Environmental Pollution towards the Workplace in the Philippines

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ABSTRACT

Introduction. Air pollution is an emerging global concern, especially in the Western Pacific and South-East Asia regions; smoke-belching and emissions from vehicles on the road are associated with air pollution. In the Philippines, the Clean Air Act of 1999 was passed to address the growing concern for poor air quality to cover mobile sources such as vehicles.

Objective. This study aimed to come up with a descriptive analysis of emissions of vehicles as this has an impact on air pollution and road-environmental safety.

Methodology. This study analyzed a secondary database of vehicle emissions violation cases from the Land Transportation Organization (LTO) office in Region 11, the Philippines. The study was retrospective in nature and involved a review of traffic violation cases. The data were encoded and analyzed using the SPSS ver. 23 software program.

Results. Two hundred eighty-two vehicle emission standard violations were recorded by the Land Transportation Office (LTO) from 2018 to 2019. Most cases were from 2018 (72.7%), with January (30.9%) recorded the highest number of unsafe vehicle emission standard violation cases. Of the apprehended drivers, the majority (88.3%) were of the driving professional license category. All the drivers (100.0%) were caught due to the violation of smoke-belching (V16). In comparison, a small proportion was also seen as cases of driving without a valid driver's license or conductor's permit (1.8%) and failure to carry driver's license/OR/CR (0.8%). All the violators were caught on daytime working and rush hours, between 6:00 am and 5:00 pm. More than half of the apprehended drivers' vehicles (55.3%) were classified as for hire, while the remaining (41.8%) were classified as private vehicles. The majority (99.3%) of the vehicles did not pass the first emissions standards. Meanwhile, the most common vehicles caught for unsafe emissions were UV vehicles (n = 239). The vehicles caught for dangerous emissions were more than ten years old, with one-third (35.9%) of the vehicles were between 10 to 19 years old. The mean years of use or age of the vehicle were 15.724 ± 8.553 years. Opacity results for the first emission testing were 6.691 ± 2.404, while the Average Light Absorption (ALA) coefficient for the second emissions testing was 1.102 ± 0.577.

Conclusion. This study provided an overview of unsafe vehicle emissions within an urban city and suggested a need for more robust monitoring of vehicle emissions within safe limits. Vehicles that do not meet safety standards should not be allowed on the road, and disposal of old inefficient running vehicles may be beneficial in reducing dangerous air pollution.

Key Words: Vehicle emissions, smoke-belching, driver violations, air pollution

INTRODUCTION

Air pollution is a growing concern among nations around the world due to its environmental and health implications. The World Health Organization estimates that 91% of individuals globally are exposed to unsafe levels of air pollutants.[1] Poor air quality was also disproportionally higher among nations in the Western Pacific and South-East Asia regions.[1]

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The means of road transportation has been identified as the primary source of air pollution in several studies as these emit toxic air pollutants.[2-4] Emissions of these pollutants are further aggravated by the number and density of motor vehicles in the area and the age of the vehicles.[3,5] Moreover, poorly maintained vehicles are also prone to smoke-belching.[6] The latter is defined as the "vigorous discharge of smoke from the vehicle's pipe and considered as the number one contributor to air pollution."[7] The air pollutants measured in vehicle emission testing are carbon monoxide (CO), nitrogen oxides (NO_x), particulate matters (PM), total hydrocarbon (THC), non-methane hydrocarbon (NMHC), and diesel smoke.[8] These emissions cause health burden as it was estimated that 4.2 million deaths were associated with cardiovascular and respiratory diseases, aggravated by air pollution.[1]

The region of Davao is located in the southeastern part of the island of Mindanao in the Philippines. The region is composed of the provinces of Davao del Sur, Davao del Norte, Davao Oriental, Davao Occidental, and Compostela Valley.[9] As of the latest census of the Philippine Statistics Authority in 2020, the Davao region is the 8th most populous region in the country with a total population of 5,243,536, and the center of commerce in Mindanao.[10]

