Intercontinental Geoinformation Days

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Creating and evaluating pollution distribution map in Aegean Region by using geographical information system (GIS) and air quality data

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Keywords
Air Pollution
Air Quality
GIS
Sulfur Dioxide
Particulate Matter

ABSTRACT
Air pollution is defined as an environmental problem that occurs as a result of foreign substances such as dust, smoke and gas exceeding normal amounts in the atmosphere and affecting the health of living things adversely. Air pollution, which is one of the leading environmental problems today, threatens future generations seriously. Air pollution is shown as the most important cause of global warming and has negative effects on other living things, especially human health. The causes of air pollution in our country can be shown as rapid and unplanned urbanization, wrong location in the industrial zone and pollutants from the chimneys. In this study, the data obtained from the air monitoring stations in the provinces of the Aegean region were evaluated in the Geographical Information System and the location analysis of particulate matter (PM) and sulfur dioxide (SO_2) causing air pollution was performed. The data used in this study has been mapped through being obtained from Republic of Turkey Ministry of Environment and Urbanisation National Air Quality Monitoring Network. Spatial distribution maps of air pollution were created by making spatial analysis of pollutants in the region with the help of the Geographical Information System and it was determined whether the pollutant parameters tend to increase or decrease.

1. INTRODUCTION

Global warming is the biggest threat to the world. Global warming is the increase in the temperature of the Earth's surface and atmosphere as a result of the increase in the amount of greenhouse gases (carbon dioxide, methane, ozone) released into the atmosphere (Başıbüyük et al. 2017). The biggest reason for the increase in global warming in recent years is industrialization. Especially since the 20th century, industrialization has increased rapidly in order to improve living standards and as a result of this increase, irreversible damages to nature have occurred.

Air pollution, which is one of the leading global warming and environmental problems today, seriously threatens future generations. Air pollution is defined as an environmental problem that occurs as a result of the increase of foreign substances such as dust, smoke and gas in the atmosphere to more than normal amounts and negatively affects the health of living things (Akyürek et al. 2013).

Air pollution can be divided into two groups as natural and artificial causes (Zencirci and Işıklı 2017). Among the artificial causes, human activities such as industrial factories, mining, transportation can be cited. Natural causes are natural processes such as volcanic eruptions and forest fires. Natural causes have a local impact on air pollution. Artificial causes affect the world on a global scale. Therefore, artificial causes are the most important factor in air pollution.

In the past, air pollution only affected industrial areas. Air pollution is seen as the most important problem in settlements with the effect of the increasing population. The first death case from air pollution was recorded in London in 1873 and it was stated that these deaths increased every year (Altıkat et al. 2011). In 2020, there was a decrease in industrial production due to the Covid-19 pandemic. As a result of this decrease, a significant decrease in air pollution was detected (Baysan and Yavaş 2020). The causes of air pollution in our country can be shown as unplanned and rapid urbanization,incorrect

choice of location in an industrial zone and pollutants coming out of chimneys (Garipağaoğlu 2003).

Air pollutants are seen as an international problem as they are spread by wind. Air pollutants are shown as carbon monoxide (CO), sulfur dioxide (SO_2), hydrocarbons (HK), nitrogen oxides (NOx) and particulate matter (PM) (Finlayson and Pitts 1986). Sulfur dioxide (SO_2) is a gas that enters the atmosphere as a result of the combustion of fossil fuels and volcanic eruptions. It has the property of being a poisonous gas for all living things (Akan and Morcalı 2017). Sulfur dioxide occurs as a result of the use of coal for heating purposes, and where urbanization occurs, sulfur dioxide is known to have a higher value. Particulate matter (PM) is solid or liquid particles that can be emitted in the atmosphere and suspended in the air. PM is divided into aerodynamic diameters in terms of mass and composition (Akyürek et al. 2013). PM10 notation is used to describe particles that are 10 micrometers or smaller, which have been selected for this study.

In this study, spatial distribution maps of Particulate Matter and Sulfur dioxide causing air pollution were created by evaluating the data from January, February and March in 2018 and 2019 from the Air Monitoring Station in the provinces in the Aegean Region in the Geographical Information System and it has been determined whether it has a decreasing trend.

