IJEPEM

International Journal of Environmental Pollution and Environmental Modelling,
Vol. 6(3):149-159 (2023)
(Original Paper)

Measuring and Modelling of PM Level in Winter Season in Hacikaymak Region, Konya (Türkiye)

Sukru Dursun[1*], Mehmet Buğrahan Çelik[2]

[1] Konya Technical University, Environmental engineering Department, Konya, Turkey
[2] Konya Technical University, Environmental engineering Department, Konya, Turkey

E-mail: *sdursun@ktun.edu.tr, mhmtbugrahan@hotmail.com*

Received 20.10.2023; Accepted 25.11.2023

Abstract: The province of Konya is Turkey's largest province in terms of surface area and is one of the first five provinces in terms of population. The fact that a large part of the surface area consists of flat areas provides convenience in creating infrastructure. With this feature, it is one of the provinces that are suitable for immigration. The middle-income level of the population causes the use of low quality fossil fuels for heating needs in the cold winter months in the residences in the settlements. Depending on the traditional food culture, the use of wood is common in some ovens. This stop is an important source of atmospheric particulate matter concentration in all seasons. This feature has therefore led to the development of flue gas control mechanisms for such enterprises. Konya residential areas and the location of the industry cause the prevailing winds to carry industrial pollutants to the city center. In the Hacıkaymak region, which was chosen as the study area, chimney pollution of fuels originating from domestic heating is important as a source of air pollution, as well as pollutants from traffic and industrial areas. The particulate matter samples taken in winter and the modelling study made by using them showed that the pollution is high from time to time, and it is important in determining the locations of the pollutant sources in the pollution dimension. In the densely populated residential area, increases in PM pollution were observed at some measurement points with the effect of meteorological factors. The fact that this situation is important for human health shows that precautions should be taken.
Keywords: Konya, Hacıkaymak district, air pollution, particulate matter, human health

INTRODUCTION

With industrialization and industrial development, the development of cities and the increase in population, and because of unplanned urbanization, environmental pollution problems have started to gain importance. In Turkey, air pollution has reached episodical dimensions, especially due to the excessive use of cheap and low-calorie, low-quality coals with high sulphur content for heating energy, the rapid increase in the number of motor vehicles in traffic, and sometimes the effect of adverse meteorological conditions. In addition, because of the production, decomposition, evaporation and similar processes of the chemical substance, many toxic substances and suspended solid particles such as soot, dust, smoke, and trace carcinogen elements in them cause air pollution events in the atmospheric environment. Air pollution is one of the most important problems brought by modern life, and its main source is the consumption of fossil fuels for various purposes. 30% of the world's energy is obtained from hydraulic, the remaining 70% is obtained by burning coal, oil, gas or their synthetic derivatives. Many are the causes of air pollution, although different factors play a role (Dursun & Alqaysi, 2016) Dursun & Qasim, 2022a).

Industry and the environment, which is one of the main sectors of development, have a very close relationship in a multifaceted and impressive way, and if measures are not taken in terms of environmental protection and appropriate technologies are not used, it has negative consequences on the environment and on the society. Environmental problems have many negative effects, gradually causing the destruction of resources and the rapid pollution of the environment. One of them is located in the city center of Konya and the others are 20 km from the city center. There are Organized Industrial Zones located in the North-North East direction, which is the dominant wind direction of the city. The contribution of the Konya Sugar Factory, which is located in the city center and consumes a significant portion of the fuel consumed in the city center, to air pollution is important. Some industrial

Corresponding E-mail: sdursun@ktun.edu.tr (ORCID: https://orcid.org/0000-0001-9502-1178)

establishments have systems that run their incineration plants with solid fuel (Dursun & Aguilera, 2022). As in many of the big cities, the main cause of air pollution in Konya city center during winter months is the fuels consumed for heating, approximately 90% of the sulphur dioxide comes from this source, 10% of it comes from industry and traffic. In Particulate Matter, 20% of non-fuel sources. share is accepted. It is thought that the main causes of air pollution caused by heating are the use of low-quality fuels in heating without being subjected to the improvement process, the application of wrong combustion techniques and the lack of regular maintenance of the used combustion systems. For this reason, there has been an increase in PM, which causes air pollution (Dursun & Qasim, 2022b).

Air pollution is the situation in which the pollutants that can be found in the atmosphere in the form of gas, particles, water vapor and odour reach levels that will harm primarily human health, living things and the environment (Garipağaoğlu, 2015). Which of the pollutants can be harmful at what concentration is determined by international organizations and also by various countries with "air pollution standards". In Turkey, regulations developed at various times regarding the protection of air quality have been put into practice. While the KVS (24 hours) particulate matter (PM10) limit value valid in 2008 and before was 300 μg/m3, it decreased to 50 μg/m3 in 2019. The UVS (annual) value is 40 μg/m3 from 150 μg/m3 (https://cygm.csb.gov.tr/yonetmelikler). Pollutant values of cities in Turkey have been improved with “Limit Values and European Union-Turkey Limit Values in Air Quality Assessment and Management Regulation dated 06.06.2008 and numbered 26898”. The pollutant values of the cities in Turkey were compared with the "Limit Values in the Air Quality Assessment and Management Regulation dated 06.06.2008 and numbered 26898 and the European Union-Turkey Limit Values".

The environmental impact of air pollution is highly variable, and pollutants in both gaseous and particulate form from atmospheric pollutants harm primarily human health, plants, animals, climate and inanimate environment (İnecik, 1994; Kırmızıhan, 2006). Particles and gaseous pollutants can have very negative effects on human health. Especially many respiratory diseases are the result of air pollution (Erinç, 1984). Particulate pollutants are very different in origin and size (PM10 and PM2.5) and are the most dangerous fraction of aerosols. Suspended particulate matter is a term used for solids and liquids released into the environment from various natural and artificial sources. Particulate matter, in terms of quality and quantity; It varies widely depending on particle size, density, chemical composition and potential for health effects (Ertürk, 2002; Evyapan, 2008; Öztürk, 2007). Particulate matter concentrations have significant variability in terms of spatial distribution according to the diversity in the sizes and types of sources. It has been determined that the particles cause harm to human health by accumulating in the regions of the lungs where the air bags are located. Current findings suggest that particulate matter also affects the brain and nervous system (Chew et al., 2020), increasing the risk of obesity and metabolic syndrome (Wei, et al., 2016). In plants, it accumulates on the leaves and negatively affects the rate of photosynthesis (Rai, 2016). Apart from the negative effects of particulate matter pollution on living things, it also has the effect of changing the structure of the soil in the ecosystem by precipitation. In addition, it accumulates on solar energy systems, reducing energy production efficiency (Sarver et al., 2013; Zeydan, 2019).