The number of vehicles registered in the Davao Region is increasing. Motor vehicles in the region grew to 632,601 in 2019 from 425,081 in 2016.[11,12] Despite the results of the air quality monitoring of Environmental Management Bureau (EMB) in 2017 that the overall air quality in the region is of Good to Fair criteria, the primary contributor of air pollutants in the area are motor vehicles or mobile sources.[13]

The latest data of emission inventory in Davao showed that Carbon Monoxide (CO) was the highest emitted air pollutant amounting to 311,941 tons. This was followed by total organic gas (TOG) and volatile organic compounds (VOC) at 103,399 tons, PM (17,040 tons), NO_x (32,861 tons), and SO_x (22,805 tons). Motorized vehicles contributed the highest in the emission of carbon monoxide (193,634 tons), volatile organic compounds (91,084 tons), and particulate matter (23,738 tons).[13]

This study aimed to determine vehicle emissions of motor vehicles caught for smoke-belching within an urban city in the Philippines using data collected from the Land Transportation Office. This is about the Philippine Clean Air Act of 1999 that was passed into law to address the issue of air pollution within the country.[14] The law recognizes the contribution of vehicles in causing air pollution and poor air quality. Within this law, parameters of acceptable emission limits for certain vehicles are emphasized. Through the Land Transportation Office, the Department of Transportation was mandated as the enforcing body to ensure safe vehicle emissions across the country. Their roles encompass inspection and monitoring vehicle emissions, prohibition of vehicles with hazardous emissions, and accreditation of emission testing centers.[14]

METHODS

This study which is a part of the Road Safety Project, is focused on vehicle emissions in the Southern part of the Philippines, Davao region, which is dubbed the commercial and government capital in the South. This study analyzes a secondary database of vehicle emissions violation cases from the Land Transportation Organization (LTO) Region 11, Office of the Philippines. The study is retrospective in nature and involves a records review of these violation cases. A total of 282 drivers fined for unsafe vehicle emissions were gathered from the years 2018 to 2019. All cases occurred within the Davao Region. The data was encoded and analyzed using the SPSS ver. 23 software program. Descriptive and inferential statistical treatments were used to analyze the data. The study's objective was to come up with a descriptive analysis of emissions of vehicles as this has an impact on air pollution and road-environmental safety. The Department of Health Single Joint Research Ethics Board approved the overall project.

RESULTS

A total of 282 cases was recorded by the LTO from the years 2018 (72.6%) to 2019 (25.9%) for having violated vehicle emissions standards. Most cases (95.2%) were among owners who lived within Davao City, while the rest even come from other parts of the country. The most common vehicle caught for unsafe emissions standards was the UV type of Utility Vehicle. Utility vehicles in the Philippines are most commonly used as public transportation to transport one passenger to another destination along the route the UV passes. Vehicles within 10 to 19 years old comprised 35.9% of cases, vehicle vehicles in use for 20 to 29 years and 1 to 9 years separately include 27% of cases. More than half of the vehicles were classified as for hire, comprising 55.3% of cases. Among the cases recorded, 41.8% are classified as private. Most cases caught were in the years 2017 (72.7%) and 2019 (25.9%). (Table 1)

The data gathered involved unsafe emissions violations; 100% of cases were caught with the violation of smoke-belching (V16). Driving without a valid driver's license or conductor's permit was also present in 1.8% of cases. This was followed by the failure to carry a driver's license/OR/CR while driving, which comprised 0.8% of cases. (Table 2)

Reporting and recording of violators were not consistent due to the lack of resources and human resources to catch violators. Most cases caught were in January (30.9%), February (20.9%), June (19.1%), and March (18.4%). The rest of the months only recorded less than 5% of violators. (Figure 1)

