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Regional Case Study

Air Quality Study in Mijen District, Semarang City in 2022

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Abstract
The higher the air pollution in an area, the more it can have a negative impact on human health status if inhaled continuously, especially in the respiratory system. This study used secondary data obtained from the Environment and Forestry Service. The data was analyzed using a descriptive method by comparing data collected in the field with ambient air quality standards based on Government Regulation Number 22 of 2021 concerning the Implementation of Environmental Protection and Management to determine air quality conditions in Mijen District, Semarang City. The impact resulting from air pollution can interfere with the health of living things and damage the ecosystem environment. Human health will be disrupted due to polluted air, which can lead to diseases such as ARI, heart disease, and even lung cancer, which is very dangerous. For this reason, it is necessary to conduct research on air quality to prevent air pollution that exceeds ambient air quality standards, which can cause health problems for the community in Mijen District. Based on research on the analysis of air quality parameter measurement results in Mijen District, Semarang City, it can be concluded that all air quality parameters do not exceed quality standards.

Keywords: Air pollution; air quality; ambient air

1. Introduction

Currently, the growth of the transportation sector is increasing every year. This increased condition has a negative impact in the form of air pollution due to increased emissions from transportation vehicles (Abidin et al., 2019). Maintenance of air functions must be carried out to maintain human health and well-being and protect other living things. In Indonesia, according to the Indonesian Lung Doctor Association, air pollution is associated with lung health problems such as decreased lung function (21-24%), asthma (1.3%), the prevalence of lung disease in nonsmokers at 6.3%, and lung cancer at 4%. Some cities in Indonesia are even included in the list of 50 cities with the worst air quality in the world and in Southeast Asia according to IQAir (Kautsar et al., 2021). These air pollution conditions can have a negative impact on human health status if inhaled continuously (Wenas et al., 2020).

The problem faced by Semarang City is the increasing density of motorized vehicles, which can have an impact on decreasing air quality. Semarang, as one of the big cities in Indonesia, also has high vehicle growth. 70% of air pollution cases in urban areas are caused by motor vehicle emissions (Agarwal & Mustafi, 2018). The addition of vehicles in the city of Semarang was as much as 3.9% in 2019–2020, and the addition of vehicles in the city of Semarang was as much as 12.1% in 2020–2021 (Central Bureau of Statistics, Semarang City). In Mijen District, Semarang City is a densely populated area, and there are many industries around it. This can affect the increase in air pollution due to community activities.

Respiratory diseases in Mijen sub-district are also a major problem in the area, with a 46% increase in respiratory disease cases in 2021 and a 50% increase in respiratory disease cases in 2022.

The impact of air pollution through exhaust gases has received the attention of various parties. Environmental quality in an area can be known by comparing air quality measurements in the field with ambient air quality standards based on Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning the Implementation of Environmental Protection and Management, which can be used as a common reference for stakeholders in measuring the performance of environmental management institutions in central and local governments in environmental protection and management living as well as measuring the success of environmental management programs.

Air Quality Pollutant Parameters are parameters used as indicators in determining air quality. These parameters consist of 7 types, namely: a) Sulfur dioxide (SO_2) is a classic pollutant that is colorless and clear, has a sharp or pungent odor, and endangers humans. SO_2 is a water-soluble exhaust gas and can be absorbed in the nose and most of the passages to the lungs (Wenas et al., 2020); b) nitrogen dioxide (NO_2) is one type of pollutant that can reduce air quality and have an impact on human health and the environment (Serlina, 2020); c) carbon monoxide (CO) gas mostly comes from burning fossil fuels with air in the form of exhaust gases (Kariada, 2011). d) PM10 is one of the air pollutants caused by sources such as motor vehicles; small particles in the air can be sucked into the respiratory system and cause respiratory diseases and lung damage (Miller & Newby, 2020). e) PM2.5 particulate dust smaller than 2.5 microns (PM2.5) as one of the pollutants from emissions that can enter and penetrate the human respiratory system and is bound to blood through gas exchange in the pulmonary alveoli so that it can cause deposits in the alveoli and cause cell damage (Sembiring, 2020); f) O_3 Ozone is an air pollutant that has a negative impact on the environment, nature, as well as man. Surface ozone (O_3) is referred to as a secondary pollutant because it is formed from the decay or destruction of other gas particles. About 70% of chemical oxidants in the atmosphere react with CO (Sulistiyono et al., 2019). HC is an air pollutant that can be in the form of gases, liquids, or solids. The higher the number of carbon atoms, the more likely this element will be in the form of a solid. Hydrocarbons with an elemental C content between 1 and 4 carbon atoms will be gaseous at room temperature, while those with an elemental C content above 5 will be in the form of liquids and solids. Whereas if it is liquid, HC will form a kind of oil mist, if it is in the form of solids, it will form a concentrated smoke and eventually clump into dust. The results of Jainal Abidin (2019) show that the air pollution problem has currently reached an alarming level. This is due to the large number of polluting substances produced from daily activities. Industrial activities, power plants, and motor vehicles always produce pollutants, and forest fires pollute clean air every day. This is a source of problems for the survival of living things on this earth.