2. METHOD

2.1. Study Area

In this study, the distribution of SO_2 and PM10 substances, which are among the air pollutants, in the Aegean Region according to the data in January, February and March of 2018 and 2019 were examined. The study area covers İzmir, Manisa, Aydın, Denizli, Muğla, Afyonkarahisar, Kütahya and Uşak provinces within the borders of the Aegean Region. The Aegean region is the second largest industrial region in Turkey after Marmara region. It is seen that these sectors have a significant share in air pollution due to the intensification of the automotive, oil and mining industry in the Aegean region.
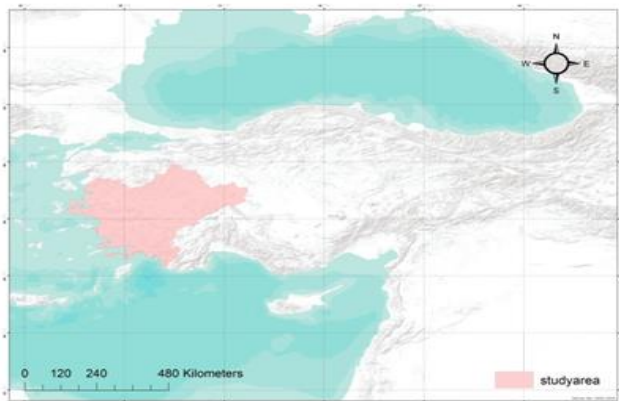

Figure 1. Study Area

2.2. Materials

The data to be used in the study were obtained from observation stations in provinces in the Aegean Region. The data were downloaded from the database of the Republic of Turkey Ministry of Environment and Urbanization National Air Quality Monitoring Network website and saved in excel table format.

2.3. Method

In this study, spatial analysis of air pollutants SO_2 and PM10 were mapped using Inverse Distance Weighting (IDW) interpolation method in ArcGIS program. The values of the points that need to be estimated with IDW are calculated by averaging the values of the sample points around each point (Göğsu and Hastaoğlu 2019). The effect of the points closer to the points to be predicted is greater, and more distant points have less effect. The IDW estimator can be given by equation (1).

$$Z(X_0) = \frac{\sum_{i=1}^n z(X_i).d_{i0}^{-r}}{\sum_{i=1}^n d_{i0}^{-r}} \tag{1}$$

The location X_0 where the predictions are made is a function of the neighboring measurements n. d is the distance separating observation location X_i and prediction location x_0, and r is the parent that determines the assigned weight of observations. As the exponent grows, the weights of observations at a distance to the point where it should be estimated become smaller. The increase in the exponent suggests that the estimates are very similar to the closest observations (Demircan et al. 2011).

3. RESULTS

Data of SO_2 and PM10 items found in the study area by IDW interpolation method. PM10 and SO_2 distributions are shown in Fig. 2, 3, 4 and 5.

When Fig. 2 and 3 are examined, it is seen that the amount of PM10 increases in Kütahya and decreases in Afyon and Uşak. The most important reason for the high air pollution in Kütahya is the coal-fired thermal power plants in the city. Air pollution limit value of PM10 is 40 µg / m3 (microgram / cubic meter) in our country (Vural 2021). When Fig. 2 and 3 are examined, it is seen that the PM10 limit amount has been exceeded in the Aegean Region.
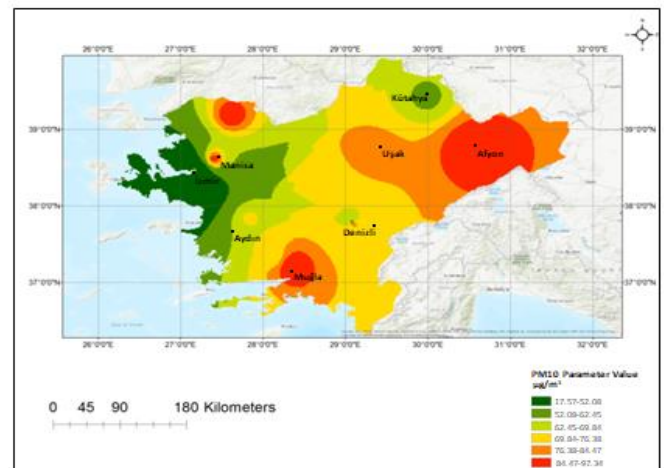

