Monitoring of Air Pollution due to Vehicles at Ratmalana, Sri Lanka

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Abstract *- Urbanization and industrialization are the main causes of air pollution in most of the areas in Sri Lanka. Air pollution is occurred due to natural and manmade activities. Monitoring of air quality especially in urban areas in Sri Lanka is significant because the quality of air is degraded day by day due to various activities. In Sri Lanka, most activities on air quality monitoring and management are concentrated in Colombo, which is the commercial capital of Sri Lanka. However, few attempts were taken to study air pollution in other industrial areas as well. Transportation sector is responsible for majority share of the most of the gaseous emissions to the environment with compared to any other sector. Therefore, this attempt has been made to discuss the air pollution due transportation sector at Ratmalana area in Sri Lanka. Sri Lanka has adopted emission standards for all vehicles, but those standards are yet to be effectively enforced. Further, there is no mechanism to evaluate the benefits due to emission control strategies as no reliable emission inventory is available, specially to estimate local concentration levels. Therefore, the main objectives of this paper are to discuss the level of air quality in this particular area and to develop a vehicle emission inventory that could be used for estimating vehicle emission with respect to special distribution. A traffic survey was conducted near Galle road at Ratmalana for about two weeks. The emission standards were collected from Automated Air Quality Monitoring station which is operated by the Central Environmental Authority of Sri Lanka. The level of emission and values of emission of each pollutant were estimated for each vehicle. It was found that the major sources of Carbon Dioxide, Nitrogen Dioxide, Sulfur Dioxide and Particulate Matter are Light Trucks and Heavy Duty Vehicles however; the major sources of Carbon Monoxide are Cars and Vans. In addition, it was estimated the paths of air pollution and percentages of each vehicle of each pollutant per hour. Finally, it was recommended to use the Carpooling system and public vehicles to mitigate the air pollution due to vehicles at Ratmalana, Sri Lanka.*

Keywords— Air Quality, Vehicular Emissions, Air Pollutants, Urban Areas

I. INTRODUCTION

Air is necessary for the survival of all higher forms of lives on earth. Normally, a person needs at least 30 pounds of air per day to live. Therefore, air is very important for us. However, air is polluted due to various activities. Air pollution is defined as the presence of certain substances in the air in high enough concentration and for long enough duration to course undesirable effects. Air pollution is occurred due to manmade activities and natural courses. Natural courses of air pollution cannot be reduced; however, the air pollution due to manmade activities can be stopped or minimized.

Urbanization and industrialization are the main causes of air pollution in most of the countries in the world for a long period of time. In Sri Lanka, air pollution is occurred due to the rapid growth of cities together with industries and transportation systems. Hence, air pollution is highly occurred especially in the main cities and industrialized areas. Estimates available to date in Sri Lanka are shown that the transport sector is responsible for majority share of most of the gaseous emissions to the environment in comparison to the other sectors such as industry, agriculture, and fisheries. Ratmalana area has been subjected to heavy pollution from various industries and vehicles for few decades. This area has been subjected to pollution by heavy metals that have some drastic adverse impacts on human beings and surrounding ecosystems. These emissions are mainly released from the heavy traffic along the Galle road which is running from Colombo to Southern Province of Sri Lanka. Few attempts were taken by various researchers to monitor the level of air pollution due to vehicles in most of the areas in Sri Lanka. However, most activities on air quality monitoring

and management are concentrated in main urbanized cities in Sri Lanka. Moreover, there is no any comprehensive study conducted so far at Ratmalana area to estimate the degree of contamination due to vehicles.

Therefore, the objectives of this research are to identify different types of vehicles which are contributed for the air pollution, estimate the amount of pollutants which are released from each vehicle, and proposed any mitigative measures to control the air pollution at Ratmalana, Sri Lanka.

II. RESEARCH METHODS

The primary data was collected by conducting traffic surveys at a point of the Galle road at Ratmalana. Further, it was exploited whatever the secondary data such as reports, paper articles, books, web sites, and journals to conduct this research. In this research, we searched literature from Central Environmental Authority (CEA) of Sri Lanka to identify all relevant publications related to this study. Emission Factor method was used to estimate the amount of pollutants that are released by each vehicle type. Emission factors related to each vehicle was collected from the available database of CEA. The following table shows the emission factor (g/hr/vehicle) of pollutant for different types of vehicles.

