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THE IMPACT OF INFRASTRUCTURE CONSTRUCTION ON AIR QUALITY

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Abstract

In numerous major urban centres, there is a frequent occurrence of infrastructure development in response to the demands of a growing population. These kinds of operations request significant infrastructure investments. However, it is imperative to acknowledge that construction projects generate greenhouse gas emissions, which, in turn, exert a notable influence on pollution levels. This research project seeks to determine the extent to which infrastructure development affects air quality. To achieve this objective, we collected samples measuring carbon dioxide (CO_2) and carbon monoxide (CO) levels at various locations within the study area. The research was conducted at three distinct time intervals: morning, afternoon, and evening. The findings of this investigation revealed disparities in CO_2 and CO concentrations across these time periods. This research serves as a pivotal benchmark for quantifying the volume of pollution stemming from infrastructure construction activities and its consequential effects on the overall air quality.

Keywords: Construction, Infrastructure, Pollution.

1. Introduction

The quality of air is contingent upon the magnitude of emissions generated, where higher emissions correspond to deteriorating air quality [1]. Typically, the primary contributors to emissions are transportation vehicles. However, there are other factors that can also generate emissions and impact air quality, namely construction projects. Construction pollution generated from heavy machinery operated on site and dust particles spread from construction activity, this increases emission rate contain on air, construction activity accounted for 36% of final energy use and 39% of energy and process-related carbon dioxide [2]. The level of pollution stemming from construction activities is contingent upon the complexity of the construction project [3].

Air quality fluctuates over time due to variations in population activity and intensity [4]. Carbon emissions released into the atmosphere, originating from motor vehicles and industrial activities, have a direct impact on the temperature of the air [5]. Increased carbon dioxide levels correlate with higher air temperatures, as carbon dioxide traps solar heat within the Earth, leading to elevated air temperatures and subsequent climate changes, increased of carbon monoxide level also could affect for air quality which will be adversely for health, also affected earth atmosphere by deplete tropospheric hydroxyl radicals, slowing down the removal of dozens of man-made and anthropogenic trace gases and thus indirectly affecting the earth's climate and possibly the stratospheric ozone layer [6].

Based on research we conducted at three different times; morning, afternoon, and evening, we obtained different results measuring temperature levels and carbon dioxide levels at each time. The research was conducted within the Universitas Pendidikan Indonesia complex from several different research points, this research was carried out at several different points aim to see the impact of air pollution due to construction activities and to discern the impact from different distances. the state of field where this research conducted describe as busy construction site, as it seems, trucks moving out and into the site, many of construction worker doing groundwork, and heavy machinery being operated to support the job.

This research aims to see how much influence infrastructure development has on air quality and the damage brought to the climate and environment, this research is expected to rise awareness about deterioration of air quality causes by construction activity and could minimize it impact. In this study, we took samples of carbon dioxide and carbon monoxide levels at several points where the research took place. The investigation was conducted at various times: in the morning, afternoon, and evening.

2. Method

This study employed a descriptive quantitative research methodology, involving data analysis and calculations based on the collected data [7-10]. Data acquisition was conducted through observational techniques, specifically by measuring air quality at three distinct time intervals: morning (08:00), midday (11:00), and afternoon (15:00). This measurement was carried out employing three distinct instruments:

(1) Carbon Dioxide meter (CO_2 meter) model HT-2000 Digital CO_2 Meter Gas Detector

Specification

Large LCD Display: 3.5″ (8.9cm) LCD display with backlight

Logger mode: Key start/ stop, Immediately, Schedule, Real-time Roll-over

Carbon Dioxide (CO_2)

Range: 0~9999 (out of scale)

Accuracy: ±50ppm ±5% rdg (0~2000)