All violators were caught between the daytime hours of 6:00 am to 5:00 pm. These usually cover regular work hours and involve the rush hours periods within the city. Most cases were caught between 10:00 to 10:59 (40.8%) hours and 9:00 to 9:59 hours (31.6%). (Figure 2)

Table 1. Frequency Distribution of emission cases from LTO Davao according to the age of the vehicle, address of the owners, vehicle type, vehicle classification, and year of apprehension (n=282)

Variable	Frequency	Percentage
Age (in years)		
1 to 9 years	76	27
10 to 19 years	101	35.9
20 to 29 years	76	27
30 to 39 years	15	5.6
Missing	14	5
Total	282	100
Location		
Davao City	268	95.2
Davao Del Sur	2	0.7
General Santos City	1	0.4
Cotabato	2	0.7
Sarangani	2	0.7
Quezon City	1	0.4
Sultan Kudarat	1	0.4
Surigao Del Sur	1	0.4
Taguig City	1	0.4
Cagayan De Oro City	1	0.4
Missing	2	0.7
Total	282	100
Vehicle Type		
Car	3	1.1
Double cab/Pick-up	3	1.1
FB Body/L300	2	0.8
Jitney	6	2.2
Jeepney	1	0.4
SUV/Van	2	0.8
Truck	18	6.4
UV	239	84.8
Missing	8	2.8
Total	282	100
Classification		
For hire	156	55.3
Private	118	41.8
Missing	8	2.8
Total	282	100
Year of apprehension		
2018	205	72.6
2019	73	25.9
N/A	4	1.4

Table 2. Frequency distribution of emissions cases from LTO Davao City (n=282)

Variable	Frequency	Percentage
License Type		
Non-professional	10	3.5
Professional	249	88.3
Temporary Driver's License	16	5.7
Total	282	100
Confiscated Item		
Driver's License	278	98.6
Motor Vehicle	6	2.1
Plate	192	68.1
Violation		
V1	5	1.8
V10	2	0.8
V11	1	0.4
V13	1	0.4
V14	1	0.4
V15	1	0.4
V16	282	100
No CPC Carried	1	0.4

Legend:
V1 – Driving without a valid driver's license/conductor's permit
V10 – Failure to carry driver's license/ OR/CR while driving
V11 – Driving an unregistered motor vehicle (MV)
V13 – Operating a right-hand drive MV
V14 – MV without or defective/improper/unauthorized accessories, devices, equipment, and parts
V15 – Failure to attach or improper attachment/tampering of authorized MV plates and or 3rd plate sticker
V16 – Smoke belching)

Aside from smoke-belching, additional violations were also noted among violators. The most common was a failure to carry license or OR/CR (1.1%). Opacity results, a central parameter in determining unsafe vehicle emissions, revealed that 99.3% of cases did not pass safety standards. After the first emissions testing, vehicles that do not pass safety standards have to be repaired and tested again before retrieving the confiscated documents. The results of the second emissions testing revealed that 94.7% were able to pass safety standards. The mean years of use or age of the vehicle were 15.724 years (SD ± 8.553). The mean K-value or Opacity results of the first emissions testing were 6.961 (SD ± 2.404). For the second emissions testing, the average light absorption was used as a parameter, which is another way to test the opacity of vehicle emissions. The mean Average Light Absorption (ALA) coefficient was 1.102 (SD ± 0.577). (Table 3)

DISCUSSION

There has been an increasing number of motor vehicles in the Davao region from 2016 to 2019.[11,12] This WAs one cause of heavy vehicular traffic.[15] This increase further aggravated the higher levels of traffic volume, which is a default situation in urban areas, such as the case of Davao.[16] In Poland and Metro Manila, the increase in car registrations leads to congestions on the road.[17,18] A report in Davao City showed that although 80% of road users are private car owners, the usage of cars in the roadways in the area is low.[19] Nevertheless, it cannot be overlooked that there has been an observed increase in Davao's annual average daily traffic (AADT) trend. For instance, the annual average daily traffic (AADT) of Davao City Diversion Road increased from 26,857 vehicles in 2016 to 41,903 vehicles in 2019.[20] The road is classified as a secondary road that connects major infrastructures in the city of Davao.[21] Other data on AADT of the various roads in the Davao region can be seen in Appendix 1.

