Temperature Inversion Winter Seasonal in Karabük-Safranbolu Basin: Possible Effects on Natural and Human Environment (Turkey)*

Karabük-Safranbolu Havzasında Kış Mevsimi Sıcaklık İnversiyonu: Doğal Ortam ve İnsan Üzerine Olası Etkileri (Türkiye)

Mücahit Coşkun** - Sevda Coşkun*** - Siracettin Gözalan****

Abstract: Increasing energy consumption has made air pollution a critical problem in residential areas, especially in cities. The expansion of natural gas use in our country and the orientation towards quality coal has not eliminated the growth of the problem, although it has partially hindered it. Topographic and climatic factors have played a significant role in growing air pollution. Topography affects pollution as a factor driving temperature reversal and wind speed due to the stability of the air. The scope of the research was determined as “temperature inversion winter seasonal around Karabük – Safranbolu, possible effects on natural and Human Environment”. The aim of the present study is to determine the effect of winter temperature reversal on the people and other living things in the region by determining the limit, degree, timing and possible effects on the natural and human environment. It is extremely important that this event is noticed and the necessary considerations are taken. The fact that the winter inversion observed between Karabük and Safranbolu has not been analyzed with quantitative data before makes this study necessary. For this reason, stations have been established in the basin through personal efforts to determine the inversion that is thought to have occurred in the basin by quantitative data. In the research, a mixed research model, in which many methods are used together, was applied. The winter season of temperature inversion has been found to occur during the months of December, January, and February. December and February began to continue until the reversal was

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** Prof. Dr., Karabük Üniversitesi, Edebiyat Fakültesi, Coğrafya Bölümü

Prof. Dr., Karabük University, Faculty of Letters, Geography Department

ORCID 0000-0002-7881-6742

mcoskun@karabuk.edu.tr

*** Dr. Öğr. Üyesi, Karabük Üniversitesi, Edebiyat Fakültesi, Coğrafya Bölümü

Asst. Prof. Dr., Karabük University Faculty of Letters, Geography Department

ORCID 0000-0002-4702-4670

sevdacoskun@karabuk.edu.tr

**** Doktora Öğrencisi, Karabük Üniversitesi, Edebiyat Fakültesi, Coğrafya Bölümü

PhD Student, Karabük University Faculty of Letters, Geography Department

ORCID 0000-0002-6721-1860

sirac.gozalan@hotmail.com

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determined. The temperatures were found lower at Karabük University and Unsallar Oil Stations on the valley floor, while at Karit, Kıran village and Safranbolu urban forest stations, higher temperatures were observed.

Structured Abstract: Introduction The troposphere layer of the atmosphere is the closest to the earth's surface, where various weather events occur. In the troposphere, where many meteorological phenomena occur, measuring weather events and keeping long-term records play an important role in revealing the climate character of the areas measured. Meteorological measurements may not always conform to the laws set forth by the basic sciences. For example, exceptions may occur that break down the general base of “temperature decreases as you higher, on the contrary, as you go downwards, the temperature increases”, it happens a feature of local weather conditions and relief. It can be seen in special cases contrary to such general principles in the natural environment. This is entirely due to local factors ahead of global conditions. The specified exceptions bring various positive or often negative results that they affect the natural environment.

According to the vertical temperature gradient, as you rise above the surface of the earth, the temperature decreases, or the temperature increases at a certain rate as it descends from higher places to the surface of the earth. This condition has been called the rate of temperature change in the atmosphere (lapse rate). As always stated in the atmosphere, normal conditions have not occurred. It is also known that sometimes the opposite has happened. Such meteorological phenomena have been called temperature inversions. Temperature inversion means that the temperature rises as it rises and it is outside the normal running of the atmosphere (Sellers, 1965; Erinc, 1969; Ardel, 1973; Donmez, 1984; Strahler & Strahler, 1992; Erol, 2011; Nisanci, 1994; Ozyuvaci, 1999; Christopherson, 2000; Barry & Carleton, 2001; Oliver & Hidore, 2002; Bonan, 2008; Turkes, 2010; Atalay, 2013; Ahrens, Jackson & Jackson, 2012).

