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Measurements and modelling of $PM_{2.5}$ level in summertime period in Novada Main Shopping Centre Konya, Turkey

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Abstract

The people are spending most more the daily time in closed environments in their life. The living atmospheric air quality is important because of this long contact time. Air pollution is the presence of particles in the atmosphere because of the interaction of dust, gas, smoke, water vapor, odor and many chemicals in amounts that can harm living things and other things. This pollution, which is an environmental health problem affecting all countries of the world in recent years, causes the death of 3 million people every year in the world. In another definition, air pollution occurs because of fossil fuel burning, that is, anthropogenic activities such as natural gas, coal, and oil, to power industrial processes and motor vehicles. Industrialized countries expect a modern living place in modern life and living spaces. Their vehicle demands bring along motor vehicles and industrialization close to city centers and this effects a damage the human and environmental health. Konya city center is one of the most crowded plan sections of Turkey, and to finish our preparations together with central planning and industrial planning. People also prefer to spend their spare time doing great shopping that Novada Shopping Centre is one of them. It turns out that the forecasts of this weather arise if it is for the air pollution of the air from the people who come from shoppers and visitors. The basic organization for a good material for obtained air quality preparations. Improvement planning in the current situation achieves the goal of the air quality specialist so that the results obtained can be achieved.

1. Introduction

Looking at the main causes of air pollution, the increasing population, urbanization, and the need for energy from industrialization have led to an increase in the need for fossil fuels [1-2]. As a result of the excessive use of fossil fuels, changes occur in the structure of the atmosphere day by day. People are constantly breathing the air around them all the time. Gases and particles in the air are exhaled together with the inhaled air. These pollutants damage people's heart, lungs, and other organs. When we look at the death cases caused by air pollution in the past, approximately 20 people died in Pennsylvania in 1948, while this event killed 63, 3000 people in Belgium in 1930 and in London in 1952 due to air pollution. Although different pollutants are released into the atmosphere because of natural physical events (volcanoes, fires), anthropogenic (human) activities have been determined as the primary source of air pollution in the environment [3-4].

Indoor air: It is expressed as the air contained in buildings such as workplaces, residences, shopping and living centers, interior spaces of transportation vehicles (bus, car, ship, train, etc.), schools and offices. Indoor air pollution, on the other hand, is the presence of substances that can harm health in the above-mentioned environments. These respirable substances are generally observed in the form of gas, dust, vapor. The amount and concentration of these substances in the environment differ according to the characteristics of the environment, the building and interior materials used in the construction of the building, and the behaviors of the individuals in it. For example, the increase in dust and particulate matter rates in the corridors caused by the movements of the students in a school building, as well as the equipment such as printing machine and photocopying machine used in a stationery shop, caused the spread of various volatile organic compounds to the environment [5].

The energy saving policies of recent times in countries and the construction of insulated buildings with insufficient ventilation, minimum indoor air circulation, no windows that can be opened to the outside, and air conditioners have had a significant impact on the air quality of these indoor environments. It is a known fact that human performance is affected by indoor air quality. For human comfort and productivity, the indoor environment must be at 19-20°C and the humidity of the air he breathes must be 30-50% [6].

Although indoor pollutants have many types, they differ from each other. Some of these pollutants occur due to indoor cleaning activities (VOC), cooking actions (CO, NO_x, particles), indoor painting processes, cigarette burning (CO, particles) and some activities such as spray perfumes used for odor removal. In addition, it is possible to spread from furniture, building materials, products containing chemicals. In addition, some indoor pollutants can be produced in the outdoor environment and transported to the indoor environment through a window or door [7].

In addition to advantages such as cleaning and hygiene, the effects of disinfectants consisting of chemicals carry a great risk on health. The effect of the volatile organic compounds emitted into the environment during the cleaning activity can also spread in the gas phase after the cleaning is completed and enter the body by inhalation. In addition, the same risk is in question for the individuals who are in the environment as well as the person doing the cleaning [8].

Environmental tobacco smoke (CTS) describes the smoke from the tip of the cigarette when the cigarette is burned by the person who smokes it. The health risks of cigarettes, which are widely used in Turkey and even in the world, cause health problems not only for the users, but also for the individuals around the environmental tobacco smoke emitted during use. Environmental tobacco smoke consists of (mainstream smoke) smoke emitted by the smoker and (side stream smoke) smoke from the end of the cigarette when it is burned [9].

The fact that the emissions from the main combustion smoke are more dominant than the afterburner emissions explain the ETS passive smoking. When we searched many epidemiological studies, it was determined that the effects of passive smoking on health were caused by the risk of lung cancer, breast cancer in women [10-11], affecting the functions of the immune system [12] and impaired sense of smell.

In 2013, The World Health Organization [13] introduced that, because of a study conducted in Turkey in 2000, it was found that approximately 20% of the patients staying in hospitals were caused by smoking and more than half of the male population in the country was consuming cigarettes daily. Turkey implemented the smoke-free policy for the first time in 2008 with a strict management to protect indoor air quality, and successful results were achieved, resulting in a 20% reduction in smoking and a 27% reduction in hospitalization rates [14].

Dursun et al. [15] evaluated the change of PM2.5 values in open environments according to certain hours of the day and different seasons in a study they conducted at Selçuk University. After determining 40 sampling sites on the campus, measurements were made in the morning, noon and evening hours during the winter and spring seasons. As a result, high PM2.5 concentrations were obtained in the morning hours of the winter season. In the spring season, the highest values were found at noon. The collected data were modelled using the ArcGIS program. PM2.5 variations created using the collected data and according to the seasons are presented as pictures. It has been suggested that the reason for the high results obtained in winter is due to the fossil fuels used. It was also observed that there was a difference between weekdays and weekends. Weekend values were lower than weekdays.

PM2.5 exposure threshold has been defined to provide a safe and complete level of protection against all adverse health effects [16]. Nevertheless, 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 PM2.5. In addition to these global standards, WHO encourages governments to define and implement national standards [13]. Along with the guideline levels, WHO has defined three intermediate exposure levels to gradually lower PM2.5 concentrations. In addition, WHO recommends the annual average, with priority over the 24-hour average, as sporadic high PM2.5 events are generally less harmful than annual exposure to high PM2.5 levels. The relationship between human diseases and poor air quality has been recognized since ancient times. In the twentieth century, the health effects of air pollution have now entered the world's consciousness. The effect of ultrafine particles on health is more effective and dangerous than coarse particles [17]. Thus, the chemical properties of particles with an aerodynamic diameter of less than 1 μm are of great importance for health [1]. particulate matter affects all population groups, but the sensitivity varies depending on the person's health status and age [18].

PM10 reaches the inside of the lungs, slows down the conversion of carbon dioxide in the blood to oxygen and causes shortness of breath. Meanwhile, there is a great and serious pressure on the heart as it has to work faster in order to eliminate the lack of oxygen [19]. To achieve this aim, particulate matter PM2.5 measurements were made in the Novada shopping center in Konya, which is called one of the most industrial cities. Modelling was done by mapping the obtained data with Surfer 16 program. The results obtained were interpreted according to three different seasons and then compared with each other.

2. Material and Method

2.1. Material

The variation of the levels of air pollutant concentrations between regions in big cities is shaped depending on the characteristics of the regions [20]. In this study, which was started based on the shopping centers in the Selçuklu district of Konya, were selected for measurements. This places, which were chosen by paying attention to the fact that they are closed environments, is located on the Novada shopping center located in the new development area of the bay was chosen as the second place for data collection.