The aim of this study is to determine the variation of particulate matter concentration in a region located in Konya city center at different times of the day on weekdays and weekends, and to estimate the source of pollution by drawing pollution distribution maps in the region based on these change values. At the same time, it is to obtain information about the relationship between pollution and meteorological factors and the type of pollutant.

MATERIALS AND METHODS

The variation of air pollutant concentrations in cities between regions and different time period have been observed. This variation depends on the characteristics of the investigate regions, time period and meteorological variastion. This study was initiated for the measurement of emission inventory based on open air areas in the Hacıkaymak region of Selcuklu district of Konya city. The circumference of this chosen region is 6301 m from sea level, and investigated area is 2.25 km² (Fig. 1). During the sampling thirteen different locations were selected for measurement points for PM concentration. These locations were chosen with due consideration to the spread and sources of existing air pollution. It was decided that the most suitable regions for data analysis to producing pollution maps of study area.

The measurement methods of dust and particles in the air vary according to the volume of the particles and the desired results in the study. The "particle counter PCE-PCO1" is a laser particle counter and dust measuring device configured to determine the concentration of airborne particles by means of electronic recording (Fig. 2).

Figure 1. Hacıkaymak region Konya, Selcuk district and determined study area measurement points

Figure 2. Particulate matter measuring device "Particle Counter PCE-PCO1"

Measurements were performed during December month in winter season. During this month, particulate matter measurement data were collected by making weekday and weekend measurements, daily measurements, day and night measurements and hourly measurements (08:00, 12:00, 15:00, 18:00, 22:00 in each day).

Surfer 19 software, produced by Golden software company, consists of a 3D graphics system. It is used for gridding scattered data recorded in different environments, creating contour maps, and obtaining 3D images. Articles prepared in accordance with the principles of writing and approved by the review board are published. After taking the coordinates of the measurement points, the data collected at the end of each season were listed in the Excel program as daily, weekly, and hourly averages. In addition to the X and Y coordinates, the Z coordinate also represents the measured PM_{10} or $PM_{2.5}$. A worksheet was created by transferring the X,Y,Z coordinates to the Surfer-16 program.

RESULTS AND DISCUSSION

Air pollution problems have been a challenging global environmental concern the source of pollution parameters. But air quality-associated repercussions are more immense in low- and middle-income countries (WHO 2021; IQAir 2022). Especially, air pollutant particulate matter, size2.5 microns (PM2.5) has been a leading cause of mortality in highly polluted cities of these countries, such as China, India, Pakistan etc. (Anwar et al. 2021).

This study aimed at measuring particulate matter, evaluating air quality, and reducing air pollution in Konya, Selcuklu region different time periods. The measurement of PM10 and PM2.5 values in this region was made and the degree of pollution was evaluated by modelling it with the Surfer-19 modelling program. Based on these values, it is aimed to contribute to reducing these values to the lowest levels by determining the regions where PM10 and PM2.5 pollution are intense and their sources, the factors causing pollution. As a result of research, measurements, and analyses, it was concluded that there are many factors affecting PM10 and PM2.5 pollution. Considering seasonal and months (Dursun & Celik, 2022a, b).

In Figure 3-7, PM10 measurement graphs was created with the results of measurements made at 13 different sampling points at 08:00, 12:00, 15:00, 18:00 and 22:0 on weekdays in December. According to the results of this graph, the highest and lowest values, respectively, are 110 µm/m3 and 5 µm/m3; 50 µm/m3 and 4 µm/m3; 95 µm/m3 and 15 µm/m3; 58 µm/m3 and 10 µm/m3 ; 110 µm/m3 and 5 µm/m3. While the most important source of PM10 is fossil fuel consumed for heating needs during the winter months, the highest fuel consumption is in the early morning hours and at night. Dursun and Çelik (2022 a,b) show that during the summer and autumn rotations, there is no precipitation and it is during the daytime hours when people's activities are high. While dry air increases the concentration of dust lifted from the ground in traffic, PM also increases the residence time in the air.

