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Air Pollution Analysis in Surigao City

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Abstract – *This research investigates and compares air pollution levels in Surigao City's Brgy. Luna, Brgy. Washington, and Brgy. San Juan, employing a quantitative descriptive research design. The primary objective is to address the critical need for assessing and mitigating air quality concerns in these areas, prioritizing the well-being of residents and the environment. To ensure a comprehensive analysis, the study leverages modern technology, specifically utilizing the Plume Labs website, which provides real-time air quality information and forecasts to users for systematic air quality monitoring.Findings reveal that there is no significant difference in air quality among Brgy. Luna, Brgy. Washington, and Brgy. San Juan, and the overall air quality in these areas is satisfactory. This unexpected result highlights the importance of objective and data-driven assessments in environmental research. The study advocates for proactive measures to maintain and enhance the observed good air quality. Recommendations include heightened awareness campaigns, stricter law enforcement, and fostering community discipline. These measures aim to sustain the current favorable air quality conditions and prevent potential deterioration. Beyond the immediate implications for Surigao City, this research underscores the broader significance of incorporating technology, such as the Plume Labs website, into environmental monitoring practices. The identified recommendations offer practical guidance for local authorities and communities, serving as a blueprint to foster a cleaner, safer, and more environmentally conscious living environment in the region. In essence, the study not only provides valuable insights into the current air quality status but also advocates for a proactive and technology-driven approach to environmental management.*

Keywords: *Air pollution, pollution, air quality, plume labs, Surigao City*

I. Introduction

In the Philippines, air pollution is the third largest cause of mortality and disability from noncommunicable diseases, it contributes to the onset and progression of a variety of diseases and affectspeople's ability or opportunity to be physically active. For example, traffic enforcers in Metro Manila who are continually exposed to high PM2.5 concentrations are 124 times more likely to suffer chronic obstructive pulmonary disease.

Cars contribute 80% to air pollution in the Philippines, while stationary sources and weather contribute 20%. Fossil fuel usage, particularly coal and oil, is the main cause of air pollution, exacerbated by limited access to clean fuels and cooking equipment for over half the population. Local authorities are urged to enforce regulations, such as Executive Order No. 28 series of 2017, to control emissions from sources like firecrackers, which release PM10 particles containing sulfur, carbon, potassium nitrate, and heavy metals.

Pollution from distant sources can harm even seemingly pristine environments, affecting plants, animals, soils, and water bodies. Nitrogen Dioxide (NO2), emitted from vehicles, power plants, and factories, contributes to approximately 4 million new cases of childhood asthma annually, with around 16 million children globally affected by NO2 pollution. Additionally, high levels of lead were found in the urine samples of Manila street children, while air pollution was linked to 66,230 deaths in the Philippines in 2019, predominantly among adults.

Rapid population growth in urban areas of the Philippines has led to increased energy consumption, transportation use, and industrial activity, significantly contributing to the decline in air quality. The extensive production and consumption of goods have further exacerbated pollution and waste generation, posing significant environmental challenges.

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The objective of this study was to compare the pollution levels and sources in Surigao City to develop conservation measures against air pollution by learning the sources of pollution in the air. This study focuses on the air quality of three contrasting settings: Brgy. San Juan, Brgy. Washington, and Brgy. Luna. By examining the variations in air pollutants over time, this research aims to uncover potential patterns and understand whether efforts to mitigate air pollution have resulted in tangible improvements or if environmental stressors have led to a decline. The research on "Air Pollution Analysis in Surigao City" lacks a localized examination of specific pollution sources, seasonal variations, and a deep exploration of health impacts on the local population. Moreover, there are deficiencies in comprehending community awareness, evaluating the efficacy of current policies, identifying spatial vulnerability in barangays, and limited research on Air pollution in Surigao City. These gaps in knowledge prompted the researchers to undertake the present study.

Sources of Air Pollution

Several studies have identified various sources of air pollution in urban areas of Surigao City. Vehicular emissions are considered the primary source of air pollution in urban areas. A study by Oropesa et al. (2021) found that nitrogen dioxide (NO2) levels were significantly higher in urban areas compared to rural areas, and this was attributed to vehicular traffic. Another study by Cantoria (2020) found that the concentration of particulate matter (PM2.5 and PM10) exceeded the annual mean limit set by the World Health Organization (WHO) due to vehicular traffic, industrial emissions, and construction activities.

