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EFFECT OF URBAN FACTORS ON AIR POLLUTION OF IGDIR

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Abstract

In this study, it was examined effects of climatic and topographic conditions, urbanization and transportation on air quality of Igdir which is the eastern province of Turkey and is an agricultural city. An important part of the city's settlements is on fertile farmland. Air pollutants arising from industry, settlements and transportation show the density on the city center mostly without transcending elevations which have bowl shape and are located around the city during the winter months. Air pollution during the winter months causes a dense fog over the city for weeks under the influence of inversion layer and is reaching significantly amount to effect on human health. Igdir province is located in the orange group (it may occur health implications for vulnerable groups) in terms of EPA air quality index. Also, it is much higher than 80 µg m-3 which is national limit value for PM10. In addition, the average wind speed of Igdir is 1.2 m s-1 and has not enough power to distribute polluted air.

Keywords: Air pollution, Air quality, Igdir, Inversion, Topography, Urban planning

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1. Introduction

Air pollution is an environmental problem that humankind are beginning to use with the industrial revolution in the 19th century, which is the beginning of modern industrialization. After known as the London episode in 1952, which resulted in the loss of thousands of lives, mankind began to realize the seriousness of air pollution. Together with technological developments and industrialization, it is understood that this problem is not only a regional but also global issue (Keser, 2002).

The air we breathe is necessary to sustain our vital activities such as the water we drink. We want to make sure that the air such as the water does not harm us, and we want to make sure that it is healthy (Vesilin et al., 2010; Ibret and Aydınözü, 2009). In general, air pollution is the effect on the environment and human health of

pollutants released into the atmosphere by human activities. Pollutants can be mixed into the atmosphere as a result of natural or human activities (Çiftçi et al., 2012). The main sources of these pollutants can be said that are factories, motor vehicles, heating, energy production. Air pollutants such as SO_2, PM, CO and NO_X arise as a result of burning fossil fuels, gasoline-burning and vehicle emissions in thermal power plants, factories, combustion plants, refineries, office buildings and houses (Özdemir, 2008).

1.1. Air Pollution and Pollutants

Air pollution can be defined as "it exists in concentration and duration that will bring about harmful effects on human health, plants, structures and materials of pollutants into the atmosphere" (Wark and Warner, 1981). In general, air pollution in our country is determined by the amount of particulate matter, aerosols and sulfur dioxide in the air. However, chemical reactions occur in the atmosphere and organic substances play an important role in these reactions. Since organic substances are the nuclei of chemical reactions, they should not be ignored whether enter reaction or not (Çiftçi, 2012).

1.1.1. Particulate matter (PM)

PM is solid and liquid particles in the air. Those with an aerodynamic diameter greater than 2.5 μm are called coarse particles. Those with an aerodynamic diameter smaller than 2.5 μm are called fine particles. Given the diversity of the source of particulate matter, species, quality and quantity, it varies from region to region, from city to city and even from within the same city (TC ÇOB - Environment Atlas, 2004; Evyapan, 2006; Seinfeld and Spyros, 2016; Öztürk, 2007; Özdemir, 2008).

1.1.2. Sulfur dioxide (SO_2)

Naturally, the burning of fossil fuels such as coal and fuel oil, which contain sulfur in the build, is formed as a result of metal smelting and other industrial activities. It is a colourless, sharp smelling, suffocating and acidic gas. SO_2 which is the most important of the sulfur compounds that cause air pollution, can soluble in water and therefore also in blood. The most important effect on human health is damage to respiratory tracts (Karpuzcu, 1996).

1.1.3. Carbon monoxide (CO)

It occurs the combustion of organic substances and fossil fuels containing carbon in the chemical structure when is not complete combustion.

1.1.4. Nitrogen oxides (NO_X)

NO_X, which is the most important pollutants in the city are nitrogen dioxide (NO_2) and nitrogen monoxide (NO). The main source of nitrogen oxides in cities is electricity generation, heating of factories, motor vehicles and industrial activities (Özdemir, 2008).

