Spatial Evaluation of Ambient Air Quality in Dobut Village, Manokwari

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Abstract

Evaluation of ambient air quality conditions in Dobut Village, Manokwari, through a spatial approach based on 12 monitoring points. The parameters measured in this study consisted of $PM_{2.5}$, NO_2, and SO_2 during the dry season. The data analysis used the Inverse Distance Weighting (IDW) interpolation method. The existing results show that most areas of Dobut Village have air quality in the "good - moderate" category, but there are several points with $PM_{2.5}$, NO_2, and SO_2 concentrations within the threshold approaching the WHO limit, namely around the industrial center area located in the suburban location. This study emphasizes the importance of spatial-based air quality monitoring in rural areas that are starting to develop in mobility and infrastructure. The measurement results show that the suburban zone has higher $PM_{2.5}$, NO_2, and SO_2 concentrations than the urban area. This is a comparison that has been the general assumption that suburban areas are cleaner. This area has a higher concentration due to industrial activities and vehicle activities by residents and industrial workers in Dobut Village so that the area becomes unclean.

Keywords: *Ambient, $PM_{2.5}$, NO_2, SO_2.*

A. INTRODUCTION

Air pollution or air pollution is the entry or introduction of living organisms, energy substances and/or other components into the air, causing the air quality to be unsuitable for its intended purpose or polluted. Air pollution is a global environmental problem influenced by urbanization, industrial activity, motor vehicle emissions, and meteorological and geographical factors (World Health Organization, 2021). The increasing level of air pollution is a global concern, and is caused by many factors, such as increasing urbanization, industrial pollution, traffic emissions, agriculture, and energy use (Ahmad et al., 2025). Air pollution has been reported to have a significant impact on global mortality (Institute for Health Metrics and Evaluation [IHME], 2018). The Global Burden of Disease study shows that ambient air pollution is included in the ten major risk factors affecting human health globally (IHME, 2018) and contributes significantly to increasing mortality rates (Cohen et al., 2017). Most cities worldwide fail to comply with pollutant standards and have reported readings far exceeding them, resulting in millions of premature deaths (Ahmad et al., 2025).

Data from the 2017 Global Burden of Disease study (Beelen et al., 2014) provides new evidence of the significant impact of air pollution globally, placing it among the top ten risks facing humanity. Most cities worldwide fail to comply with pollutant standards and have reported readings far exceeding them, resulting in millions of premature deaths (Ahmad et al., 2025). At the forefront of pollutants exceeding concentration limits are coarse and fine particulate matter (PM), defined as particles with a nominal mean diameter of less than 10 µm (PM10) and 2.5 µm (PM_{25}), respectively. A World Health Organization (WHO) report on ambient air pollution indicates that the annual average concentration of $PM_{2.5}$, or PM10, increased by more than 10% between 2010 and 2016 in at least 280 cities worldwide (BMKG, 2025). Air pollution is a major global health risk, evident in the increasing pollution in several regions due to industrial emissions, geographic conditions, and meteorological factors such as dust and sea salt (Brook et al., 2010).

Monitoring ambient air quality is part of air quality management aimed at improving air quality in the surrounding environment. Furthermore, ambient air quality monitoring aims to determine the Air Quality Index at the research location, which is a village far from urban activities.

Spatial approaches based on geographic information systems (GIS) and interpolation methods such as Inverse Distance Weighting (IDW) are widely used to map the distribution of air pollutants and identify pollution risk zones in greater detail (Jerret et al., 2005). This approach allows for representative analysis of the spatial distribution of air quality, especially in areas with limited monitoring points (Ahmad et al., 2025).

The side effects of exposure to NO_2 and SO_2 at low concentrations can cause watery and sore eyes, while at high concentrations they can cause shortness of breath, throat irritation, and even death. The impact on plants can damage them through holes or pores in the leaves and even burn plant tissue. Another impact is ozone layer depletion, which leads to global warming. This occurs when sunlight reaches the Earth's surface without being reflected and absorbed.

The economic impact of air pollution in Indonesia is estimated to be significant, primarily related to increased public health costs due to exposure to pollutants from motor vehicles and industrial activities (BMKG, 2025). Around 220 million Indonesians are expected to live in large and small cities by 2045, resulting in increased economic activity and deteriorating environmental quality (Cohen et al., 2017). The increase in economic activity is a manifestation of the successful development of Manokwari City, Dobut Village, Manokwari Regency, West Papua Province. The number of industries and motorized vehicles has an impact on the environment due to the activities of residents, industries, and motorized vehicles. Based on the problem, the purpose of this study is to analyze air quality data in understanding the level of pollution by comparing it to applicable air quality standards. Through research and monitoring results, it can be seen the condition of air quality in Dobut Village, Monokwari District, West Papua Province.