Based on research from Restiani (2019), Mijen District is the place with the largest emission income in Semarang City based on the calculation of area sources. In addition, Mijen District is an area with access to the main road, namely the Semarang-Jakarta Road. The growth of settlements in Mijen District is fast because there is a Bukit Semarang Baru area with a total number of buildings exceeding 10,000 units, so it can be said that the number of residents in Mijen District will increase (Khadiyanto, 2020). The number of motorized vehicles will increase as the population increases in an area (Rahmawati, 2021). Therefore, this study was conducted with the aim of determining the air quality in Mijen District.

2. Methods

This research is of the descriptive type by comparing field data with ambient air quality standards based on Government Regulation Number 22 of 2021 of the Republic of Indonesia concerning the Implementation of Environmental Protection and Management to determine air quality conditions in Mijen District, Semarang City. The location of this research is in Mijen District, Semarang City, with coordinates 7° 04' 34.5"S and 110° 18' 34.4". The period of this study is from September to November 2022. This study used secondary data from ambient air quality monitoring stations operated by the Environment and Forestry Service of Central Java Province in the January–June 2022 period during the dry season. The

parameters studied include PM10 (particulate 10), PM2.5 (particulate 2.5), SO2 (sulfur dioxide), O3 (ozone), CO (carbon monoxide), NO2 (nitrogen dioxide), and hydrocarbons. The instrument used is the ISPU quality data recording sheet of the Environment and Forestry Service of Central Java Province. Data collected from January to June 2022 totaled 180 days (6 months) and was then simplified into per week to represent the overall data from January to June 2022. Data presented in graph for analysis and trend comparison. Field observation is also needed in knowing several locations of industrial activities and vehicle activities in Mijen District. This research uses theory triangulation analysis that compares the data obtained with relevant theories to obtain truth in the results of the study so that it can be analyzed and obtained conclusions as a whole and thoroughly.

3. Result and Discussion

3.1 Research Site Review

Mijen District is a district with an altitude of 310 meters above sea level, the highest when compared to other districts in Semarang City. Mijen District has 14 villages with a population of around 76,000 and a population growth rate of 12.92% per year. It occupies about 4.19% of the total population of Semarang City with a population density of around 1,321 people per km2. The Mijen sub-district is dominated by gentle slopes, with an area of 32,79 km2 in all existing villages. Based on research from Choirunnisa (2021), 77% of the Mijen District area is dominated by low rainfall spread across Wonoplumbon, Ngadirgo, Pesantren, Kedungpane, Wonolopo, Mijen, Jatibarang, Purwosari, Polaman, and Karangmalang Villages. While the other 23% has had moderate rainfall spread over parts of Wonoplumbon, Wonolopo, Jatisari, Tambangan, Cangkiran, Bubakan, and Karangmalan villages. Mijen District has several industrial activities located in the *Bukit Semarang Baru* area.

