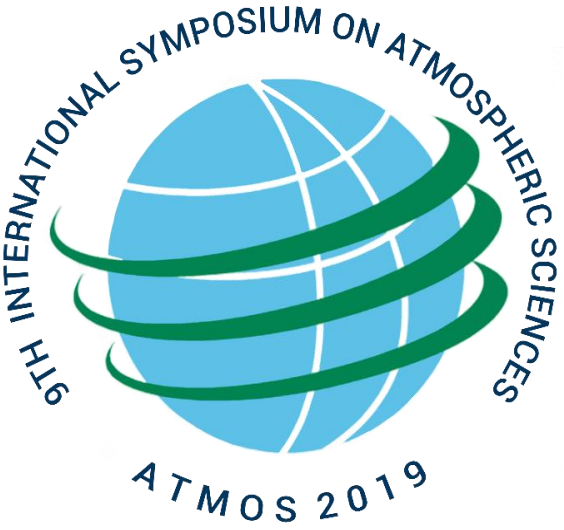

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Evaluation of PM10 Behaviour In Iğdır

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ABSTRACT

Air pollution is one of the significant problems that are faced by humanity. The main reasons for air pollution that are more active in the cities are that human activities such as industry, transportation, and heating are seen as more intense in the cities. World Health Organization emphasized that air pollution values are above the recommended limit values for health and outdoor air pollution has affected the death of more than 4 million people every year. In the change of the air pollution values in the cities at time and space scale; human activities, geographic structure of the settlement and meteorological variables play a role. In this study, hourly data of PM10 values that are measured by the Ministry of Environment and Urbanization in Iğdır province between 2014-2019 were investigated. The behavior of data was examined according to the years, months, days and its behavior in the day. Particularly in the evening, the density of PM10 increases in Iğdır. Sharing of the PM10 intensity behavior with researchers, administrators and residents of the region will contribute to facilitating for the solution of the problem. When the behavior of the parameters of air pollution data is examined, the revealed result is tried to explain to the researchers both with topography, meteorological variables and with human activities in the later studies to clarify the main components of the air pollution in the city. The results are thought to shed light on the other researchers.

Keywords: *Iğdır, Air Quality, PM10, Health*

INTRODUCTION

The airborne pollutants rates have rapidly increased because of the total number of vehicles in transportation, the use of poor quality fuel, unplanned settlement, dust from the roads, high tree cutting rates, insufficient planting trees and the rapid increase of the industry since the French Revolution. Air pollution caused by pollutants has extremely critical impacts on the health of living things. The concentration of pollutants in the air is determined by the rate of gas released to the atmosphere, the amount of particulate matter, the rate of solar radiation from meteorological factors, mixing ratio, pressure, fog, temperature inversion, and the moisture parameters. PM_{10} (Particulate Matter), SO_2 (Sulfur Dioxide), Heavy metals, PAHs (Polycyclic Aromatic Hydrocarbons), PCB, Various VOC (Volatile Organic Substances), CO_X (Carbon Monoxide), NO_X (Nitrogen Monoxide), O_3 (Ozone) etc. substances are hazardous substances released into the atmosphere from pollutant sources (Kadıoğlu, Toros, Bayraktar and Çavuş, 2016). The air pollution problem that is one of the serious issues facing humanity is not only local and regional but also a global one (WHO, 2018). This issue has also negative influences on the ecosystem, these impacts have been emphasized as a result of the studies carried out worldwide and in our country. Besides, these effects lead to material and moral losses. In the result of concentration of air pollutants, pollutants have demonstrated more toxic and carcinogenic properties. Therefore, living health is under threatened, and vital losses also take place (Kadıoğlu et al., 2016). Air pollution causes to reach serious proportions the socio-economic losses on a global scale. According to the World Health Organization 2018 study reports, air pollution cause life of 12.6 million people more than %90 percent of people living in urban are under the threat. In particular, more than 90% of people living in the city are at risk for health because of breathing of dirty air. Every

year 7 million people die because of air pollution. This ratio higher in undeveloped countries. Air pollution has a negative impact on the living comfort of all alive. Particularly, there are many air pollutant sources in the big cities. Therefore, when air pollution rate in the air is high, it poses a vital danger to living things. It is known that air pollution gives rise to the most deaths such as heart attacks, strokes, chronic bronchitis and acute respiratory infections, specially in big cities where air pollution sources are high (Toros, 2019).

Air pollution in Turkey generally is occurred by heating, industry and motor vehicles. It has reached serious levels from time to time due to the excessive consumption of fossil fuels such as petroleum, coal (low-quality lignite) particularly in the big cities. Istanbul, Ankara, and Izmir are big cities of Turkey, where the population rate, number of buildings and traffic rate are excessively high. In Turkey, particulate matter (PM) is a major air pollutant, it continues to threaten human health, especially due to meteorological conditions. According to the 2015 statistics, particulate matter that have occurred by the reason of could cost at least 4 times than traffic accidents and also tens of times in earthquakes (Kadıoğlu et al., 2016). Meteorological factors and topography are 2 sources of local sources that can exceedingly impress the spatial and temporal variability of particular matters (Unal et al., 2011). Alteration in pollutant concentration in a region not only depends on the amount of pollutants released into the atmosphere, but also on meteorological conditions and topography factors. The concentration of the pollutants in the air determine air quality (Toros et al., 2018). Initially, air pollution should be measured to reduce the socio-economic losses of its. T.C. Ministry of Environment has significantly enhanced its measurement network in recent years. Since air quality varies according to the meteorological variables and the topography, evaluation of measurement data under meteorological and topography conditions is extremely significant.

The number of vehicles is quite high with the influence of receiving too much migration. Although Iğdır province was an established later on 27 May 1992. These vehicles also pollute the ambient air. In Iğdır region is not industrial area therefore there is no industrial emission inventory in there. While 13 fuel oil (LPG, auto gas) stations are exempted from emission permits due to their low capacity, there are 20 facilities subjected to emission permits. Not only unplanned urbanization in Iğdır but also the use of wood, coal and fuel-oil for heating plays an significant role in the increase of air pollution. From 2017 year, 12000 out of 22000 apartments has started to use natural gas (Aras and Tekay, 2018).