2.1.1. Working area

Novada outlet shopping and living centre located in the bus station area, which is known as the new development area of the bay, was opened for use in 2015. This shopping centre, with a total area of 33000 m², has 2 outdoor and one indoor parking lots, 51 stores, 12 restaurants and 3 playgrounds. Consisting of 4 floors, this building looks like the letter L when viewed from the satellite image, and 3 of the 4 entrance doors are located on the front of the building facing the main street. For this reason, it is directly exposed to air pollution caused by traffic. The other entrance door is used as a parking garage entrance on the -1 floor and there is no direct exposure to outdoor air pollution. There are cash machines, travel agency and tailor shops on this floor. The first measurement point was chosen right in front of the entrance door (Figure 1).

Figure 1. Novada shopping and living centre [21]

The ground floor (0 in order) has two entrance doors at the same level on the north and south facades. On this floor, there are mostly household goods, electronic goods stores, cosmetics, a small number of cafes and clothing stores. The possible source of pollution was mostly thought of as the exhaust fumes carried in from the open parking lot located at the front of the shopping mall and where both doors open directly there. The first floor consists entirely of clothing stores, and the possible source of pollutants is considered as fabric types and store perfumes. The fourth entrance door is located at the back of this floor. There is a ventilation system on the ceiling and the floor in the entire building is covered with ceramic porcelain.

The third floor consists of restaurants, fast food kitchens and children's playgrounds. The most significant source of pollutants of this floor is emissions from cooking in restaurants. Restaurants are defined as publicly communal indoor environments where many people spend most of their time. For this reason, the clean and healthy air in these areas not only protects the visual appearance, but also protects the health of employees and visiting customers [22]. Small-sized particulate matter (organic and inorganic) and carbon monoxide in kitchens are the main source of combustion in cooking activities [23].

When we look at the playgrounds, the floor coverings that can affect the air quality and cause the spread of volatile organic compounds, the play building materials used, the respiratory rate and mobility during the activities can be listed as the inadequacy of the ventilation system in that area.

This mall has fresh air handling unit on the entrance, first and second floor. The air conditioning system at the entrance and the first floor gives the indoor air to the floors, after taking the air from the outside in normal air temperatures and returns it to the inside by passing it through the filter inside itself (Figure 2).

The first measurement point is located at the entrance of the parking lot on the -1 floor, a single measurement point was considered sufficient due to its area on this floor. The points (2-5) were taken at different points of the ground floor to show the concentration difference in front of the entrance doors and other parts of the floor. The points (6-11) were taken by choosing certain places along the length of the first floor. (12-17) points were chosen in front of the restaurants and playgrounds on the second floor. Measurement points are shown on the map in Figure 3.

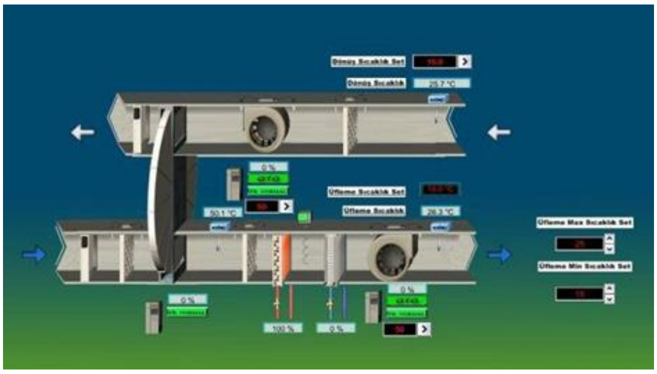

Figure 2. The filter system for aeration of Shopping centre

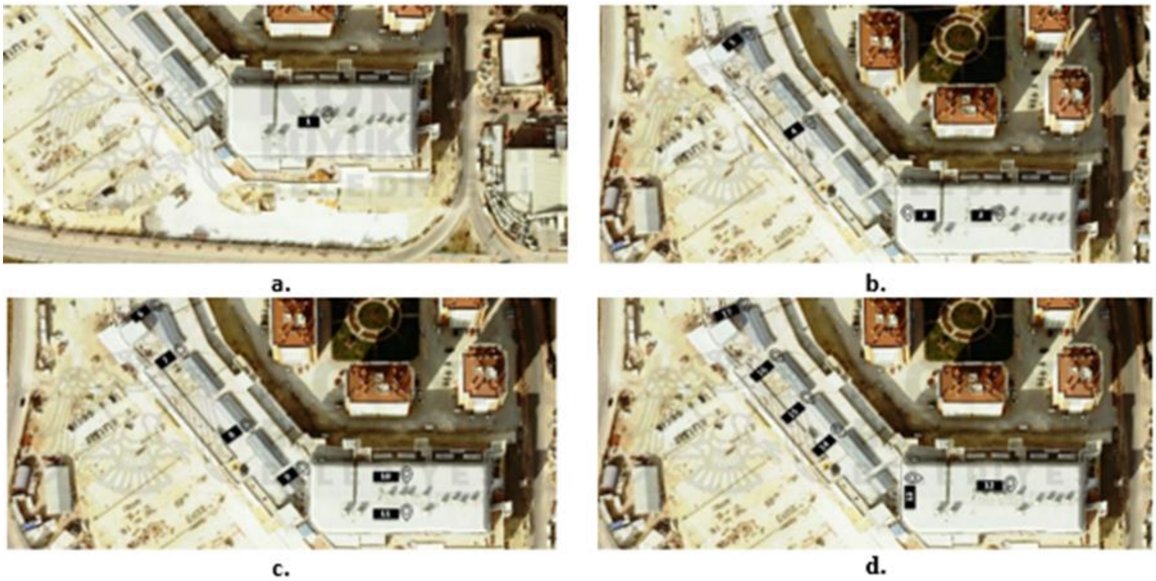

Figure 3. Measurement points according to floors in Novada AVM, a. (-1) floor, b. (0) floor, c. (1) floor, d. (2) fold [14]

2.1.2 Particulate matter measuring device

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. Data can be displayed numerically from the particle counter PCE-PCO1 device (Figure 4). This device is used in clean rooms, indoor air quality, exposure to exhaust, tobacco or cigarette smoke and other harmful air pollutants, and for monitoring airborne dust levels.

Figure 4. Particulate matter measuring device "particle counter PCE-PCO1"

The particle counter was developed to precisely determine the pollution level. The device measures 6 different particle sizes (0.3 µm, 0.5 µm, 1.0 µm, 2.5 µm, 5.0 µm, 10 µm), measurements (more than 5000 measurements) can be saved in the internal memory, A large color LCD with backlight, for image and video recording It includes a built-in camera, sensors to measure air temperature, dew point and relative humidity, displaying temperature measurements in degrees Celsius (°C) or degrees Fahrenheit (°F).

This device, which is deemed suitable for taking measurements at different points in terms of its easy portability, should be charged and prepared before going to the measurement site, and should be zeroed by making (calibration) in a dust-free environment before the measurement. After reaching the measurement area, the device is turned on by pressing the power button and the ENTER button is pressed to switch to the particle counting screen. The covers of the dust and temperature sensors on the top of the device are opened and they are made ready to detect the dust and temperature in the environment and the START / RUN button is pressed. The unit starts measuring for 30 seconds. After the measurement time is over, the data is saved by pressing the F2 button. The device also has 3 different sampling modes: cumulative, differential (differential) and concentration. The desired mode must be selected before measuring. In addition to these features, the date and time, language and screen brightness can be adjusted optionally from the system settings.