Table 1. The Emission factors used in Sri Lanka

	CO	CO_2	NO x	HC	CH_4	NMV	PM	Pb	SO x	N_2O
Vehicle Type										
Cars Diesel	1.50	275	2.20	0.75	0.01	0.25	0.40		1.20	0.014
Cars Petrol	32.50	200	1.40	4.20	0.07	4.16	0.10	0.04	<.1	0.003
Cars Gas	0.50	175	1.10	0.10			<.01		<.01	
Van Diesel	1.80	400	3.00	2.00			0.80		1.7	
Vans Petrol	45.00	285	2.50	6.00			<.1	0.06	<.1	
Motor cycle Petrol	26.00	60	0.25	2.50	0.11	6.74	0.10	0.01	<.01	0.001
Land vehicle Diesel	0.73	113	0.67	0.27			0.33			
Taxi(3-Wheeler Petrol)	30.00	130	0.65	4.30			0.30	0.02	<.01	
Medium Bus Diesel	8.93	788	10.63		0.06	2.02				0.032
Bus Diesel	2.50									

(Source: Central Environmental Authority, Sri Lanka)

A suitable point of the Galle road at Ratmalana was selected to count the number of vehicles passing through that point during a period of one hour. The number of vehicles travel to both directions was counted separately according to the type of vehicle during the four consecutive 15min periods. The same procedure was repeated to calculate the number of vehicles for another three hours period in one day. Similarly, the vehicle survey was conducted in selected days for two weeks period of time.

The emission of pollutants from different vehicles was estimated from the following formula.

Transport Emission = **Emission Factor** * **Number of Vehicles Travelled in an hour**

III. RESULTS AND DISCUSSION

This section describes the results and discussion related to the traffic survey conducted at Galle road. The collected data was analysed in different ways to understand which vehicle type releases dangerous pollutants to the environment. The first analysis was done to estimate the level of emission of a certain pollutant among different types of vehicles. This analysis was used to understand the type vehicle that mostly contributed to generate any particular pollutant.

Figure 1 shows the variation of Carbon Monoxide (CO) among different types of vehicles. The figure depicted that the higher concentration of CO is released mainly by Vans followed by Cars and Three-Wheelers. It is clear from the figure that the main sources of CO are light vehicles. Figure 2 shows the variation of CO_2 with different vehicles types. It is obviously clear that Light Trucks and Heavy Duty Vehicles are the major sources of CO_2. This is mainly because Light Trucks and Heavy Duty Vehicles are operated by combusting Diesel.