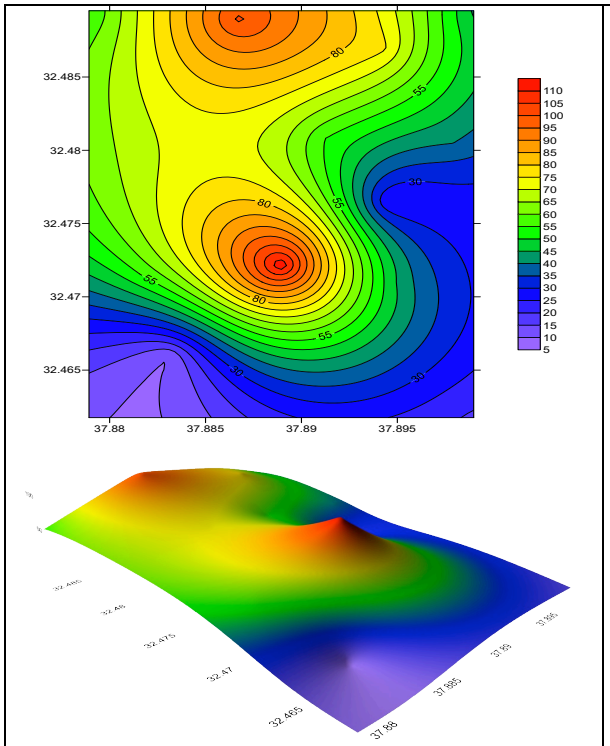

Figure 3. PM10 values of December weekdays at 08:00

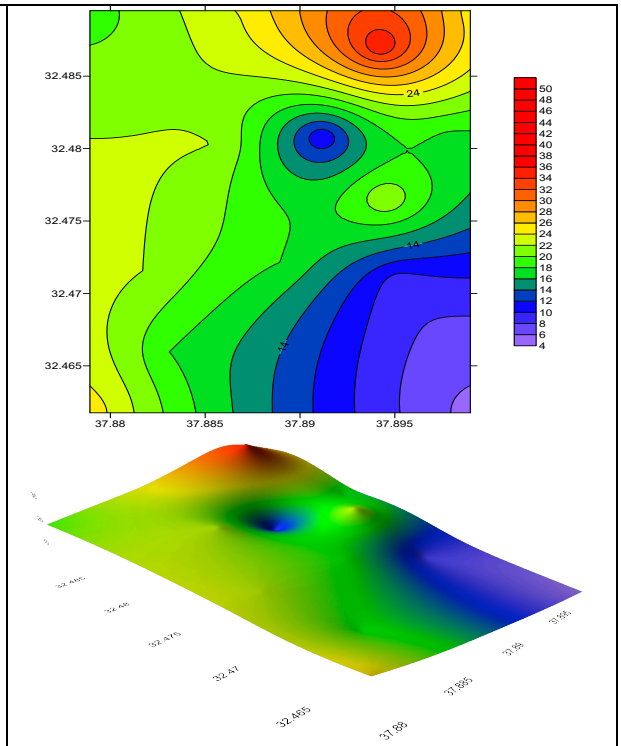

Figure 4. PM10 values of December weekdays at 12:00

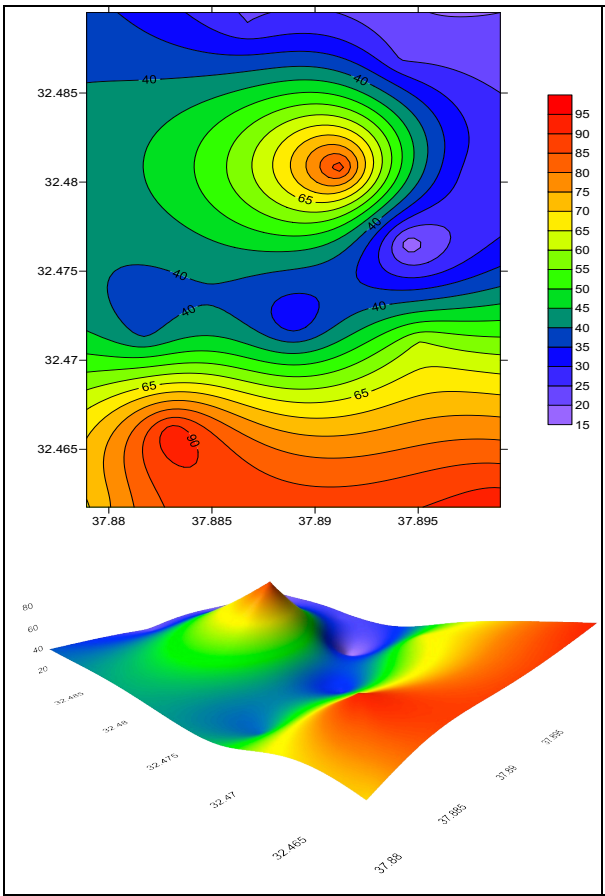

Figure 5. PM10 values of December weekdays at 15:00

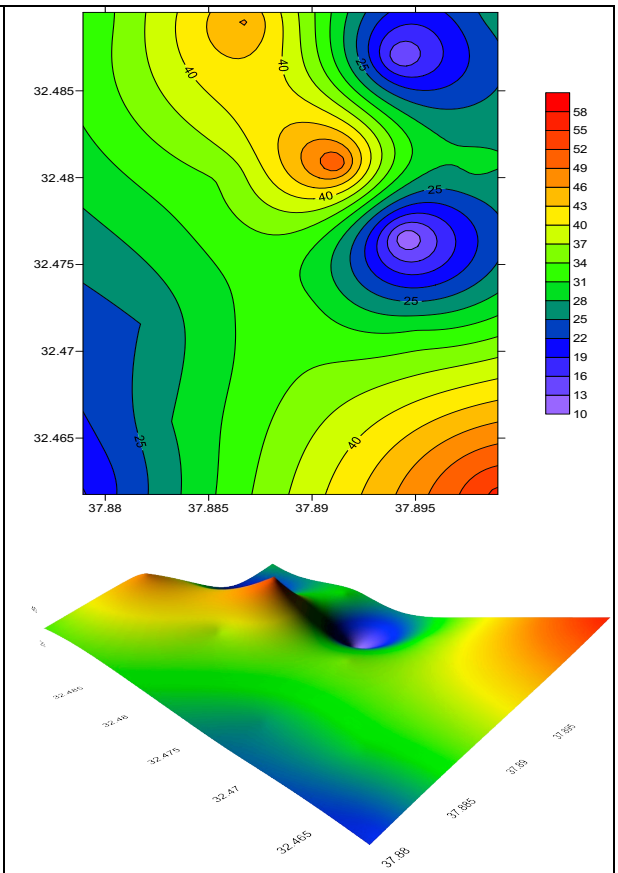

Figure 6. PM10 values of December weekdays at 18:00

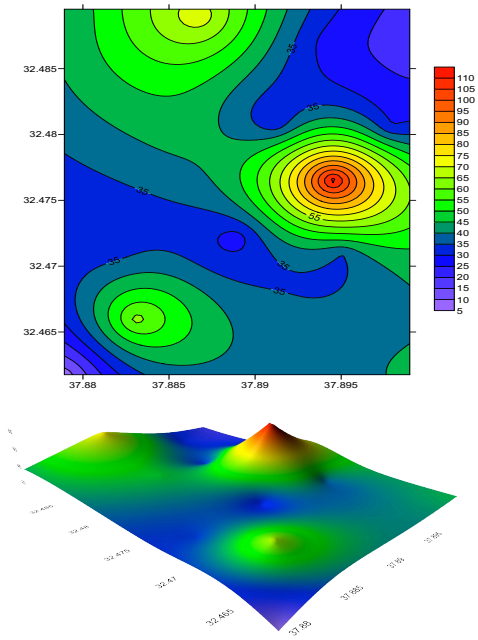

Figure 7. PM10 values of December weekdays at 22:00

In Figure 8-12, PM10 measurement graphs was created with the results of measurements made at 13 different sampling points at 08:00, 12:00, 15:00, 18:00 and 22:0 on weekends in December. According to the results of this graph, the highest and lowest values, respectively, are 90 µm/m3 and 10 µm/m3; 52 µm/m3 and 8 µm/m3; 90 µm/m3 and 10 µm/m3 ; 60 µm/m3 and 14 µm/m3 ; 62 µm/m3 and

10 µm/m3. While the maximum PM10 values at the weekend are lower than during the week, the average values are close to each other. In the study of Dursun and Çelik (2022a,b), while weekend values were higher in summer and autumn, they were not similar in this study. While human activities are higher on weekends in summer months, weekend values are relatively low due to less activity in winter months.

