (conversions from gas to particles). Accordingly, they are divided into two groups as primary

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and secondary (Rosenson et al., 1991; Seigneur, 2019; U.S. DHHS, 2021). The World Health Organization (WHO) has identified 6 main air pollutants harmful to health: PM, tropospheric ozone, sulphur dioxide, nitrogen dioxide, carbon monoxide and lead (Manisalidis *et al*., 2020). According to World Health Organisation attributed about 7 million people death to the impact of PM (outdoor and indoor) (WHO, 2014).

Particulate matter is an atmospheric pollutant of natural or anthropogenic origin, which can be in liquid or solid form, organic and inorganic, and of primary origin (combustion of fossil fuels) or secondary origin formed by reaction with other substances in air (Manisalidis *et al*., 2020; D'Amato et al., 2010; Yeşilyurt & Akcan, 2001). Particulate matter may diffuse directly into the atmosphere or may consist of precursors such as SOx, NOx, NH_3 and volatile compounds in the atmosphere (Kaya & Öztürk, 2013). Particulate matter does not have a specific chemical structure. They may consist of a mixture of organic and inorganic substances with variable physical and chemical composition due to their origin (Abulude, 2016; Daellenbach *et al*., 2020). Climate change and air pollution have environmental problems that make the same denominator with human activities. Climate change is the effect of air pollution produced by changing the composition and chemical concentration of gases in the atmosphere. However, these two problems affect the environment at different temporal and spatial scales. While air pollution is a problem that can manifest itself in a certain period and in a certain area, climate change is a global and long-term problem that affects all lifestyles in the worldwide (Manisalidis, *et al*., 2020).

Air pollution causes a decrease in air quality in the short term. Second, it is a concept related to human exposure to a polluted environment. Due to the growing concern about the health problems caused by air pollution, governments and non-governmental organizations have started to emphasize the need to improve air quality through public policies. Air quality is a concept that assumes that humans are the most important part of the environment and therefore the receiver of pollution (Ott, 1982). Similarly, air quality is assessed through indicators (air pollutants) whose half-life in the atmosphere is long enough (more than a week) to directly affect the receiver or be transported elsewhere (Akimoto, 2007; Griggs & Noguer, 2002).

The Air Quality Index (IQA) was prepared by the Environmental Protection Agency during 1971 (EPA, 2022). The index considers 5 pollutants: carbon monoxide, particulate matter (PM_{10}), sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and tropospheric ozone (O_3). This index is a number representing the level of contamination based on the hazard level for human exposure. The index was developed to provide a decision-making tool for creating plans focused on reducing air pollution (Suman, 2019; Buonanno & Hänninen, 2018). IQA has succeeded in achieving some targets set by Environmental Protection Agencies and Ministries of Environment in some countries. These targets relate to limiting climate change; It reduces the risk of toxic pollutants and protects the ozone layer from degradation. Some studies show that although visible air pollution has decreased, there are still health risks due to low pollutant concentrations (invisible pollution). This is because indices such as IQA use high tolerance thresholds in the form of numerical values that categorize air pollution as good or bad (Domingo et al., 2021; European Commission, 2010; Suman, 2019). Some air quality studies have been conducted using databases of monitoring stations away from the exposure area. The reason for this is the economic difficulty of having monitoring stations at different points (Dursun & Aguilera, 2022; Ott, 1982).

Particulate matter (PM_{10} and $PM_{2.5}$) concentrations were monitored during autumn period, for determining the air pollution level in the Kosovo region of Konya city. The information was analysed through a standard pollutant indicator (Standard Contaminant Index). The obtained data were used in cartographic modelling to determine its distribution in the district and to evaluate people's exposure levels. The study was carried out using Kriging model method in Surfer programming to determine the air quality of Konya province. These analyses provide elaboration of scenarios for pollution distribution trends and source identification. The PM10 pollutant database of the monitoring stations determined for pollution analysis in Konya was used. The analysed information corresponds to the autumn months of 2021.

MATERIALS AND METHOD.

Research Area

The study area is in Konya, Selçuklu Municipality, Kosova District. The neighborhood has an area of 756.39 hectares. The location coordinates are X = 457944.68 and Y = 4202719.58 WGS 1984 UTM

Zone 36N (Fig. 1). The district is 12 kilometres away from Konya city center (Figure 1). Its average height above sea level is 1,016 m (Ministry of Environment & Urbanization, 2020). Kosovo District is bordered by Bosnia-Herzegovina region and Academy districts in the north in the east, Sancak District in the south, Beyhekim and Yazır Districts in the west and finally Büyükkayacık District in the east. According to the data of Selçuklu Municipality, approximately 31,900 people live in the Kosovo district (Selçuklu Municipality, 2016).