Response time: 10sec

Power Supply: 1A Output 5V AC Adaptor or 4*1.5V AAA batteries

(2) Air Quality Monitor (AQM) model 8-in-1 TVOC HCHO PM2.5 PM10

Continuous Working Time: 300 minutes

Battery: 2000mAh Lithium Polymer Battery

Input Voltage: 5.0V/1000mA

Charging Temperature: -10 °C to 45 °C

Measurement Range: 0.000-9.999 mg/m^3

Testing Technology: Semiconductor Sensor

Sample Type: cfusion Type

Concentration Unit: mg/m^3

Testing Time: 5 minutes

(3) Carbon Monoxide Meter (CMM) model AMF075

Gas Detection: Air, Carbon Monoxide

Measurement Range: 0 - 1000 ppm

Resolution: 1 ppm

Minimum Reading: 1 ppm

Accuracy: ±5% (Full Scale), ±10 ppm

Response Time: 60 seconds

Sensor Type: Electrochemical CO Sensor

Operating Environment: 0 - 50 °C, 32 - 122 °F, 10 - 90% RH

Storage Environment: -10 - 80 °C, -14 - 176 °F, 10 - 75% RH

Dimensions: 55.7 × 29.9 × 135.5 mm

Weight: 104 g

Power: 2 × 1.5 V AAA Batteries

The data collection process occurred at two specific locations: one in proximity to the half finish construction site, and the other situated in a shaded area considerably distant from the construction site. The selection of these two locations aimed to facilitate a comparative analysis of the data derived from the vicinity of the construction site and an area far removed from any construction activity. Figure 1 illustrates the precise locations where data collection was undertaken (location coordinate -6.859843320599144,107.5902929903234. & -6.860311689328513, 107.59305484058852.)

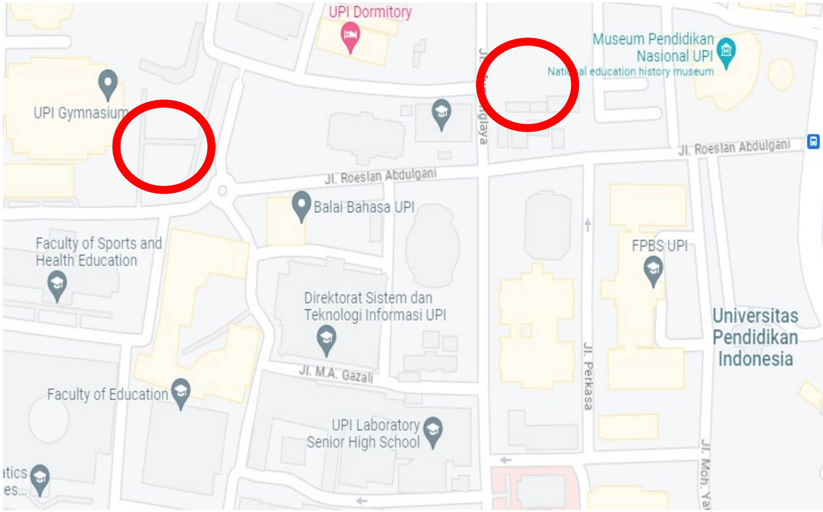

Fig. 1. Research location, Universitas Pendidikan Indonesia.

3. Result and Discussion

The assessment of air quality at UPI encompassed two distinct sites: one situated in the vicinity of the building construction area and the other at the UPI Gymnasium. Data collection was meticulously executed in the morning (08.00), midday (11.00), and afternoon (15.00). Table 1 shows the EPA's measurement using PM 2.5 indicator as a benchmark for classifying air pollution that is still safe to breathe.

Table 1. PM2.5 on EPA air watch.

Air Quality Category	PM2.5 µg/m^3 averaged over 1 hour	PM2.5 µg/m^3 averaged over 24 hours
Good	Less than 25	Less than 12.5
Fair	25-50	12.5-25
Poor	50-100	25-50
Very Poor	100-300	50-150
Extremely Poor	More than 300	More than 150

A comprehensive overview of the air quality measurements conducted at an educational institution in Indonesia is presented in Tables 2 and 3. Table 3 unequivocally demonstrates that the concentrations of air pollution components exhibit markedly elevated values in the vicinity of construction sites.

Tables 2 and 3 present the data stemming from the initial measurement session, which specifically targeted the development construction site. This first data collection took place in the morning, commencing at 08.00 and concluding at 08.10 WIB, at point 1, situated within the construction area.

Table 2. The place of UPI construction.