Iğdır is one of the cities where air pollution is seen intensively under the meteorological and topographic influences in Turkey. There is the low air quality in the Iğdır and its air quality decreases day by day. Also; it is one of the provinces with the highest rate of deaths due to air pollution in 2017 to province-based deaths (Hava Kirliliği ve Sağlık Etkileri Kara Rapor, 2019). Special meteorological conditions take place in the this region, since Iğdır is surrounded by mountains. This situation creates unique atmosphere in the Iğdır province, also the specific meteorological factors of Iğdır play an crucial role in the alteration of air pollution intensity. Wind speed and direction are crucial meteorological parameters in transporting and decreasing the density of polluted air. It was observed that as a result of the study by using various analysis programs, air pollution approached the limit values and in some days it exceeded the limit values when there was no strong northern winds. Furthermore, the air pollution in Iğdır differs from the other provinces thanks to the topography it has (Toros, 2019).

This study aims to determine the source of air pollution in order to provide a healthy and quality habitat for people living in Iğdır. When we designate the source of air pollution, we can both prevent air pollution and provide clean air with high air quality. It is expected that this study will contribute both the air quality study in the Iğdır region and evaluation data of air pollution in other cities.

DATA AND METHOD

Pollutants data and meteorological parameters data were used in this study. PM_{10} (particulate matter) and SO_2 pollutants measurements data were taken from T.C. Ministry of Environment and Urbanization between January 01, 2014 and July 17, 2019 dates. In addition, meteorological

parameters, which are temperature (T), total precipitation (P), humidity, wind speed and direction measurement values data were obtained from T.C. Ministry of Agriculture and Forestry General Directorate of Meteorology between January 01, 2014 and July 17, 2019 dates. Besides, an inventory of emissions that are come from industry, traffic, heating and dust on the roads was obtained for Iğdır from Turkish Statistical Institute (TUIK).

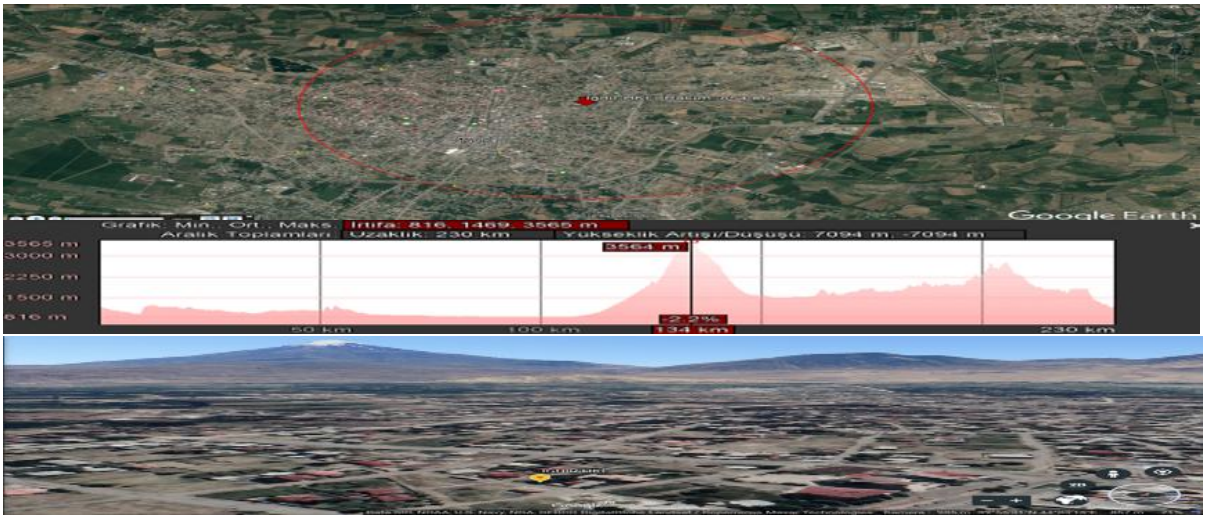

Figure 1. Study area topography and Air Quality Station in Iğdır

In this study; R program is used for the analysis of air pollution rate on Iğdır. Pollutant values of Iğdır Air Quality Measurement Stations were analyzed not only by statistical methods but also relationship between the air pollutants and the measured meteorological parameters. Analyzation of pollutant not only in terms of meteorological but also in terms of contaminants was made by use of R program and Open-air package. R program, with regards to the statistical analysis, is highly reliable program. We obtain information on the air pollution rate which time it is high from the graphics that we acquire through the program. They analyzed between January 01, 2014 – July 17, 2019 in order to designate the external air pollution level in Iğdır province. Limit values of pollutants are determined and shown as graphically by using R programme. Moreover, "Air Quality Indexes" (Figure2) were used to determine the daily air quality levels.

AQI Category, Pollutants and Health Breakpoints								
AQI Category (Range)↓	→ Categories for the various readings of the pollutant based on the health breakpoints or health impacts							
	PM_{10} 24-hr	$PM_{2.5}$ 24-hr	NO_2 24-hr	O_3 8-hr	CO 8-hr (mg/m^3)	SO_2 24-hr	NH_3 24-hr	Pb 24-hr
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.5 –1.0
Moderately polluted (101-200)	101-250	61-90	81-180	101-168	2.1- 10	81-380	401-800	1.1-2.0
Poor (201-300)	251-350	91-120	181-280	169-208	10-17	381-800	801-1200	2.1-3.0
Very poor (301-400)	351-430	121-250	281-400	209-748*	17-34	801-1600	1200-1800	3.1-3.5
Severe (401-500)	430 +	250+	400+	748+*	34+	1600+	1800+	3.5+

*One hourly monitoring (for mathematical calculations only)

Figure 2. AQI category, pollutants and health breakpoints & air quality index (National Air Quality Index and smnewsnet.com)

We generated various graphics by using R programme. First of all, pollutant data (PM_{10}, SO_2) changes were determined in accordance with values that are not only under average pressure but also upper average pressure, times that were rainy days and dry days and times that are high winds and breeze. We demonstrated alteration of pollution levels from obtained graph. We also observed previously mentioned subject how affect air pollution levels. Graphics that we obtained according to high

pressure, low pressure, rainy days-dry days and windy days and windless days are time change graph of PM_{10} and SO_2 data for values under average pressure (Figure4), time change graph of PM_{10} and SO_2 data for values above average pressure (Figure5), hourly change PM_{10} and SO_2 data (Figure6-Figure7), seasonal winds obtained from wind data in the days below the average pressure (Figure8), PM_{10} and SO_2 dirty calender for 2014-2019 years (Figure9), PM10 and SO2 monthly average time series graph only created in rainy times (Figure10), PM10 and SO2 monthly average time series graph created only for not rainy times (Figure11) PM10 and SO2 monthly average time series created 5 hours after rain (Figure12).