2.1.3 Modelling and graphics program surfer 16

This 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 [24]. People from many different disciplines use Surfer. Since 1984, more than 100,000 scientists and engineers worldwide have discovered the power and simplicity of Surfer. The program's exceptional guiding and Shaping capabilities have made it the software of choice for working with XYZ data. Over the years, this program has seen use by hydrologists, engineers, geologists, archaeologists, oceanographers, biologists, geophysicists, climatologists, educators, students, and more. It performs well to visualize XYZ data with stunning clarity and accuracy [25].

This program, which transforms the collected data into information, visualizes the data in high quality while preserving its accuracy and sensitivity. Along with Surfer's extensive modeling tools, interpolation and grating parameters can be adjusted, define errors and breaks, or perform grid calculations such as volumes, transformations, smoothing or filtering [26]. It consists of map types such as contour, calculation, 3D surface, color 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 XYZ data loaded on the worksheet into a grid, the map is created by selecting the desired map type. 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 colour scales, combining multiple maps, text, line, fill, and symbol properties [26].

2.2 Method

2.2.1 Particulate matter PM2.5 measurement method

The research 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 [27]. 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. In summer and autumn seasons, measurements were made for one week at Selçuk University rainbow social facilities and Novada shopping center, and during the winter season, weekday and weekend measurements were made in both locations. The total measurement period was completed as 4 days.

In all three seasons when the measurements were made, the daily measurement program lasted for 10 hours depending on the working hours of the places, and the measurements were repeated 6 times a day at 2-hour intervals. After taking the coordinates of the measurement points, the data collected at the end of each season are listed in the Excel program in a way that daily, weekly, and hourly averages will be taken. Besides the X and Y coordinates, the Z coordinate represented the measured PM2.5 values. A worksheet was created by transferring X Y coordinates and measurement values to the SURFER 16 program. All statistical calculations were made by making the prepared data into a grid. Then, contour map was selected from the map options to show the contour lines, and the customization window was used to clearly show the high and low concentrations and the distribution lines on the map.

3.Results

Within the scope of the thesis, three measurement periods were determined in the Novada shopping centre located in the Kosovan district. The first measurement period was made in the summer season, the second measurement period in the autumn season, and finally the third measurement period in the winter season. The measurements started one day after they were completed in Novada AVM for the season and ended after 1 week. The first measurement of the day started at 11:00, with a two-hour break between each measurement, a total of 6 measurements were made, and the last measurement was made at 21:00. According to the measurement points made, a separate map was drawn for each floor. As a result of the study, the average values of PM2.5 obtained from the examination of all data on weekdays and weekends are 336.97 μg/m³ and 322.55 μg/m³ for summer, 345.98 μg/m³ and 652.57 μg for autumn, respectively. It was found to be 595.88 μg/m³ and 906.4 μg/m³ for the winter season (Table 1).

Table 1. Seasonal particulate matter PM2.5 weekday and weekend averages in Novada mall

Measurements time	$PM_{2,5}$ weekday average value μg/m³	$PM_{2,5}$ weekend average value μg/m³
Summer	336.97	322.55

The results obtained from the measurements made during the summer season, at 11:00 on weekdays, were found as follows, respectively: minus the first floor 1650 μg/m³, (zero) ground layer 720 μg/m³, first layer 460 μg/m³ and the second layer 720 μg/ m³. At the first measurement hour of the day, the highest PM2.5 concentration was found on the minus first floor Figure 5. This floor, where there are barbers, Attar, PTT, cash machines and tailor machines, has a single door. This door opens to the indoor parking lot of the shopping mall, so it was observed that the vehicle emissions in the parking lot spread into the atmosphere of this floor when the doors were opened, while the pollution level in the indoor environment was expected to disperse to the outside environment. In addition, the fact that the ceiling height of this floor did not exceed approximately 3.5 m caused the particles to be trapped in a narrow space and closer to the respiratory level. Looking at the ground floor, it is seen that the pollution level at the 2nd measurement point in the lower right corner of the building (2nd and 1st measurement points are on different floors and coincides) is more intense than the other parts of the building. This means that the pollution from the minus 1st floor has spread to the 2nd point. When looking at the other floors, lower concentrations are generally observed because the ventilation is working, less visits by people and the cleaning activities have just been done. The maps are shown in Figure 5.

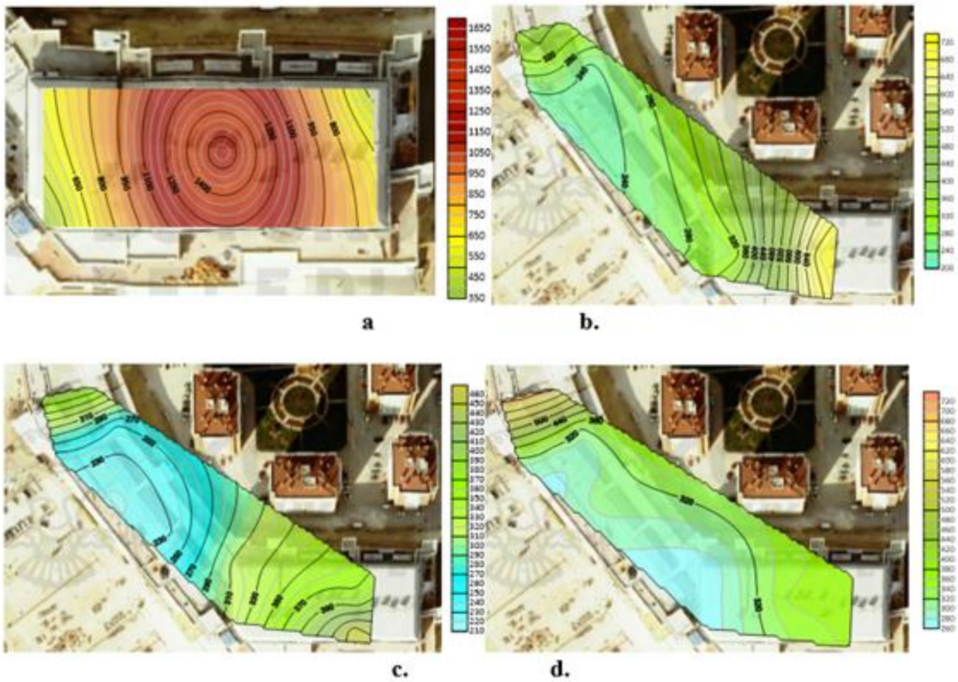

Figure 5. In Novada AVM, summer season is at 11:00 a.m. on weekdays. (-1) floor, b. (0) floor, c. (1) floor, d. (2) floor average

Weekend values were found to be relatively lower than during the week. As a result of the measurements, the PM2.5 concentration in each floor is as follows, respectively: minus 600 μg/m³ for the first layer, (zero) entry layer 430 μg/m³, first layer 560 μg/m³ and second layer 245 μg/m³. Maps indicating weekend concentrations are shown in Figure 6.