B. METHODS

The spatial interpolation method used in this study refers to the Inverse Distance Weighting (IDW) based GIS approach, which is effective in mapping the distribution of air pollutants in areas with limited sampling points. The monitoring parameters $PM_{2.5}$, NO_2, and SO_2 were chosen because they are the main indicators of ambient air quality and have a significant impact on human health. Sampling was carried out in Dobut Village, Manokrawi, West Papua, over a period of 4 days with 12 monitoring points during the dry season in 2025. Monitoring points from 12 strategic points based on location variations with a sampling time of 1 hour. The monitoring parameters for $PM_{2.5}$, NO_2, and SO_2 while the tool used is the Impinger Air Sampler consisting of 4 main parts including an impinger tube or midget impinger, a suction pump, a flow meter and a water vapor absorber tube. The impinger tube functions as a container for taking test samples and is equipped with a glass cylinder tip in a flask with a maximum diameter of 1 mm. The suction pump draws the air sample into the impinger, while the flow meter measures air velocity during sampling. A water vapor absorber acts as a safety valve for the pump during the air sampling process. The water vapor in the pump acts as a humidifier.

C. RESULTS AND DISCUSSION

The results of this study indicate that suburban areas have higher concentrations of PM_2, NO_2, and SO_2 than urban areas. This finding aligns with previous research suggesting that industrial activity and traffic density in suburban areas can lead to higher accumulation of air pollutants compared to urban areas (Kumar et al., 2014).

Differences in pollutant concentrations are also influenced by local meteorological conditions, such as high air temperature, low humidity, and relatively low wind speeds, which slow the process of pollutant diffusion in the atmosphere (Seinfeld & Pandis, 2016).

Table 1. Meteorological Data of Air Sample Area

No	Description	Results/Units
1	Temperature	31°/oc
2	Humidity	7,6/%

The table shows that the temperature and humidity at the sample location ranged from 31°C to 76.6%. The data provides an overview of conditions that can affect air quality in Dobut Village. Qualitative data analysis was conducted by comparing pollutant concentrations to applicable ambient air quality standards to assess pollution levels and potential risks.

The measurements showed that the suburban zone had higher concentrations of $PM_{2.5}$, NO_2, and SO_2 than the urban area. This comparison contradicts the common assumption that suburban areas are cleaner. These higher concentrations are due to industrial activity and vehicle traffic by residents and industrial workers in Dobut Village, making the area unclean. The following are the results of pollution levels based on three parameters.

Table 2. Average Results of Three Parameters

Zone	**$PM_{2.5}$**	**NO_2**	**SO_2**
Urban	15.82	35.93	21.81
Suburban	20.76	41.61	29.44

Figure 1. Bar graph and spatial map based on combined pollution levels

The bar graph shows a comparison of the average concentrations of air pollution parameters:

1. $PM_{2.5}$ ($\mu g/m^3$): Suburban (20.76) higher than Urban (15.82)
2. NO_2 (ppb): Suburban (41.61) higher than Urban (35.93)
3. SO_2 (ppb): Suburban (29.44) higher than Urban (21.81)

This indicates that we have always known that suburban locations or areas are clean, but in the context of research, suburban locations or zones actually show higher pollutant concentrations. On the map, we can see two representative points:

1. Meto Urban zone: marked with a lighter color, indicating a lower combined pollution level
2. Suburban zone: marked with a darker color, indicating a higher combined pollution level.

The combined pollution level is calculated based on the average of three parameters ($PM_{2.5}$, NO_2, SO_2), which provides a general overview of air quality in Dobut Village, Manokwari. Spatial analysis shows zones with higher pollution levels located around industrial areas and areas of vehicle activity.

D. CONCLUSION

Air is a vital environmental component for human life, and its quality must be maintained and improved to support the lives of humans and other living things. Air pollution originates from human activities, particularly motor vehicle emissions and industrial emissions that emit NO_2 and SO_2. Monitoring the spatial distribution of air quality in Dobut Village, Manokwari, Papua, shows that suburban areas have higher pollutant concentrations than urban areas. The monitoring results show a comparison of the average concentrations of air pollution parameters as follows: $PM_{2.5}$ (μg/m³): Suburban (20.76) higher than Urban (15.82), NO_2 (ppb): Suburban (41.61) higher than Urban (35.93), dan SO_2 (ppb): Suburban (29.44) higher than Urban (21.81).

This demonstrates that suburban locations or areas are generally clean, but in the context of research, suburban locations or zones actually exhibit higher pollutant concentrations. The results of direct field monitoring of samples taken and averaged in a bar graph provide a picture to support this analysis. The research was conducted in Dobut Village, where there is high community activity and industrial activity.

Measurements were made using an Impinger air sampler equipped with a suction pump, flow meter, and water vapor absorption tube. Data were collected through direct field observations, followed by laboratory testing to determine the concentrations of CO_2, NO_2, SO_2, O_2, and solid particles. The analysis results compared pollutant concentrations to ambient air quality standards to assess the level of pollution and potential risks. Differences in pollutant concentrations between urban and suburban areas are influenced by variations in industrial activity, traffic density, and local meteorological conditions (Hoek, G., et al., 2013).

The implementation of ambient air quality standards established by the government in regulations allows for routine monitoring. Recommendations include increased monitoring in suburban areas, community education, and the integration of spatial data in future village planning.

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