3.2 Air Quality

Based on the Government Regulation of the Republic of Indonesia No. 22 of 2021 concerning the Implementation of Environmental Protection and Management, there are seven key parameters of ambient air quality. The following are the parameters and ambient air quality standards:

Table 1. Ambient Air Quality Standards

No	Parameters	Measurement Time	Quality Standards	Information
1	Sulfur dioxide	1 hour	150 $\mu g/m^3$	-
2	Carbon monoxide	1 hour	10000 $\mu g/m^3$	-
3	Nitrogen dioxide	1 hour	200 $\mu g/m^3$	-
4	Ozone	1 hour	150 $\mu g/m^3$	-
5	Hydrocarbon	3 hours	160 $\mu g/m^3$	Measurements were carried out at 06.00-10.00 local time
6	Particulate 10	24 hours	75 $\mu g/m^3$	-
7	Particulate 2.5	24 hours	65 $\mu g/m^3$	-

Source: PP RI No. 22 of 2021

Based on Table 1, it indicates the normal threshold of ambient air. If there are parameters that exceed these quality standards, it is feared that it will interfere with the health of the surrounding community and the living things that breathe it. The danger of air pollution is a significant concern due to its adverse impacts on human health and the environment. Air pollution, primarily caused by industrial emissions, vehicle exhaust, and burning fossil fuels, releases harmful pollutants into the atmosphere (Miao et al. 2019). These pollutants, such as particulate matter, nitrogen oxides, and volatile organic compounds, have detrimental effects on respiratory health and can lead to cardiovascular diseases and premature death.

Exposure to air pollution, particularly fine particulate matter, can penetrate deep into the lungs and enter the bloodstream, causing inflammation, lung damage, and increased vulnerability to respiratory

infections (Glencross et al., 2020). Additionally, air pollution contributes to the formation of smog, which contains high levels of ground-level ozone that can irritate the respiratory system and impair lung function. Apart from its impact on human health, air pollution also has severe consequences for the environment. It contributes to climate change by releasing greenhouse gases, leading to global warming, melting ice caps, rising sea levels, and altered weather patterns (Zandalinas et al., 2021). Air pollution also contaminates soil, water, and vegetation, disrupting ecosystems and threatening biodiversity. The following are the results of air quality studies based on seven parameters.

3.2.1. Particulate 10 (PM_{10})

Based on the monitoring results from January–June on particulate parameters, trends are obtained as in Figure 1. In the figure, the PM10 value for 25 weeks from January to June is below the quality standard of 65 µg/m3. Meanwhile, there was an increase in particulate value of 10 in April (Week 13), which amounted to 29 figures still included in the medium category. April is the beginning of the dry season, so the value of air pollution parameters increases compared to the rainy season. This is because in the dry season, vegetation activity is higher when compared to the rainy season, and many people burn garbage in the dry season (Subardi et al., 2020). Based on research from Sari (2019), this can be because motorized vehicle activity is quite high in the area because Mijen District is a district that connects Boja District, Kendal Regency, and Ungaran, Semarang Regency. In addition, waste incineration is also the main cause of the high number of particulate matters (Aziz et al., 2021). Particulate 10 can consist of several heavy metals (Zn and Fe), light metals (Na, Ca, K, Mg, and Al), and chemicals (Cl, Si, and S) (Gusnita & Cholianawati, 2019). This content can be harmful to human internal organs based on the nature of the content elements that are in the particulates because the content can react with blood vessels and other organs (Ihsan et al., 2021).