Time of Collection	TEMP	HUM	PM2.5	PM1.0	PM10	HCHO	TVOC	CO_2	%Rh
Morning	30.6	46%	45	29	60	0.036	0.048	621	55.1
Afternoon	27.9	49%	28	17	36	0.030	0.260	535	54.7
Evening	28.5	48%	25	15	32	0.027	0.254	546	49.7

Table 3. UPI construction.

CO	Time	08.00	11.00	15.00
PPM		0	0	0
CELCIUS		30.6	27.9	28.7

Over the course of ten minutes, research data was systematically gathered utilizing the Air Quality Monitor (AQM) device, and the recorded parameters included the following: PM2.5 at 45 ug/m^3, PM1.0 at 29 ug/m^3, and PM10 at 60 ug/m^3. In addition to these particulate matter measurements, the formaldehyde (HCHO) content was documented at 0.036 mg/m^3, while the total volatile organic compound (TVOC) concentration reached 0.048 mg/m^3.

Temperature (TEMP) was registered at 30.6°C, and the humidity level (HUM) reached 46%. The measurements pertaining to carbon dioxide (CO_2) yielded a result of 621 ppm, with the temperature recorded in Celsius units at 27.9, and the relative humidity (RH) level measured at 55.1%. Meanwhile, on other devices, carbon monoxide (CO) measurements showed results of 0 ppm, and the temperature was noted at 30 °C.

The second data collection session took place during the daytime, spanning from 10.00 to 10.10 WIB, once again at Point 1. This time, the measurements indicated a reduction in several parameters. The concentration of PM2.5 decreased to 28 ug/m^3, whereas PM1.0 remained constant at 29 ug/m^3, and PM10 reached 36 ug/m^3. The formaldehyde (HCHO) content declined to 0.030 mg/m^3, while the total volatile organic compounds (TVOC) increased to 0.260 mg/m^3.

Temperature (TEMP) exhibited a reading of 27.9 °C, with humidity (HUM) registering at 49%. The measurements for carbon dioxide (CO_2) yielded a result of 535 ppm, with the temperature recorded in Celsius units remaining at 27.9, and the relative humidity (RH) level measuring 54.7%. On the other hand, carbon monoxide (CO) measurements using alternate devices remained constant at 0 ppm.

During the third data collection session, which occurred at 15.00, the data revealed a further decline in the levels of hazardous particulate matter parameters. The concentration of PM2.5 was documented at 25 ug/m^3, while PM1.0 reached 15 ug/m^3, and PM10 was measured at 32 ug/m^3. The formaldehyde (HCHO) content was recorded at 0.027 mg/m^3, and Total Volatile Organic Compounds (TVOC) reached 0.254 mg/m3. Temperature (TEMP) recorded a value of 28.5 °C, and the humidity level (HUM) stood at 48%. Carbon dioxide (CO_2) measurements yielded a result of 546 ppm, with the temperature in Celsius units remaining at 27.9, and the relative humidity (RH) level measuring 49.7%. On the other hand, carbon monoxide (CO) measurements utilizing different devices remained steady at 0 ppm as shown in Fig. 2.

The data collected at these three data collection sessions provided a clear picture of changes in air quality during the construction period at the selected sites, indicating an increase in air pollution that has the potential to be detrimental to health and the environment [11-15].

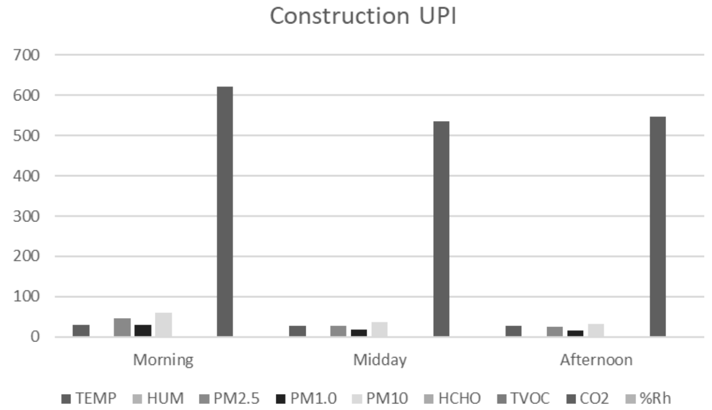

Fig. 2. UPI construction.