In addition; in this study, dispersion models were used to understand at which time intervals of air pollutants are present. The modeling method is of strong support for fresh air plans. With this method, it can be determined how the pollutants emitted by the existing pollutant sources that will be distributed, as well as what kind of air quality deterioration of the facilities that are currently in the plan or project stage will be established. Thus, it can be evaluated whether the facility will be established in that region or its alternatives. In Iğdır, measurements were made at 10 different points between 2-16 July 2019 to model the spatial distribution of air pollution. The measurements were made by a certified company. Moreover, not only Kriging interpolation method (Best Intermediate Value Calculation) but also Inverse Distance Weighting (IDW) Interpolation were used. Kriging method is the most widely used method for interpolation of spatial data. Most spatial distiribution software uses Kriging method as the predefined method. By using this method, same alteration curves can be obtained effectively from the irregular scattered data. This method is also evaluate inclination in data. By using suitable variogram program model, it can develop a suitable model for all data. Kriging method in the simplest term:

$$Z = \mu + \varepsilon \tag{1}$$

Z: Predicted value, μ: constant mean, ε: spatial dependency errors

IDW is a geo-statistical based-method used for positional estimation. Also, it is an interpolation method based on the weighted average of the data. IDW that is used for requirement of softened and fast result is produce a result with mathematical operations (Toros et al., 2018).

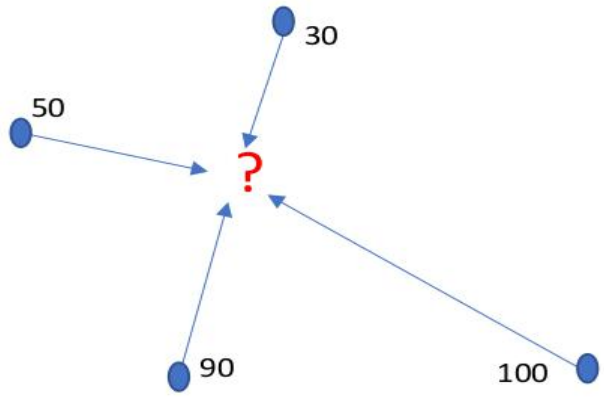

Figure 3. Obtaining the value at one location from the values at the other measured points (Toros et al., 2018)

IDW depend on the distance of near point to the examined region is more heavy than far point (Figure3). According to weighted mean , it calculates a surface intermediate value.

In addition to all this, backward Hysplit Trajectory Model was run for Iğdır province and Aralık district for 3 days backward to able to understand the air pollutant sources. Also, sample neighborhood design was made for Iğdır province. Reducing air pollution brings about the redesign of cities for the happiness of the inhabitants. Topography and meteorological conditions are among the factors that

adversely affect Iğdır's air pollution. Owing to contribute to the reduction of air pollution in Iğdır, a new neighborhood design has been proposed instead of the existing agricultural lands on less productive lands. The ecological system was taken into consideration in the draft and considering the flow of mountain - valley breezes, the city's continuous ventilation was considered. Furthermore, neighborhood and housing design are based on environmental and human life sustainability (Figure 18 and Figure 19).

RESULTS

Table 1. Statistical analysis of Iğdır province center

Type	NM	DP	Min.	%25	Mean	OD	%75	Max.	SD
Wind speed	48575	93	0	0.5	1.1	0.9	1.5	11.8	0.9
Temperature	48575	100	-19	4.9	13.6	13.8	22.5	41.1	11.3
Moisture	48575	99	2	39	56.9	55	75	99	21.5
Pressure	48575	99	899.9	913.5	917.9	917.2	921.8	938.1	5.9
Precipitation	48575	99	0	0	0	0	0	12.4	0.2
PM_{10}	48575	93	1.2	42.6	114.5	72.5	136.9	1108.2	118.3
SO_2	48575	77	1	4	10	6.7	11.4	194.8	11.5
NO	48575	46	1	2.8	11.8	4.3	10.9	1341.9	23.8
NO_2	48575	55	1	12.4	28.9	22	41.5	163.7	21
NOX	48575	55	1.5	14.8	38.4	25.9	52.5	1375.8	36
O_3	48575	59	1	16.9	42.4	40.3	63.8	231.5	28.8

Explanation: NM: Number of measurements, DP: Percentage of daily data acquisition, Min.: Minimum Value, 25%: 1st quarter value, Mean: Average, OD: Average value, 75%:3rd quarte value, Max.: Maximum value, SD: Standard deviation