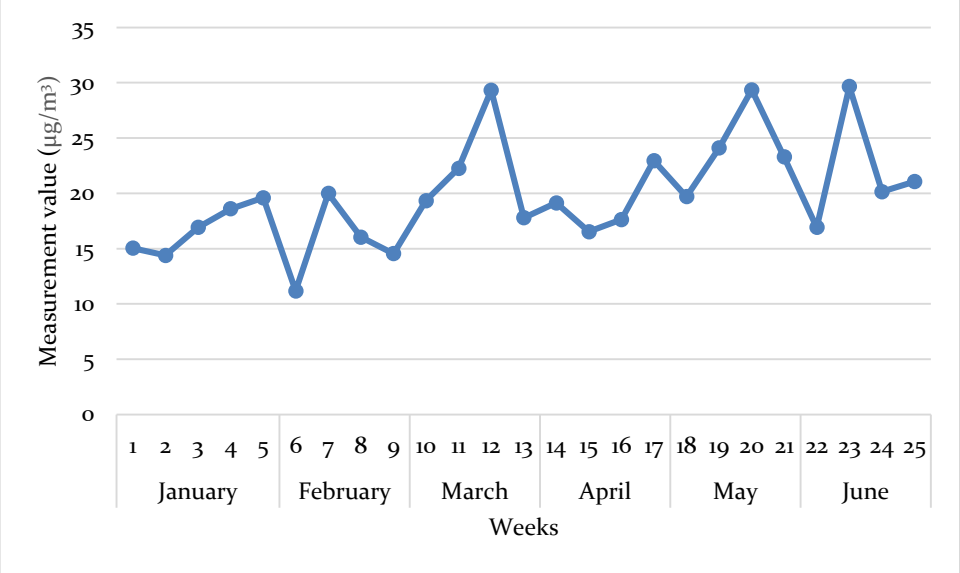

Figure 1. Air quality graph PM_{10} parameters

3.2.2. Particulate 2.5 ($PM_{2.5}$)

In Figure 2, the air quality at particulate parameter 10 is still below the number 75 µg/m³. In contrast to particulate 10, PM2.5 values tend to be higher in weeks 1–16, or from January to April. Just like particulate 10, particulate 2.5 also comes from motor vehicle combustion emissions and dusty road pollution, especially unpaved roads (Nur et al., 2021). Particulate 10 can harm the heart, infect the respiratory tract, interfere with bone growth in toddlers, and interfere with visibility (Armninarahmah & Kurniawan, 2020).

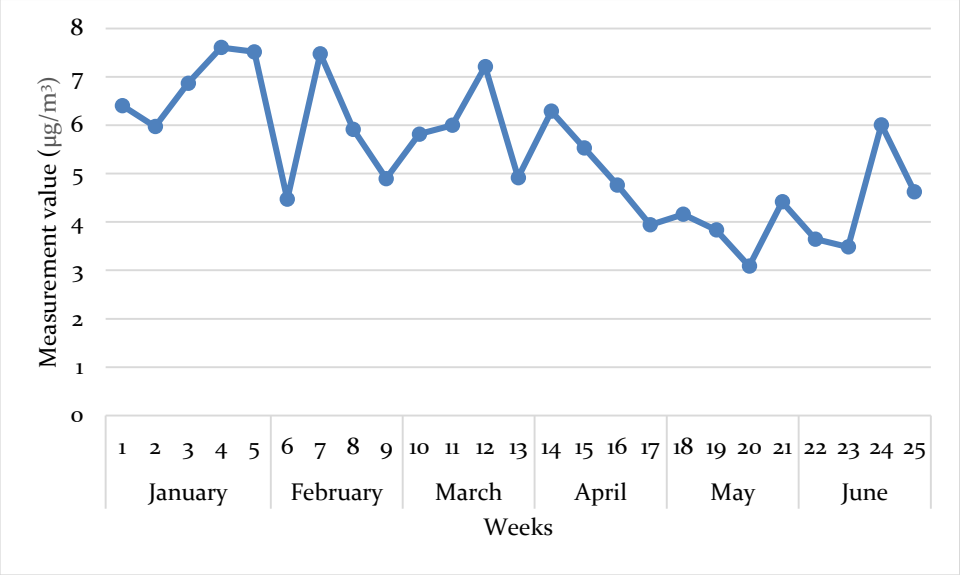

Figure 2. Air quality graph $PM_{2.5}$ parameters

3.2.3. Ozone (O_3)

Based on data from Figure 3, ozone values in January to June are under normal conditions, which are below the number. Based on research from Zhang (2019), the value of pollutants in ozone will decrease as the value of pollutants in PM2.5 increases to 150 µg/m3 and vice versa, the value of PM2.5 will increase when the surface ozone content decreases, where PM2.5 will react with free radicals to form ozone compounds. Thus, it can be interpreted in this study that PM2.5 reacts with free radicals to form ozone, which results in high ozone parameter values and low PM2.5 parameter values. Research from Zhang (2019) is evident from Table 4, where PM2.5 values tend to be constant while ozone values tend to exceed PM2.5 values. Ozone in high concentrations can cause irritation of the respiratory tract and, if exposed continuously, will cause damage to the lungs (Ritz et al. 2019).