In places where temperature reversal occurs, the density of polluting factors decreases air quality and brings the lives of living things to levels that can be endangered from time to time. For example, in the inversion incident in December 1952, 4,000 people died, and 10,000 of them were hospitalized in London (England). One another incident happened in October 1948, 20 people died and 6,000 people fell ill in the incident in Donora, Pennsylvania, USA. The subject can't be tolerated and neglected.

In the scope of the study, winter temperature inversion, which is thought to occur in the vicinity of Karabük-Safranbolu, was discussed. The study aims to determine the possible the inversion event around Karabük-Safranbolu Basin with the help of established meteorological stations. Weather observations of the site, keeping periodic records, temperature reversal limits, degree and timing of the measurements made by determining the living lives. The absence of a study on this subject in the field of research and the presence of an iron and steel industrial plant near the city of Karabük with a population of 132,000 makes the issue more important.

In the study, temperature values obtained from the established meteorological stations' measurements by personal efforts in Safranbolu urban forest, Kıran village, Karit, Karabük University and Unsallar oil fields were analyzed, and the area and depth of the inversion was determined. Karabük is located in the Western Black Sea section of the Black Sea region, one of the seven geographical regions of Turkey. The examination area covers part of Karabük and Safranbolu district and is located between 40° 15' and 40° 50' North latitudes and 32° 15' and 32° 45' East longitudes.

Material and Method

The meteorological stations for the site research were established in the least high parts of Arac and Soganlı where it is surrounding is the highest. The winter inversion event was thought to have occurred and 5 stations was installed in the measurements of (2014-2015 winter period). The raw data obtained from the stations were evaluated by converting them into regular data using quantitative research methods. 1/ 25,000 scale map sheets related to the research area were used. At this stage, all data collected in the terrain was transferred to the GIS environment as a “point layer”. The survey data was analyzed and mapped in the ArcGIS 10.4 and Microsoft Excel 2010 package programs. In the project, the regional approach is the basis of the research; however the systematic approach has been applied from time to time while evaluating the data. The methodical stages of the project are given below:

- Supply of suitable stations to make the measurements in a safe and healthy manner,
- Determination and installation of station locations,

- Creation of measurement periods for recording temperature values by means of stations installed in the field of study,
 - Providing suitable materials for recording and sheltering station data throughout the year,
 - Determining the duration of inversion period, and limit with the measurements made,
 - Analyzing and mapping the frequency and limits of inversion events within the specified time frame in ArcGIS 10.4 package program,
 - Contact the necessary institutions and organizations to reduce the potential impacts identified,
- In the research, a mixed research model, in which many methods are used together, was applied.

Research Findings

Karabük is one of the provinces where temperature reversals are most severe due to its dish-looking topographic surface. January and December the depth of intensity of the area was increased. The inversion occurred in the winter months in Karabük province, beginning in December and the area is seen to expand, while in February, the area was narrowed but the depth intensity was found to increase.

In the study area, it was found that the temperature reversal which started in december was 1.8 °C at the Unsallar Oil Station and Karabük University in the valley floor, while in Karit, Kıran village and Safranbolu urban forest at higher temperatures were between 2.7°C and 5.7°C. The depth of inversion appears to be 3.9 °C in December.

January's inversion was examined, it is seen that winter inversion continues in January. The mean temperature at the lower level of the valley is 2.6 °C, while at the higher stations Safranbolu urban forest and Kıran village it is 4.4 °C to 5.4 °C. The depth of the inversion was determined to be 2.8°C.

February's temperature inversion is examined, winter inversion is seen in february as it continues is seen in February. It was determined that the depth of inversion increased to 3.7°C. The temperature was 6.9°C at Unsallar Oil and Karabük University stations on the valley base, while it was 10.6°C at Karit station, 9.1°C at Kıran station and 8.2°C at Safranbolu urban forest meteorological station.