1.1.5. Ozone (Tropospheric O_3)

It is an air pollutant formed in the troposphere layer as a result of reactions between volatile organic compounds (VOC) and nitrogen oxides under sunlight in the atmosphere (Özdemir, 2008).

1.1.6. Lead (Pb)

Pb, which is the best-known of heavy metal pollutants, is a poison that accumulates in the living structure. Although some industrial activities lead to lead emissions, the biggest source of emissions is the use of leaded fuel in motor vehicles (Özdemir, 2008).

1.2. Causes of Air Pollution

1.2.1. Air pollution from warming and urbanization

It causes air pollution in fires due to natural phenomena as well as artificial burning events. The most important factor in air pollution is the combustion of coal, gas, oil and petroleum derivatives known as fossil fuels for heating purposes. In particular, improperly used fuels, improperly used incineration boilers, the lack of proper cleaning of flue and boilers cause a serious increase in the number of emissions to be generated (Çiftçi et al., 2012). The surface form of a settlement center, the structure of the land, the productivity, the amount of green area per person, the state of natural habitat and the buildings affect the concentration of air pollution (Çiftçi et al., 2012).

1.2.2. Impact of industrial resources

As a result of the industrial activities, the emission of the formed pollutant effect comes out of the use of fossil fuels as the energy source, with the emission of different types according to the activity type. Concentrations of industrial pollutants in urban centers vary according to the height of the chimney, the distance to the city's industrial foundation, the topographic structure of the city and the prevailing wind direction (Keser, 2002).

1.2.3. Influence of topographic features

The characteristics of the surface features of the area affected affect the durability of the polluted air on the settlement. Earth surface forms do not have a direct pollutant effect, but they affect the durability of pollution in the settlement (Toros, 2000; Stone, 2006; Farmer et al., 2012). Topographic features; affect the distribution of polluted air or the presence of secondary pollutant parameters in the atmosphere to a significant extent. When geographical locations and physical characteristics are considered, they have a direct influence on current activities such as transportation, heating and production. They are located directly or indirectly in important places in the changes in pollution quantity and characteristics (Özdemir, 2008).

1.2.4. The impact of climatic factors

All air pollutants emitted from various sources are transported, spread or collected to a zone depending on meteorological conditions. During this transport, pollutants dilution or undergo photochemical reactions. The cycle is complemented by the washing of pollutants from the atmosphere with precipitation and by deposition of contaminants on plants, surface waters, soil and other materials or by removed from the environment with some factor influencing. The main parameters that make up the climatic effect are temperature, pressure, wind and

humidity (Noordijk and Visser, 2002; Özdemir, 2008; Kaya and Öztürk, 2013).

1.2.5. Pressure and wind

In a region where high-pressure conditions exist, air pollutants tend to collapse continuously. For this reason, the polluted air cannot rise and disperse. Cyclones (low pressure) exhibit an ascending characteristic by having turbulence and convective movements. In this way, pollutants can be transported to the upper layers of the atmosphere and the pollution can be dispersed by the effect of wind. The wind does not reduce the contamination, It only transports contamination from a place to place and helps change direction. For this reason, in one place the calm, mild or non-existent wind means that the polluters remain where they are (Kaya and Öztürk, 2013).

1.2.6. Moisture

The higher water vapour in the lower layers of the atmosphere causes the solar energy that is near earth to be retained and, consequently, to become warmer (Kaya and Öztürk, 2013).

1.2.7. Temperature and inversion

With the inversion, the pollution cannot rise because the cold air is located close to the earth, and it stays in the cold air layer. In some cases, there is no change in temperature with altitude, in which case it is called the isothermal layer. Another effect of the temperature is to determine the amount and duration of the fuel to be used (Çiftçi et al., 2012, Kaya and Öztürk, 2013).

2. Material and Method

2.1. Properties of Igdir

The population of the province is 105 276, the surface area is 3 588 km^2 and the average height of the Igdir varies between 800 – 900 m. The altitude around Igdir is 1000-2000 m above sea level (Karaoğlu, 2011; Aras and Tekay, 2017).