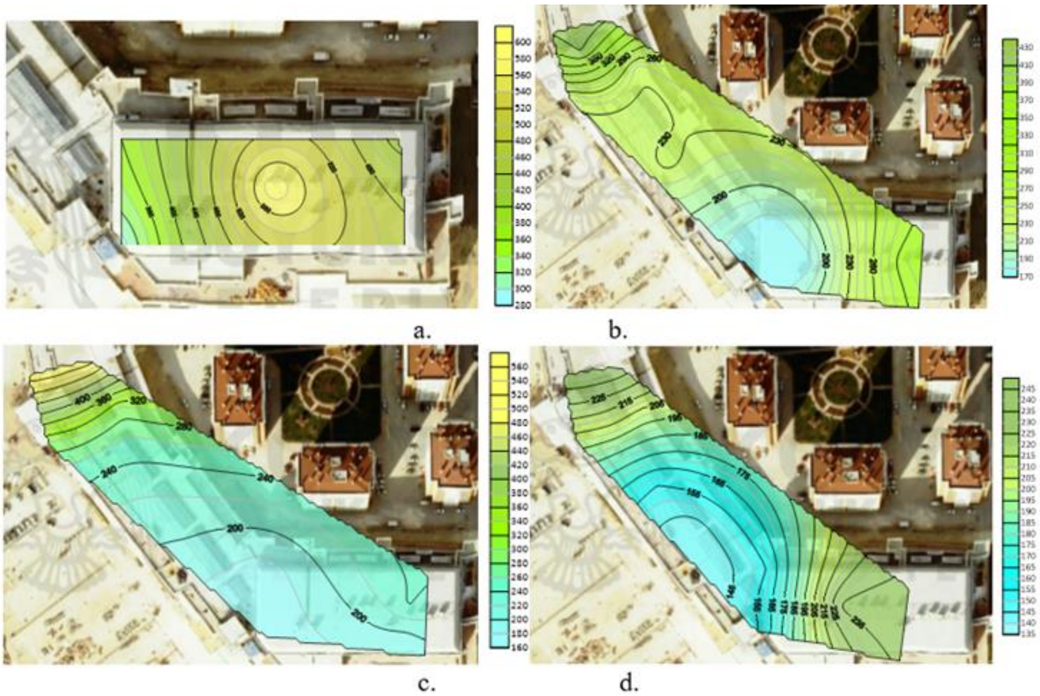

Figure 6. At Novada AVM on summer weekend, at 11:00 a.m. (-1) floor, b. (0) floor, c. (1) floor, d. (2) floor average

PM2.5 concentrations seen in the shopping mall at 13.00, when the second measurement of the day is made, are respectively: minus 1020 μg/m³ for the first floor, (zero) 540 μg/m³ for the ground floor, 400 μg/m³ for the first floor and 680 μg/m³ for the second floor. Again, while the values were found to be high at the first measurement point, lower concentrations were found in the other floors thanks to ventilation. The maps are shown in Figure 7.

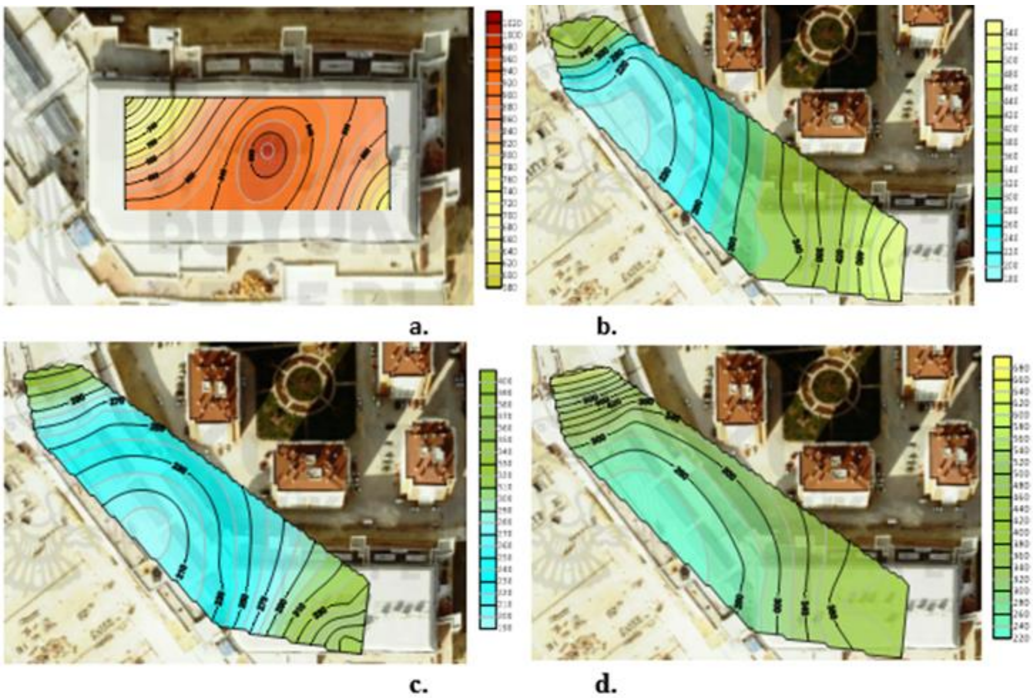

Figure 7. In Novada AVM, summer season is 13.00 a.m. on weekdays. (-1) floor, b. (0) floor, c. (1) floor, d. (2) floor average

At 13.00 on the weekend, PM2.5 concentrations did not show a sharp difference and decreased. Concentrations were found for each coat: minus 640 μg/m³ for first coat, (zero) ground coat 420 μg/m³, first coat 560 μg/m³ and second coat 540 μg/m³. According to the color scale on the particulate matter measuring device, green areas indicate respirable pollution, and as the concentrations increase towards orange and red, it means that the pollution in that environment is dangerous. The maps are shown in Figure 8.

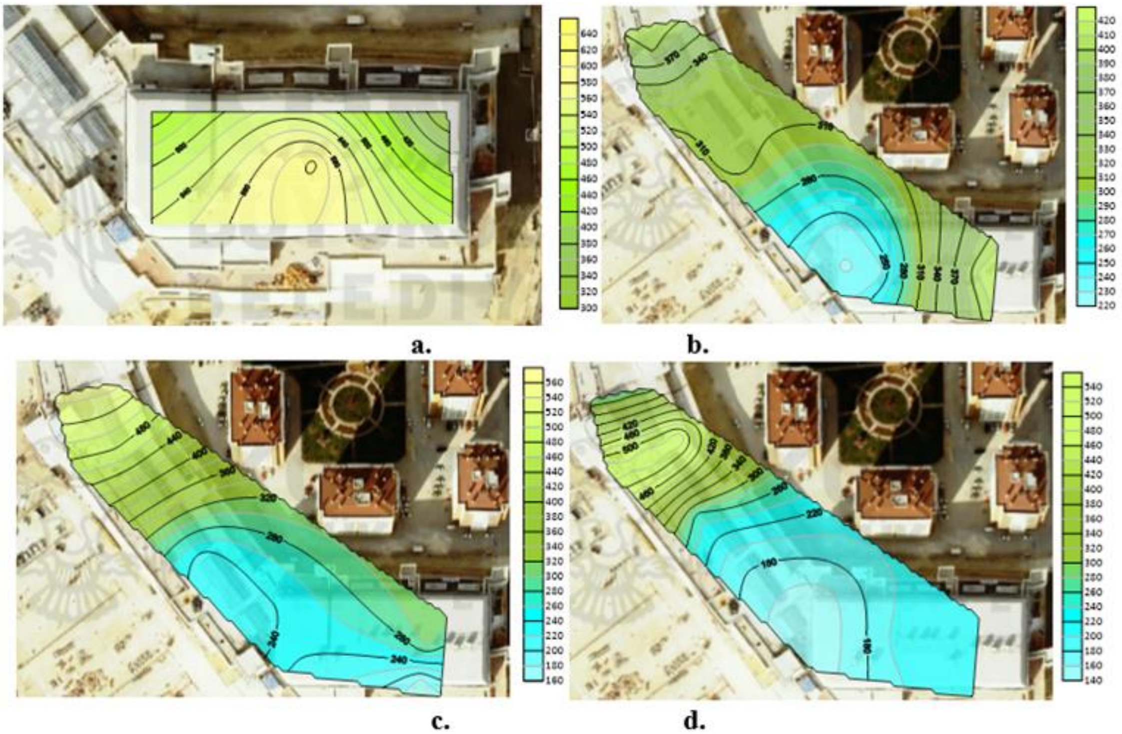

Figure 8. At Novada AVM on summer weekend, 13.00 a. (-1) floor, b. (0) floor, c. (1) floor, d. (2) floor average

The weekday values of the measurements made at 15:00 were found as: minus 1040 μg/m³ for the first layer, 540 μg/m³ for the (zero) entrance layer, 530 μg/m³ for the first layer, and 410 μg/m³ for the second layer, respectively, for each layer. It is similar to the results found at 13:00. The maps are shown in Figure 9.