Conclusion and Discussion

According to the data obtained from the established meteorological stations, to determine whether there is a temperature reversal in the vicinity of Karabük-Safranbolu within the borders of Karabük province, winter inversion is also observed and seen in the field.

December January and February is the winter season, when the temperature inversion is understood to occur in all of the months. Karabük University and Unsallar Oil stations located on the valley floor, temperatures were lower but at Karit, Kıran village and Safranbolu urban forest stations higher temperatures were found. The month in which inversion is most severe has been determined as to be February, and the depth of inversion is 3.7°C.

The results of the study were compared with the results of some studies in the field;

Buldur and Sari (2018) "Effect Of Temperature İncersiyonu On Air Pollution (Isparta City Center Example" study concluded the following. November 26, 2011 to December 3, 2011 in Isparta, there was a significant increase was seen in the intensity of SO₂ and PM₁₀. On the same days, there is also an obvious temperature reversal. In other words, the ground temperature in Isparta is lower than the levels of the troposphere, and the temperature difference between the floor and 850 hPa (1500 meter) on these days varies between 5.7 to 10.3 °C, indicating a significant temperature reversal on those days (Buldur & Sari, 2018).

Ciftci, Dursun, Levend and Kunt (2013) the study "Topographic Structure Climatic Conditions And The İmpact Of Urbanization On Air Pollution" concluded the following. On some days during winter, air pollution is caused by heavy fog and inversion layer which occurs during the week to reach the extent that people will be uncomfortable in the city center. Unfortunately, a similar event is seen in many cities in Turkey where air pollution is an important issue and a remedy should be found (Ciftci et.al 2013).

Kamisoglu (2008) "Morpho-Climatic Features in And Around Yatağan Environment-Human Health Relationship And Environmental Education" the following conclusions were reached in the study. The study

site shows a depression characteristic. Flue gas pollutants originating from thermal power plants increase the density of polluting gases on the site by the temperature reversal event that occurs occasionally at the work site. In this case, air pollution and its adverse effects affecting human health are experienced simultaneously (Kamısoglu, 2008).

Kardemir iron- steel factory where the factory is located on the valley base from heavy and harmful gases like (SO₂), (CO₂), (CO), CH₄, C₃H₈ such as heavy inversal determined depending on air circulation, and in the valley basic residential areas (the city of Karabük) people in long-term cardiac, respiratory diseases and can be the potential to cause cancer. The other major settlement in the watershed, the town of Safranbolu with a population of 45,000, is higher than the city of Karabük and is located on the plateau, limiting the impact of pollution. In Karabük-Safranbolu, it is recommended that authorized institutions take precautions for possible disturbances especially during the winter season, control of the limits of pollution sources, the creation of a clean air space and conduct deeper research on the subject.

Keywords: Temperature Inversion, Stable Stratification, Radiation Loss, Air Pollution

Öz: Enerji tüketiminin artması başta şehirler olmak üzere, yerleşim alanlarında hava kirliliğini önemli bir sorun haline getirmiştir. Ülkemizde doğalgaz kullanımının yaygınlaşması ve kaliteli kömüre olan yöneliş, sorunun büyümesini kısmen engellere de ortadan kaldırmış değildir. Beşeri faaliyetlerin bir sonucu olan hava kirliliği üzerinde topografik ve iklimik faktörlerin etkisi oldukça önemlidir. Topografya, havanın kararlılığını dolayısı ile sıcaklık terselmesini ve rüzgâr hızını yönlendiren bir faktör olarak kirliliğe tesir etmektedir. Araştırmanın konu kapsamını; Karabük – Safranbolu havzasında kış mevsimi sıcaklık terselmesi (inversiyonu); doğal ve beşerî ortama olası etkileri’’ olarak belirlenmiştir. Havzada meydana geldiği düşünülen kış sıcaklık terselmesinin, sınırı, derecesi, zamanlaması, doğal ve beşerî ortama olası etkilerini belirlemek araştırmanın amacını oluşturmaktadır. Meydana gelen bu olayın fark edilmesi ve gerekli önemlerin alınması son derece önemlidir. Karabük- Safranbolu arasında gözlemlenen kış mevsimi sıcaklık terselmesinin daha önce nicel verilerle analiz edilmemesi bu çalışmayı önemli kılmaktadır. Bu nedenle bölgede meydana geldiği düşünülen terselmenin nicel verilerle belirlenmesi için havzaya istasyonlar kurulmuştur. Araştırmada pek çok yöntemin bir arada kullanıldığı karma araştırma modeli uygulanmıştır. Sıcaklık terselmesinin kış ayları olan aralık, ocak ve şubat aylarında sınırları tespit edilmiştir. Terselmenin aralık ayında başlayıp şubat ayına kadar devam ettiği belirlenmiştir. Vadi tabanında bulunan Karabük Üniversitesi ve Ünsallar Petrol istasyonlarında sıcaklıkların düşük olduğu fakat daha yüksekte bulunan Karıt, Kıranköy ve Safranbolu kent ormanı istasyonlarında ise daha yüksek sıcaklıkların olduğu görülmüştür.