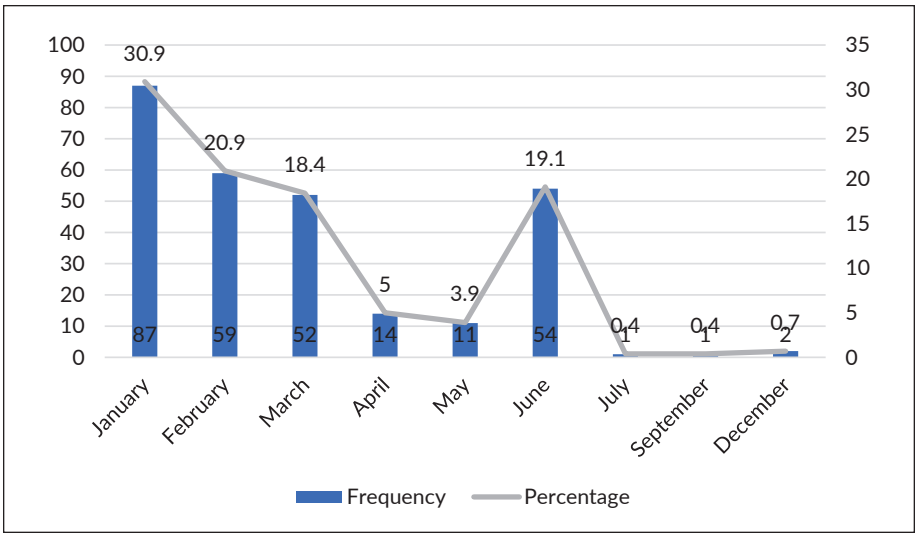

Figure 1. Frequency Distribution of emissions cases from LTO Davao according to the month of apprehension (n=282).