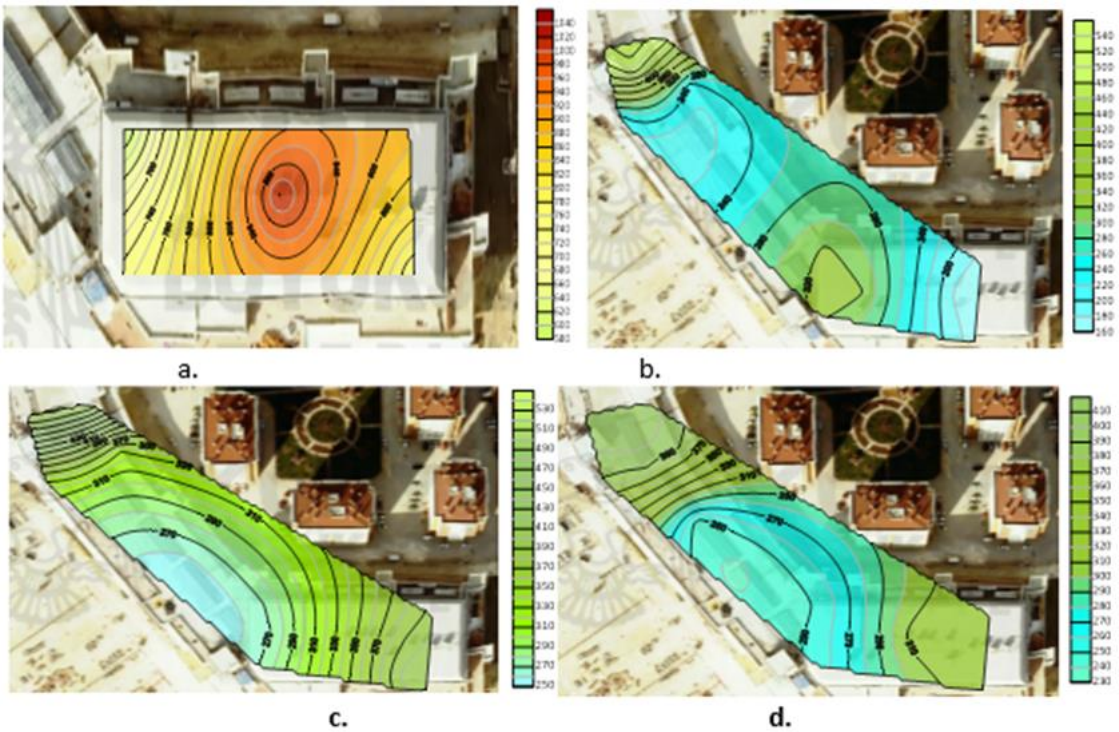

Figure 9. In Novada AVM, summer season is at 15.00 a.m. on weekdays. (-1) floor, b. (0) floor, c. (1) floor, d. (2) floor average

Lower values were found in the results obtained from the measurements made at the end of the week than the results obtained during the week. Concentrations were found for each layer, respectively: minus the first layer 1040 μg/m³, (zero) ground layer 540 μg/m³, first layer 530 μg/m³ and second layer 410 μg/m³. Distribution maps of PM2.5 concentrations are shown in Figure 10.

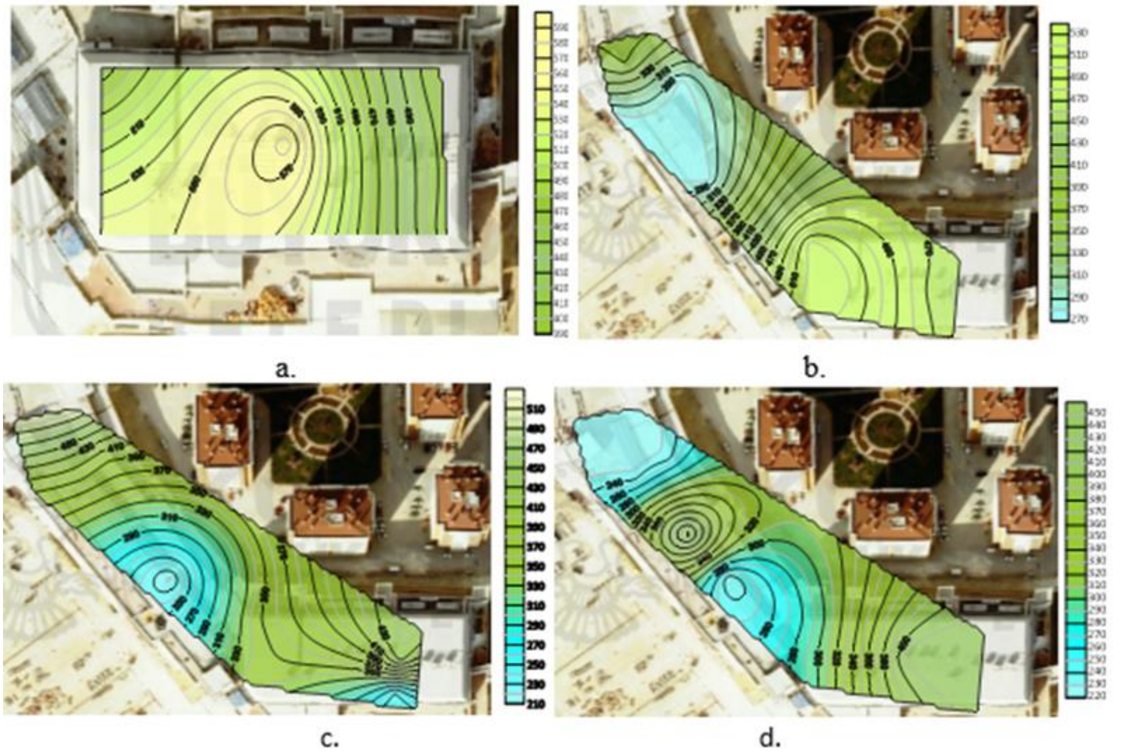

Figure 10. Summer season at Novada AVM at 15.00 a.m. on weekends. (-1) floor, b. (0) floor, c. (1) floor, d. (2) floor average

The weekday results of the measurements made at 17.00 were found as follows for each layer, respectively: minus the first layer was 840 μg/m³, (zero) the ground layer was 780 μg/m³, the first layer was 460 μg/m³ and the second layer was 540 μg/m³. Distribution maps of PM2.5 concentrations are shown in Figure 11.

