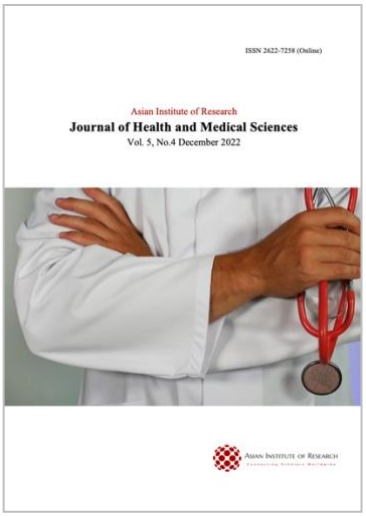

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Air Chemical Quality and Noise Level in Tourism City Center of Bali 2022

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Abstract
Tourist destinations activities in Bali, particularly in Tabanan, Badung and Gianyar increased the crowded traffic jam, and impacted to air chemical quality and noise level. This is an observational study in tourist destinations in Tabanan, Badung, Gianyar Regency, totaling 18 sample points. Sampling of air chemistry CO, O3, SO2 and NO2 are measured using an imfinger and analyzed by spectrophotometer, noise level using a sound level meter. The data obtained were analyzed using a free sample t test, both parametric and non-parametric. The results of air chemistry research for CO in Tabanan Regency is 23.33 gr/Nm3, Badung Regency 521, 67 gr/Nm3 and Gianyar Regency 1050.00 gr/Nm3. Meanwhile O3 parameter in Tabanan Regency is 0.17 gr/Nm3, Badung Regency 0, 20 gr/Nm3 and Gianyar Regency 0.12 gr/Nm3. SO2 parameter in Tabanan Regency is 100.00 gr/Nm3, Badung Regency 57.62 gr/Nm3 and Gianyar Regency 41.62 gr/Nm3. NO2 parameter in Tabanan Regency measured 1 ,83 gr/Nm3, Badung Regency 1.83 gr/Nm3 and Gianyar Regency 0.95 gr/Nm3. The concentration is still below the requirements of the Governor of Bali regulation number 16 of 2016 concerning Environmental Quality Standards and Environmental Damage Standard Criteria. While the noise level in Tabanan Regency is 68.55 dB, Badung Regency 70.68 dB and Gianyar Regency 67.85 dB exceeding the maximum noise level for residential area activities of 55 dB. In conclusion, the air chemistry in regencies of Tabanan, Badung, Gianyar are below the standards of local government. Nevertheless, there is an exceeding noise level in those regencies.

Keywords: Air Chemical Quality, Bali, Noise Level, Tourism

1. Introduction

In big cities, motor vehicle exhaust gases contribute as a source of air pollution reaching 60-70%. Important factors that cause the dominant influence of the transportation sector on urban air pollution in Indonesia include rapid (exponential) growth of vehicles, unbalanced transportation infrastructure with the number of existing vehicles, concentration-oriented urban traffic patterns due to the centralization of economic activities and offices in the city center, derivative problems resulting from the implementation of existing urban development policies, such as residential areas moving away from the city center, equality of traffic flow time, type, age and characteristics of vehicles, vehicle maintenance factor; type of fuel used, type of road surface as well as driving cycles and patterns (Nurdjanah, 2015).

Tourist destinations in Tabanan, Badung and Gianyar regencies such as the Tanah Lot area in Tabanan Regency, Kuta in Badung Regency and Ubud in Gianyar Regency have become the attractions for tourist.. These have been the destination visited by many domestic and foreign tourists. Consequently, many vehicles transporting tourists pass the route of the tourist destination and this often cause traffic jams. Crowded traffic jams cause air chemistry quality and noise levels to increase (Rajé et al., 2018).