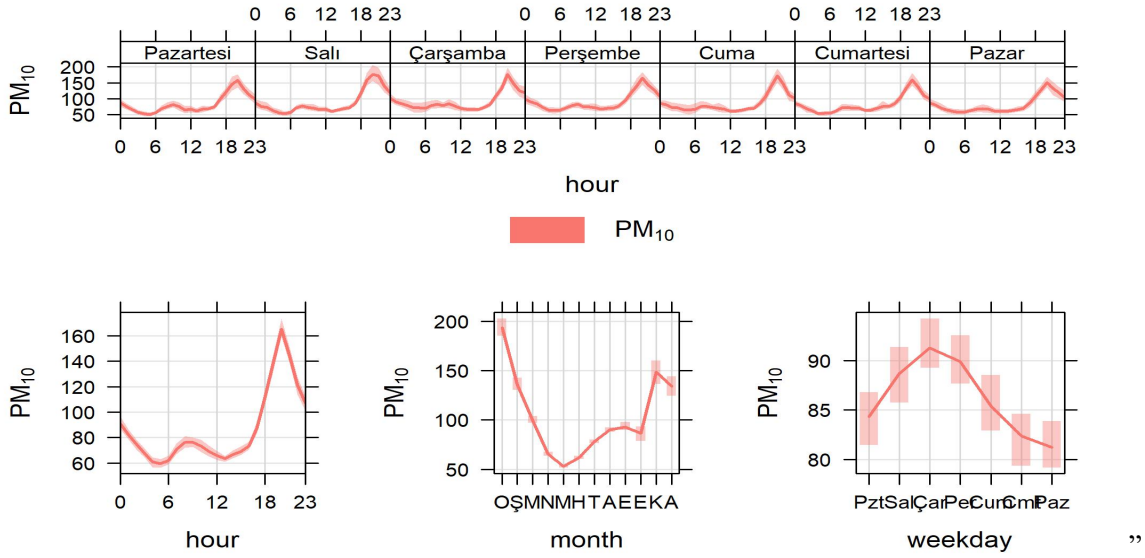

Figure 4. Time change graph of PM_{10} data for values under average pressure in the center of Iğdır

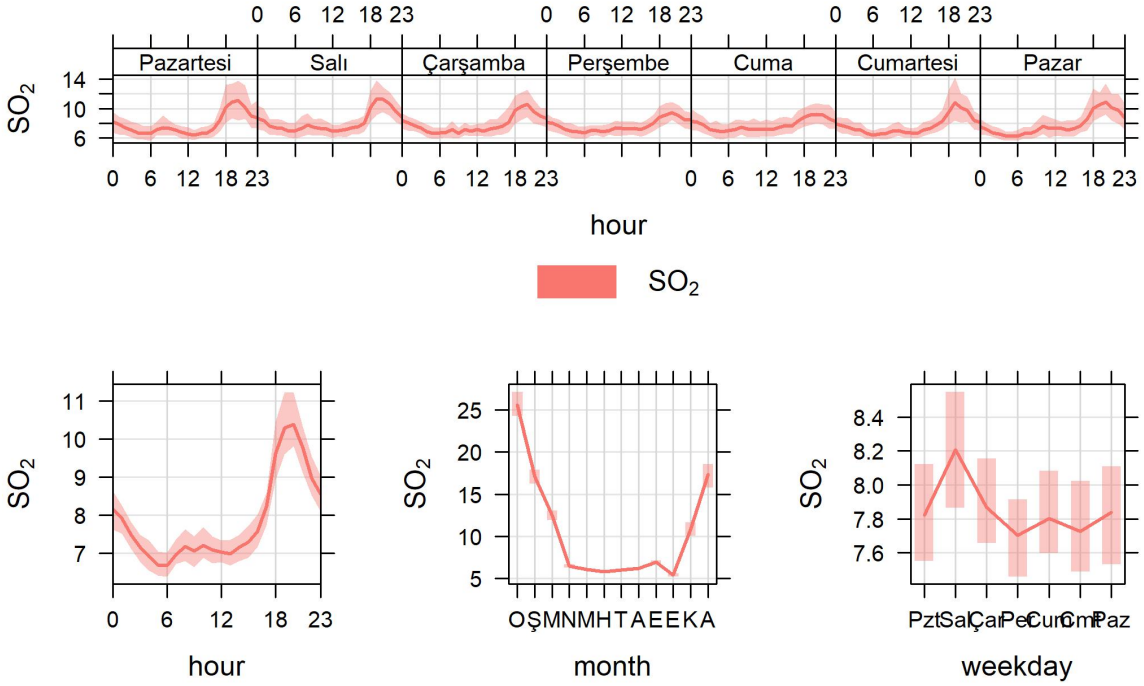

Figure 5. Temporal change graph of SO_2 data for values under average pressure in the Iğdır center

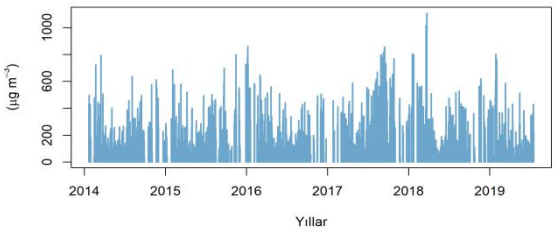

Figure 6. Hourly change PM_{10} data for the values center under average pressure in Iğdır center between between 2014-2019 years

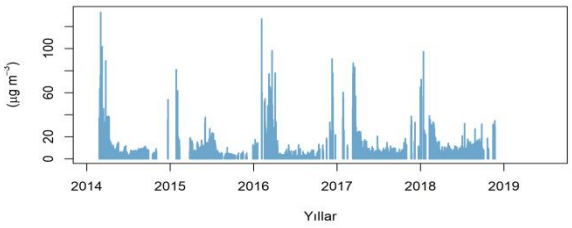

Figure 7. Hourly change SO_2 data for the values under average pressure in Iğdır between 2014-2019 years

When pressure is below from the average pressure, maximum value of PM_{10} is seen 200 µg/m³ in January that is colder than other months. Pollution rate have taken place high values between at 18:00 and 23:00 hours. PM_{10} values at night are almost 200 µg/m³ (Figure4). In addition, PM_{10} took maximum value in 2018 year (Figure6). Maximum value of SO_2 is nearly 26 µg/m³. It has obtained maximum value between at 18:00 and 23:00 hours. This means that people used coal, fuel oil for heating in the winter.