Anahtar Kelimeler: Sıcaklık İversiyonu, Kararlı Tabakalaşma, Radyasyon Kaybı, Hava Kirliliği

1. Introduction

The troposphere layer of the atmosphere is the closest to the earth's surface, where various weather events occur. In the troposphere, where many meteorological phenomena occur, measuring weather events and keeping long-term records play an important role in revealing the climate character of the areas measured. Meteorological measurements may not always conform to the laws set forth by the basic sciences. For example, exceptions may occur that break down the general base of “temperature decreases as you higher, on the contrary, as you go downwards, the temperature increases”, it happens a feature of local weather conditions and relief. It can be seen in special cases contrary to such general principles in the natural environment. This is entirely due to local factors ahead of global conditions. The specified exceptions bring various positive or often negative results that they affect the natural environment.

According to the vertical temperature gradient, as you rise above the surface of the earth, the temperature decreases, or the temperature increases at a certain rate as it descends from higher places to the surface of the earth. This condition has been called the rate of temperature change in the atmosphere (lapse rate). As always stated in the atmosphere, normal conditions have not occurred. It is also known that sometimes the opposite has happened. Such meteorological phenomena have been

called temperature inversions. Temperature inversion means that the temperature rises as it rises and it is outside the normal running of the atmosphere (Sellers, 1965; Erinc, 1969; Ardel, 1973; Donmez, 1984; Strahler & Strahler, 1992; Erol, 1993; Nisanci, 1994; Ozyuvaci, 1999; Christopherson, 2000; Barry & Carleton, 2001; Oliver & Hidore, 2002; Bonan, 2008; Turkes, 2010; Atalay, 2013; Ahrens, Jackson & Jackson, 2012). In inversion formation, the above air is warmer than the following air. Temperature sweating situations represent stable stratification of the air, which means no turbulence. The stable stratification of the air close to the ground occurs when low-level air cools down or when high levels of air heat up or both processes occur at the same time. These processes occur more easily on cloudless days. For this reason, inversions occur mostly on clear, cloudless nights.

Temperature reversal has make calm and stable the lowest layer of atmosphere in terms of the higher weather movement. Air polluters like NO, SO₂, fliable dashes and various particles must occur effective air pollution because of no diffusion in the atmosphere. Because of this, the weather inversion is a phenomenon that it describes the meteorological formation of air pollution and it needs to be known and observed for taking precaution (Dönmez, 1984). Under normal weather conditions, the weather layer on the surface gets warm the result that sun is gotten heated the surface and to hot up weather layer gets higher. These raise have reasoned to remove the polluted air layer. In temperature reversal phenomena, the weather layer on the surface gets cold as a result that the surface become cold quickly especially in autumn and winter months as well. This cold weather squeeze into the surface and warm weather layer due to the fact that it can not be on the warm weather layer (Sayhan, 2002; 2003a & 2003b). As a result of temperature reversal polluted weather layer which squeezes onto the city affects negatively the people who live here and another alives. This polluted weather layer can diffuse with strong air stream (Figure 1).