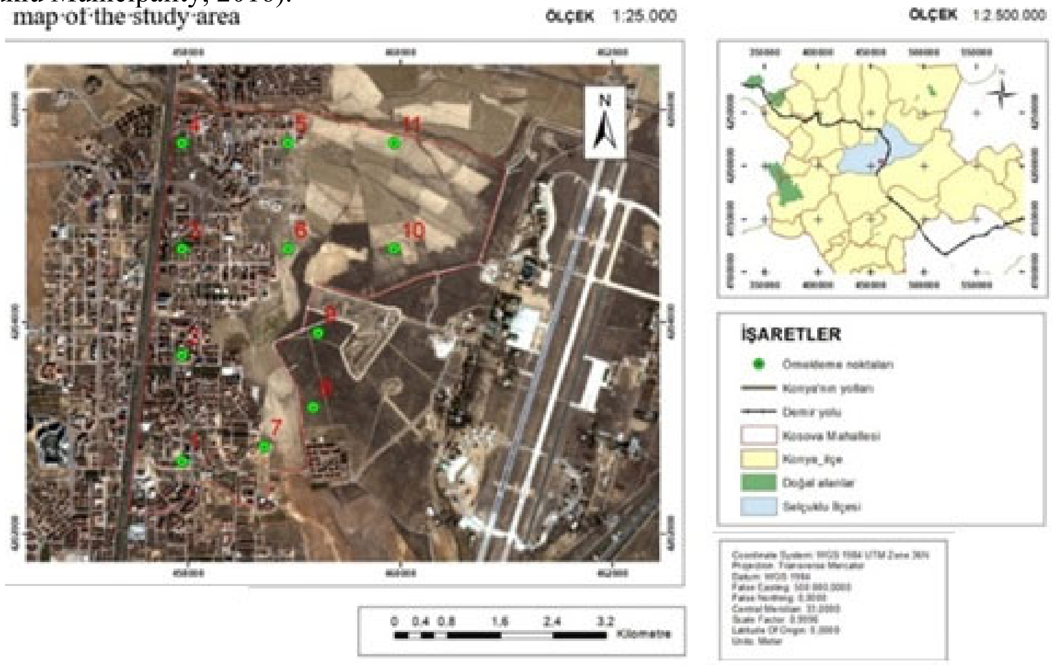


Figure 1 Location map of the study area including sapling points.

The research area has a continental climate with low precipitation levels ranging from 280 to 350 mm annually. The average daily temperature in the region is about 11ºC. The dominant wind direction is from north-northwest, and the annual wind speed is about 2 ms^{-1}. The research area is in a wide plateau surrounded by 2 high mountains ranges in the north and west (Ministry of Environment & Urbanization, 2020; Çiftçi *et al*., 2013; Topak & Acar, 2006).

Materials

Particle Counter PCE-PCO-1 equipment was used for the air quality measurement sampling. This equipment has a laser automatic particle counter feature, that enables the measuring of particle dimensions from 0.1 to 10 µm in size. The device has a sensor that measures the temperature, relative humidity, and dew point of the air. Using Surfer 11 software, the distribution from the pollutant sampling point was modelled using the Kriging spatial interpolation method and the distribution density map was created. This tool will be used in thematic cartography, such as detailing PM concentration maps at 11 sampling points in the Kosovo region.

Air Quality Measurement

Considering the dimension of this study area, were 11 temporary sampling points determined. The sampling stations were taken as homogeneous as possible and completely representing the settlements within the study area. In October 2021, PM 10 µm and 2.5 µm dimensions measurements were made to determine the air quality in 5-time intervals in 4 different days, as Thursday-Friday weekdays and Saturday-Sunday weekends at each of the sampling stations, including weekdays and weekends. Measurements times were performed at 06:00, 09:00, 12:00, 17:00 and 23:00 on the all-sampling days.