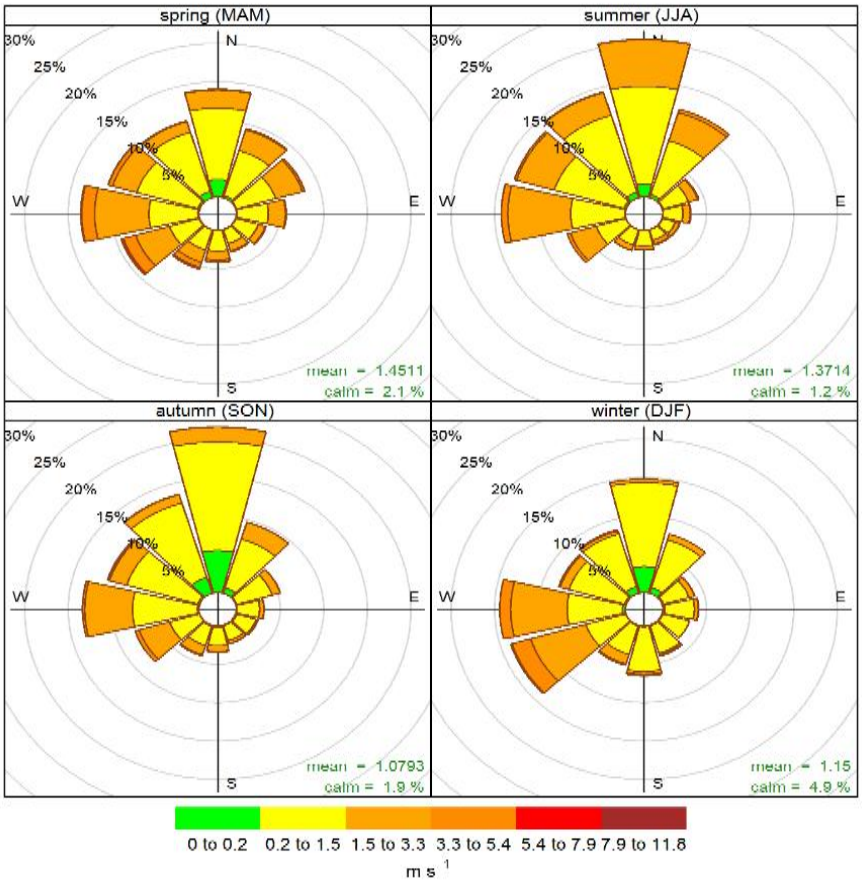

Figure 8. Seasonal winds obtained from wind data in the days under the average pressure between 2014 and 2019 in Iğdır center

First predominant wind direction is south. Second predominant wind direction is west (Figure 8).

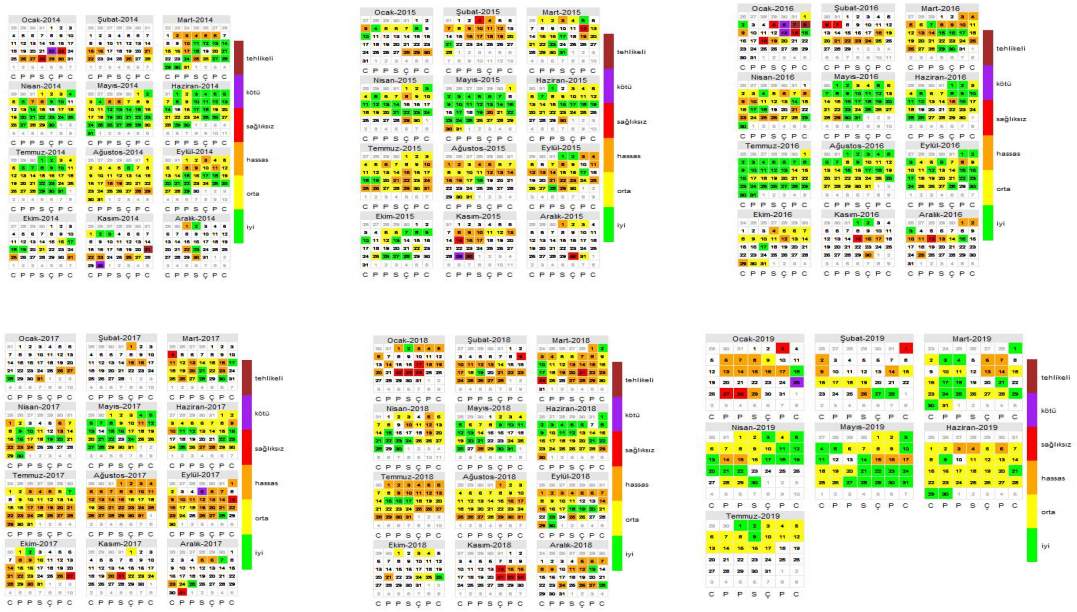

Figure 9. PM_{10} dirty calender for values under average pressure in the Iğdır center for 2014-2019 years

When pressure is low, vertical movement in the air is surplus. Therefore, pollution has dispersed in low pressure days. We can see that only 7 days are very unhealthy. Other days are more healthy (Figure9).