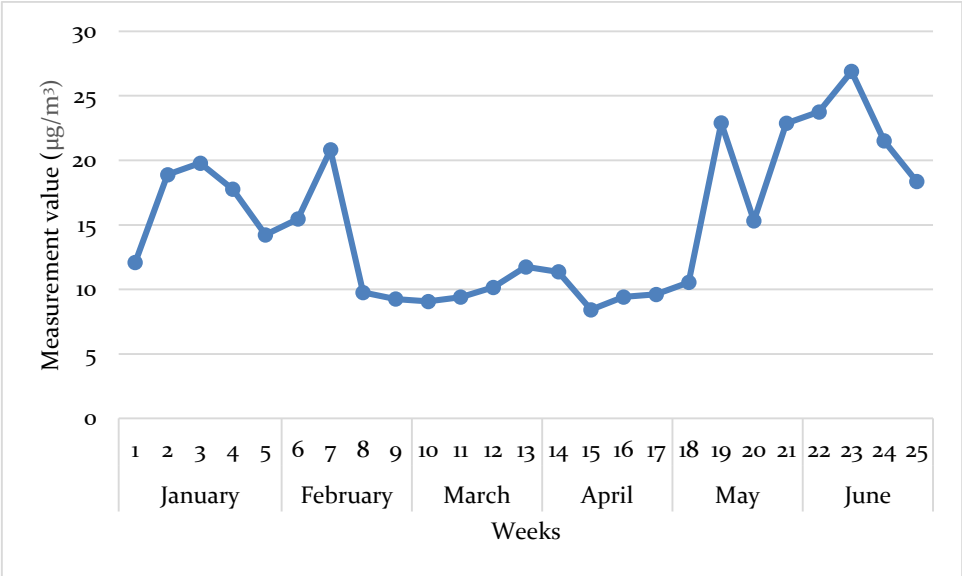

Figure 3. Air quality graph parameter O_3

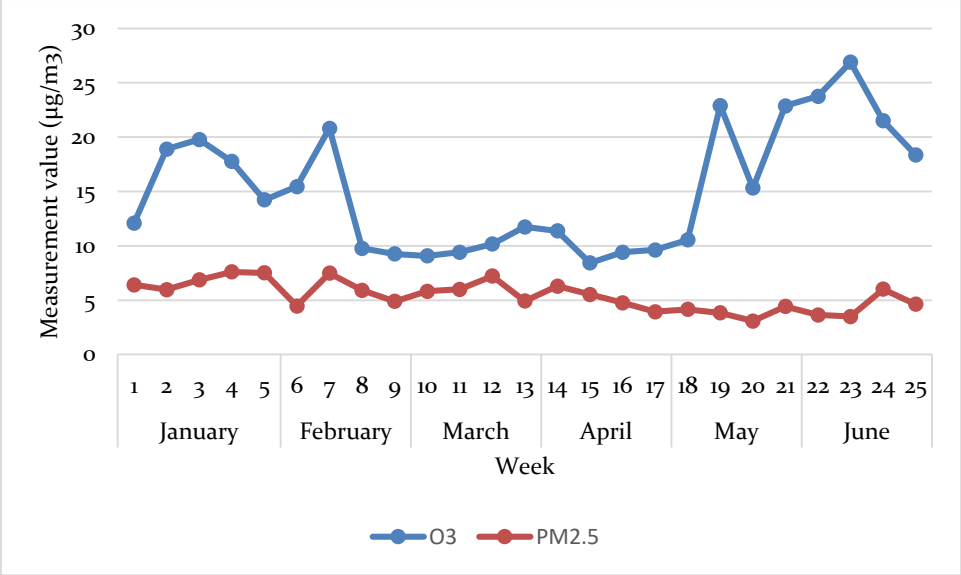

Figure 4. Comparison graph of parameters O_3 and $PM_{2.5}$

3.2.4. Sulphur Dioxide (SO_2)

In Figure 5, the value of SO2 in weeks 1–25 is below the number, meaning that it is still below the quality standard. There is an increase in 150 µg/m3, the value of SO2, in weeks 19–25 or in May–June, which month has entered the dry season. This is in line with Hoque's (2020) research that, in drier seasons, it tends to increase the amount of SO2 in the air. In addition, the higher value of SO2 in May–June can be caused by industrial activities that still use fuel in the form of coal (Ruhban & Rahmadana, 2019). Furthermore, the high SO2 in May-June is also caused by motorized vehicles, and people tend to travel more in the dry season compared to the rainy season (Mulyadim et al., 2022). This triggered a significant increase in SO2 in May–June compared to the previous wet month, namely January–March (Fedkin et al., 2019). There are several industries at several points in *Bukit Semarang Baru* Industrial Park that can be a source