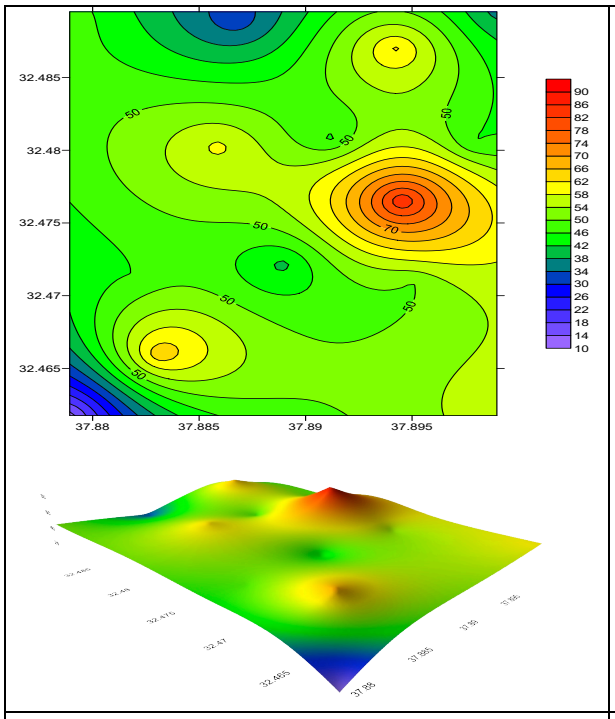

Figure 8. PM10 values of December weekends at 08:00

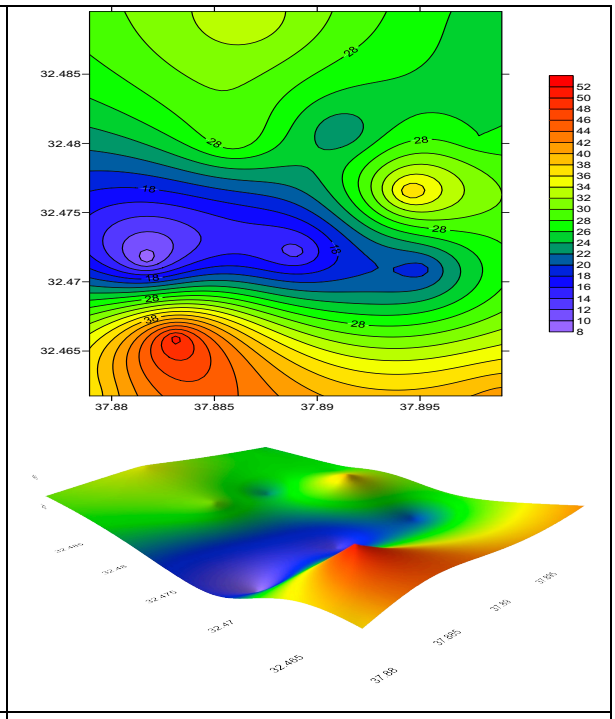

Figure 9. PM10 values of December weekends at 12:00

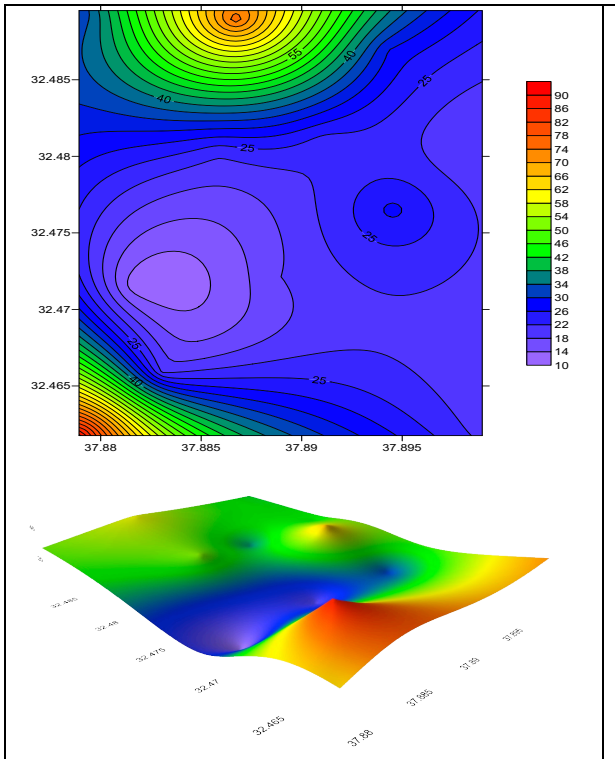

Figure 10. PM10 values of December weekends at 15:00

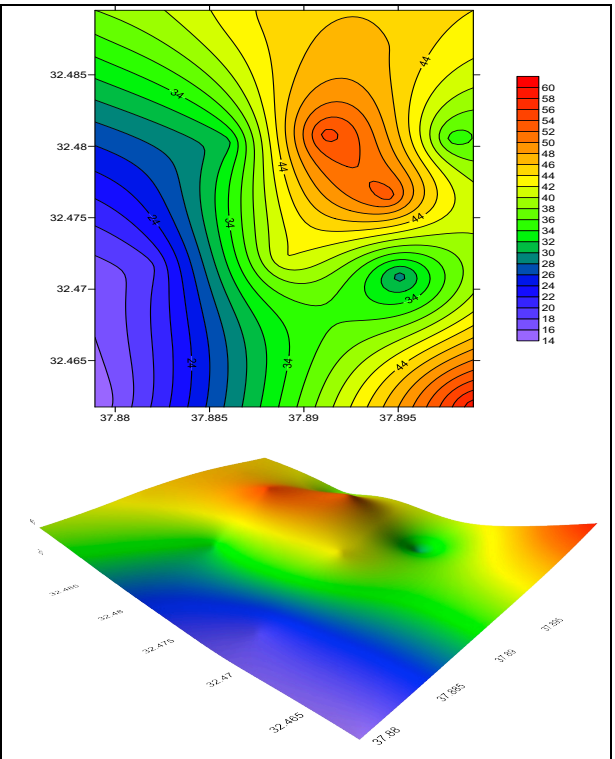

Figure11. PM10 values of December weekends at 18:00

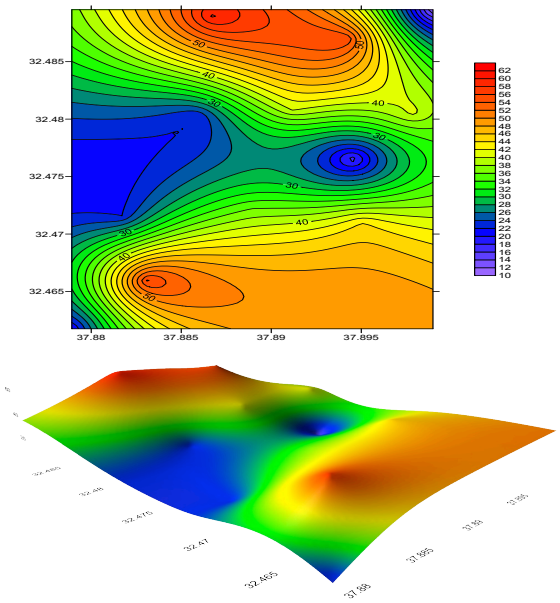

Figure 12. PM10 values of December weekends at22:00

Şekil 13-17'de PM2.5 measurement graphs was created with the results of measurements made at 13 different sampling points at 08:00, 12:00, 15:00, 18:00 and 22:0 on weekdays in December. According to the results of this graph, the highest and lowest values, respectively, are 1650 µm/m3 and 850 µm/m3; 825 µm/m3 and 300 µm/m3; 1450 µm/m3 and 550 µm/m3 ; 1150 µm/m3 and 450 µm/m3 ; 1350 µm/m3 and 550 µm/m3. When the PM2.5 daytime values measured in December are compared with the PM10 values, they seem to be very high. Although PM10 values seem to be below the limits as an average value, they could not be evaluated for PM2.5 values because there are no limit values for Turkey, but it can be said that they are above international standards. As a source of PM2.5, it can be said that it is mostly caused by the exhausts of the vehicles in the traffic. Higher values were observed during the hours when the traffic was active.