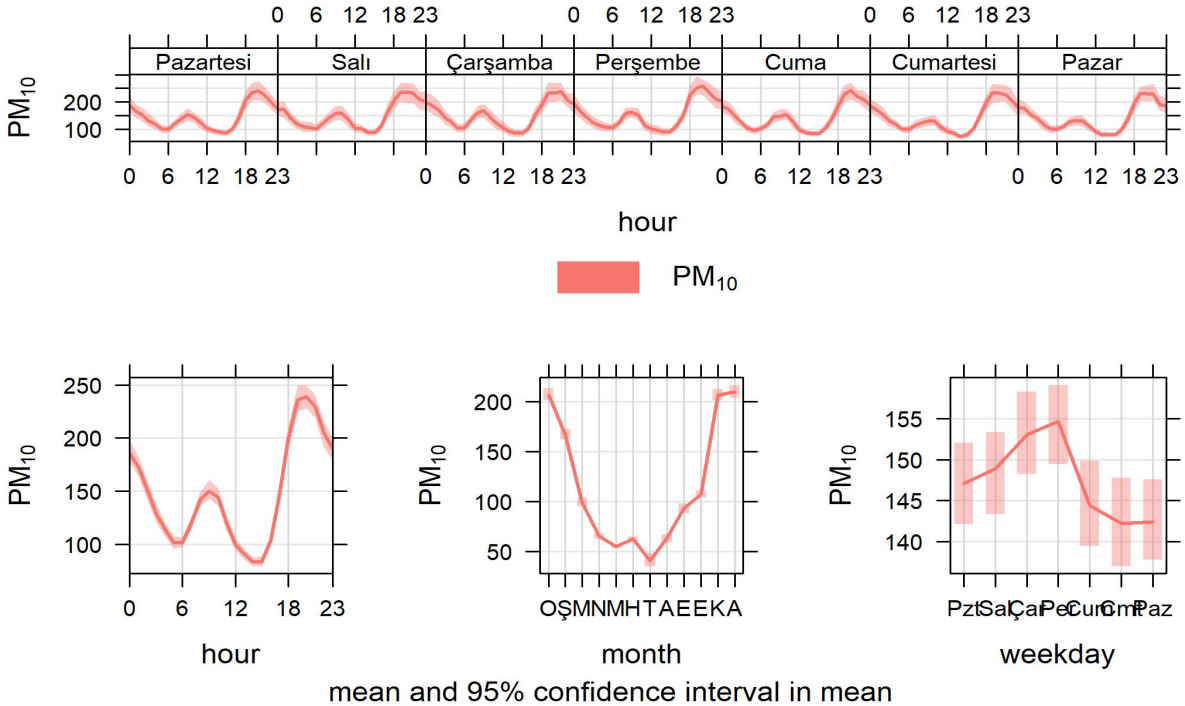

Figure 10. Time change graph of PM_{10} data for values above average pressure in the center of Iğdır

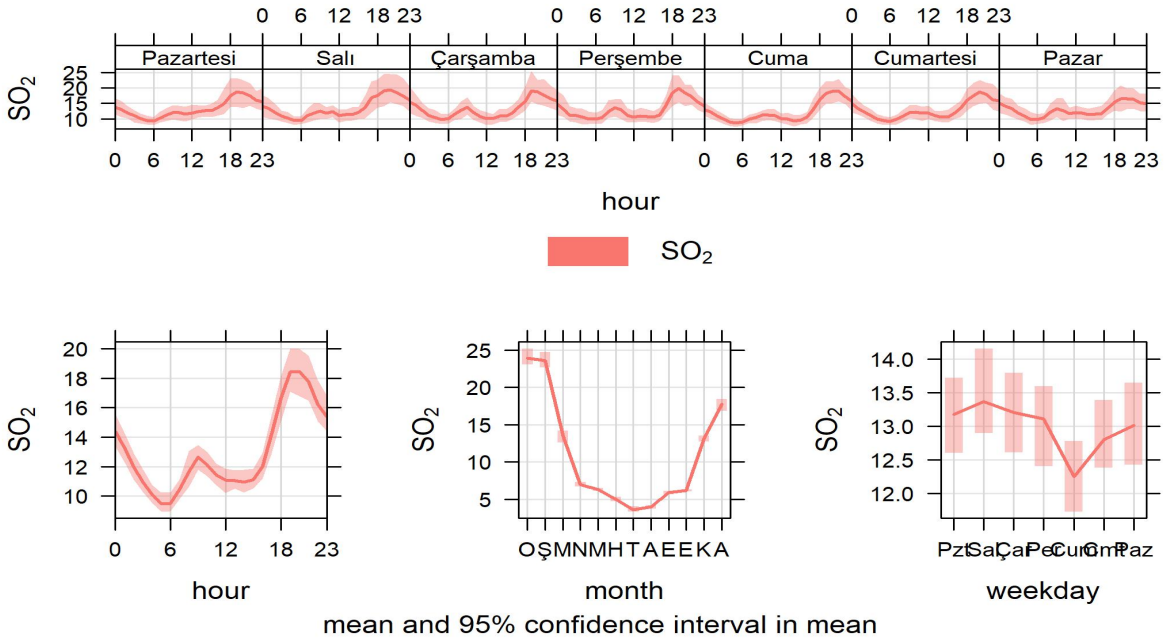

Figure 11. Time change graph of SO_2 data for values above average pressure in the center of Iğdır

When pressure is above from the average pressure, maximum value of PM_{10} is seen between (200 - 250) µg/m³ in January and December months. Pollution rate have taken place high values morning times and evening times. PM_{10} values at night are almost 250 µg/m³ (Figure10). Maximum value of SO_2 is nearly 25 µg/m³. It has obtained maximum value at 00:00 and 06:00 hours and 18:00 and 23:00 hours. This means that people used coal, fuel oil for heating in the winter.

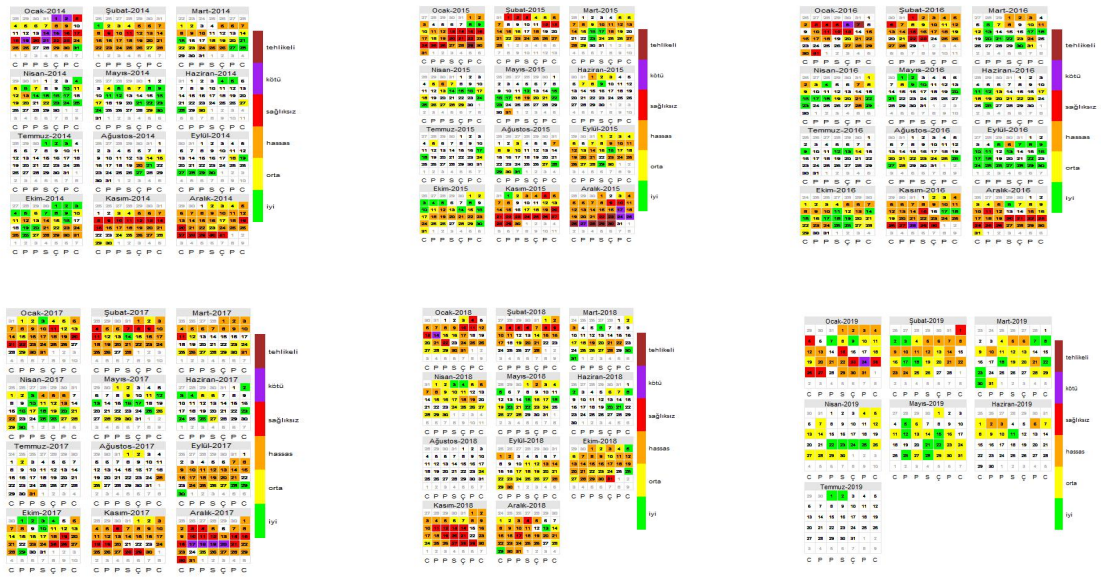

Figure 12. PM_{10} dirty calender for values above average pressure in the Iğdır center for 2014-2019 years

When pressure is high, there is no movement in the air. Therefore, pollution has not dispersed in high pressure days. We can see from the calender that 6 days are hazardous days. 18 days are very unhealthy. Winter months are unhealthy (Figure9).