of pollutants in the air. In addition, SO2 also comes from volcanic activity that actively emits volcanic ash (Liu et al., 2019). However, there is no volcanic activity in the Mijen region.

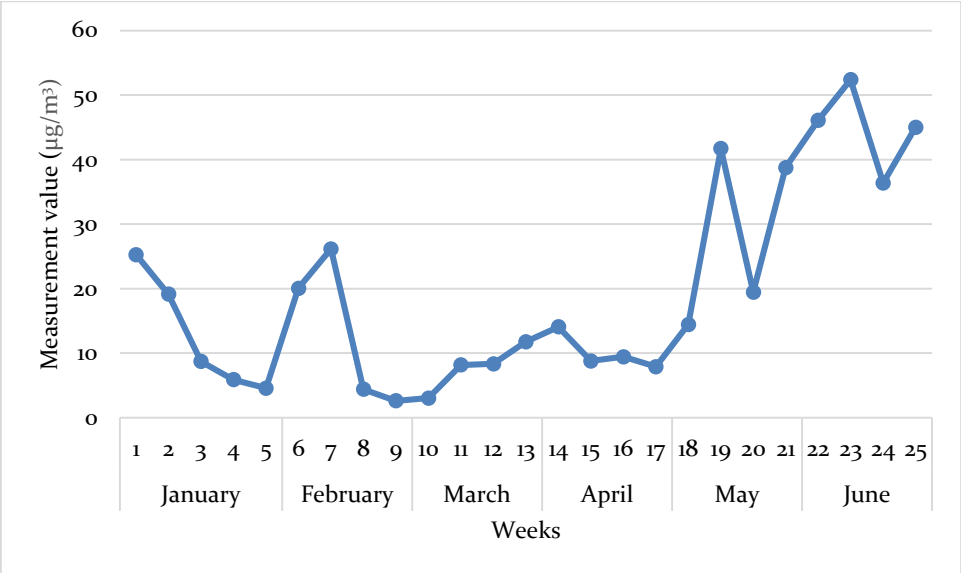

Figure 5. Air quality graph SO_2 parameters

3.2.5. Carbon Monoxide (CO)

Based on Figure 6, carbon monoxide values in weeks 1–25 tend to be stable at numbers between 1000 and 2000 µg/m³, still far below the number 10000 µg/m³. However, there is a slight upward trend in the week of May 19–25 or in May–June, which month enters the dry season. This is in line with research from Mukta (2020), which found that the high carbon monoxide content will increase as it peaks in the dry month, which in Indonesia is the dry season. The high number of CO events in February, May, and June can be caused by the dense number of vehicles passing through Mijen District (Afwa et al., 2021). This is because Mijen District is a connecting route between three provinces and cities at once, namely Kendal Regency, Semarang City, and Semarang Regency. In addition, industrial activities can also increase CO levels in the air (Cheng et al, 2021).