Air is an important factor in life. However, along with the increase in urban and industrial development as well as the number of vehicles, air quality has changed. This situation will endanger the health of humans, animals and plants, and will change the balance of the environment. The atmosphere around the earth whose function is essential for life is oxygen (O_2) for breathing, carbon dioxide (CO_2) for photosynthesis by leaf chlorophyll, and ozone (O_3) to block ultraviolet rays from the sun (Shykoff & Warkander, 2012).

Fuel containing sulfur will produce pollutant sulfur dioxide (SO_2), fuel containing ash (fly ash) will produce pollutant particles and dust. The process in the industry will affect the quality of pollutant emissions. For example, the wet process in the cement industry will produce less dust than the dry process. The direction and speed of the wind will affect the process of dilution of pollutants in the air and their distribution. The greater the wind speed, the smaller the concentration of pollutants in the air because these pollutants experience dilution. Wind direction determines the direction of the spread of pollutants (Kim et al., 2015).

Each type of engine has its own emission characteristics. Four stroke combustion engines tend to emit CO, HC, and NO_x but are generally low in particulate emissions. The 2 stroke engine has the same emission characteristics but is dirtier because the use of an excessive oil mixture that will result in the emission of unburned oil and the use of oil with a high smoke content. Diesel engines on trucks and buses tend to emit lower CO and HC than gasoline engines, but higher NO_x and particulates (Yasar et al., 2013). The products released from the complete combustion of fuel by vehicles into the atmosphere by mass are carbon dioxide gas and water vapor. However, this condition rarely occurs because some of the carbon dioxide-based fuels become carbon monoxide (CO). The formation of CO is also influenced by the presence of oxygen (O_2) and temperature (Panov et al., 2020).

Preliminary observations in Tabanan, Badung and Gianyar regencies in tourist destinations obtain the information that the traffic jams often occur. This is in accordance with data from the Bali Provincial Transportation Service, the number of vehicle ownership in Bali is 4.1 million, with a ratio of one resident to one vehicle, where the current population of Bali Province is approximately 4.2 million.

This study aims to measure air chemical parameters (CO, O3, SO2 and NO2) and noise levels as well as analyze differences in air chemical parameters and noise levels in the tourism destination areas and city centers of Tabanan, Badung and Gianyar Regencies.

2. Method

This study is observational research with a cross sectional approach. The research locations are tourist destinations and city centers of Tabanan, Badung and Gianyar Regencies; for Tabanan Regency where Tanah Lot is located, Badung Regency with Kuta and Gianyar Regency is with its Ubud. The study was conducted from April to August 2022. The research population is the atmosphere in Tabanan, Badung and Gianyar Regencies. Measurements of air chemistry quality and noise levels were carried out in tourist destinations and the city center of each district. The location of the sample point is shown in Figure 1.

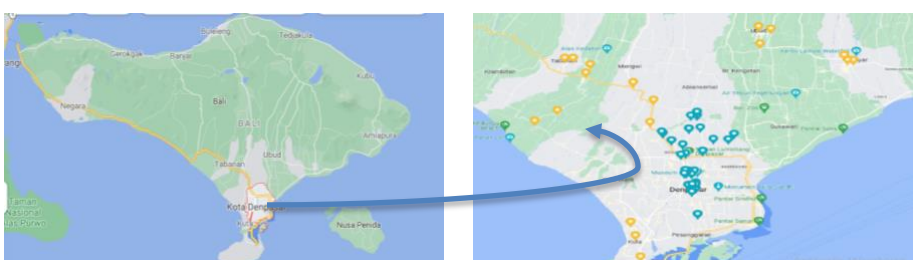


Figure 1: Sampling Location

Figure 1 shows that the location points with the yellow star symbols are chemical sample points and noise levels with a total of 18 points. The sample point for the tourist destination area for Tabanan Regency is in the Tanah Lot, Badung Regency with Kuta and Gianyar Regency is in Ubud.