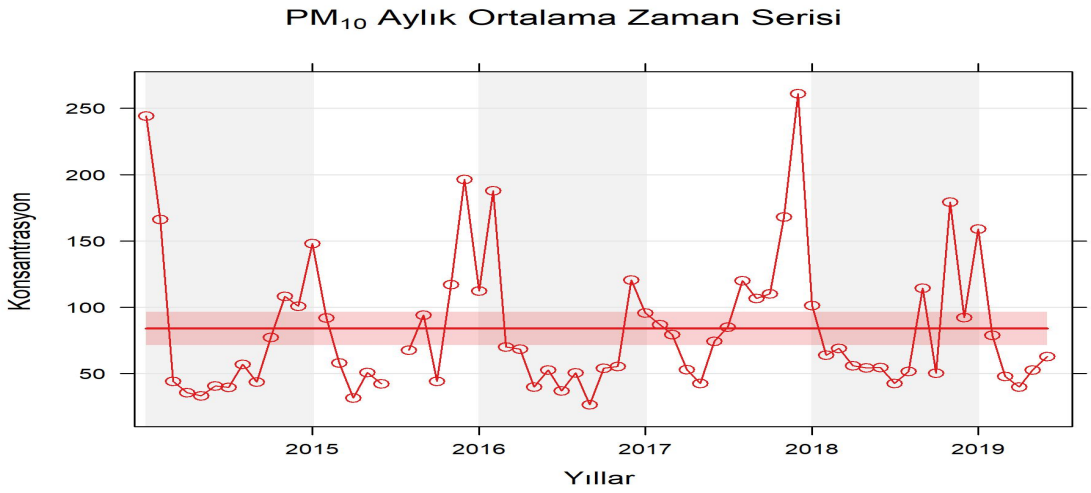

Figure 13. PM_{10} Monthly average time series graph created only in rainy times

When we look at PM_{10} Monthly average time series graph created only in rainy times, PM_{10} average values change 70-100 µg/m³. Rain can disperse air pollution (Figure13).

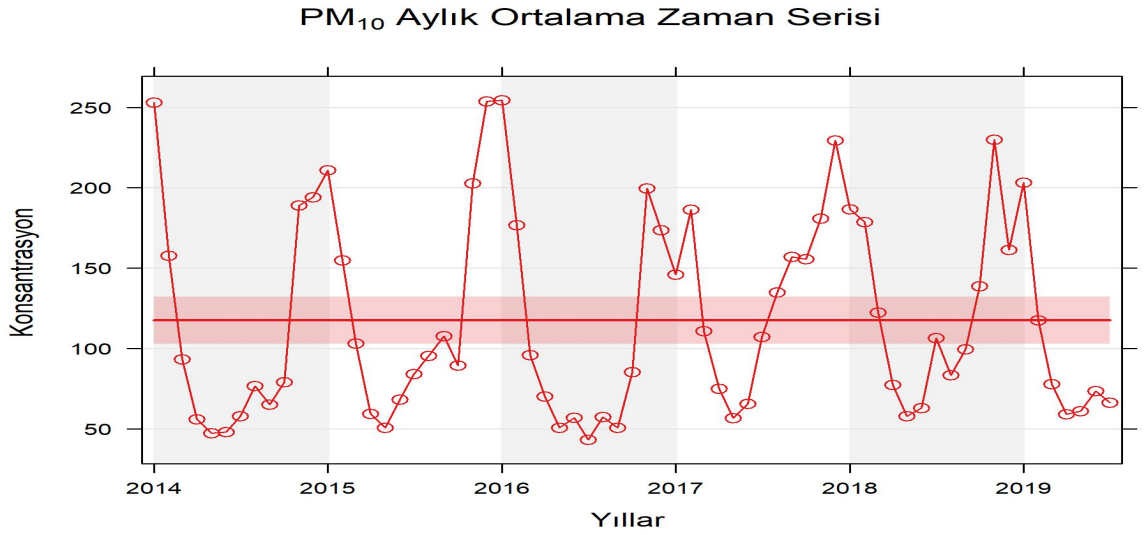

Figure 14. PM_{10} monthly average time series graph only created for not rainy times

When we look at PM_{10} Monthly average time series graph created only for not rainy times, PM_{10} average values change 100-130 µg/m³ (Figure14).

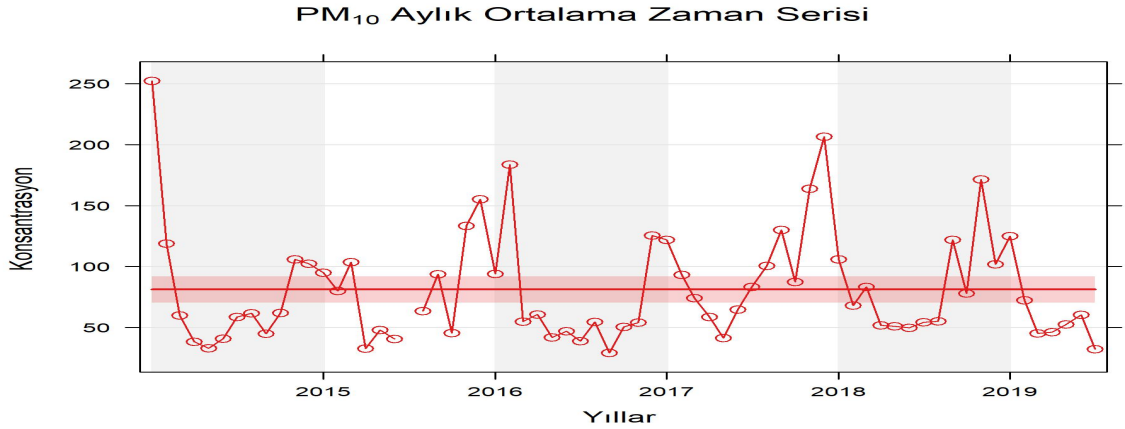

Figure 15. PM_{10} monthly average time series graph created 5 hours after rain

When we look at PM_{10} Monthly average time series graph created 5 hours after rain, PM_{10} average values change 90-65 $\mu g/m^3$ (Figure15).