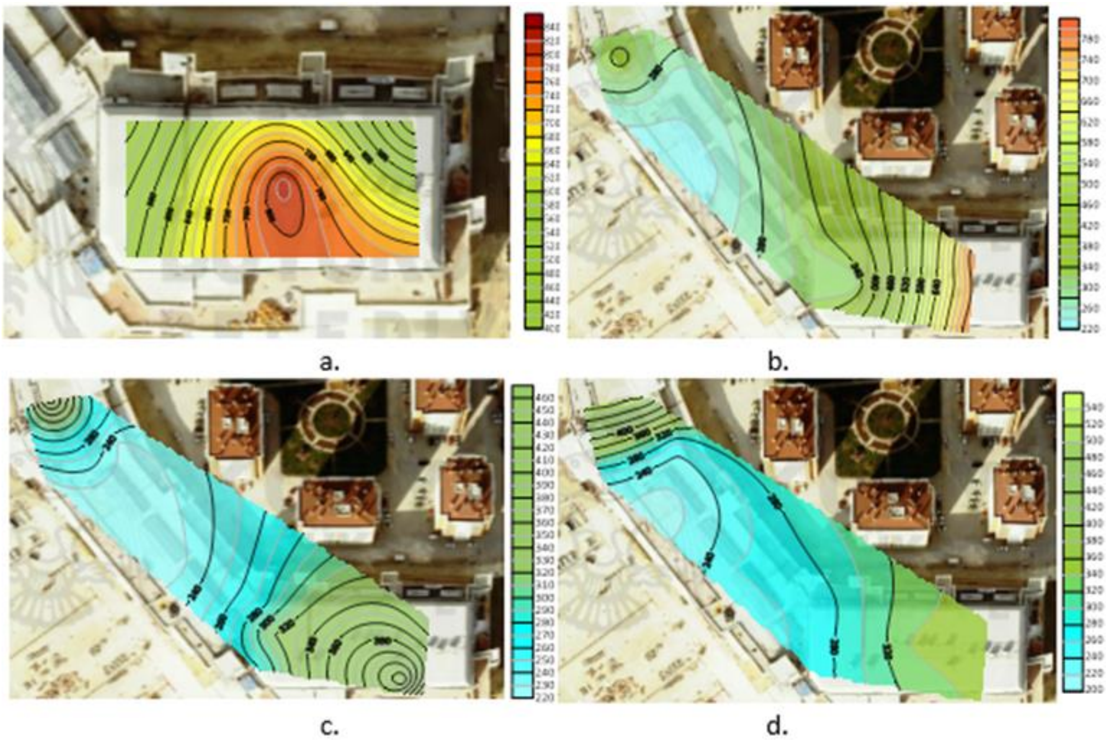

Figure 11. In Novada AVM, summer season is 17.00 a.m. on weekdays. (-1) floor, b. (0) floor, c. (1) floor, d. (2) floor average

The weekend results of the measurements made at 17.00 were as follows: minus 640 μg/m³ for the first layer, 370 μg/m³ for the (zero) ground layer, 560 μg/m³ for the first layer and 315 μg/m³ for the second layer. Distribution maps of PM2.5 concentrations are shown in Figure 12.

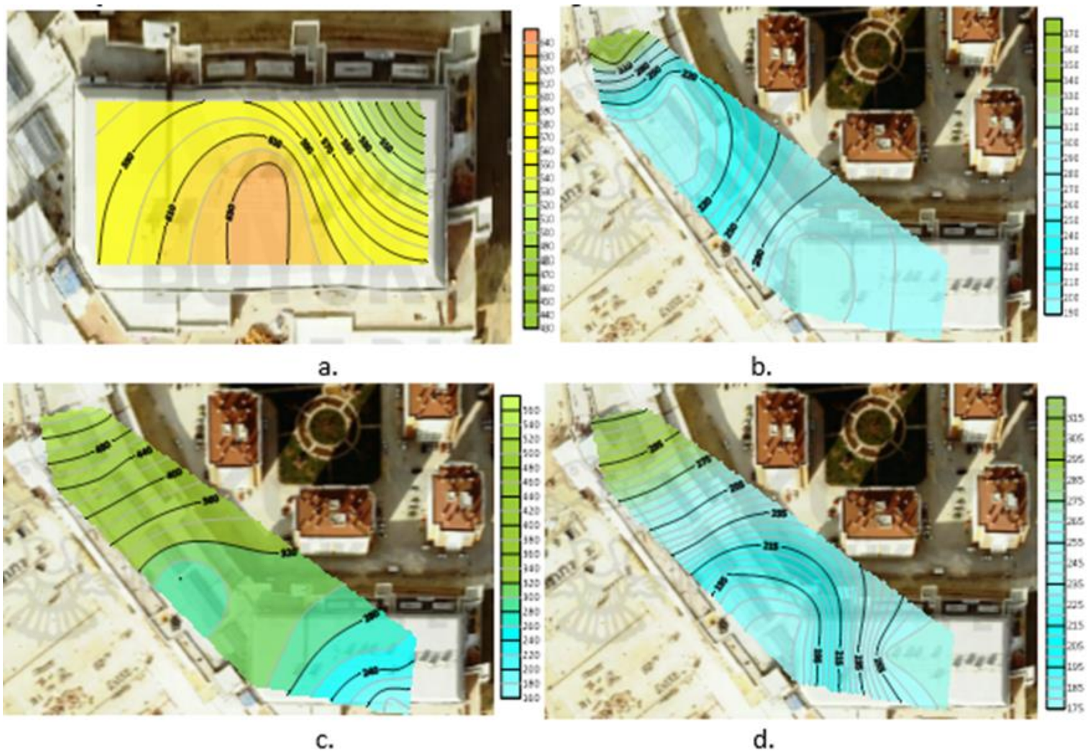

Figure 12. At Novada AVM on the summer weekend at 17.00 a. (-1) floor, b. (0) floor, c. (1) floor, d. (2) floor average

The weekday results of the measurements made at 7:00 pm were found as follows: minus the first floor was 940 µg/m^3, (zero) the ground floor was 520 µg/m^3, the first floor was 580 µg/m^3 and the second layer was 420 µg/m^3. Distribution maps of PM2.5 concentrations are shown in Figure 13.