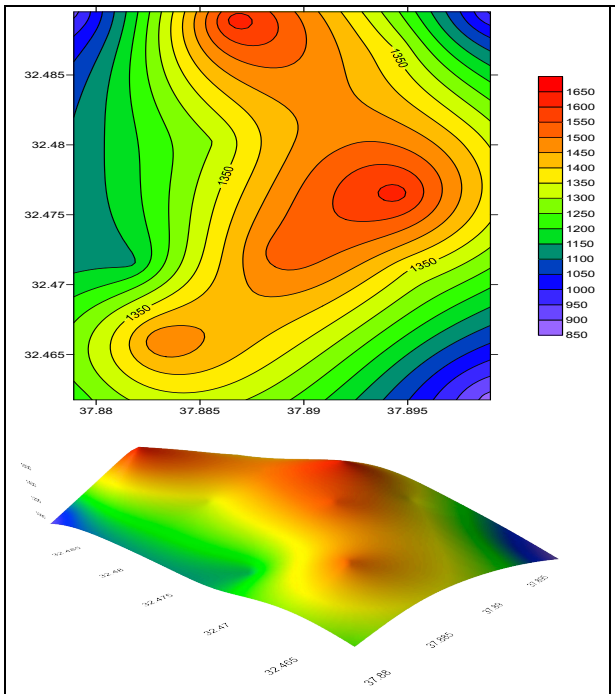

Figure 13. $PM_{2,5}$ values of December weekdays at 08:00

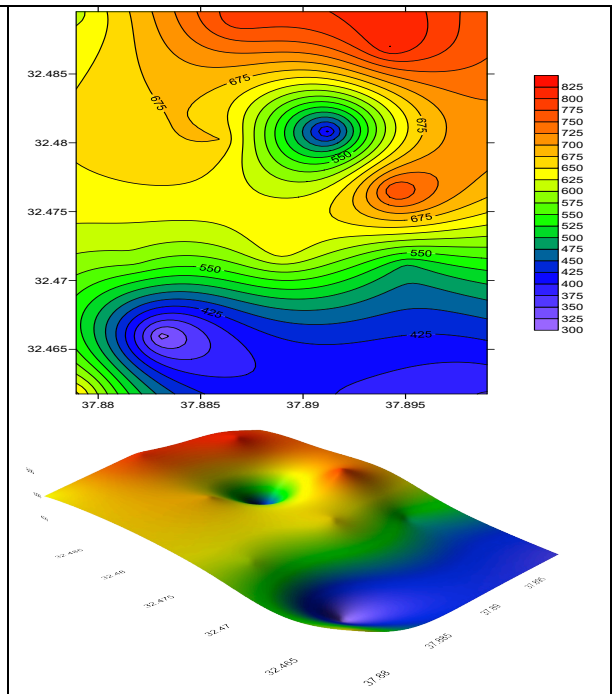

Figure 14. PM2,5 values of December weekdays at 12:00

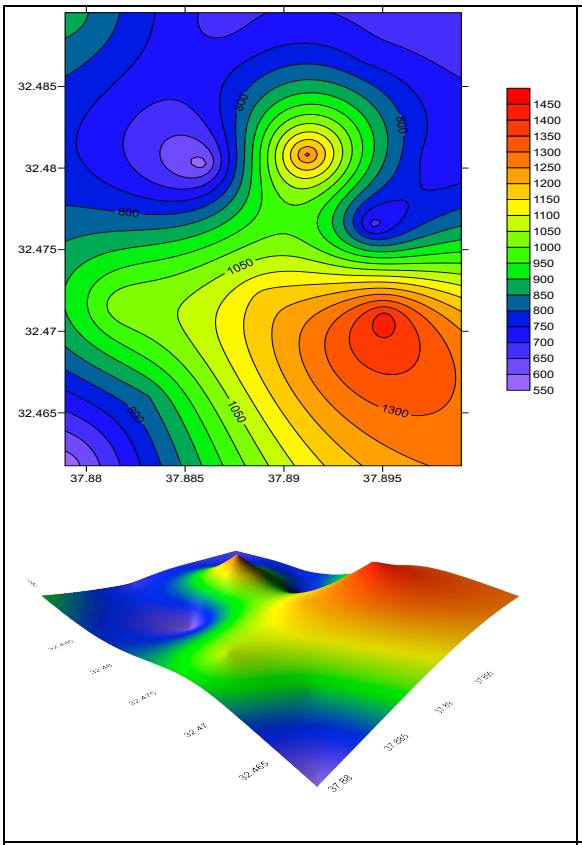

Figure 15. PM2,5 values of December weekdays at 12:00

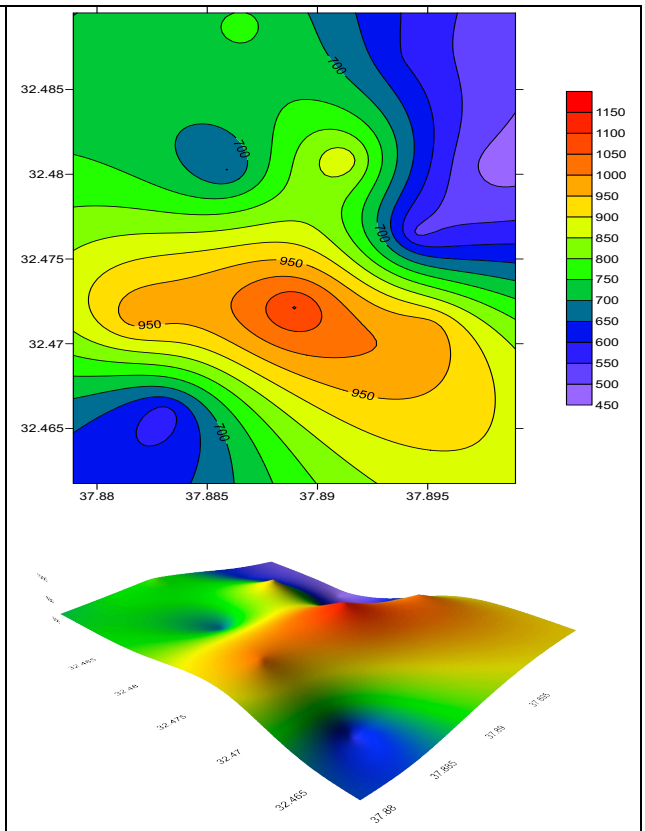

Figure 16. PM2,5 values of December weekdays at 18:00

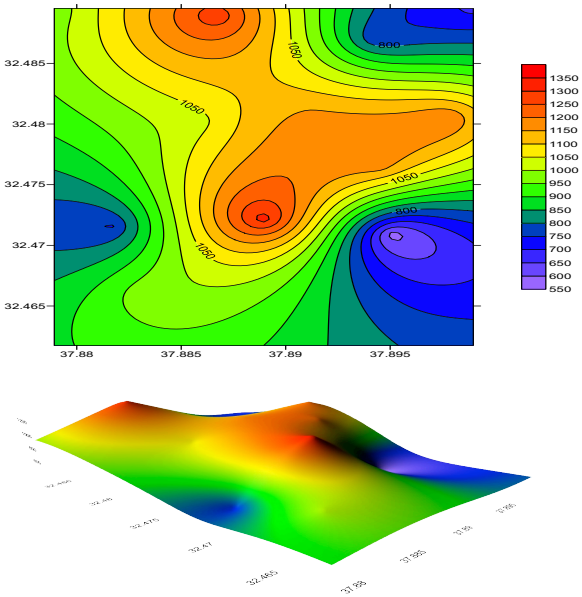

Figure 17. PM2,5 values of December weekdays at 22:00

Şekil 18-22'de PM2.5 measurement graphs was created with the results of measurements made at 13 different sampling points at 08:00, 12:00, 15:00, 18:00 and 22:0 on weekends in December. According to the results of this graph, the highest and lowest values, respectively, are 1550 µm/m3 and 600 µm/m3; 820 µm/m3 and 280 µm/m3; 1390 µm/m3 and 350 µm/m3 ; 1200 µm/m3 and 700 µm/m3 ; 8050 µm/m3 and 240 µm/m3. Although PM2.5 values are observed to be smaller when compared to weekday values, they are considerably higher than PM10 values. At the end of the error

values, the values in the afternoon are relatively lower than the values before the afternoon. However, it is several times higher when compared to PM10 values. Since there is no standard value for PM2.5 for Turkey, there is no activity to take any measures for 2023. Considering that PM2.5 source is mostly combustion product emissions, the issue should be evaluated well in terms of air pollution.