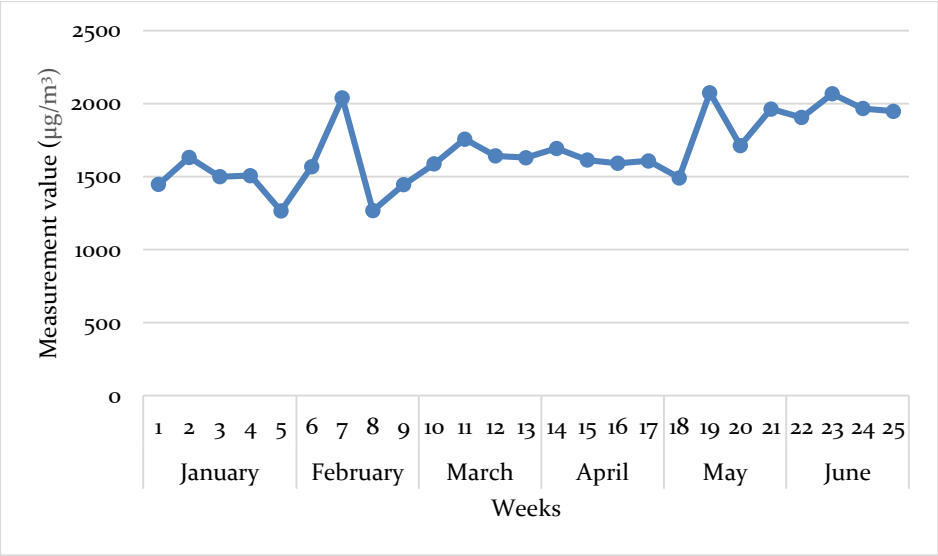

Figure 6. CO parameter air quality graph

3.1.1. Nitrogen Dioxide (NO_2)

Based on Figure 7, the value of NO2 in weeks 1–25 is below the quality standard, which is below 200 µg/m³, meaning that the parameter NO2 is still in good air quality and does not cause effects on human health or living things. In Figure 6, the value of NO2 also tends to decrease in weeks 1–10 or in January–March, namely at numbers 2–9 µg/m³, a far difference with quality standards based on Government Regulation Number 22 of 2021 for the Republic of Indonesia. High and low NO2 values can be caused by motor vehicles, power plants, industrial emissions, and off-road sources such as construction equipment, grass, and gardening (Liu et al., 2021).