Since there are no major industrial facilities in the city, industrial emissions are less than other sources. Igdir also has 20 plants subject to emission permits. The plain structure called the Sürmeli pit forms Igdir and Yerevan together. The nuclear power plant in Yerevan is here at Metsamor. Therefore, it is not possible for the nuclear plant to affect a place on the same lowland (Altikat et al., 2015, Aras and Tekay, 2017).

There are 3 626 passenger cars, 7 901 light commercial vehicles, 5 267 heavy commercial vehicles and 918 other vehicle types. The ring road passes through the city centre and there is no green wave in the signalling system (Aras and Tekay, 2017).

The total proportion of green spaces, park gardens and playgrounds in the city is around 10%. The amount of green space per capita is about 24 000 m^2. The proportion of used traffic roads and pedestrian roads within the total area is around 20% (Aras and Tekay, 2017).

2.2. Igdir Province Topography

Most of the city's facades are surrounded by mountains (Figure 1, 2, 3). Because the area where Igdir is located is surrounded by mountains, it resembles a bowl shape and limits air movement and wind formation in this region. Especially in the winter, it prevents the polluted air from going out of the city, causing fog, smoke and particulate matter to concentrate on the city, and as a result, air pollution increases (Dursun and Gürü, 1995; Dursun, 1996; Dursun, 1997).

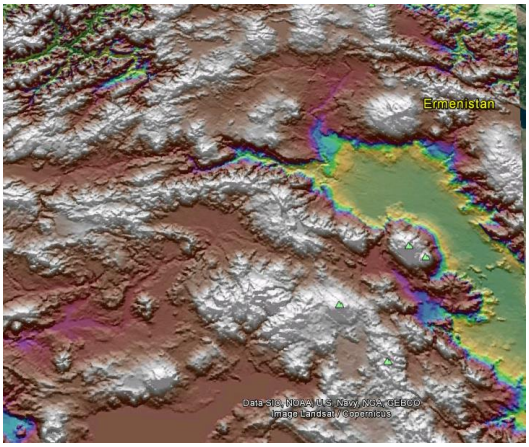

Figure 1. Physical map of Igdir province

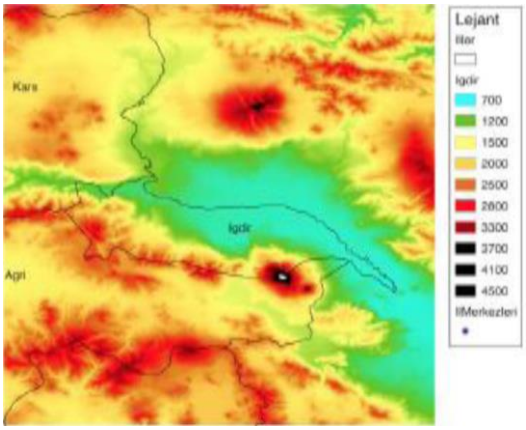

Figure 2. Map of Igdir province mixture heights (THEP, 2014)

Figure 3. View of Igdir province from the satellite

Looking at the Igdir province, the region can be considered in two parts. The first is the lowland area of 922 km², which accounts for about 26% of the area, and the second is the mountainous area of 26 178 km², which accounts for about 74%. The extension of the Central Taurus extending in the west-east direction south of Igdir and the eastern part of the mountainous area, starting with Munzur Mountains and continuing with Karasu-Aras Mountains, takes place. The lowland is consist of two parts. The first part is 832 km² Igdir (Sürmeli) lowland and the second part is 90 km² Language Plain. The mountainous area between the Erzurum-Kars and the Upper Murat-Van sections of the Eastern Anatolia Region and the mountainous masses surrounding the Igdir lowland from the south; from west to east are composed respectively of Durak Mountain (2 811 m), Zor Mountain (3 196 m), Haççа Hill in the Zor Mountains (2 486 m), Köroğlu Hill (2 895 m), Pamuk Mountain (2 639 m), Great Ağrı Mountain (5 137 m) and Minor Ağrı Mountain (3 896 m) and extinct volcano mountains. Mount Ararat is the highest mountain in Turkey and there are plateaus in its skirts.

