

## Investigation of Air Quality Levels on 19-Day National Lockdown Period for Covid-19 of Isparta City in 2020 using Grey Incidence Analysis

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**Abstract** – The COVID-19 pandemic had a notable impact on air quality worldwide. With widespread lockdowns and restrictions on mobility and industrial activities, there was a significant reduction in air pollution levels. The decrease in vehicular traffic and industrial emissions led to cleaner air in many urban areas. However, as restrictions eased and activities resumed, air quality gradually returned to pre-pandemic levels. Nonetheless, the pandemic highlighted the potential for positive changes in air quality through sustainable practices and reduced emissions. In this study, the research problem has been conducted to investigate air quality index variations on 19-Day National Lockdown Period for Covid-19 of Isparta City in 2020 for the following years using the grey incidence analysis. Some attractive results are obtained with the proposed methodology.

**Keywords** – Air Quality Index, Lockdown Period, Grey Incidence Analysis, Covid19

### I. INTRODUCTION

Increasing population and energy demand increase air pollution. Air pollution is the gas, water vapor and dust particles in the atmosphere reaching a level that will harm people and other living things. The places with the highest air pollution rate appear in industrially developed areas [1]. Due to air pollution, many respiratory diseases such as bronchitis, asthma and pneumonia cause an increase in diseases and sometimes result in death [2].

In this context, air quality is of great importance for humanity. Air quality has attracted the attention of researchers and some of the international studies are shown below. Zangari et al. (2020) conducted a study on the air quality of New York state from January to May 2020 at the time of the covid-19 pandemic. According to the parametric analysis, it was observed that there were 36% and 51% reductions in  $PM_{2.5}$  and  $NO_2$  concentrations respectively, because of the cautions taken [3]. Lian et al. (2020) investigated the effect of the measures

taken in the city of Wuhan during covid 19 on the air quality of the city. As a result of the measures taken, they found that  $PM_{2.5}$  and  $NO_2$  values decreased while  $O_3$  values increased. In addition, the authors observed that  $PM_{2.5}$  remains the main pollutant [4]. Another study was done by Dantas et al. (2020) In their study, they examined the air quality of the city of São Paulo in Brazil. As a result of their studies, authors reported a decrease of 77.3%, 54.3% and 64.8% in  $NO$ ,  $NO_2$  and  $CO$  values, respectively [5].

Studies conducted by researchers on air quality in Turkey are listed below. Topuz and Karabulut (2021) examined the change in air quality of the restrictions applied during the Covid-19 period in some provinces in the Eastern Mediterranean region (Adana, Mersin, Hatay, Kahramanmaraş and Osmaniye). As a result of the analyzes, authors observed that  $NO_x$ ,  $SO_2$  and  $PM_{10}$  parameters affecting the air quality decreased significantly compared to the previous year as a result of the restrictions applied [6]. Celik and Arıcı (2021)

investigated the changes in air quality before and during the Covid-19 pandemic in Zonguldak using different machine learning methods. According to the RMSE outputs, they found that the best solution method was in the decision tree, while the worst result was Naive Bayes [7]. Betul and Tereci (2022) experimentally studied the air quality of a university library at the time of the pandemic. According to the experimental results, it was observed that the  $CO_2$  concentration was below 1000 ppm thanks to the applied restrictions. Moreover, they also stated that the ventilation installation of the library should be rearranged [8]. Nese and Yetiskul (2021) studied the effects of  $PM_{10}$  concentration on air quality for the province of Izmir during the covid-19 pandemic. As a result of the evaluations, it was emphasized that the curfew had a significant effect on air quality. However, it has been stated that the factors contributing to air pollution are transportation and the transportation industry the most [9]. Azgin et al.(2021) analyzed air quality and equivalent  $CO_2$  alterations for Kayseri province throughout of the covid-19 pandemic outbreak. As a result of their studies, they claimed that the concentration of  $PM_{10}$  and  $SO_2$  decreased by 40% and 34%, respectively. It has also been observed that the amount of  $CO_2$  emissions released into the atmosphere is approximately 1 million tons less [10]. Yıkıcı and Unal (2022) evaluated the change in air quality of Turkey during Covid-19 by means of TOPSIS method. As a result of parametric analysis, they determined that the improvement in  $PM_{10}$  was low, while there was a reduce in  $O_3$  and rise in  $NO_2$  level [11]. Ozen (2022) conducted a study on the effect of restrictions on greenhouse gas during the covid-19 epidemic. According to analysis, the author claimed that there was a 17.3 Gg reduction in the amount of greenhouse gases released to the environment during the pandemic compared to the previous year [12]. An et al. (2023) proposed a newly the tetrahedron integrated incidence model to describe the air pollution of the Yangtze River delta in China. As a result of work, the authors found the Kendall coefficient of the gray projection tetrahedron integrated incidence model of 0.9031 [13].

In this study, the research problem has been conducted to investigate air quality index variations on 19-Day National Lockdown Period for Covid-19 of Isparta City in 2020 for the following years using the grey incidence analysis. Some attractive results are obtained with the proposed methodology.