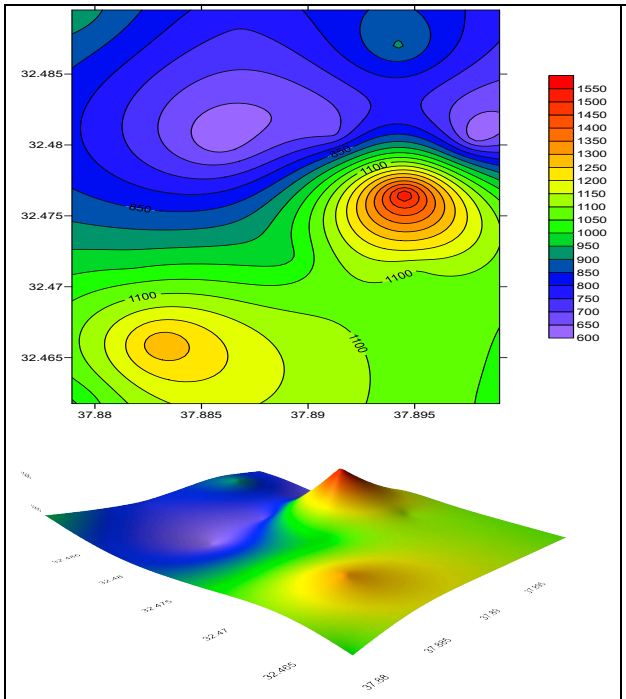

Figure 18. PM2,5 values of December weekends at 08:00

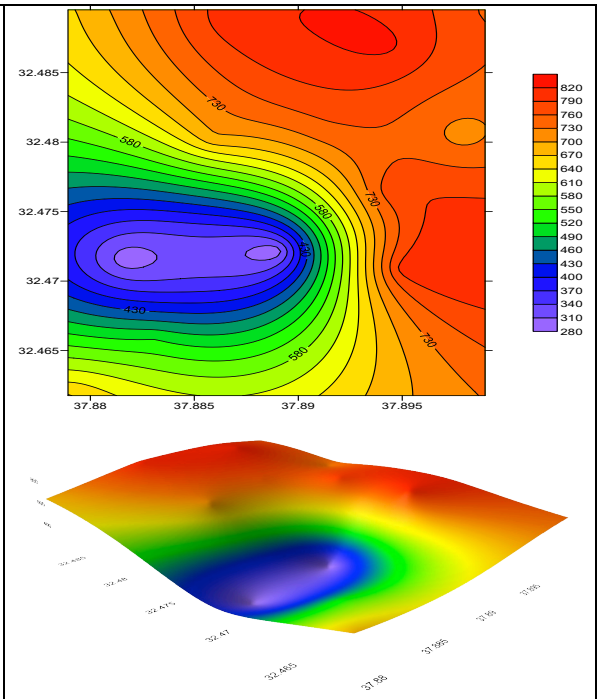

Figure 19. PM2,5 values of December weekends at 12:00

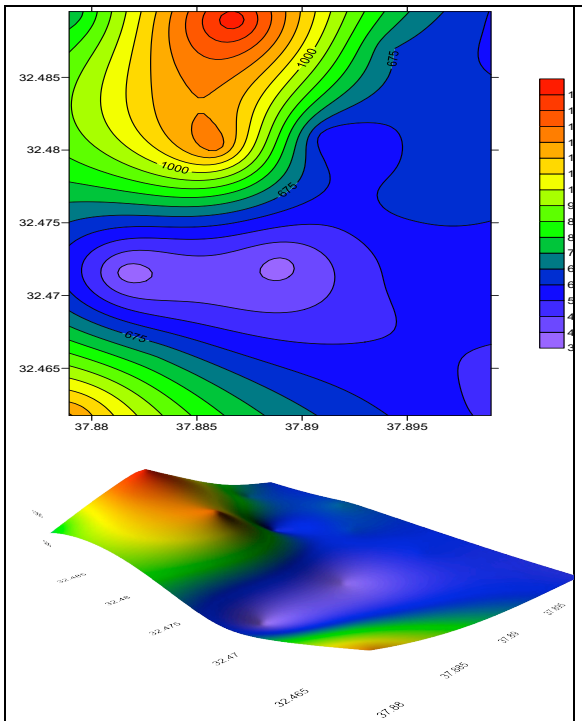

Figure 20. PM2,5 values of December weekends at 15:00

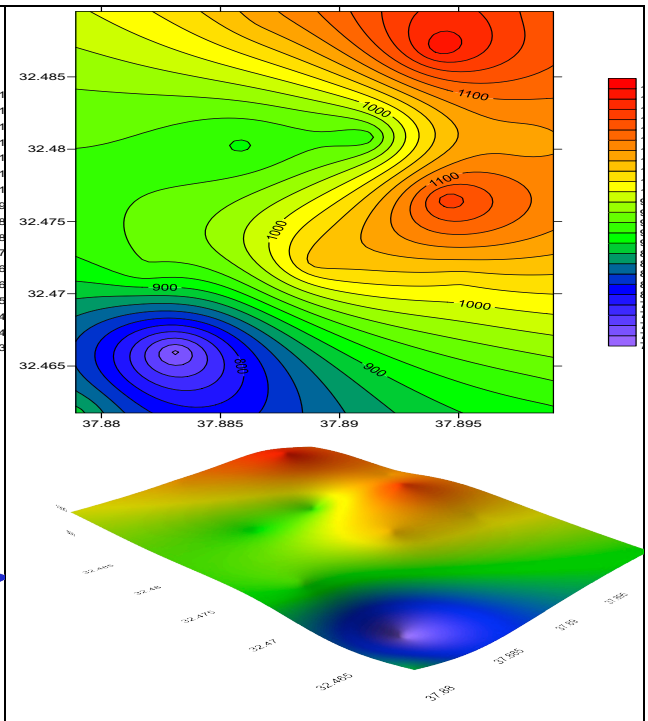

Figure 21. PM2,5 values of December weekends at 18:00

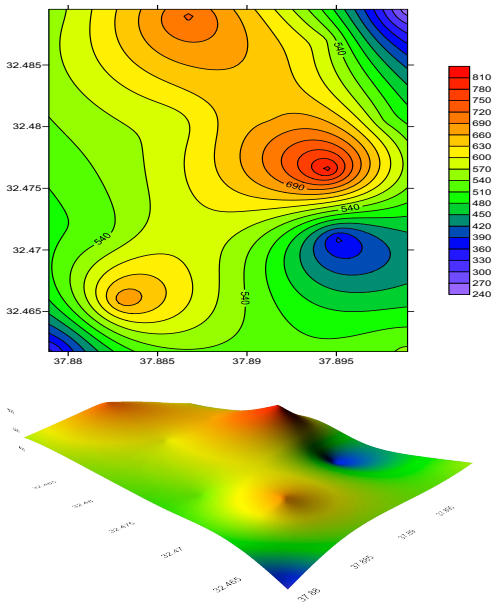

Figure 22. PM2,5 values of December weekends at 22:00

The areal sourced emission inventory of Konya, Selçuklu District Hacıkaymak district, PM10 and PM2.5 pollutants were measured, the measurement values were converted into 2D and 3D graphics, and spatial, seasonal, weekly, and hourly analyses were made. From the graphs obtained, while the regions with high pollution in the region are seen, information is also obtained about the possible sources of the pollutants. Especially considering the wind blowing directions, it is understood from which regions the pollutants are transported. On the other hand, in areas with high buildings in the region, local pollution increases because the distribution of pollution is insufficient. On rainy days, on the other hand, relatively pollutants are estimated to be reduced by wet precipitation. With the measurement of particulate matter and evaluation of air quality in Konya Selcuklu region, it is aimed to draw attention to the pollution dimension and to conduct a study to reduce air pollution. The situation of the region was revealed by measuring the PM10 and PM2.5 values in this region, modelling it with the Surfer-19 program, and evaluating the degree of pollution.