3. Results

3.1. Igdir Province Meteorological Data

Precipitation and temperature data from meteorological data have been taken by The Ministry of Forest and Water Affairs official website of the General Directorate of Meteorology (Mgm, 2017). Air pressure, relative humidity and wind speed data have been taken by the Ministry of Environment and Urban Planning.

The average annual temperature at Igdir is 12.1 °C. The average temperature is 3.5 °C during the period when air pollution is high (October-March). The average temperature is -3.3 °C in January that is the coldest month for Igdir. July is the warmest month for Igdir and the average value is 25.9 °C (Figure 8). The dominant wind direction of Igdir is West-Northwest (Figure 9) (Kadıoğlu, 2011). The average wind speed between 2015 and 2017 is 2.15 ms^{-1} (Figure 6). Between 2015 and 2017, the average wind speed in Igdir is 1.86 ms^{-1}, when air pollution is the highest (October-March). In other words, it is below the 2015-2017 period average. It is not enough to disperse the air pollution that is caused by low wind in Igdir and it causes pollution to concentrate in the centre. Igdir's average monthly relative humidity for the period 2015-2017 is 32.3% (Figure 7) and 1940-2016 is the number of long-term monthly mean precipitation days 7 (Figure 4). Especially during the October-March period, due to the low rainfall, the concentration of air pollution cannot be sufficiently decreased. Igdir also has a monthly average air pressure of 941 mbar between 2015 and 2017 (Figure 5).

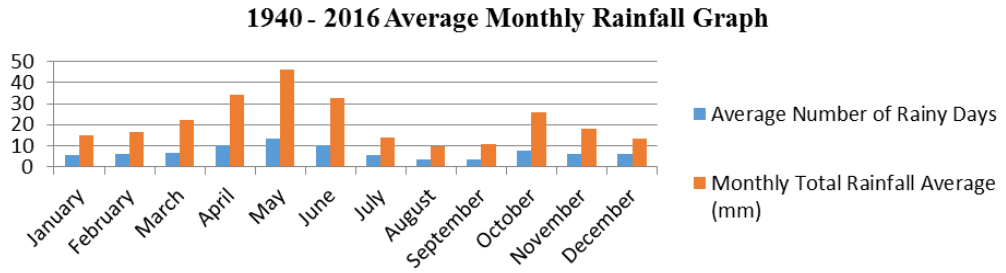

Figure 4. Igdir province 1940 - 2016 monthly average rainfall

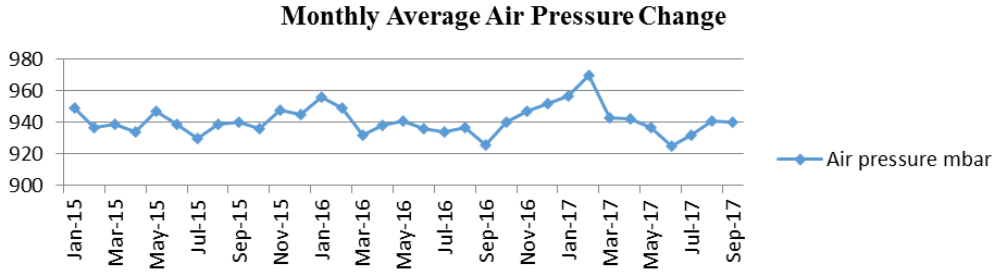

Figure 5. Monthly average air pressure change between 2015 - 2017 in Igdir province

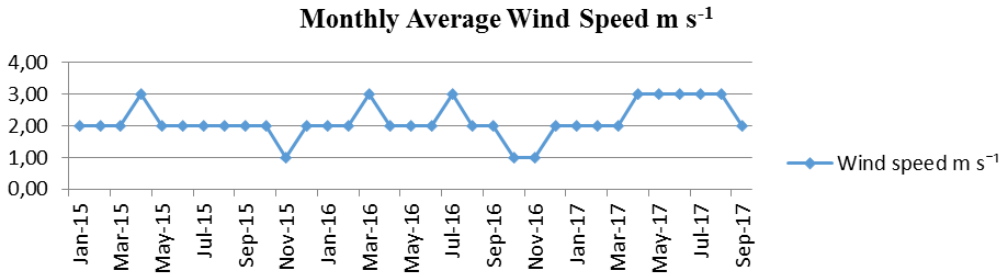

Figure 6. Monthly Average Wind Speed Change Between 2015 - 2017 in Igdir Province