An air sampling using impinger was applied to get the levels of CO, O_3, SO_2 and NO_2 gases in the atmosphere, with the testing of O_3 parameter with the neutral buffer potassium iodide (NBKI) method using a spectrophotometer (7119-8:2017 SNI 2017), SO_2 parameters using pararosaniline method using a spectrophotometer (7119-7:2017 SNI 2017) and NO_2 parameters using the Griess Zaltzman method using a spectrophotometer (7119-2:2017 SNI 2017). Measurement of the concentration of carbon monoxide (CO) in ambient air uses the direct reading method (real time sampling). This method uses a measuring instrument to directly determine the concentration of carbon monoxide. This tool uses a sensor system based on the chemical and physical properties of the contaminants. The tool used in this study was the Kimo HQ 210 brand CO Analyzer, a handheld portable carbon monoxide (CO) analyzer used to detect and display CO gas concentrations between 0 and 2000 ppm. Measurement of the noise level in the ambient air employed a sound level meter. Differences in air quality in tourist destinations and centers in Tabanan, Badung and Gianyar regencies used free sample t-test analysis at a 95% confidence level.

3. Results

3.1 Weather Condition

Weather conditions at the time of sampling in Badung Regency, Tabanan were quite sunny while in Gianyar Regency the weather was moderately rainy. Weather conditions regarding the average air temperature, humidity, wind speed in tourist destinations and city centers of each district are presented in Table 1.

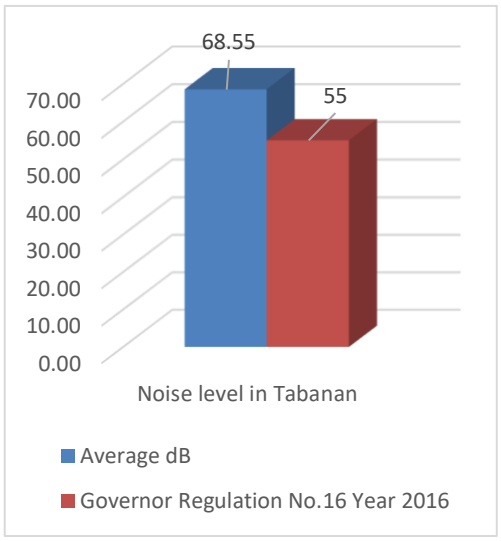
Table 1: Conditions of average temperature, humidity and wind speed in tourist destination areas and city centers of Tabanan, Badung, Gianyar Regencies

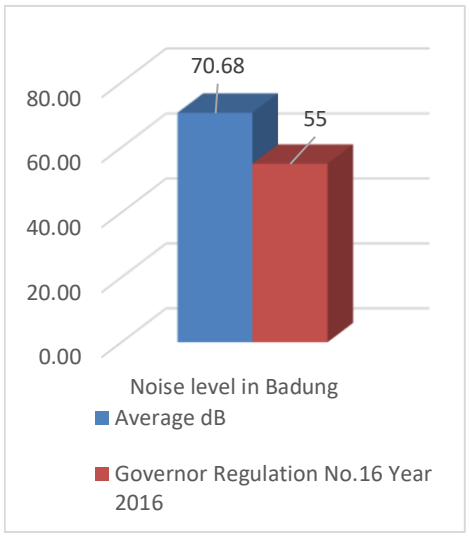
No	Regency	Area	Average Air Temperature (ºC)	Average Humidity (%)	Average Wind Speed (km/h)
1	Tabanan	Tanah Lot	28.67±0.58	78.00±1.73	20.60±7.31
		City center	27.33±0.58	78.67±3.21	11.47±0.12
2	Badung	Kuta	29.00±1.00	75.33±3.21	17.20±2.69
		City center	28.67±1.15	74.67±9.02	17.93±2.64
3	Gianyar	Ubud	26.33±0.58	87.67±0.57	11.00±0.70
		City center	26.33±0.58	87.33±1.52	12.37±0.23

Based on Table 1, it shows that for Tabanan Regency there is a difference in the average wind speed in tourist destinations with a speed of 20.60 ± 7.31 km/hour and the city center with a speed of 11.47 ± 0.12 km/hour. This statistics is reinforced by the regional Tanah Lot tourist destination in Tabanan Regency is located in the coastal area.