Methods Used in Data Modelling

Each data set was arranging with the measurements results made in the research area. Every dataset was subjected to an exploratory dimension and structural data analysis to evaluate and observe the behaviour of all data. This initial analysis allows to identify correlation, identify outliers, and analyse trends in data (Jumaah *et al*., 2019; Shukla *et al*., 2020). For the modelling was the Kriging spatial interpolation method used to model the concentration data of PM_{10} and $PM_{2,5}$. This method provides estimation of values from observed samples using weighted averages (Kumar et al., 2016). Equations of of method were given by [1 and 2].

$$Z^{*}(x) - m(x) = \sum_{i=1}^{n(u)} \lambda_i [Z(x_i) - m(x_i)] \qquad [1]$$

λi= are the weights assigned to the *Z (Xi)* data*; Z*(x)* is predictive*; Z(Xi)* is the value at the observation point*; XiM(x)* is the expected value or mean of the estimator*; m(Xi)* is the expected value or average of the observed data*; n* is the number of observations

$$I_p = \frac{I_{Hi} - I_{Lo}}{BP_{Hi} - BP_{Lo}} \left(C_p - BP_{Lo}\right) + I_{Lo} \qquad [2]$$

C_p (average pollutant P concentration by standards); BP_{Hi} and BP_{Lo} are the upper and lower breakpoints of C_p, respectively; I_{Hi} and I_{Lo} = AQI values of BP_{Hi} and BP_{Lo}

Characterization of the Study Area

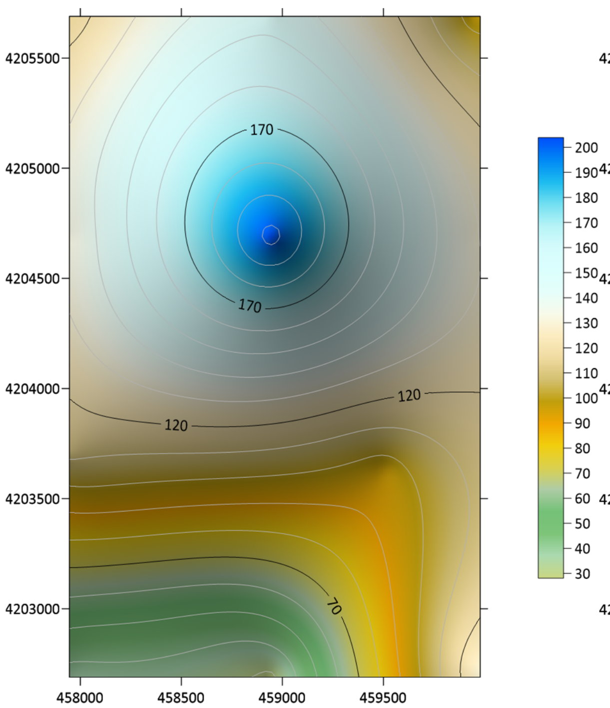
Soil particles on the surface exposure to the active wind can become suspended, increasing the particle matter levels in the ambient air (Buschiazzo *et al*., 1983). Since Konya has an arid-semi-arid climate ecosystem has limited agricultural development, it is inclined to wind erosion (Ministry of Environment & Urbanization, 2020). The eastern part of the study area is covered with an open area without vegetation extending to the airport (Figure 2). Much of the land is used for growing corn. However, there are areas where the land has been converted into construction. It shows that the green areas in the region show a high level of vegetation, but some areas are scattered and have low vitality. Much of the area has bare soil and dead vegetation. There is an industrial zone in the north-east of the region. Kosovo neighbourhood is developing rapidly, and constructions are continuing. Construction areas in the region are separated from plant areas and separated from areas covered with vegetation. Since the measurement point is around the settlements, the emissions of vehicles used in traffic along with fossil fuels used for heating increase during the rash hour periods.

Figure 2. Sampling points in the study area and the area used in the modelling.

Results

The following prediction maps were obtained by interpolating the particulate matter concentration variables (PM10 and PM2.5) with the Kriging method, considering data trends and their fit to the model with the global function. Figure 3 shows the distribution map of PM_{10}. 5 different hourly values from each point on Thursday-Friday were obtained by analysing the Periodic average value. In Figure 4, the average of PM_{10} values obtained from 11 measurement stations at 5 different time intervals on weekends (Saturday and Sunday) corresponds to the different sampling averages evaluated. It is seen that PM_{10} concentrations are separated by contour lines obtained from the modelling. While the highest values were observed in the central northern region of the weekday map (around the sampling point 6), lower concentrations were observed in the south/southwest part of the region. Weekend PM_{10} values are higher than during the week, reaching the highest value in the North-West corner compared to the central areas. The south bay is seen with a lower concentration like weekdays in the region. When the hours measured in October 2021 are examined, higher concentrations are observed during the hours when the activities increase, while lower concentrations are observed in some hours.

