Determination and modelling of PM$_{2.5}$ level in summer time in Selcuk University Shopping Centre Konya, Turkey

Sukru Dursun *1, **Mina Naseer Qasım** 2

^{1}Konya Technical University, Environmental engineering Department, Konya, Turkey, sdursun@ktun.edu.tr
^{2}Konya Technical University, Environmental engineering Department, Konya, Turkey, mineenviro@gmail.com

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ABSTRACT

Most of the people spend their most more the time in closed environments during their life. The quality of living atmosphere is really important because of this long contact time period. In inhaled respiration air is contain particle matters pollutant sources in the atmospheric environment, like volatile organic compounds, dusts and different sizes of particulate matters. The health impact of these substances has been investigated in recent years on may scientifically research. In this investigation, particulate matter PM$_{2.5}$ size dimension, which is one of the indoor air pollutants, was carried out in Selcuk University public shopping center and the data were compared according to seasons, weekday and weekends. For the preparing 3-dimensional mapping, Surfer v.16 computer packed program was used and data modelling was investigated. Certain intervals were measured during three seasons. The measured shopping center is located in the Alaeddin Keykubat campus of Selcuk University. Measurement PM$_{2.5}$ values in the center of Gökkuşağı shopping center exceed the standards of WHO, and it was observed that summer values were lower than winter seasons. Higher values were observed in the winter season. In terms of measurement area, higher PM concentrations were found in Gökkuşağı shopping center than in similar shopping malls.

Introduction

Many of the epidemiological studies on particulate matter in the world have shown that the high air pollution caused by these substances, respiratory tract diseases, cardio vascular system and lung problems are great importance on human health [1]. The fact that people generally spend about 90% of their time indoors is clear how important the air quality of these environments is. However, most of the studies to determine the amount of particulate matter in the world have been carried out outdoors, and the studies carried out in closed environments are limited. Particulate matter, which is a mixture of organic and inorganic compounds, is defined as an important source of air pollution. These particles, which are generally divided into two groups in terms of mass; defined as coarse particles (above 10 μm) and fine particles (below 2.5 μm). The residence time of the particles in the air depends on the particle size, the smaller the size of the particles, the longer the residence time in the air [2]. PM$_{2.5}$ exposure threshold has not been defined to provide an unequivocally safe and complete level of protection against all adverse health effects [3]. However, in order to limit the health effects of fine particle pollution, the World Health Organization (WHO) has proposed guidelines for annual and short-term (24 hours) human exposure to PM$_{2.5}$. In addition to these global standards, WHO encourages governments to define and implement national standards [4]. Along with the guideline levels, WHO has defined three intermediate exposure levels to gradually reduce PM$_{2.5}$ concentrations. In addition, WHO recommends an annual average, with priority over the 24-hour average, as high PM$_{2.5}$ events are generally less harmful than annual exposure to high PM2.5 levels. The current WHO's annual average air quality guide (AQG) is 10 μg/m^3. Australia and the Canadian province of British Columbia are national jurisdictions that introduced a lower standard of 8 μg/m^3.

Material and method

Study area

In this study, which was started on the basis of shopping centres located in Selçuklu district of Konya province, it was chosen as the appropriate location for measurements. This place, which was chosen by paying attention to its indoor environment, is located on the campus of Selcuk University. Social facilities serving students and staff in Selçuk University Alâeddin Keykubat Campus were deemed suitable as a location for carrying out measurements and collecting data. Rainbow is located in front of the medical faculty, approximately 400 meters from the campus entrance. This building, which covers an area of approximately 13000 m², consists of 63 stores, stationery, bookstores and restaurants.

It consists of map types such as contour, calculation, 3D surfaces, colour relief, etc., and provides tools to visualize and model all types of data. The type of map obtained in this study is contour map. After making all the statistical calculations by turning the 3D data loaded on the worksheet into a grid, the map is created by selecting the desired map type. In order to make the map more meaningful and readable, the map can be personalized with various customization options, thanks to the window in the lower left corner of the screen. These options include sections, magnifiers, scale bars and edits such as multi-axis, linear or logarithmic color scales, combining multiple maps, text, line, fill, and symbol properties.

Particulate matter PM2.5 measurement method

In the researches carried out to determine the particulate matter concentrations, the pollutant sources in the external environment were examined. By comparison, there is little information on indoor particulate matter pollution, its concentrations, sources, and exposure levels to people who spend most of their time in various indoor environments [5]. In this study, which was started to determine the effect of seasonal changes on particulate matter, summer, autumn and winter seasons were selected to take measurements, and two-day measurements were made on weekdays and weekends. The total measurement period was completed as 4 days in each period.

In all three seasons when the measurements were made, the daily measurement program lasted for 10 hours, depending on the working hours of the venues. Measurements were repeated 6 times a day with an interval of 2 hours. After taking the coordinates of the measurement points, the data collected at the end of each season are listed in the Excel program in such a way that daily, weekly and hourly averages are taken. X and Y coordinates and Z coordinate represented the measured $PM_{2.5}$ values. A worksheet was created by transferring X,Y coordinates and measurement values to the SURFER-16 program. Statistical calculations were made by converting the prepared data into tables. Then, contour map is selected from the map options in order to show the contour lines. The customization window is used to clearly show high and low concentrations and dispersion lines on the map.