3.2 Noise Level

Noise measurements using a sound level meter in Tabanan district yielded a noise level of 68.55 ± 3.89 dB, Badung Regency with a noise level of 70.68 dB ± 4.85 dB and Gianyar Regency with a noise level of 67.85 ± 2.1 dB. These results are compared with the standard regulations of the Governor of Bali Province number 16 of 2016 concerning Environmental Quality Standards and Standard Criteria for Environmental Damage which can be seen in Figure 2.





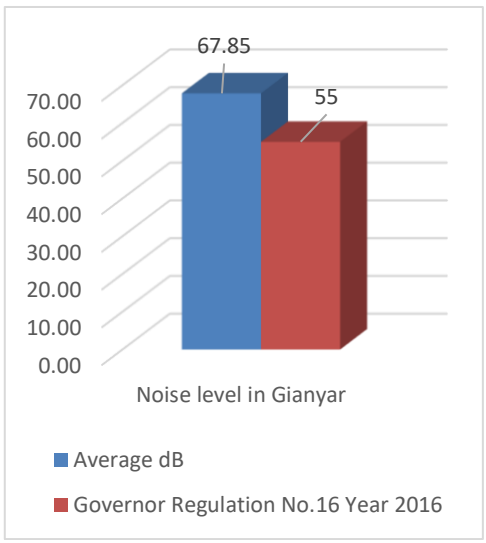


Figure 2: Noise level in Tabanan, Badung and Gianyar regencies in 2022

Figure 2 shows the results of noise levels in Tabanan, Badung and Gianyar regencies that exceed the maximum noise level limit for residential area activities as stated in the Bali Provincial Governor Regulation No. 16 of 2016 of 55 dB. Table 2 shows the comparison of the average noise level between tourist destinations and the city center in each district.

Table 2: Noise level

No.	Regency	Noise Level (dB)	
		Tourism destination	City center
1	Tabanan	67.37±3.51	69.73±4.61
2	Badung	67.16±1.10	74.20±4.52
3	Gianyar	67.10±0.36	68.60±3.08
Total		67.2±1.85	70.84±4.40

Table 2 shows that the average noise level in tourist destinations tends to be lower than the city center in Tabanan, Badung and Gianyar regencies. This shows that the density of transportation in the city center is denser and traffic jam occurs.

3.3 Air Chemical Parameter

Air chemistry measurements for CO, O3, SO2 and NO2 parameters in Tabanan, Badung and Gianyar regencies are presented in Figure 3.

Figure 3: Average air chemistry parameters CO, O_3, SO_3 and NO_2

According to Figure 3, the average results of CO, O_3, SO_3 and NO_2 are still far below the requirements of the Governor of Bali Province regulation number 16 year 2016 concerning Environmental Quality Standards and Standard Criteria for Environmental Damage. Comparison of the average air chemistry of CO, O_3, SO_2 and NO_2 for tourism destination areas and the city center of each district is shown in Table 3.

Table 3: Average air chemistry CO, O3, SO2 and NO2 in tourist destinations and city centers