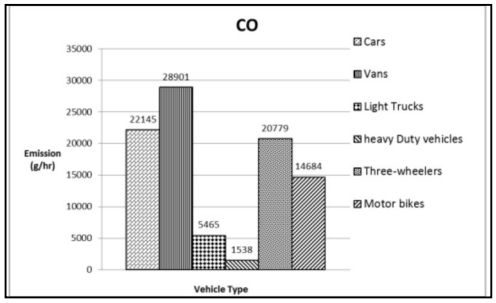

Figure 1. Variation of Carbon Monoxide (CO) with the vehicle types

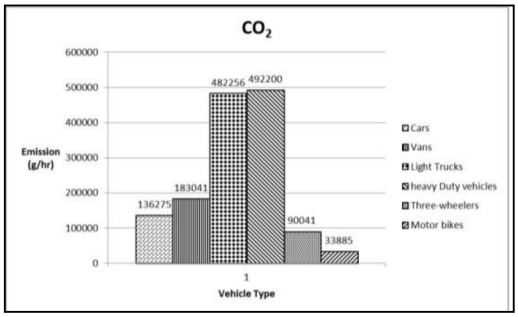

Figure 2. Variation of Carbon Dioxide (CO_2) with the vehicle types

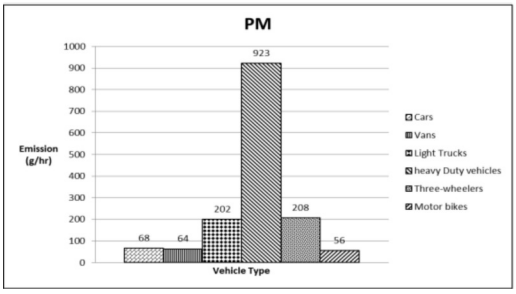

Figure 3. Variation of Particulate Matters (PM) with the vehicle types

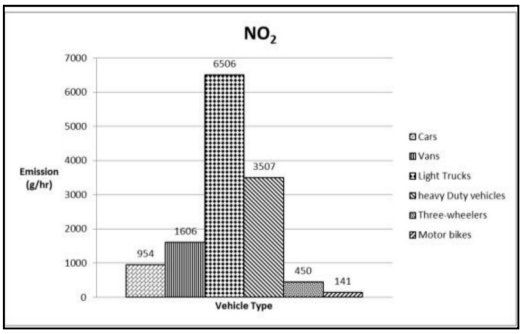

Figure 4. Variation of Nitrogen Dioxide (NO_2) with the vehicle types

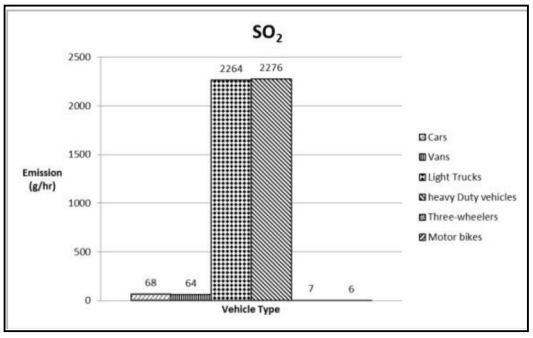

Figure 5. Variation of Sulfer Dioxide (SO_2) with the vehicle types

Figure 3 depicts the variation of Particulate Matters (PM) with vehicle types. Heavy Duty Vehicles indicated the highest concentration of PM. Figures 4 and 5 show the variation of Nitrogen Dioxide (NO_2) and Sulfer Dioxide (SO_2) with vehicle types, respectively. Figures depicted that both NO_2 and SO_2 are largely emitted by Light Trucks and Heavy Duty Vehicles. This is mainly due to the combustion of Diesel in the engines of these vehicles. Nitrogen and Sulfer concentrations in Diesel are comparatively higher than those in Petrol.

The following table shows the percentages of vehicles contributed to release different types of pollutants.

Table 2. Percentages of vehicles contributed to release each pollutant

	Cars	Vans	Light Trucks	heavy Duty vehicles	Three-wheelers	Motor bikes
CO	24%	31%	6%	2%	22%	16%
CO2	10%	13%	34%	35%	6%	2%
NO 2	7%	12%	49%	27%	3%	1%
SO2	1%	1%	48%	49%	0%	0%
PM	4%	4%	13%	61%	14%	4%

The table depicted that the light vehicles such as Cars, Vans, Three-Wheelers and Motor Bikes are mainly contributed for the emission of CO; whereas, heavy vehicles such as Light Trucks and Heavy Duty Vehicles are mainly contributed for the emission of CO_2, NO_2, SO_2, and PM.

Air pollution is known to have many adverse effects, including those on human health, other exposed materials, vegetation, agricultural crops, animals, aquatic and terrestrial ecosystems and the climate of earth as a whole. The most important effect of air pollution is the harm it causes human health. Generally, air pollution is most harmful to the very old and the very young people. Major health effects are categorized as being acute, chronic or temporary. Acute effect is short-lasting, but severe, and may even result in death. Chronic (or long-term) effects usually include respiratory illnesses such as bronchitis, emphysema, asthma and perhaps lung cancer. Temporary effects include intermittent periods of eye or throat irritation, coughing, chest pain, malaise and general discomfort.

Air pollution causes significant damage to material objects as well particularly in heavily polluted urban areas. This includes soiling and deterioration of building surfaces and public monuments, corrosion of metals, and the weakening of textiles, leather, rubber, nylon, and other synthetic products.

These consequences highlighted that air pollution creates many adverse effects on both human and environment. Most of these pollutants are released from automobiles and hence, it is necessary to find some preventive measures in order to control or minimise the air pollution due to vehicles.