According to the data gathered from the UPI Construction site, the highest concentration of CO_2 was observed during the morning session, specifically from 08.00 to 08.10. Subsequently, in the afternoon and evening measurements, a gradual decrease in CO_2 levels was noted, with recorded values of 535 and 546, respectively. The elevated CO_2 concentration in the morning is attributed to the commencement of construction activities, which generate an increased volume of CO_2 emissions during this period as shown in Tables 4 and 5.

Table 4. UPI gymnasium at UPI construction.

Time of Collection	Temp	Hum	PM2.5 (ug/m^3)	PM1.0 (ug/m^3)	PM10 (ug/m^3)	HCHO (mg/m^3)	TVOC (mg/m^3)	CO_2	%Rh
Morning	25.6	58%	23	13	29	0.018	0.321	581	52.7
Afternoon	28.9	52%	22	13	28	0.034	0.062	572	58.4
Evening	30.8	47%	25	14	31	0.027	0.046	569	58.5

Table 5. UPI gymnasium.

UPI Construction				
CO	Time	08.00	11.00	15.00
	PPM	0	0	0
	CELCIUS	32.7	33.2	34.2

Data collection at Point 2 was conducted within the gymnasium building of the Universitas Pendidikan Indonesia (UPI), spanning across three distinct observation sessions. The initial session transpired in the morning, commencing at 8.00 and concluding at 8.10. During this time frame, the AQMO2 device was utilized to measure air quality over a 10-minute period. The recorded measurement results indicated the following parameters: PM2.5 particulate matter at 2 ug/m^3, PM1.0 at 13 ug/m^3, and PM10 at 29 ug/m^3.

Additionally, the formaldehyde (HCHO) content was documented at 0.018 mg/m3, while Total Volatile Organic Compounds (TVOC) reached 0.321 mg/m^3. Temperature

(TEMP) was registered at 25.6 °C, with humidity (HUM) measuring at 58%. The measurement of carbon dioxide (CO_2) employing a CO_2 meter yielded a CO_2 concentration of 581 PPM, with the temperature recorded in Celsius units at 28.7 °C and the relative humidity (RH) level measuring 52.7%. Meanwhile, carbon monoxide (CO) measurements using alternate devices remained consistently at 0 ppm.

The second session of data collection using the same AQM device also lasted 10 minutes. The results of this measurement session exhibited alterations in air quality parameters. The PM2.5 concentration saw an increase, reaching 22 ug/m^3, while PM1.0 remained steady at 13 ug/m^3, and PM10 reached 28 ug/m3. The formaldehyde (HCHO) content also increased, now registering at 0.034 mg/m3, while Total Volatile Organic Compounds (TVOC) reached a level of 0.062 mg/m^3. Temperature (TEMP) was documented at 28.9 °C, with humidity (HUM) measuring at 52%. Carbon dioxide (CO_2) measurements, executed with a CO_2 meter, produced results of 572 ppm, with the temperature recorded in Celsius units at 28.9 and the relative humidity (RH) level measuring 58.4%. In parallel, carbon monoxide (CO) measurements employing alternative devices remained consistently at 0 ppm.

The final data collection session at Point 2 was conducted over a span of 10 minutes. The results of this measurement session revealed a consistent evolution in air particle parameters. PM2.5 concentrations increased to 25 ug/m^3, while PM1.0 reached 14 ug/m^3, and PM10 surged to 3114 ug/m^3. The formaldehyde (HCHO) content remained stable at 0.027 mg/m^3, while Total Volatile Organic Compounds (TVOC) reached 0.046 mg/m^3. Temperature (TEMP) was recorded at 30.8 °C, with humidity (HUM) measuring at 47%. Carbon dioxide (CO_2) measurements showed a result of 569 ppm, with the temperature recorded in Celsius units at 28.9 and the relative humidity (RH) level measuring 58.5%. Furthermore, carbon monoxide (CO) measurements performed with alternative devices consistently registered at 0 ppm, with temperatures reaching 34.2 °C as shown in Fig. 3.

Based on the provided data, the highest CO_2 levels were observed during the morning, peaking at 581 ppm. This occurrence was attributed to the increased number of visitors engaged in nearby activities during that time. Conversely, CO_2 levels gradually decreased in the afternoon and evening, registering at 572 and 569 ppm, respectively. Moreover, the highest temperature was recorded in the afternoon between 03.00 and 03.10, reaching 30.8 degrees Celsius.