No.	Regency	Area	Ordinate	Air chemical			
				CO µgr/Nm^3	O_3 µgr/Nm^3	SO_2 µgr/Nm^3	NO_2 µgr/Nm^3
1	Tabanan	Tanah Lot					
		Area 1	-8.554610.115.140410	20.00	0.20	100.00	3.00
		Area 2	-8.593401.115.120338	20.00	0.20	100.00	2.00
		Area 3	-8.604242.115.104324	20.00	0.10	100.00	2.00
		Average		20.00	0.17	100.00	2.33
		City center					
		Area 4	-8.545774.115.143459	30.00	0.30	100.00	2.00
		Area 5	-8.539179.115.131289	30.00	0.10	100.00	1.00
		Area 6	-8.539202.115.125422	20.00	0.10	100.00	1.00
		Average		26.67	0.17	100.00	1.33
2	Badung	Kuta					
		Area 7	-8.708389.115.171894	70.00	0.30	50.00	2.00
		Area 8	-8.722407.115.175430	10.00	0.30	50.00	2.00
		Area 9	-8.744284.115.179000	50.00	0.20	50.00	2.00
		Average		43.33	0.27	50.00	2.00
		City center					
		Area 10	-8.564566.115.173704	1,000.00	0.10	60.00	2.00
		Area 11	-8.582437.115.188133	1,000.00	0.10	50.00	2.00
		Area 12	-8.605417.115.185628	1,000.00	0.20	50.00	1.00
		Average		1.000,00	1.33	53.33	1.67
3	Gianyar	Ubud					
		Area 13	-8.509149.115.271181	900.00	0.10	40.00	2.00
		Area k14	-8.506892.115.262431	900.00	0.20	40.00	1.00
		Area 15	-8.524374.115.263500	900.00	0.10	40.00	0.80
		Average		900.00	0.13	40.00	1.27
		City center					
		Area 16	-8.536417.115.322829	1,200.00	0.10	40.00	0.60
		Area 17	-8.541378.115.325167	1,200.00	0.10	50.00	0.70
		Area 18	-8.541671.115.329146	1,200.00	0.10	40.00	0.60
		Average		1,200	0.10	43.33	0.63

As seen from Table 3, it shows that the average air chemistry parameters CO and SO_2 are higher in the city center compared to tourist destinations for Tabanan, Badung and Gianyar Regencies. Carbon monoxide (CO) is a gas that is colorless, odorless, tasteless, and a toxic gas that makes up the atmosphere (Girach & Nair, 2014). (Strode et al., 2015) in his research stated that CO is one of the precursors (formers) of ozone and the main absorber of hydroxyl radicals (OH) in the troposphere. Consequently, CO indirectly impacts the climate by increasing surface ozone where there is sufficient NOx, and increasing the lifetime of methane and other short-term greenhouse gases (GHGs).

3.4 Differences in Chemical and Physical Quality of Air

Based on the results of the independent t test and Mann Whitney for air chemistry parameters CO, O_3, SO_2, NO_2 and noise level, the following results were obtained in Table 4.

Table 4: Independent and Mann Whitney t test results for air chemistry parameters CO, O3, SO2, NO2 and noise level

No	Variable	Average µgr/Nm^3 in tourist destination	Average e µgr/Nm^3 in city center	Sig. t / independent Mann Whitney
1	CO	321.11	742.22	0.032
2	O3	0.19	0.13	0.094
3	SO2	63.33	65.55	0.677
4	NO2	1.87	1.21	0.046
5	Noise	67.21 dB	70.84 dB	0.023

Based on the statistical test results in Table 4, the significance value of the air chemistry parameters CO, NO_2 and noise level is less than 0.05, meaning that there are differences in the results of the average measurement of air chemistry parameters CO, NO_2 and noise levels between tourist destinations and the city center in Tabanan, Badung and Gianyar regencies. Meanwhile, for parameters O_3 and SO_2, a significance value greater than 0.05 indicates that there is no difference in the average values of O_3 and SO_2 parameters between tourist destinations and the city center in Tabanan, Badung and Gianyar regencies.

The results of this study indicate that the level of density or congestion between tourist destinations and the city center in Tabanan, Badung and Gianyar Regencies is different. There are differences in the values of the air chemistry parameters CO, O_3, SO_2, NO_2 and noise levels at each location because there has been an increase of visitors to tourist destination after the global pandemic attack. Meanwhile for the city center there are contributions of vehicles at busy hour and doing office activities. Transportation management is very important to be carried out by the government of Tabanan, Badung and Gianyar Regencies such as car free days, and it is necessary for tourist destinations to add cycling or pedestrian paths as well as do reforestation on the road sides.