## II. MATERIALS AND METHOD

Grey incidence analysis which is to measure similarity as a degree between the sequences' behaviors on geometrical shape of their curves. The generalized method is to turn the observed values of discrete behaviors of systematic factors to piecewise continuous lines through linear interpolation and further construct models to measure the degree of grey incidence according to the geometrical characteristic of the lines on the sequences. The procedure of grey incidence analysis is given as follows for  $n$  observation data on  $m$  sequences [14-17]:

*Step 1.* Establish the initial pattern (or average pattern) of each sequence.

$$X'_1 = \frac{X_i}{x_i(1)} = (x'_i(1), x'_i(2), \dots, x'_i(n)), k = 0, 1, 2, \dots, n \quad (1)$$

*Step 2.* Calculate the absolute difference sequences.

$$\Delta_i(k) = |x'_0(k) - x'_i(k)| \quad (2)$$

$$\Delta_i = (\Delta_i(1), \Delta_i(2), \dots, \Delta_i(n)), \quad i = 0, 1, 2, \dots, m \quad (3)$$

*Step 3.* Find the maximum and minimum differences.

$$M = \max_i \max_k \Delta_i(k) \quad (4)$$

$$m = \min_i \min_k \Delta_i(k) \quad (5)$$

*Step 4.* Calculate the grey incidence coefficients.

$$\gamma_{oi}(k) = \frac{m + \zeta M}{\Delta_i(k) + \zeta M}, \zeta \in (0, 1) \quad (6)$$

Here  $k = 1, 2, \dots, n; i = 1, 2, \dots, m$ .

*Step 5.* Calculate the grey incidence degrees.

$$\gamma_{oi} = \frac{1}{n} \sum_{k=1}^n \gamma_{oi}(k), \quad i = 0, 1, 2, \dots, m. \quad (7)$$

The generalized grey incidence analysis model also receives much attention from the researchers about the advantages of practical calculations and easily applied the large number of research problems such as stock index [18], covid19 case analysis [19], import & export analysis [20], employment data [21]. In this paper, even if the further studies on grey incidence analysis models are commonly conducted to improve the solution

quality, the generalized grey incidence analysis model is also developed to clarify the closeness and similarity on air quality index values according to Isparta City of Türkiye on 19-Day National Lockdown Period for Covid-19. The data are given as Table 1 for the years of 2020-2023 [22].

Table 1. Air quality index values of Isparta City [22]

	<b>29.Apr</b>	<b>30.Apr</b>	<b>1.May</b>	<b>2.May</b>	<b>3.May</b>	<b>4.May</b>	<b>5.May</b>	<b>6.May</b>	<b>7.May</b>	<b>8.May</b>
<b>2020</b>	47.29167	43.83333	33.29167	27.33333	29.41667	22.20833	27.58333	28.58333	32.41667	31.16667
<b>2021</b>	50.91667	43.58333	43.87500	50.87500	55.00000	55.00000	50.91667	39.62500	39.04167	41.66667
<b>2022</b>	35.04167	31.54167	23.25000	18.83333	21.41667	28.45833	26.95833	30.04167	24.75000	22.70833
<b>2023</b>	14.33333	13.75000	20.04167	26.95833	30.58333	32.29167	23.79167	30.83333	20.54167	18.91667
	<b>9.May</b>	<b>10.May</b>	<b>11.May</b>	<b>12.May</b>	<b>13.May</b>	<b>14.May</b>	<b>15.May</b>	<b>16.May</b>	<b>17.May</b>	
<b>2020</b>	30.04167	33.70833	33.54167	38.83333	42.95833	41.29167	43.50000	55.00000	55.45833	
<b>2021</b>	48.75000	39.95833	37.91667	34.62500	39.70833	37.45833	39.79167	36.16667	34.37500	
<b>2022</b>	23.29167	24.75000	23.04167	26.33333	28.33333	29.12500	26.95833	28.54167	27.20833	
<b>2023</b>	25.29167	25.37500	34.70833	30.62500	22.66667	21.33333	18.87500	29.66667	43.04167	

### III. RESULTS

The parametric analyses were made according to the air quality index values of Isparta province between 2020-2023. The selected dates were determined as April 29-May 17.

The results of the analyses are given in Table 2. The year 2020 was selected as the reference year. As a result of the analyses made according to the years, it was calculated as 0.7957, 0.7331, 0.5506 respectively.

Table 2. Results of grey incidence degrees

<b>AQI</b>	
<b>2020</b>	<b>Ref</b>
<b>2021</b>	0.7957
<b>2022</b>	0.7331
<b>2023</b>	0.5506

### IV. DISCUSSION AND CONCLUSION

Air pollution occurs when the natural composition of the atmosphere changes undesirably, posing serious threats to human and environmental health. It is caused by various chemical, physical, and biological substances. While natural factors like volcanoes and oceans contribute to air pollutants, the majority of these harmful substances are a result of human activities. The Covid-19 outbreak, first identified in Wuhan, China, rapidly affected the entire world and caused significant disruptions in daily life. To combat the pandemic, governments implemented measures such as curfews, remote work, suspension of non-essential activities, and travel restrictions to reduce population mobility. As a result, people's movements were limited to essential tasks like obtaining food, medicine, going to work, or seeking medical attention. These behavioural changes, along with the implemented measures, have led to remarkable improvements in air quality.

In this study, the research problem has been conducted to investigate air quality index variations on 19-Day National Lockdown Period for Covid-19 of Isparta City in 2020 for the following years using the grey incidence analysis.

The analyses show that the amount of emissions released from the quarantine period to the environment has decreased. The reasons for these decreases are that people are more sensitive to the environment and the government's efforts for clean air.

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