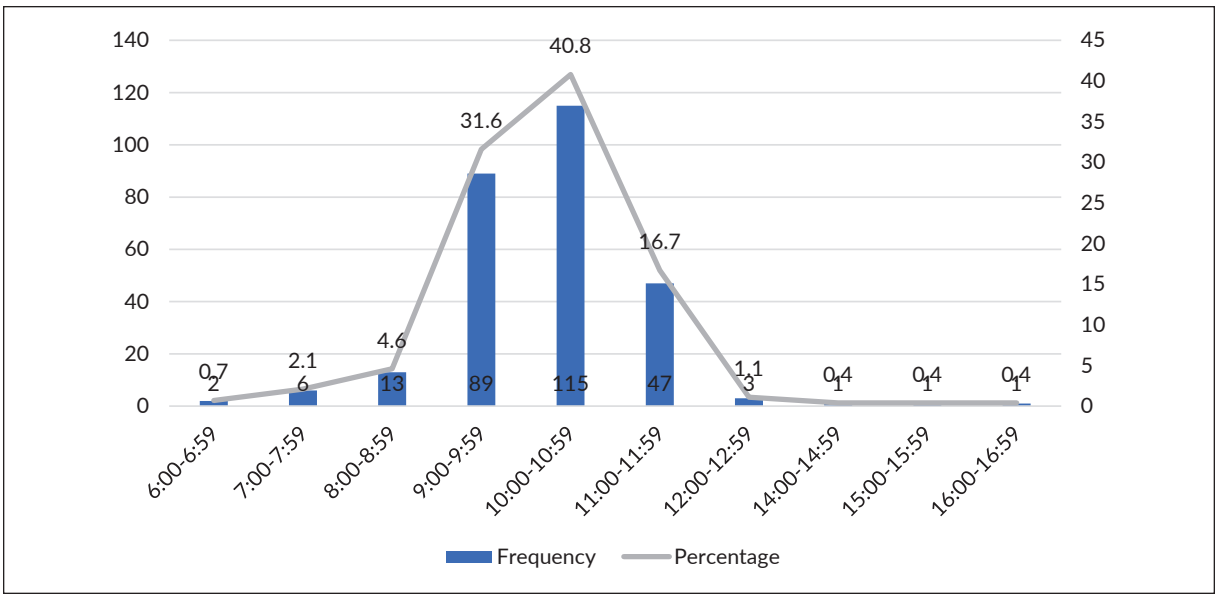

Figure 2. Frequency Distribution of emissions cases from LTO Davao according to the hour of apprehension (n=282).

Generally, the Davao region has an average Good to Fair air quality according to the air quality monitoring of EMB in 2017.[13] However, the latest emission inventory data in 2015 showed Carbon Monoxide (CO) emissions at 311,941 tons, total organic gas (VOC/TOG) at 103,399 tons, among others. Motorized vehicles contributed the highest in the emission of carbon monoxide (193,634 tons), volatile organic compounds (91,084 tons), and particulate matter (23,738 tons).[13]

The majority of cases were among utility vehicles (UV). These vehicles are commonly used as a form of public transportation and require commuters to wait on the side of the road in the UV's route. The UV can hold around 6-10 passengers, depending on the vehicle size. Hailing a UV already exposes individuals to poor air quality, requiring them to stand on the roadside for prolonged periods. This is similar to the findings of a study done in Georgia, where more inferior air quality was found when people left their homes or passed through roads.[22] Moreover, congestion of urban roads plays a significant role in air pollution at a given time. During high traffic volume, the speed, volume, and acceleration patterns of the vehicle and road change. During congestion, periods of acceleration from frequent increments of stopping and moving caused higher emissions among vehicles.[23]

Vehicles in the present study were commonly older in terms of year model, and the years they have been in use

Table 3. Frequency distribution of smoke-belching cases from LTO Davao according to additional violations, first emissions result upon fining of the ticket, second emissions result, and the Mean and Standard Deviation of K-value Average and ALA Coefficient of First Emissions Test (n=282)

Variable	Frequency	Percentage
Added Violation		
No other violation	276	97.9
MV Operated Defective	1	0.4
No CPC Carried	1	0.4
Unauthorized MV modification	1	0.4
Failure to carry license or OR/CR	3	1.1
Total	282	100
First Opacity Results		
Not passed	280	99.3
N/A	2	0.7
Second Opacity Results		
Passed	267	94.7
N/A	15	5.3
Total	282	100
Testing Parameter	**Mean**	**Standard Deviation**
K-Value/Opacity	6.961	2.404
ALA Coefficient	1.102	0.577

ALA – Average Light Absorption

or owned. These may have significant implications for the condition of the vehicle. Moreover, more recent vehicle models are equipped with technology that reduces the vehicle's harmful environmental impact. In the present study, the mean age of the vehicles was 15.724 years (SD ± 8.553), while the mean vehicle year model was 2002.5 (SD ± 8.547). Evidence suggests that as the vehicle's year model decreases and its age increases, the higher its emission of air pollutants.[24,25]

The principle of wear-and-tear also applies to vehicle use. In a study in Korea among Euro-4 light-duty diesel vehicles, older models were more likely to have faulty exhaust gas recirculation (EGR) valves, which are essential for preventing large amounts of nitrogen oxides from being emitted. Suppose the EGR valve does not function due to damages over time and soot accumulation around the valve. In that case, the gas flow becomes less efficient, leading to higher amounts of emitted air pollutants.[26] In this study, the majority of the vehicles caught for unsafe emissions had fuel types classified as just diesel (62.8%) or diesel, non-turbo engine (32.3%). These are important to note as they influence the type and amount of pollutants emitted. Machines that usually utilize diesel fall under the compression ignition type of internal combustion engines. Moreover, when the engine is noted to be turbocharged, the internal combustion of fuel has higher efficiency and fewer emissions (e.g., NOx, CO, CO_2).[27]