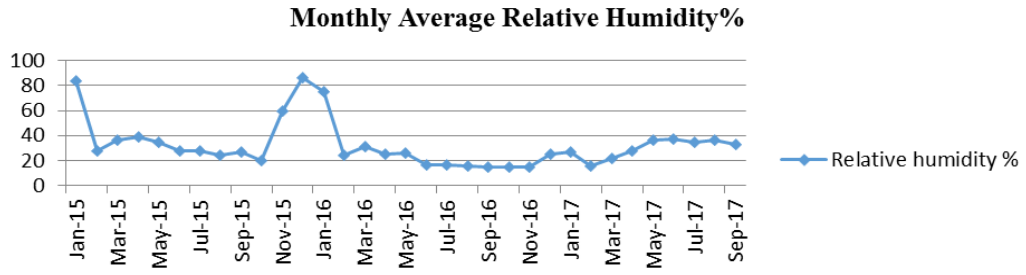

Figure 7. Monthly mean relative humidity change in Igdir province between 2015 and 2017

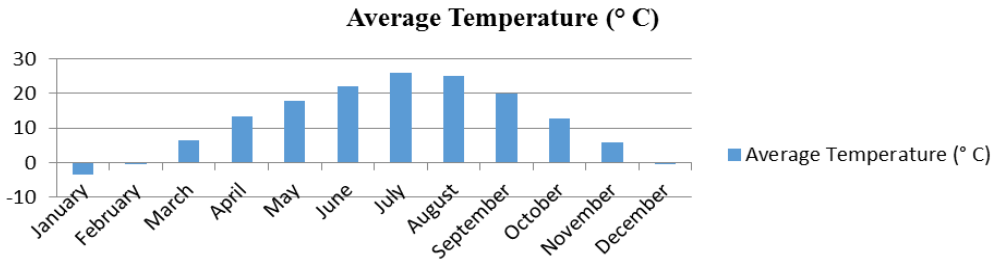

Figure 8. Igdir province 1940 - 2016 average monthly temperature

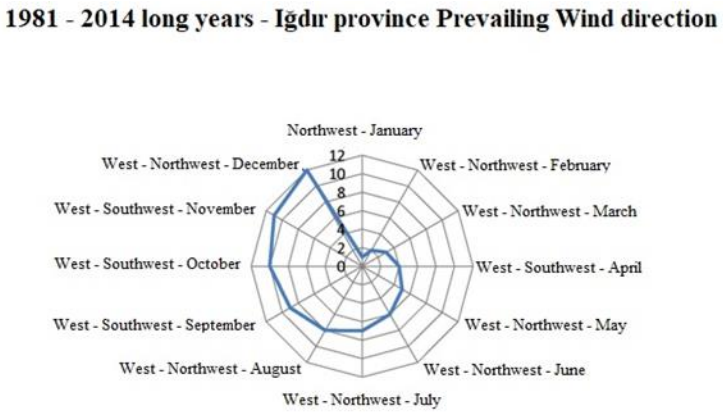

Figure 9. Igdir province prevailing wind direction

3.1.2. Igdir province of air pollution data

Air Pollution Data were obtained from the Ministry of Environment and Urban Affairs Air Quality Stations WEB page (Figure 10,11,12,13) (Havaizleme, 2017). The data used in the graphs were obtained from the Ministry's page by taking the hourly average data and converting it to the monthly average. As a result of the obtained data, the graphs show that the NO_X and PM_{10} values exceed the limit values. PM_{10} values are sometimes seen above the limit value and sometimes even near the limit value, not only in winter but also in summer.