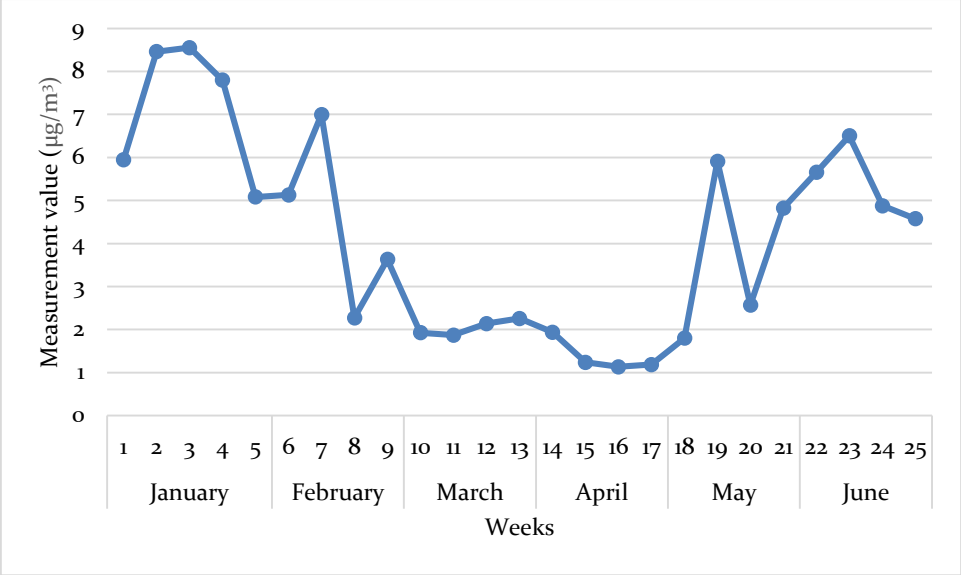

Figure 7. Air quality graph parameter NO_2

3.1.2. Hydrocarbons (HC)

In Figure 7, HC values tend to be constant in weeks 7–22 or in March–May, which is constant in numbers but still below the quality standard, which is. However, in week 23, there was an increase in hydrocarbon concentration values of by, an increase of 8 times from the previous week of 5 µg/m³. This can be caused by domestic emission sources of household activities such as burning garbage, burning wood, cooking on oil/gas stoves and kerosene/wood stoves, and using other housing heaters (Ofori et al., 2020). In weeks 22–25 or in June, it is the peak of the dry season (Yuda et al., 2018). People in the dry season tend to burn garbage more often compared to the rainy season (Faradila et al., 2022). In addition, the burning of agricultural waste is like the burning of rice husks, which are in agricultural areas. High hydrocarbon pollution in rural areas is mainly caused by domestic and agricultural sources, while in urban areas it is due to industrial, mobile, and domestic sources (Patel et al., 2020). HC parameters in the form of gases are more toxic than those in the form of liquids and solids. When HC, solids (particles), and liquids mix with pollutants, Iain will form new chemical bonds often called polycyclic aromatic hydrocarbons (PAHs). This PAH stimulates the formation of cancer cells when sucked into the lungs, and this carcinogenic PAH is widely found in industrial areas and heavy traffic areas. HC gas can cause irritation of mucous membranes and cause lung infection when inhaled.

There are several ways to reduce air pollution, including transition to renewable energy sources, Shift from fossil fuels to renewable energy sources such as solar, wind, and hydropower. Governments and industries should invest in sustainable energy infrastructure, incentivize renewable technologies, and promote research and development (Parinduri & Parinduri, 2020). This transition reduces hydrocarbon emissions, creates job opportunities, and fosters economic growth. In addition, enhanced energy efficiency also needs to be done (Sinaga et al., 2021). Enhance energy efficiency in industries, buildings, and transportation systems. Implement energy-saving measures, establish energy efficiency standards, and offer incentives for adopting energy-efficient practices. Public awareness campaigns can educate about the benefits of energy conservation and encourage behavior changes (Santoso et al., 2023).

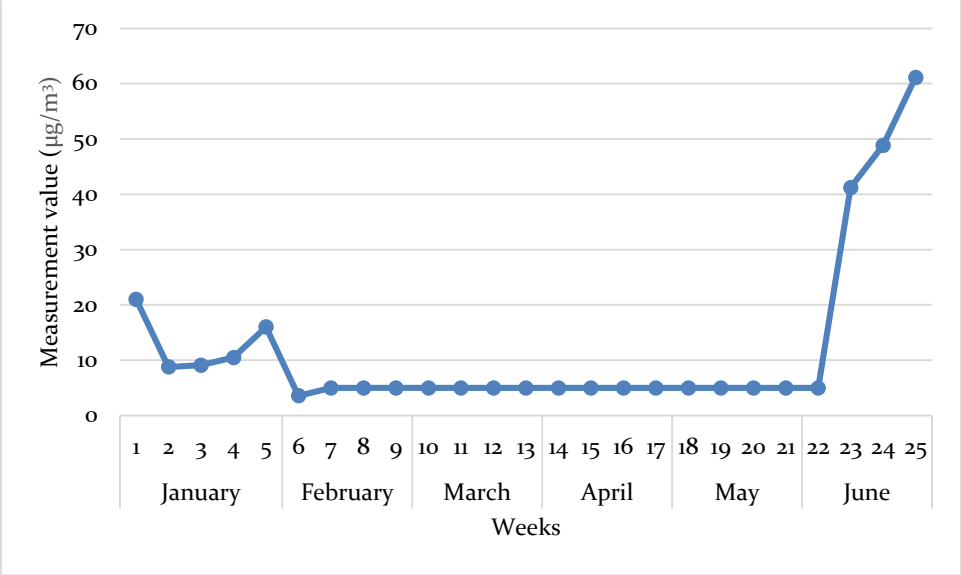

Figure 8. HC parameters air quality graph

4. Conclusions

Based on research on the analysis of air quality parameter measurement results in Mijen District, Semarang City, all air quality parameters do not exceed quality standards as stipulated by Government Regulation Number 22 of 2021. There was some improvement in some parameters in April and June. The increase in measurement results can increase by 2 to 8 times from the previous month. This can be caused by the dry season and increased vehicle use.

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