Figure 5 includes the map of $PM_{2.5}$ concentration distribution on weekdays in October. Figure 5 is the distribution modelling of $PM_{2.5}$ versus the result of the average of the measurements at 5 different sampling hours from Thursday to Friday. Like PM10 weekday values, the highest value is observed in the northern part of the study area (around sampling point 6). The densities decrease from south to east and the lowest value is in the southwestern part of the map, the densities show lower values towards the center and west of the map. PM10 was nearly 10 times higher when compared to weekday values. Figure 6 presents the modelling map of PM2.5 measurement values at 5 different sampling times from 11 measurement points on the weekend of October (Saturday-Sunday). It is seen that the highest concentration for $PM_{2.5}$ weekend values is in the south-west of the study area (around sampling point 9). The high value here is inconsistent with other measurement parameters and concentrations. $PM_{2.5}$ Weekend values were approximately 10 times higher than PM_{10} weekend values, just like weekday values. Weekend $PM_{2.5}$ concentrations are relatively higher than weekdays. In addition, values can be investigated that both $PM_{2.5}$ and PM_{10} pollution concentration maps have shown a real correlation in measured concentration record where both of PM_{10} and $PM_{2.5}$ values are high.



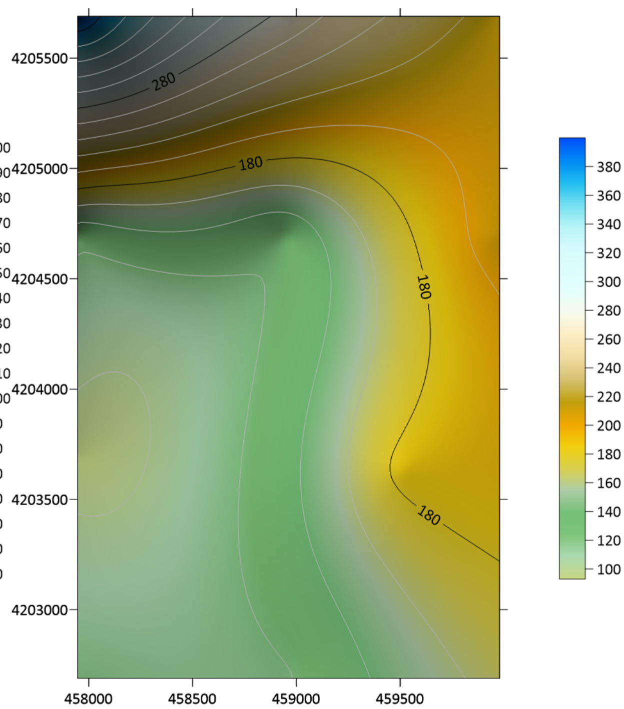


Figure 3 Map of PM10 concentrations weekday **Figure 4** Map of PM10 concentrations weekend