IV. CONCLUSIONS AND RECOMMENDATIONS

Most of the researchers have monitored air quality in Colombo district where industrial and vehicular emissions are predominated. However, few studies have been done in other districts such as Kandy, Galle and Anuradhapura to study the air pollution especially due to vehicles. Implementing air quality monitoring programs and reporting their results to the public in other urban areas would be an effective tool to increase awareness on air pollution in areas outside Colombo Metropolitan Area, if resources are available to enable it. This study was done to identify different types of vehicles which are contributed for the air pollution and to estimate the amount of pollutants which are released from each vehicle at Galle road at Ratmalana.

The different types of vehicles such as Cars, Vans, Light Vehicles, Heavy Duty Vehicles, Three-Wheelers and Motor Bikes were used in this study to estimate the level of pollutants which are released by each type of vehicle. The study revealed that the major sources of CO are light vehicles including Cars, Vans, and Motor Bikes. However, the major sources of CO_2, NO_2, SO_2, and PM are Light Trucks and Heavy Duty Vehicles.

Normally, transport emission is occurred due to increased number of vehicles. In urban areas, numbers of vehicles are increased largely nowadays because; most of the families use their own vehicles. In addition, a large number of vehicles are entered to the urban areas from the outside cities. As a result, huge amount of pollutants are released to the environment degrading the quality of air. Based on our research, the following recommendations could be proposed to mitigate the pollution of air due to vehicles.

<u>Carpooling:</u>

This method is used to reduce the individual personal vehicles in urban areas. People have to use a common vehicle inside the city instead of using their own vehicles. This will help to reduce the number of vehicles in the city and hence, to reduce the emission of pollutants.

<u>Reduce the travels in peak hours:</u>

This method is used to reduce the number of vehicles in the city in peak hours and therefore, to reduce the emission of pollutants. In addition, this would be a solution for the traffic congestion as well.

<u>Use public vehicles:</u>

The number of vehicles which are entered to the city can be minimized by implementing this method. This is directly contributed to the control of emissions.

REFERENCES

Central Environmental Authority (CEA) - Sri Lanka (http://www.cea.lk/)

Chan KY and Jian L (2013), "Identification of significant factors for air pollution levels using a neural network based knowledge discovery system", Neurocomputing, vol. 99, 564-569pp.

Gerdol R, Marchesini R, Iacumin P, and Brancaleoni L (2014), "Monitoring temporal trends of air pollution in an urban area using mosses and lichens as biomonitors", Chemosphere, vol. 108, 388-395pp.

Kim Y and Guldmann JM (2011), "Impact of traffic flows and wind directions on air pollution concentrations in Seoul, Korea", Atmospheric Environment, vol. 45, 2803-2810pp.

Lee BK, Jun NY, and Lee HK (2005), "Analysis of impacts on urban air quality by restricting the operation of passenger vehicles during Asian Game events in Busan, Korea", Atmospheric Environment, vol. 39, 2323-2338pp.

MacNaughton P, Melly S, Vallarino J, Adamkiewicz G and Spengler JD (2014), "Impact of bicycle route type on exposure to traffic- related air pollution", Science of The Total Environment, vol. 490, 37- 43pp.

Mavroidis I and Ilia M (2012), "Trends of NO*x*, NO2 and O3 concentrations at three differen types of air quality monitoring stations in Athens, Greece", Atmospheric Environment, vol. 63, 135-147pp.

Oakes M, Baxter L, and Long TC (2014), "Evaluating the application of multipollutant exposure metrics in air pollution health studies", Environment International, vol. 69, 90-99pp.

Quintana PJE, Dumbauld JJ et al (2014), "Traffic- related air pollution in the community of San Ysidro, CA, in relation to northbound vehicle wait times at the US–Mexico border Port of Entry", Atmospheric Environment, vol. 88, 353-361pp.

Rai PK, Chutia BM, and Patil SK (2014), "Monitoring of spatial variations of particulate matter (PM) pollution through bio-magnetic aspects of roadside plant leaves in an Indo-Burma hot spot region",

Urban Forestry & Urban Greening, DOI: 10.1016/j.ufug.2014.05.010.

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