Results and discussion

Particulate matter measurements were carried out in three different seasons in the rainbow shopping center of Selçuk University Alaeddin Keykubat campus, an important shopping center in Konya. The sampling period was carried out between 21.05.2018 - 03.06.2018. During the measurement periods, measurements were made for one week. Weekly average distributions of particulate matter $PM_{2.5}$ were prepared with Surfer 16 by measuring 6 times a day. Within the scope of the research, it was arranged to be close to the opening and closing hours of the shopping center between the hours of weekdays and weekends (09-19). As a result of the study, the average values of $PM_{2.5}$ obtained from the examination of all data during the week and at the weekend are shown in Table 1.

Table 1. Seasonal weekday and weekend averages of particulate matter $PM_{2.5}$ in Gökkuşağı shopping center

Sampling period	Weekday average $PM_{2.5}$ μg/m³	Weekend average $PM_{2.5}$ μg/m³
Summer	600	528

According to the summer period data, the average of PM2,5 at 9:00 in the morning was 580 μg/m3 on weekdays and 720 μg/m3 on weekends. While the most intense point of pollution was at point B on weekdays, it was seen intensely at points B and C on weekends. point B; it is in a narrow and closed corridor with cooking stoves, hairdressers, tailors and locksmiths. Thanks to these shops that are actively working, there is not much difference between weekday and weekend values. Point C, on the other hand, corresponds to the aforementioned corridor in the shopping mall, on the west side of the building. There is a restaurant material entrance area, a medical equipment sales point and a clothing store door opening to this corridor. The value seen over the weekend appears to have increased due to the material loading in the corridor. The modelling results are shown in Figure 2.

(a)   (b)
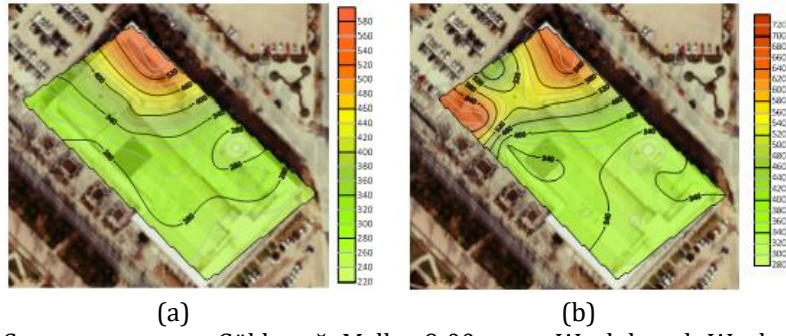
Figure 2. Summer season at Gökkuşağı Mall at 9:00 a.m. a-Weekdays, b-Weekend average

As the middle of the day approaches, the values increase slightly and the measurements made around 11:00 reflect the modelling in both weekday and weekend averages. The average of $PM_{2.5}$ at 11 o'clock was found to be 1040 μg/m³ on weekdays, and very close values were obtained as 1050 μg/m³ at the end of the week. The intense pollution zone seen on weekdays exactly coincides with the middle parts of the building, some of the corridors and restaurants. With a general interpretation, as a result of the measurements made in the summer period, the lowest $PM_{2.5}$ value is 370 μg/m³. This value exceeds the hourly 25 μg/m³ limit set by WHO, EEA and EPA for $PM_{2.5}$. In the outdoor air quality assessment management and regulation updated in 2008 in Turkey, the standard value for $PM_{2.5}$ is 200 μg/m³. While the indoor air should be lower than these values, the results obtained exceed the HKDYY limit value.

Conclusions and Recommendations

In this study, indoor air quality, the importance of which has started to be noticed in Turkey in recent years, has been examined. In this study, which was started in Konya, one of the most important industrial cities of the country, based on shopping centers, particulate matter $PM_{2.5}$ measurements, which carry serious risk factors on human health and which is in the second rank among air pollutants by the World Health Organization, were made. Two different environments were selected for the measurements. Rainbow shopping center located on Selçuk University Alaeddin Keykubat campus was chosen as the first location for measurements. Measurements were made in three separate periods. Sampling was carried out during the summer season between 09:00 and 19:00 between 21.05.2018 – 03.06.2018. When investigated how particulate matter $PM_{2.5}$ affects indoor air quality throughout the season and what causes it. The results were mapped and modelled using the Surfer 16 program. While modelling, the results were interpreted as weekday and weekend averages. As a result, measurement PM2.5 values in the center of Gökkuşağı Mall did not exceed WHO's standards.

Author contributions:

Sukru Dursun: Conceptualization, Methodology, -Reviewing and Editing; **Mina Naseer Qasım:** Investigation, Data curation, Writing-Original draft preparation, Modelling.

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

References

[1] Brunekreef, B., Holgate, S. T., (2002), Air pollution and health, The lancet, 360 (9341), 1233-1242.
[2] Kaya, D. & Öztürk, H., (2012), Hava Kalitesi Yönetimi, Ankara, p. 352.
[3] Kiesewetter, G., Schoepp, W., Heyes, C., Amann, M., (2015), Modelling PM2. 5 impact indicators in Europe: health effects and legal compliance, Environmental Modelling & Software, 74, 201-211.
[4] WHO, (2013), World Health Organization (2013). Review of evidence on health aspects of air pollution
[5] Challoner, A. ve Gill, L., (2014), Indoor/outdoor air pollution relationships in ten commercial buildings: PM2. 5 and NO2, Building and Environment, 80, 159-173.