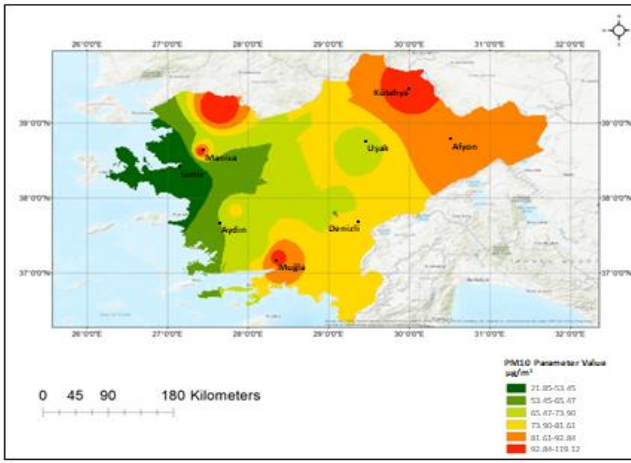**Figure 2.** PM10 Distribution in January, February and March 2018

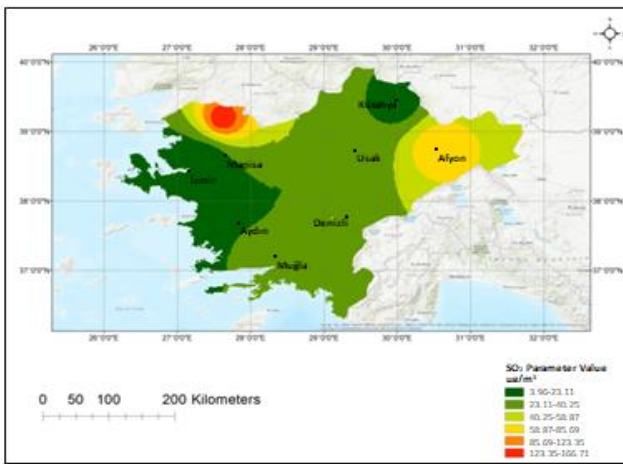**Figure 3.** PM10 Distribution in January, February and March 2019

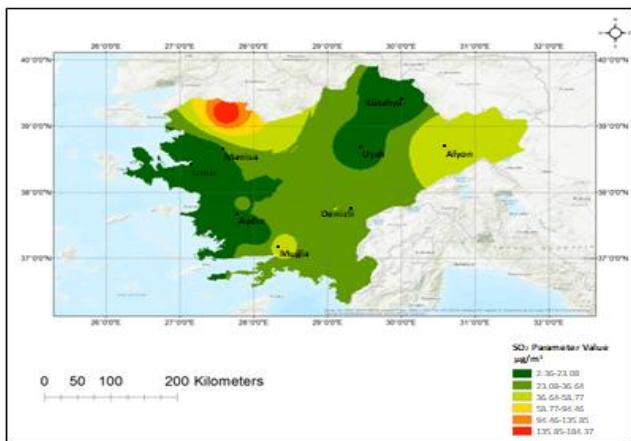**Figure 4.** SO$_2$ Distribution in January, February and March 2018

Figure 5. SO$_2$ Distribution in January, February and March 2019

When Fig. 4 and 5 are examined, it is seen that the distribution of SO$_2$ in the provinces in the Aegean Region has decreased in 2019 compared to the previous year. The air pollution limit value of SO$_2$ is 20 µg / m3 (microgram / cubic meter) in our country (Vural 2021). It is seen that many provinces in the Aegean Region exceed this limit value. Considering the years 2018 and 2019, İzmir is the cleanest province in the region in terms of SO$_2$ amount.

4. CONCLUSION

Today, air pollution, which has negative effects on human health, is a global threat that affects future generations. Industrialization, increase in the number of vehicles, rapid population growth and urbanization cause a rapid increase in air pollution. Fuels used in industrial production and coal used for heating can be shown among the reasons for the high level of air pollution in the region during the winter months. In order to improve the air quality, especially the increase of natural gas should be encouraged. If natural gas cannot be made widespread, the use of high-calorie coal for heating should be encouraged and attention should be paid to thermal insulation in buildings.

Air pollution causes respiratory diseases in humans. Effective strategies for preventing air pollution should be determined and implemented in order to protect human health in the region. Industrial facilities should be located outside of the settlements and the prevailing wind direction should taken into consideration.

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