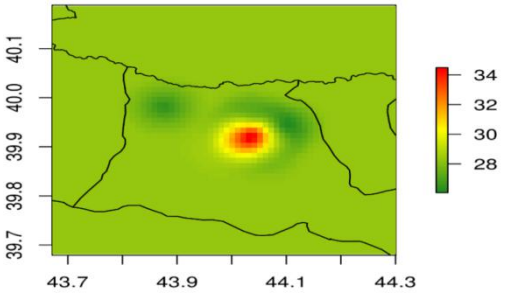

Figure 16. Distribution of PM_{10} values measured measured at 10 different points by Kriging method weighted

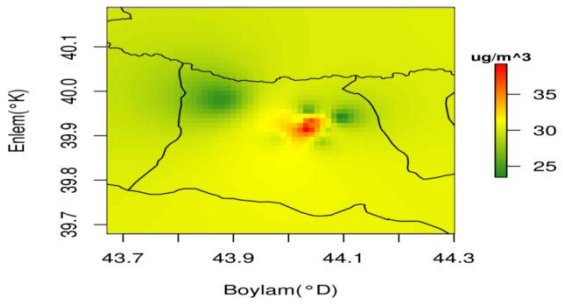

Figure 17. Distribution of PM_{10} values at 10 different points by inverse distance interpolation method

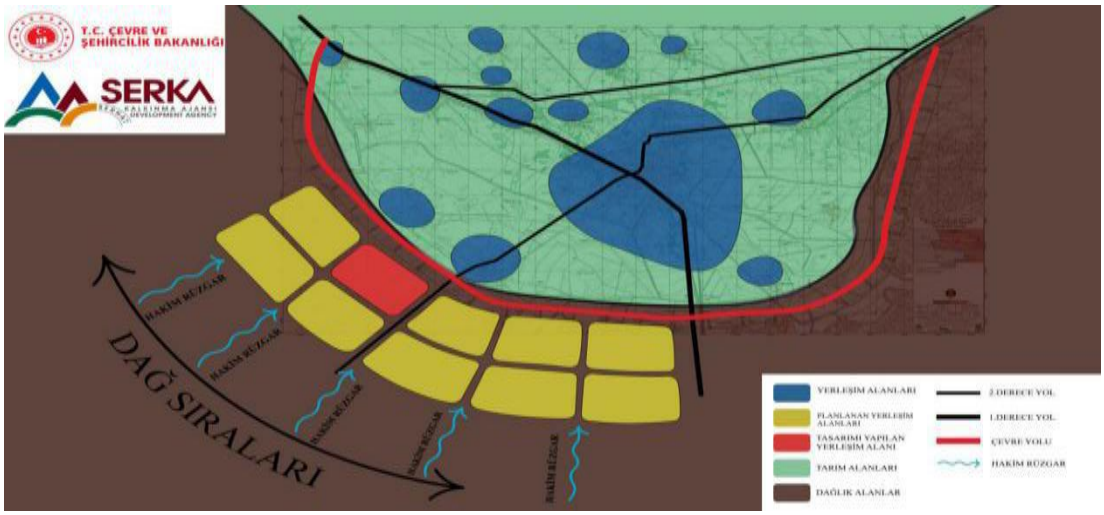

Figure 18. Conceptual map of Iğdır province

Figure19. Sample neighborhood design of Iğdır province

CONCLUSION

Although decrease in air quality is caused by harmful substances such as dust, gas, smoke released from the pollutant sources to the atmosphere, it is also caused by meteorological parameters and topography that have negative or positive effects on air pollutants. The natural structure and proportion of the air changes due to pollutants emitted into the atmosphere. This leads to irreversible

dangerous consequences for our planet. Air pollution has been recognized as a local event for many years. However, pollutants occurring in a region are transported and underwent the chemical processes because of the atmospheric weather events. The transport of pollutants to the atmosphere can occur both at close distances and long distances. Air pollution increases and threatens the human health due to intense and unplanned urbanization, which has been increasing rapidly every day since the industrial revolution, the depletion of fossil fuels in both motor vehicles and heating uses, the use of low quality fuel in industrial facilities and residential heating, and topography and meteorological conditions (Incecik, Sen, Kadıoğlu and Alp, 1994).

When Iğdır Air Quality Station data are analyzed, it is seen that PM_{10} values that are measured parameters are very high both in summer and winter. Especially air pollution in the cold days of winter; it is increasing due to the use of low-quality coal, heating, misapplication of heating techniques and the maintenance of heating systems. The main reason for this is due to the high number of dwellings and busy roads in the center of Iğdır. Iğdır PM_{10} pollution is much higher than SO_2 pollution. The primary reason for this is the dust coming from most of the roads and mines. A secondary reason is the poor quality of the fuels used for heating purposes, especially in the winter. The third reason is that the meteorological factors and topography conditions influence the pollutants. Moreover; since the province of Igdir is surrounded by mountains, temperature reversal occurs at night. Temperature inversion causes to stay the pollutants in the area for a long time and increases the effect of air pollutants. In times of high pressure, the pressure causes to settle the pollutants and remain in the area. Wind, precipitation and unstable atmosphere, which are the meteorological parameters, cause to dissipate and dilute the air pollutants, thus air pollution has reduced.

ACKNOWLEDGEMENTS

Due to the finding solutions to the air pollution problem of Iğdır province, we thank Serhat Development Agency (SERKA) which provides financial contributions, T. C. Ministry of Environment and Urbanization that is provided air pollutants data and General Directorate of Meteorology that provided meteorological data.

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