Industrial emissions also contribute to air pollution in urban areas. A study by Cantoria (2020) found that the air quality in urban areas of Surigao City was significantly affected by industrial activities such as mining, port activities, and power generation. Similarly, a study by Oropesa et al. (2021) found that sulfur dioxide (SO2) levels were higher in urban areas due to industrial emissions.

Studies on sources of air pollution in rural areas of Surigao City are limited. However, agricultural practices such as burning crop residues and waste are considered significant sources of air pollution in rural areas. A study by Pacuribot et al. (2021) found that agricultural burning practices negatively affected air quality in some rural areas. The study recommended the promotion of sustainable agricultural practices to reduce air pollution levels in rural areas.

Air Pollution Monitoring

Monitoring air pollution levels serves to safeguard public health as exposure to high levels of pollutants can lead to respiratory diseases and cardiovascular problems (Quitoriano et al., 2020; Pacuribot et al., 2021). Furthermore, it facilitates the identification of pollution sources and the formulation of effective emission reduction strategies, with vehicular traffic, industrial emissions, and agricultural burning highlighted as primary contributors to air pollution in Surigao City (Cantoria, 2020; Pacuribot et al., 2021).

Plume Labs

Plume Labs, established in 2014, has evolved its offerings to include an array of products focused on air pollution data, including a mobile app and an AI-powered platform (Romain, 2022). Their flagship product, the "Flow" personal air quality monitor, utilizes advanced techniques like laser diffraction and conductivity fluctuations to measure pollutants such as particle matter and nitrogen dioxide (Plume Labs, n.d.).

Employing cross-validation, Plume Labs ensures the accuracy of their pollution maps by testing against real-world data from monitoring stations (Plume Labs, n.d.). They assert that their street-level maps effectively capture the geographic variability of air pollution in major cities worldwide with minimal errors (Plume Labs, n.d.).

II. Statement of the Problem

This study aimed to discover and compare the different Pollution Levels and Trends in San Juan, Washington, and Brgy. Luna of Surigao City. Specifically, it sought to answer the following questions:

1. What are the estimated measurements of the Air Pollutants in Brgy. Luna, brgy. Washington, and Brgy. San Juan in terms of:
    a. Particulate Matter (PM2.5 and PM10)
    b. Nitrogen Dioxide (NO2)
    c. Ozone (O3)
2. At what time was the Air Quality high in each area;
    a. Brgy. Luna
    b. Brgy. Washington
    c. Brgy. San Juan
3. Was there a significant difference in the air quality index of Brgy. Luna, brgy. Washington and Brgy. San Juan?
4. What conservation measures were proposed?

III. Methodology

This study employed descriptive-evaluative research design, which tends to trade air quality over a period of time to evaluate and compare the air pollution levels and trends in areas of Surigao City (Brgy. Luna, Brgy. Washington, and Brgy. San Juan, Surigao City) the locations where the study was conducted.The researchers used Plume Labs online, an alternative platform that utilizes satellite imagery to estimate pollutants in specific areas (Plume Labs, n.d.). This remote monitoring system enabled the researchers to gather data on pollutants like NO2, O3, PM2.5, and PM10 in different parts of Surigao City; compensating for the limitations of the unavailable device, no longer requiring physical materials or field preparation, the team was able to conduct remote monitoring from their base. The use of a car, masks, and specialized tools has been replaced by personal devices, eliminating the need for transportation and ensuring a more efficient process. The monitoring period was 30 days. This was monitored daily, be it sunny days, rainy days, or cloudy days. All information was digitally recorded, labeled by the sample size, and used for comparative analysis at the end of the study period. The data gathered were tabulated, analyzed, and interpreted.

IV. Results and Discussions

The Air Quality Index of the Air Pollutants in Brgy. Luna, Brgy. Washington, and Brgy. San Juan.

Table 1. The Air Quality Index of the Air Pollutants in Brgy. Luna, Brgy. Washington, and Brgy. San Juan.

Parameter	**Brgy. San Juan**			**Brgy. Washington**			**Brgy. Luna**		
	Mean	SD	Interpretation	Mean	SD	Interpretation	Mean	SD	Interpretation
Air Quality	16.46	9.51	Good	16.42	9.50	Good	16.33	9.00	Good
Nitrogen Dioxide	1.47	0.27	Good	1.53	0.28	Good	1.63	0.42	Good
Ozone	14.45	3.25	Good	14.47	3.24	Good	14.40	3.19	Good
Particulate Matter 2.5	21.12	12.23	Good	21.08	12.21	Good	21.16	12.22	Good
Particulate Matter 10	11.81	6.81	Good	11.76	6.82	Good	11.51	5.93	Good

Table 1 presents data on the Air Quality Index (AQI) and various air pollutants in three distinct barangays: Brgy. San Juan, Brgy. Washington, and Brgy. Luna. The AQI values, mean concentrations, standard deviations, and interpretations of air quality are provided for each pollutant. Across all three barangays, the AQI values indicate "Good" air quality, suggesting minimal pollution levels. Nitrogen dioxide (NO2), a common pollutant from combustion processes, shows relatively low mean levels with moderate variability.