Aside from ensuring that vehicle condition is enough to meet vehicle standards, the strength of enforcement is also necessary to reduce air pollution. However, the results of this study showed inconsistent reporting of smoke-belching cases from the years 2016-2020 and the months of the year. The high reporting frequency was concentrated in 2018 (72.7%) and 2019 (25.9%), and the first three months of the year. Apprehension of violators was also within daytime hours, with most cases mostly occurring during the morning rush hour. Cases of reduced air pollution have been seen after the effective implementation of safer emissions standards. In China, improving their fuel standards led to a significant reduction of their air pollution, which subsequently contributed to their economy.[28] Their programs involved improving engine types, switching fuel types, restricting certain vehicles on specific roads, and addressing traffic congestion, which was enforced effectively.[29] In Korea, in addition to improving engine types, the country has also provided a financial incentive for car owners whenever they choose to retire old vehicle models that are no longer fit for use on the road.[30] In Tehran, a study sought to assess the best policy areas to reduce emissions and air pollution. It was observed that upgrading engine type to Euro 4 while reducing the energy consumption of specific industries and factories was the most effective path to addressing air pollution.[31]

Another way to improve compliance among road users is through penalizing violators and taking away their capacity to continue unacceptable behaviors. In the present study, this was achieved through confiscating vehicle plates and licenses, which would prevent drivers from driving until they can comply with the law. In this study, 94.7% of vehicles passed the second emissions testing. The mean Average Light Absorption (ALA) coefficient was 1.102 (SD ± 0.577), below the reference value of 2.2. ALA Coefficient is the value calculated to determine the light absorption of gases emitted by vehicles using an opacimeter.[32] Opacimeter is commonly used in vehicle emission inspection to measure the attenuation of a beam of light shining across a smoke plume.[33] The result of the study also showed that among the apprehended violators, the fee implemented and confiscation of items were effective in promoting vehicle safe emissions standards. It should be noted. However, that income also plays a role in reducing vehicle emissions.

CONCLUSION

Ensuring safe vehicle emissions plays an instrumental role in reducing air pollution within the country. Emissions testing revealed that vehicles caught for smoke-belching released more than twice the acceptable limit. Vehicles emitting unsafe levels of air pollutants were observed to be old and outdated. The findings of this study showed there was a need for more robust implementation and monitoring of vehicle emissions within safe limits. Additionally, it may be beneficial for the country to encourage vehicles owners to retire or dispose of vehicles that no longer meet safety standards due to old age. In terms of penalizing, the

confiscation of items helped ensure compliance, as evidenced by the high passing rate of the second emissions testing.

The country still has much to improve in addressing the contribution of vehicles to air pollution. More research is needed to assess the factors that affect the enforcement of safe vehicles within the country. The present study provided a picture of unsafe vehicle emissions within an urban city.

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Statement of Authorship

The author participated in the collection and analysis of data and approved the final version submitted.

Author Disclosure

The author declared no conflicts of interest.

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APPENDIX

Appendix 1. Annual Average Daily Traffic for Major Roads in Davao from 2016 to 2019

Road Name	2016	2017	2018	2019
Davao City Div Rd	26,857	25,682	24,230	41,903
Davao Regional Med Trng Ctr	10,313	10,313	10,532	10,946
Davao-Bukidnon Rd	7,011	9,991	18,511	18,758
Davao-Cotabato By-Pass Rd	10,718	10,718	10,943	7,104
Davao-Cotabato Old Rd	25,598	21,578	25,403	22,771
Davao-Cotabato Rd (Davao City-Jct Digos Sect)	16,352	27,259	23,900	36,516
Davao-Cotabato Rd (Jct Digos-Cotabato Sect)	8,750	8,902	15,228	17,553