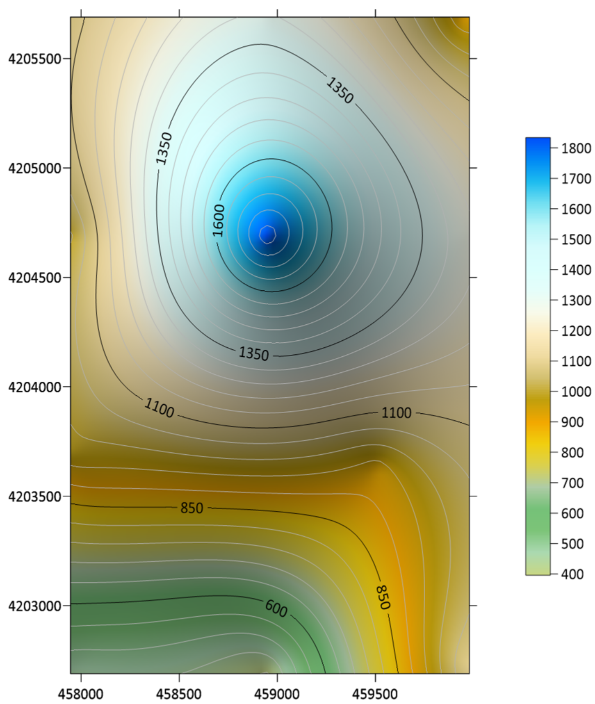


Figure 5. Map of PM2.5 concentrations weekday

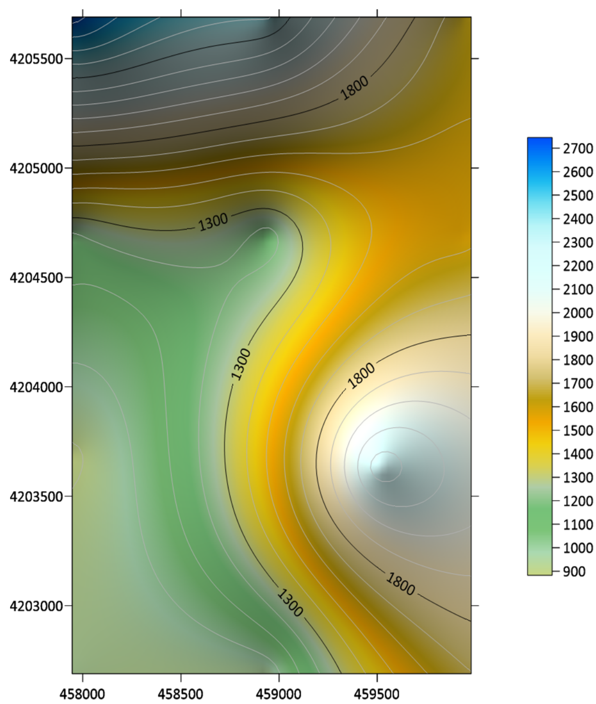


Figure 6. Map of PM2.5 concentrations weekend

Conclusion

Particulate matter concentrations for the Kosovo region of Konya city vary spatially and temporally. The temperature and wind speed effects affect the suspended particulate matter concentration in the ambient air. For the affecting air quality, another factor is new constructions, cultivated areas, wasteland, poor quality fuel using for the heating system in winter and the presence of vehicle traffic. Even if there is no change in emission sources and amounts, sometimes meteorological conditions cause regional pollution to peak. Figure 2 shows that the eastern part of the study area is characterized by unplanted soils as well as an area where new apartments and houses are built. The research area covered with poor vegetation, there is a park place, garden and having ornamental areas of the city affiliated to the Selçuklu Municipality.

The results from modelling current measurements confirmed that the research area where the bad air quality was measured the areas poor vegetation. Figures 3 and 5 have shown the research areas with the higher PM concentration. As the eastern part of the Kosovo region is in the process of urbanization and new home construction, this region saw the highest PM10 and PM2.5 values especially in October. Green areas show lower concentration levels, but this does not mean that the air quality in these areas is good enough. Similarly, PM concentrations increase further in winter, mainly due to weather conditions. The station with a high PM10 rating has high atmospheric pressures and low wind speed levels that prevent pollution from dispersing easily.

The air quality in the district of Selçuklu, Kosovo varies according to the hours during the day. Due to the denser vehicle traffic, PM concentration values were found to be higher in the morning hours and towards the evening hours. Even if the results obtained are not dangerous for human health, long-term interactions may have negative effects or may be effective on people with some respiratory problems. Better air quality values were obtained at noon, indicating that the activities in this region are less at these times. Air quality should be monitored seasonally in the research areas. Since it is observed that there is a significant inverse relationship between the air temperature and the PM concentrations between the seasons, the best air quality is obtained in the summer months. Autumn season medium category air quality has stability with a higher frequency. There is an increasing deterioration in air quality during the winter season. This variability is close to the standards in the light of important findings from a meaningful perspective. It can be said that the average air quality in the Kosovo region is of medium quality. It can be said that the current conditions will not pose any health risks. Daily average PM10 concentrations are close to the permissible limits. According to these results, only January 2022 concentration values were found in the allowable range, except for one day.

Suggestions

To reduce air pollution in areas where people breathe, it is necessary to have stations where air pollution measurements are made and to increase their number. Although it is expensive to have automatic measuring stations, in some regions it may be preferred to measure air pollutant concentrations with classical passive or active methods. Therefore, it should be supported by laboratory studies to determine the emission sources and types in more detail. In this study, it will be beneficial to consider the reasons that affect the $PM_{2.5}$ and PM_{10} concentration in the district of Selçuklu, the use of poor-quality fuel as an energy source, the exhaust emissions of the vehicles in traffic, the weather conditions, and the improvement of the vacant land areas in terms of vegetation. The existence of vacant land in the region has been determined. However, the pollution values originating from the industrial establishments close to the researched neighbourhood should also be considered. For this reason, it will be necessary to conduct chemical analyses to determine the PM composition. It is necessary to include researchers on the subject in the decision-making processes on air pollution. It is recommended that district municipalities, especially Konya metropolitan municipality, encourage their students to create databases and thesis projects on environment. The results obtained will provide knowledge for future studies.

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