Similarly, ozone (O3), despite being both a natural and man-made pollutant, exhibits low mean concentrations, indicating favorable air quality conditions. Fine inhalable particles (PM2.5) and larger inhalable particles (PM10) also show low mean levels, suggesting minimal risk to respiratory health. Despite these positive indicators, it's essential to recognize that even in areas classified as having "Good" air quality, susceptible individuals may still experience health issues related to air pollution. Therefore, while the data portrays a favorable air quality status across these barangays, ongoing monitoring and measures to mitigate pollution remain important for safeguarding public health.

Particulate Matter 2.5

Table 2.1. Particulate Matter 2.5 ($PM_{2.5}$) in Surigao City.

Area	Mean	SD	Interpretation
Brgy. Luna	21.16	12.22	Good
Brgy. Washington	21.08	12.21	Good
Brgy. San Juan	21.12	12.23	Good

Air Quality Index for Particulate Matter 2.5 (*$PM_{2.5}$). Good 0-30, Satisfactory 31-60, Moderately Polluted 61-90, Poor 91-120, Very Poor 121-250, Severe 250+*.

As presented in table 2.1, the data provided presents the levels of Particulate Matter 2.5 (PM2.5) in Surigao City, with a focus on specific barangays within the city. The table outlines the average PM2.5 concentrations, represented as mean values, along with the standard deviation (SD) for each area.

Notably, the mean PM2.5 levels across all barangays—Brgy. Luna, Brgy. Washington, and Brgy. San Juan—are quite similar, ranging from 21.08 to 21.16 micrograms per cubic meter (µg/m³). Furthermore, the standard deviations indicate minimal variability around these mean values. The interpretation column categorizes the air quality based on the PM2.5 levels, with all areas falling under the "Good" category. According to the provided Air Quality Index (AQI) ranges for PM2.5, "Good" signifies a healthy air quality environment, with PM2.5 concentrations below 30. Thus, the data implies that Surigao City, particularly in the mentioned barangays, maintains satisfactory air quality conditions with PM2.5 levels within the healthy range, as per air quality standards.

Particulate Matter 10

Table 2.2. Particulate Matter 10 (PM_{10}) in Surigao City.

Area	Mean	SD	Interpretation
Brgy. Luna	11.51	5.93	Good
Brgy. Washington	11.76	6.82	Good
Brgy. San Juan	11.81	6.81	Good

Air Quality Index for Particulate Matter 10 (*PM_{10}). Good 0-50, Satisfactory 51-100, Moderately Polluted 101-250, Poor 251-350, Very Poor 351-430, Severe 430+*.

The provided data presented in table 2.2 pertains to the levels of Particulate Matter 10 (PM10) in Surigao City, specifically focusing on different barangays within the city. The table displays the average PM10 concentrations, represented as mean values, alongside the standard deviation (SD) for each area.

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Similar to the PM2.5 data, the mean PM10 levels across all barangays—Brgy. Luna, Brgy. Washington, and Brgy. San Juan—are relatively close, ranging from 11.51 to 11.81 micrograms per cubic meter (µg/m³). Additionally, the standard deviations indicate a relatively low level of variability around these mean values. The interpretation column categorizes the air quality based on the PM10 levels, with all areas classified as "Good." According to the provided Air Quality Index (AQI) ranges for PM10, "Good" signifies a healthy air quality environment, with PM10 concentrations below 50. Thus, the data suggests that Surigao City, particularly in the mentioned barangays, maintains satisfactory air quality conditions with PM10 levels within the healthy range, as per air quality standards.

Ozone

Table 3.3. Ozone (O_3) in Surigao City.

Area	Mean	SD	Interpretation
Brgy. Luna	14.40	3.19	Good
Brgy. Washington	14.47	3.24	Good
Brgy. San Juan	14.45	3.25	Good

Particulate Matter 2.5 (*$PM_{2.5}$). Good 0-50, Satisfactory 51-100, Moderately Polluted 101-168, Poor 169-208, Very Poor 209-748, Severe 748+*.