Based on these values, it is aimed to contribute to reducing these values to the lowest levels by determining the regions where PM10 and PM2.5 pollution are intense and their sources, the factors causing pollution. As a result of research, measurements, and analyses, it has been concluded that there are many factors affecting PM10 and PM2.5 pollution. PM10 and PM2.5 pollutant values considering seasonal and months; It was determined that the weather was higher in the winter months and lower in the summer months. When we investigate the reason for this, it is primarily the pollution that occurs due to the fuels burned for heating purposes. In addition, due to the low air temperature values, people prefer to use public transport, walk, or bike, etc. The use of special vehicles instead of using them also increases the pollutant values.

Considering the weather conditions, PM10 and PM2.5 pollutant values; It was determined that it was lower in rainy weather and higher in windy weather. When the weather is rainy, some of the particulate matter in the air falls to the ground with precipitation and the measurement values are lower. The opposite happens in windy weather. It was observed that particulate matter increased in conditions such as wind, breeze and storm. PM10 and PM2.5 pollutant values considering the days of the week; were found to be lower on weekdays and higher on weekends. The traffic density on the weekend is higher than during the week. For this reason, the measured values are higher at weekends and lower during weekdays. PM10 and PM2.5 pollutant values considering hours; At certain times of the day, the measurement results were above the average. These hours are the starting and ending hours. Due to heavy traffic, the measurements we made at 08:00 and 18:00 were very high. Considering point sources, PM10 and PM2.5 pollutant values differ. As a result of our measurements, we encountered high values at some points. The measuring point region was examined. There were high pollutant sources located near the selected points. The pollution sources of the selected points are as follows. Neighborhoods with heavy traffic, Torku factory, bakery, Old Industrial Zone, railway and stove use are high.

SUGGESTIONS

The fuel specs in the Clean Air Program prepared for the 2022-2023 Winter season in order to reflect the target limit values reached as of the winter season averages with the fuel regime applied in the before winter seasons, by preventing the entry of high-sulphur and low-calorie poor-quality coal to the center of our city. protection, intense piracy and smuggled fuel. Taking all kinds of measures to reduce the pollution caused by traffic, meanwhile better control of exhaust emissions, Accelerating the emission permits of industrial facilities, Especially in newly constructed buildings, great importance is given to thermal insulation and the application is followed very well, Reviewing the burning mechanisms of buildings and apartments with heating, with a team that has the qualifications to be installed, and working on improving the mechanisms that do not comply with the standard, Meticulously following the implementation of the decisions taken so far within the framework of the *Clean Air Program* prepared by the Local Environment Board every year, maintaining its existing effectiveness, Continuing consumer awareness training activities, Consideration of meteorological environmental factors in site selection of new settlements and industrial zones, The use of natural gas in additional industry and heating brought to our city should be carried out urgently.

Acknowledgement: This paper has been prepared a part of Mehmet Bugra Celik's M Sc. Thesis and presented at 1st Advanced engineering Days, Mersin, 2021.

Funding: This research has not been funded with any Project

Author contributions: Sukru Dursun: Conceptualization, Methodology, Writing-Original draft preparation, Reviewing and Editing; Mehmet Bugra Celik: Investigation, Data curation, Modelling.

Conflicts of interest: The authors declare no conflicts of interest.

REFERENCES

Anwar MN, Shabbir M, Tahir E, Iftikhar M, Saif H, Tahir A, Murtaza MA, Khokhar MF, Rehan M, Aghbashlo M, Tabatabaei M, Nizami AS (2021) Emerging challenges of air pollution and particulate matter in China, India, and Pakistan and mitigating solutions. J Hazard Mater 416:125851. https://doi.org/10.1016/j.jhazm at. 2021.125851

Dursun Ş, Aguilera MAR, (2022) Modelling of Particle Matter Pollution in 2021 Autumn in Kosovo Region of Konya province, Turkey. Journal of International Environmental Application and Science, 17(4) 148-155

Dursun S, Qasim MN, (2022a) Measurements and modelling of PM2. 5 level in summertime period in Novada main shopping centre Konya, Turkey. Engineering Applications, 1(1) 19-32.

Dursun S, Qasim MN, (2022b) PM2. 5 Level in Autumn Period Measurements And Modelling In Novada Mall (Konya, Turkey). Journal of International Environmental Application and Science. 17(2) 63-74

Dursun S, & Çelik MB, (2022a) Measuring Pm Level in Summer Season and Preparing Dispersion Modelling For Hacikaymak Region In Selcuklu, Konya, Turkey. 5th Advanced Engineering Days (AED) – 3-4 December 2022 – Mersin, Türkiye PP:18-21. Mersin, Türkiye.

Dursun S & Çelik MB, (2022b) Autumn Season Pm Measurements And Spatial Modeling For Konya City, Selçuklu, Hacikaymak District. International Marmara Sciences Congress (Imascon Autumn) 2022 Proceedings Book. Pp:20, 09 – 10 December 2022 KOCAELI

Dursun S, Alqaysi NHH (2016) Estimating Air Pollution Quality In Istanbul City Centre By Geographic Information System. International Journal of Ecosystems & Ecology Sciences. 6,3

Gupta N, Agarwal AK, Singhal R, Jindal SK, (2023) A Comparative Assessment of the Some Commercially Available Portable Bipolar Air Ionizers Particulate Pollutants (PM2.5) Removal Efficacies and Potential Byproduct Ozone Emission. Aerosol Science and Engineering, https://doi.org/10.1007/s41810-023-00182-9

IQAir (2022) Air quality in India. https://www. iqair.com/in- en/india Accessed 17 Sep 2022

WHO (2021) Air Pollution. https://www. who. int/health- topics/air- pollution# tab= tab_1 Accessed 11 Sep 2022