4. Discussion

The concentration of pollutants in the air depends on weather conditions. Wind speed and direction, vertical temperature distribution, and humidity are elements that play a role in this weather change. Wind speed affects pollutant distribution. Pollutant concentrations will decrease if the wind is strong and distributes these pollutants horizontally or vertically. The land surface also affects wind speed, whether it is hilly or valleys. Narrow passages for the wind can increase the speed of wind. Temperature change is also a big changing factor. Upward turbulence will bring pollutants to areas with lower temperatures. Pollutants will decrease in concentration and then spreaded by the wind. In addition, the factors influencing air quality and green-housing as a reduction in CO_2 emissions are related to environmental structural elements, such as temperature, wind direction and speed, humidity, rainfall, air pressure, orography and topography which will vary with space and time (Diener & Mudu, 2021).

Traffic noise comes from the sound produced by vehicles, especially from the engines, exhaust, as well as due to the process between the wheels and the road. Heavy vehicles (trucks, buses) and passenger cars are the main noise sources on the highway. In general, controlling noise is divided into three elements, i.e. control of noise sources, control of noise lanes and control of noise receivers (González, 2022). The increase and difference in noise at the location of each atmosphere/ambient air is mostly due to the contribution of the hectic number of vehicles, considering that all sampling locations are located on the edge of the main road in the city center which is often traversed by motorized vehicles, especially large vehicles such as passenger cars, buses, trucks and other heavy vehicles. Noise is caused by the density of traffic flow in each location and busy hours and days for work (Radam & Heriyatna, 2018).

Several studies have shown that CO administration for 1 to 3 weeks at concentrations up to 100 ppm has no significant effect on higher plants. However, the ability to fix nitrogen by free bacteria will be hampered by giving CO for 35 hours at a concentration of 2000 ppm. Likewise, the ability to fix nitrogen by bacteria found in plant roots is also hampered by giving 100 ppm CO for one month (Srikandi, 2008).

Carbon monoxide (CO) is produced by chemical reactions in the atmosphere between hydroxyl radicals (OH) and methane (CH4) and other hydrocarbons, in addition to reactions between alkenes and ozone (O_3), and reactions of isoprene and terpenes with OH and O_3 (Rozante et al., 2017). In addition, other meteorological factors besides air temperature can also affect the concentration of CO in the atmosphere. These meteorological factors include air pressure, and the structure of the boundary layer. Air pressure will affect the diffusion of CO gas in the horizontal and vertical directions in the air, and the boundary layer structure plays an important role in the diffusion of CO gas in the vertical direction (Zeng & Zhang, 2017).

Every human breathes; an average adult inhales more than 3,000 gallons (11.4 m^3) of air each day. The air we breathe, if it is polluted by hazardous and toxic materials, will have a serious impact on human health, especially children who play more in the open air and are more vulnerable to their immune system. Apart from causing cancer and respiratory diseases, air pollutants can also cause smog (pollution), acid rain, reduce the resistance of the ozone layer in the upper atmosphere and have the potential to play a role in global climate change.

Ozone is not a hydrocarbon but the concentration of O_3 in the atmosphere increases as a direct result of the reaction of the hydrocarbons, whereas PAN is a hydrocarbon derivative. The result of the reaction between O and hydrocarbons is a very reactive intermediate product called a hydrocarbon free radical (RO2). Free radicals of this kind can further react with various components including NO, NO2 , O2 , O3 , and other hydrocarbons (Srikandi, 2008)

Sulfur dioxide emissions mainly arise from the burning of fossil fuels containing sulfur, especially coal used for electricity generation or household heating. This sharp-smelling but colorless gas can cause asthma attacks and because this gas stays in the air, it reacts and forms fine particles and acids (Perraud et al., 2015).

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