The data provided in table 2.3 pertains to the levels of Ozone (O3) in Surigao City, specifically focusing on different barangays within the city. The table displays the average O3 concentrations, represented as mean values, alongside the standard deviation (SD) for each area.

Similar to the previous datasets, the mean O3 levels across all barangays—Brgy. Luna, Brgy. Washington, and Brgy. San Juan—are quite similar, ranging from 14.40 to 14.47 parts per billion (ppb). Additionally, the standard deviations indicate a relatively low level of variability around these mean values. The interpretation column categorizes the air quality based on the O3 levels, with all areas classified as "Good." According to the provided Air Quality Index (AQI) ranges for O3, "Good" signifies a healthy air quality environment, with O3 concentrations below 50 ppb. Thus, the data suggests that Surigao City, particularly in the mentioned barangays, maintains satisfactory air quality conditions with O3 levels within the healthy range, as per air quality standards.

Nitrogen Dioxide

Table 3.3. Ozone (O_3) in Surigao City.

Area	Mean	SD	Interpretation
Brgy. Luna	14.40	3.19	Good
Brgy. Washington	14.47	3.24	Good
Brgy. San Juan	14.45	3.25	Good

Particulate Matter 2.5 (*$PM_{2.5}$). Good 0-50, Satisfactory 51-100, Moderately Polluted 101-168, Poor 169-208, Very Poor 209-748, Severe 748+*.

The provided data presented in table 2.4 focuses on the levels of Ozone (O3) in Surigao City, with specific attention given to different barangays within the city. The table presents the average O3 concentrations, depicted as mean values, accompanied by the standard deviation (SD) for each area.

Similar to the interpretation of previous datasets, the mean O3 levels across all barangays—Brgy. Luna, Brgy. Washington, and Brgy. San Juan—are relatively close, ranging from 14.40 to 14.47 parts per billion (ppb). Moreover, the standard deviations suggest a moderate degree of variability around these mean values. The interpretation column categorizes the air quality based on the O3 levels, with all areas classified as "Good." According to the provided Air Quality Index (AQI) ranges for O3, "Good" indicates a healthy air quality environment, with O3 concentrations below 50 ppb. Hence, the data implies that Surigao City, particularly in the mentioned barangays, maintains satisfactory air quality conditions with O3 levels falling within the healthy range, as per air quality standards.

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V. Conclusions

The comparison concluded that the Air Quality in Brgy. San Juan, Brgy. Luna, and Brgy. Washington is not polluted. Implementing the recommended measures is expected to improve air quality, reduce health risks, and enhance overall well-being, leading to a better quality of life.

Thus, the study holds significant implications for each barangay, offering insights into air pollution levels that can guide local authorities in implementing targeted measures for improved air quality and resident health. The findings benefit San Juan by identifying specific pollutants for focused policy interventions. Luna gains valuable information to educate residents about health risks and inform local strategies for pollution reduction, while Washington can leverage the study's dynamics to address specific concerns and implement initiatives promoting a healthier environment.

1. Tourists visiting the studied areas will experience a positive impact as the researcher's recommendations aim to enhance air quality, creating a healthier and more enjoyable environment for their stay. The improved conditions contribute to a more attractive destination, offering tourists a positive and memorable experience and potentially increasing their likelihood of return visits.
2. Local residents stand to gain significantly from the researcher's recommendations, as the focus on improving air quality directly impacts their well-being. Better air quality contributes to a healthier living environment, reducing the risk of respiratory and cardiovascular issues. The enhanced quality of life for residents becomes a lasting positive outcome of the recommended measures.
3. Local government officials have the opportunity to demonstrate their commitment to public health through the implementation of targeted measures. Successful execution of the researcher's recommendations fosters trust and satisfaction among residentsand showcases the government's dedication to creating a sustainable and healthy living environment for the community.
4. NGOs and advocacy groups can leverage the researcher's findings to bolster their initiatives and collaborate effectively with local authorities. The focus on sustainable practices aligns with the goals of these organizations, providing them with valuable data and insights to advocate for positive change. This collaboration can lead to impactful and community-driven environmental initiatives.
5. Researchers and academics benefit from the researcher's recommendations as they contribute valuable insights to the field of air quality dynamics and intervention effectiveness. The study's findings offer a foundation for further research, fostering a continuous cycle of knowledge development. This positive impact extends to the broader academic community, advancing the understanding of local air quality issues and solutions.

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