Figure 1. Relationship Between Temperature Reversal And Air Pollution

(Source: <https://www.eea.europa.eu/A.H.13.02.2020>)

In places where temperature reversal occurs, the density of polluting factors decreases air quality and brings the lives of living things to levels that can be endangered from time to time. For

example, in the inversion incident in December 1952, 4,000 people died, and 10,000 of them were hospitalized in London (England). One another incident happened in October 1948, 20 people died and 6,000 people fell ill in the incident in Donora, Pennsylvania, USA. The subject can't be tolerated and neglected.

In the scope of the study, winter temperature inversion, which is thought to occur in the vicinity of Karabük–Safranbolu, was discussed. The study aims to determine the possible the inversion event around Karabük–Safranbolu Basin with the help of established meteorological stations. Weather observations of the site, keeping periodic records, temperature reversal limits, degree and timing of the measurements made by determining the living lives. The absence of a study on this subject in the field of research and the presence of an iron and steel industrial plant near the city of Karabük with a population of 132,000 makes the issue more important.

2. Research Area

In the study, temperature values obtained from the established meteorological stations' measurements by personal efforts in Safranbolu urban forest, Kırın village, Karit, Karabük University and Unsallar oil fields were analyzed, and the area and depth of the inversion was determined (Table 1).

Table 1: Meteorological station and elevation values (2014-2015 Winter Seasonal)

Stations	Height (m)
Karabuk University	280
Karit	350
Kırın Village	382
Safranbolu Urban Forest	700
Unsallar Oil Station	340

Karabük is located in the Western Black Sea section of the Black Sea region, one of the seven geographical regions of Turkey. The examination area covers part of Karabük and Safranbolu district and is located between 40° 15' and 40° 50' North latitudes and 32° 15' and 32° 45' East longitudes. When the physical map of the study site is examined, Karabük is a region with a depression characteristic, surrounded by high hills and with an average height of 250-500 m (Figure 2).

Figure 2: Location map of Karabük- Safranbolu

3. Material and Method

The meteorological stations for the site research were established in the least high parts of Arac and Soganli where it is surrounding is the highest. The winter inversion event was thought to have occurred and 5 stations was installed in the measurements of (2014-2015 winter period). The raw data obtained from the stations were evaluated by converting them into regular data using quantitative research methods. 1/ 25,000 scale map sheets related to the research area were used. At this stage, all data collected in the terrain was transferred to the GIS environment as a “point layer”. The survey data was analyzed and mapped in the ArcGIS 10.4 and Microsoft Excel 2010 package programs. In the project, the regional approach is the basis of the research; however the systematic approach has been applied from time to time while evaluating the data. The methodical stages of the project are given below:

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In the study area, it was found that the temperature reversal which started in december was 1.8 °C at the Unsallar Oil Station and Karabük University in the valley floor, while in Karit, Kıran village and Safranbolu urban forest at higher temperatures were between 2.7°C and 5.7°C. The depth of inversion appears to be 3.9 °C in December (**Figure 3**).

Figure 3. Temperature reversal map for December

In figure 4 when January's inversion was examined, it is seen that winter inversion continues in January. The mean temperature at the lower level of the valley is 2.6 °C, while at the higher stations Safranbolu urban forest and Kıran village it is 4.4 °C to 5.4 °C. The depth of the inversion was determined to be 2.8°C.

Figure 4. Temperature reversal map for January

In figure 5 February temperature inversion is examined, winter inversion is seen in february as it continues is seen in February. It was determined that the depth of inversion increased to 3.7°C. The temperature was 6.9°C at Unsallar Oil and Karabük University stations on the valley base , while it was 10.6°C at Karit station, 9.1°C at Kıran station and 8.2°C at Safranbolu urban forest meteorological station.

Figure 5. Temperature reversal map for February

5. Conclusion and Discussion

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