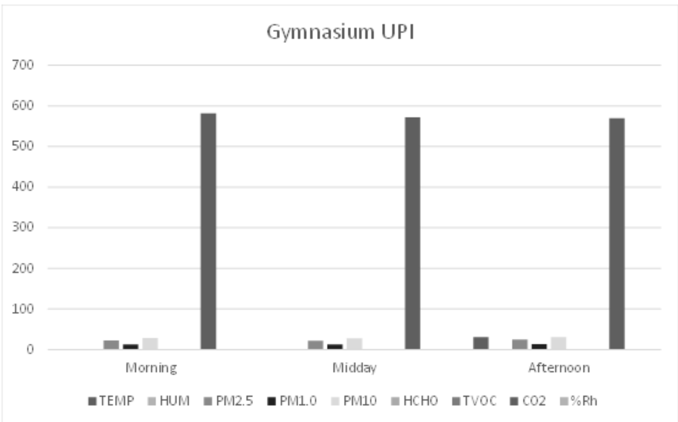

Fig. 3. Gymnasium UPI.

Comparing the data from these two locations, it is evident that CO_2 levels were notably higher in the morning at the construction site, reaching 621 ppm, whereas in the Gymnasium, they reached 581 ppm. Consequently, the construction site exhibited lower air quality in comparison to the Gymnasium.

The monitoring of air quality data during the infrastructure construction phase has revealed a noteworthy escalation in the concentrations of PM2.5 and PM10 particulates. These heightened concentrations, often stemming from construction-related dust and air pollution generated by construction vehicles, have exhibited a substantial increase during periods of infrastructure construction [16, 17]. This research has ascertained that during the peak of construction activities, PM2.5 and PM10 concentrations experienced a significant surge in comparison to the Gymnasium site. This observation underscores the discernible contribution of infrastructure development to elevated levels of air pollution, which, in turn, poses potential health risks to the human population [18-24].

The comparative analysis of data from the two distinct locations also highlights that the second site, namely the UP Gymnasium, exhibits superior air quality. This phenomenon can be attributed to the influence of environmental factors, particularly the presence of abundant vegetation and natural surroundings, which serve as innate filters against air pollutants. The trees encompassing the gymnasium effectively capture particulate matter and other air contaminants, resulting in a noteworthy reduction of harmful particles dispersed in the atmosphere.

Consequently, the air quality in the vicinity of the gymnasium building is notably healthier, thereby exerting a positive influence on the well-being and comfort of students and visitors in the vicinity. These findings underscore the critical importance of green vegetation in urban areas as an efficacious means of mitigating air pollution and sustaining the overall quality of the air we respire.

The lasting repercussions of infrastructure construction on air quality demand attention from all stakeholders. While air pollution levels may eventually revert to their initial state following the conclusion of construction, certain studies have indicated that the long-term effects can persist for several years post-project completion. This phenomenon can be attributed to the enduring influence of pollutants released during construction, which may lead to cumulative impacts that pose potential risks to public health.

Within this context, the incorporation of efficient mitigation strategies during the execution of infrastructure projects assumes critical significance. These strategies encompass the adoption of advanced dust control technologies and the rigorous monitoring of air quality. Furthermore, the implementation of pollution control measures and stringent regulations is imperative to curtail the detrimental effects on air quality that may emanate from infrastructure development. Prudent and meticulous planning is indispensable to ensure that infrastructure progress occurs without compromising air quality, a factor that significantly impacts the well-being of the populace.

4. Conclusion

The primary objective of this research is to quantify and discern the impact of construction activities on air quality within the environment of the Universitas Pendidikan Indonesia. Based on the data presented above, it is evident that the air quality at the first data collection point has been moderately perturbed by pollution originating from ongoing construction work. Conversely, at the second data collection point, the air quality remains relatively favourable. This can be attributed to the presence of trees and the location's considerable distance from the main road, resulting in limited vehicular traffic and the absence of construction activities, thereby preserving a relatively good air quality environment at the second data collection point.

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