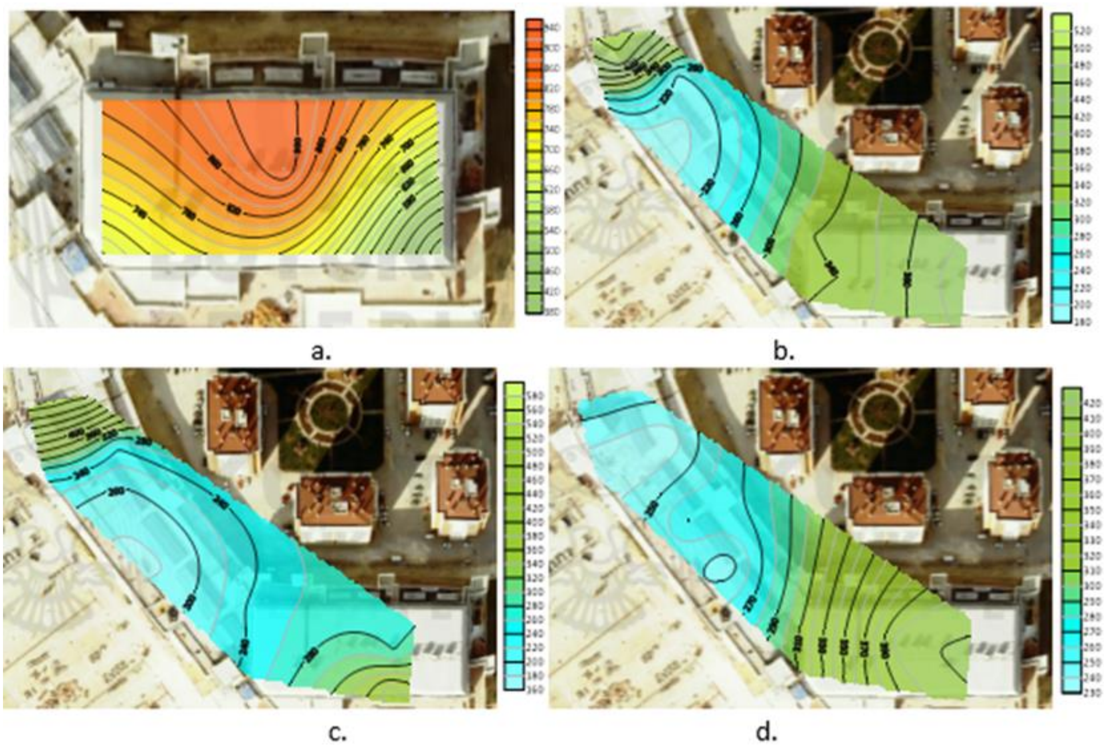

Figure 13. In Novada AVM, summer season is at 19.00 a.m. on weekdays. (-1) floor, b. (0) floor, c. (1) floor, d. (2) floor average

The weekend results of the measurements made at 7:00 pm were found as follows: minus 660 µg/m^3 for the first layer, (zero) ground layer 390 µg/m^3, first layer 360 µg/m^3 and the second layer as 305 µg/m^3. Distribution maps of PM2.5 concentrations are shown in Figure 14.

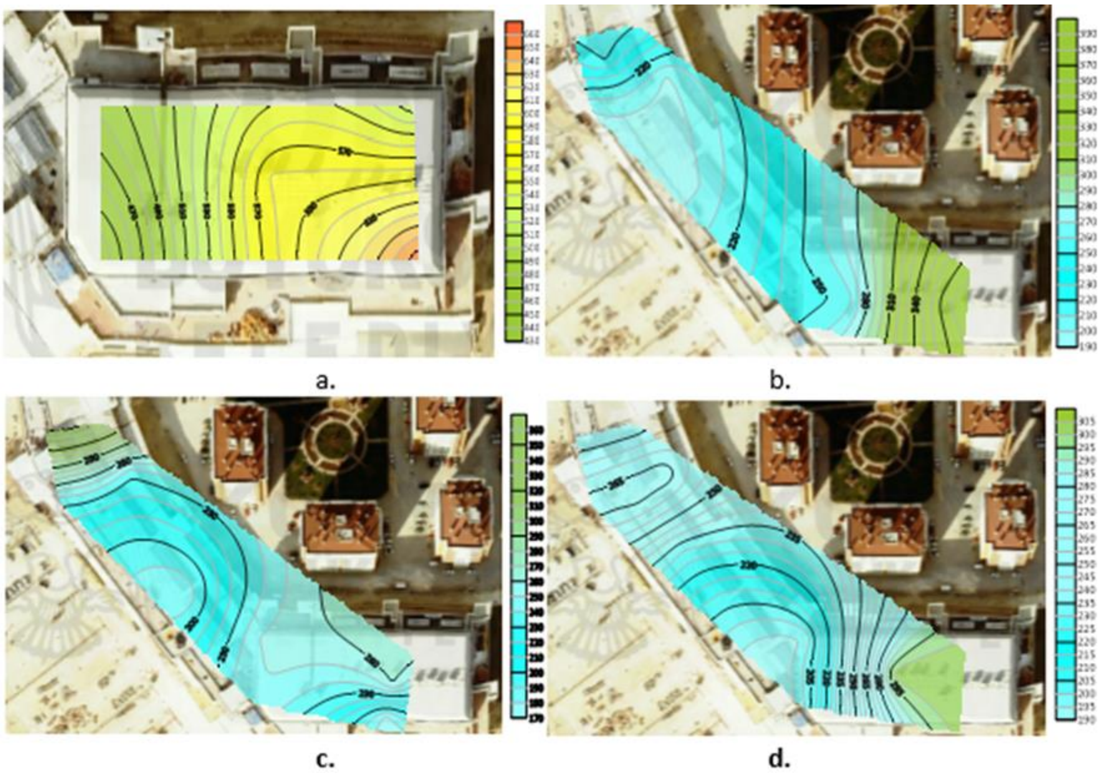

Figure 14. Novada AVM at 19.00 a.m. on the summer season weekend. (-1) floor, b. (0) floor, c. (1) floor, d. (2) floor average

The weekday results of the measurements made at 21:00 were found as follows: minus 1400 μg/m³ for the first layer, 840 μg/m³ for the (zero) ground layer, 1250 μg/m³ for the first layer and 1050 μg/m³ for the second layer. It was observed that the concentrations increased again in the minus first floor. Since the shopping mall was close to closing time, vehicle emissions increased due to the activity in the parking lot, causing PM2.5 values to increase. Rising values were seen on the ground floor, on the first and second floors, on the upper corner of the building. It is thought that the indoor particulate pollution caused by the cooking activities of the restaurants on the second floor is distributed to the first and ground (zero) floors. Distribution maps of PM2.5 concentrations are shown in Figure 15.

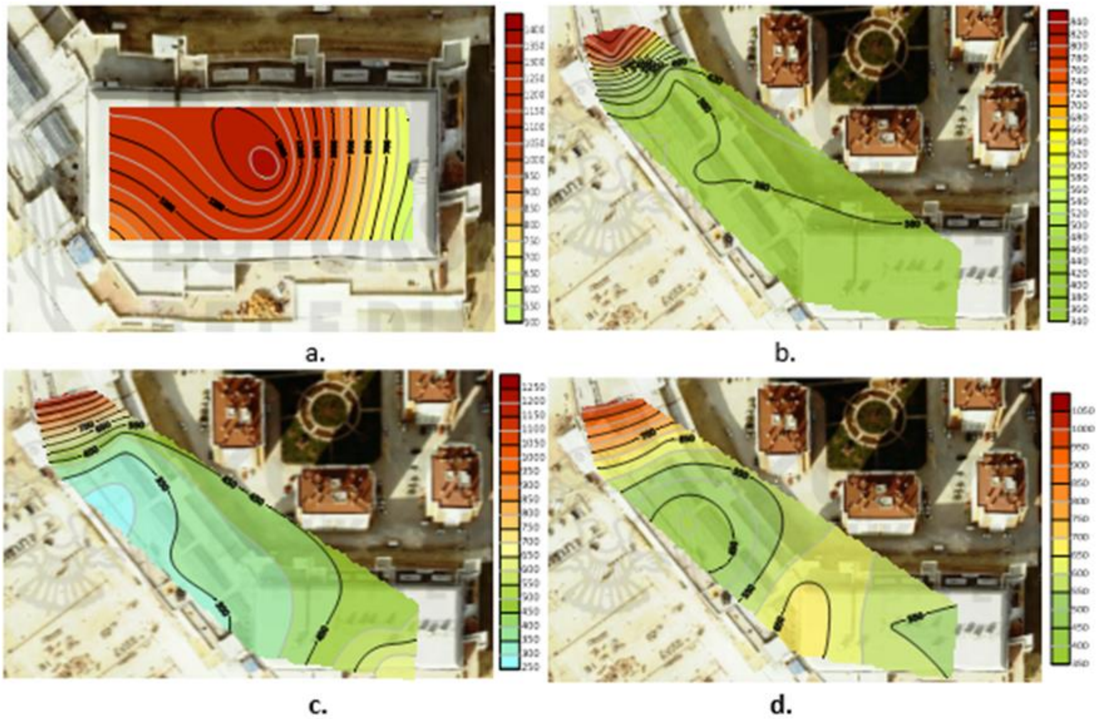

Figure 15. In Novada AVM, summer season is 21.00 a.m. on weekdays. (-1) floor, b. (0) floor, c. (1) floor, d. (2) floor average