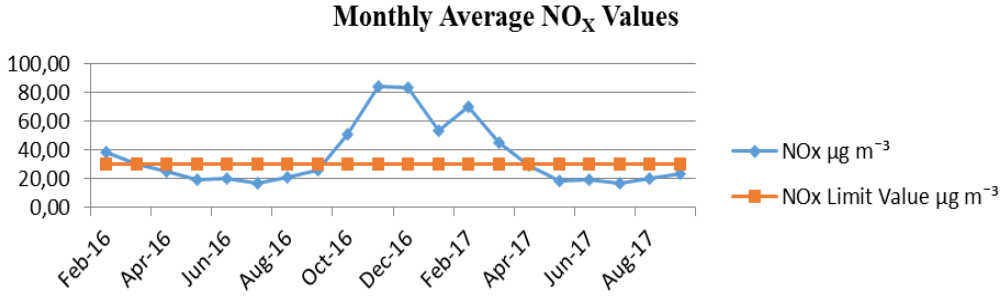

Figure 10. Monthly average NO_X change in Igdir province between 2015 and 2017

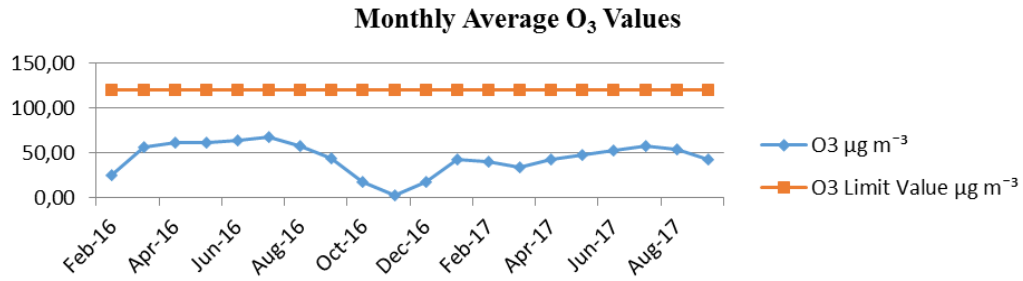

Figure 11. Monthly average O_3 change in Igdir province between 2015 and 2017

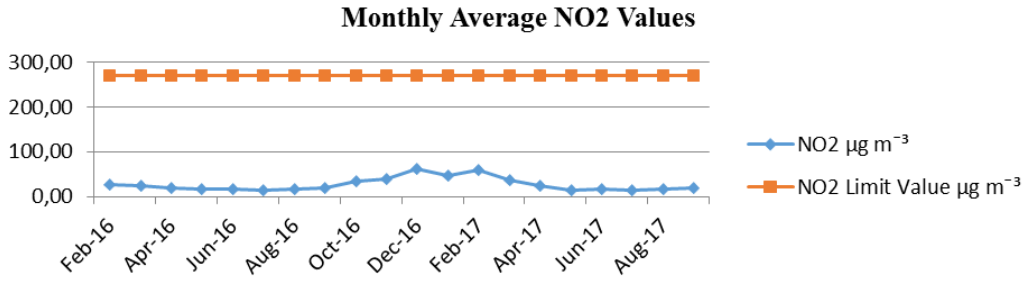

Figure 12. Monthly average NO_2 change in Igdir province between 2015 and 2017

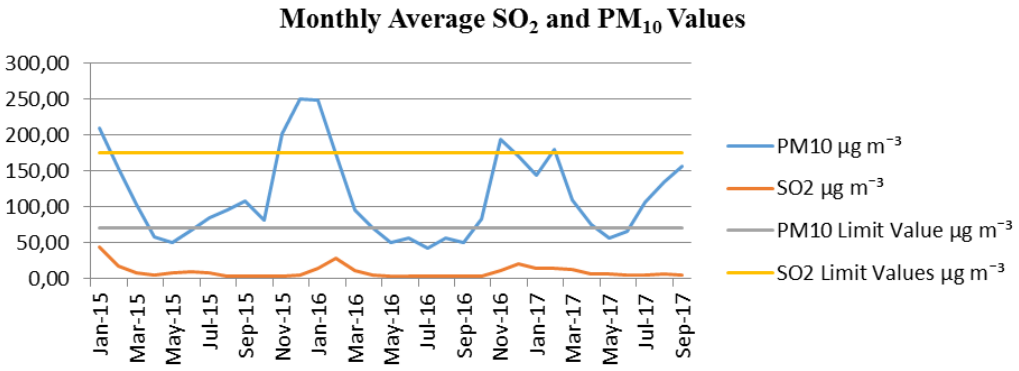

Figure 13. Monthly mean SO_2 and PM_{10} change between 2015 and 2017 in Igdir province

4. Discussion

It is seen that the concentration of particulate matter in Igdir province is higher than the limit values. It is observed that the levels of SO_2 and PM_{10} values increased in October - March period. In this context, it has been observed that air pollution increases in parallel with the burning of fuels used for heating together with the decrease in temperature. When compared to 2016 winter period and 2017 winter period air pollution data, it is clear that there is a decrease in pollution in 2017. This decline can be attributed to the fact that about 10% of the Igdir was used natural gas for heating purposes in the winter of 2017. However, in the months when the temperature is rising, even in the summer months, the PM_{10} concentration is close to the limit values and this is indicating that air pollution is not caused solely by the fuel used for heating purposes.

Due to the topographical structure of Igdir, the southwestern, north and west part of the region are covered to the mountain and only south-east is open. Due to the occurrence of temperature inversion in the province and the low level of wind speed in the province, air pollution does not dispersion, and it is collected in the centre.

On the other hand, the mountains and hills around Igdir are bare and are carried above the province of particulate matter along with wind erosion and It is believed that the transport of dust due to the dryness of Iranian Uriniye lake floor may have an impact on Igdir's air quality. there is also serious an emission from the Metsamor Nuclear Power Plant in Armenia and this could have an impact on the Igdir's emission load. The roads in the city are of low quality and can cause dust formation. All of the above-mentioned issues are among the reasons for the high PM_{10} value even in summer in the region.

5. Conclusion

Igdir has been in the first order in the air pollution ranking. Air pollution in winter causes people living in the city to reach the dimensions where they will feel uncomfortable with intense fog and inversion effect ongoing for weeks. The same situation is observed in

other province suffering from air pollution cases in Turkey and it is necessary to remedy this problem which is important for human health. For this reason, a series of precaution must be taken to reduce air pollution. Some of these can be listed as follows;

The number of contaminant parameters must be increased and the limit values checked again in the Air Quality Protection Directive. Limit values should be reduced at least to European standards. It should be included as more detail to air pollution originating from heat. Considering the topographic and meteorological factors, especially the wind situation, urban and industrial settlement restructuring should be planned. The Ring road passing through the city centre must be transported out of the city. Beginning from primary education, in all schools, place of worship, coffeehouse should be educated in awareness about air pollution and also non-governmental organizations should prepare awareness program for this purpose. Fuel-burning techniques should be developed and disseminated in residences and participation of heater element in stoker training courses should be ensured. The amount of green space per person should be increased by afforestation. Social responsibility projects should be developed for this purpose. Unnecessary energy usage should be avoided. Green energy use must be widespread. Heat insulation system should be used in the buildings. Care must be taken to ensure that selected fuels for heating purposes are high calorific, low in sulfur and moisture. Buildings should be inspected and encouraged. Natural gas usage should be promoted and encouraged. To reduce the emission of flue gas, filters must be installed in the chimneys of industrial plants and buildings. The buildings should be encouraged to switch to the central heating system and the appropriate firing time for stoves and heaters should be determined. At the beginning of each winter season, stovepipes and boilers must be cleaned. Insulation of windows, doors and roofs should be given importance, heat and economic loss should be prevented. Periodic maintenance of the heater boiler must be done. City roads must be covered with suitable materials that will not cause dust formation. Public transport should be widespread and public transport should be preferred to personal vehicles. Waste must be prevented from uncontrolled incineration of waste. Preventing the increase in the price of natural gas and due to rising natural gas prices, the again use of coal should be averted.

Conflict of interest

The authors declare that there is no conflict of interest.

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