The weekend results of the measurements made at 21:00 were found as follows: minus the first floor was 410 µg/m^3, (zero) the ground floor was 345 µg/m^3, the first floor was 450 µg/m^3 and the second floor was 680 µg/m^3. Distribution maps of PM2.5 concentrations are shown in Figure 16.

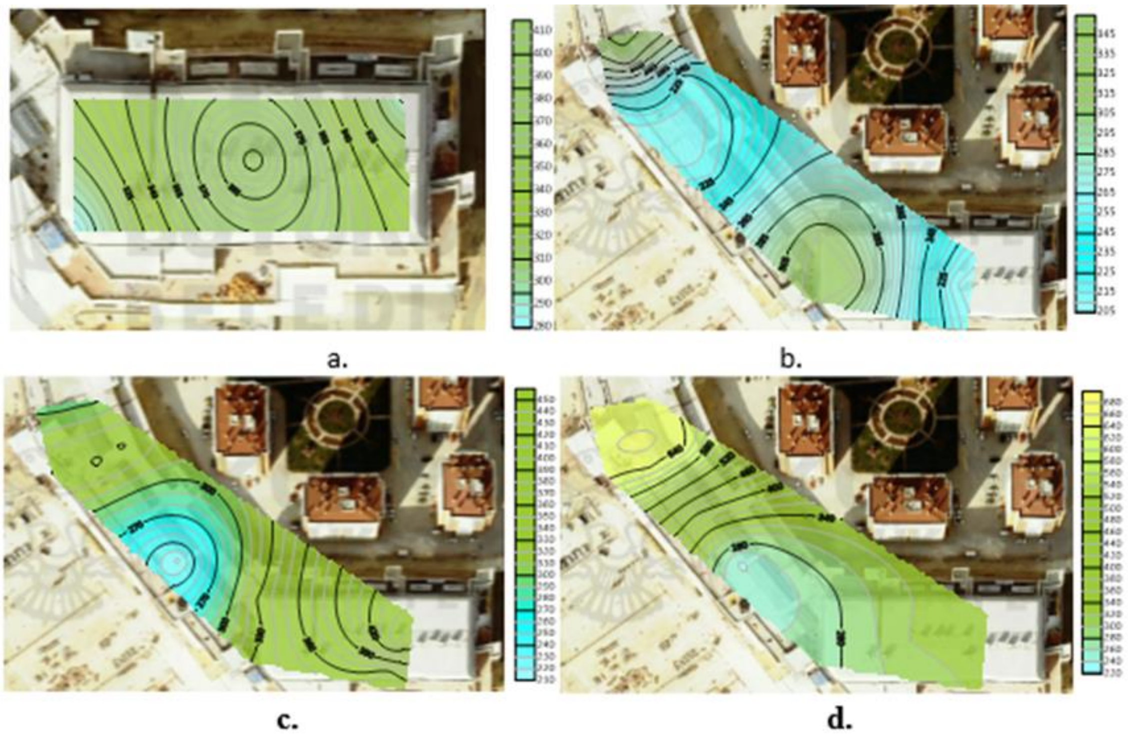

Figure 16. Summer season at Novada AVM at 21.00 a.m. on weekends. (-1) floor, b. (0) floor, c. (1) floor, d. (2) floor average

With a general interpretation, as seen in the maps of the measurements made in Novada AVM during the summer season, PM2.5 concentration averages were found to be higher on weekdays than at weekends. As a result of the measurements made in the summer period, the lowest PM2.5 value is 245 µg/m^3. This value exceeds the hourly 25 µg/m^3 limit set by WHO, EEA and EPA for PM2.5. The standard value for PM2.5 in the air quality assessment management and regulation, which was last updated in 2008 in Turkey, is 200 µg/m^3. The results obtained exceed the HKDYY limit value.

5. Discussion and Recommendations

In this thesis, the importance of indoor air quality, which has started to be noticed in Turkey in the last few years, has been prepared. In this study, which was started in Konya, one of the most important industrial cities of the country, based on shopping centers, particulate matter PM2.5 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 [28]. 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 [29-30]. Novada outlet mall was deemed suitable for the second location. Measurements were made in three separate periods. The first sampling period was carried out between 21.05.2018 - 03.06.2018 in the summer season, the second sampling period was carried out between 24.09.2018 - 07.10.2018 in the autumn season, and the third sampling period was carried out between 25.12.2018 - 07.01.2019 in the winter season. While sampling hours in Novada AVM were held at (09.00-19.00) intervals in all three seasons, they were held at (11.00-21.00) intervals in Novada AVM due to the opening time. How particulate matter PM2.5 affects indoor air quality over three seasons and from what causes it has been examined. 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, the lowest PM2.5 values were found in summer in both shopping malls.

Lower concentrations were obtained in all three seasons in Novada shopping center. Measurements were made on the minus first, entrance, first and second floors of the shopping mall. The highest concentrations were seen in this mall minus the first floor. Opening the only door on this floor where there is no ventilation to the parking garage caused the emissions from the vehicles to spread indoors. The fact that the measurements made in the summer season coincide with the month of Ramadan caused the results to be lower than the weekend values compared to the weekdays. In the autumn and winter measurements, the situation differed, and the weekend averages were generally higher than the weekday results. The fact that the concentrations found in Novada AVM are lower than that of Rainbow is due to the presence of a clean air plant operating here. These power plants, operating on the entrance, first and second floors, changed the indoor air of the building and helped to breathe quality air. In addition, cleaning activities continue throughout the day. High concentrations are mostly in the food layer; It has been found in areas where restaurants and playgrounds are located. This building, which was put into use in 2015, has less pollution reflected in the environment due to the building material and the age of the building.

For people to breathe healthy air in indoor living spaces where people spend 87% of their day, these environments and the ventilation systems, devices and vehicles in them must be maintained by constantly monitoring and controlling in terms of quality atmosphere. For this reason, it is necessary to implement methods that will ensure an acceptable indoor air quality in shopping malls. These methods are respectively.

• Removal of the source affecting the environment,
• Making central ventilation systems according to standards suitable for the environment in which they will be used, using them appropriately and maintaining them at regular intervals,
• It is recommended to take precautions against smoking in closed environments.
Moreover, Universities should organize lectures, symposiums, and educational seminars in educational institutions about the importance of indoor air quality and its effects on health.

Due to the lack of standards determining indoor air quality in Turkey until today, it is recommended that the relevant institutions act as soon as possible to establish standard values for this air, which has a direct impact on the health of living things.

It should be ensured that the parameters determining the air quality in all provinces of Turkey are measured and modeling maps are created.

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Author contributions

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

Conflicts of interest

The authors declare no conflicts of interest.

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