Air pollutant exposure levels of passengers using public transport to reach Colombo from surrounding cities

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ABSTRACT: People living in urban area and roadside households are the group which is most susceptible for the exposure to vehicular emissions. Passengers who travel through high traffic urban areas in public buses with open windows are also exposed to air pollutants associated with automobile emissions. Most of the passengers are office staff, school children and the people who travel in peak hours for their day today activities. This study was carried out to determine the passenger exposure levels to air pollutants during heavy traffic time within the Colombo Metropolitan City. Samples were collected in public transport buses in six major routes from the Colombo main bus stand to destinations about 50 km far. Air pollutants concerned are Sulfur Dioxide (SO2), Nitrogen Dioxides (NO2) and Suspended Particulate Matter (SPM). Study results indicate that exposure levels of NO2 and SO2 are in the range of 96-550 µg/m3 and 30-700 µg/m3 respectively when travelling to one direction either from Colombo to destination or destination to Colombo. SPM exposure levels were in the range of 400-850 µg/m³. All concentrations of pollutants recorded were noticeably higher than concentrations in ambient air in the study area. The bus route from Colombo to Gampaha was observed as the highest polluted route when compared to other routes where the highest concentrations (SD) of SO2, NO2 and SPM recorded were 716 (119) µg/m3, 542(40) µg/m3 and 832(28) µg/m3 respectively. High exposure levels are significant in routes with heavy traffic and they vary with the rush hours. Minimizing the travel time with good traffic management and use of quality public transport system would reduce passenger exposure to air pollutants.

1 INTRODUCTON

Colombo Metropolitan City located in the Western Province is the commercial capital of Sri Lanka. The city area is highly populated and has a population density of 137 people/ha. More than 500,000 of people travel to the city for their day to day work. About 656000 vehicles are registered within the Colombo district and in addition an average about 200,000 vehicles are moving through the city in each day (Dept. Census and Statistics, 2015). The main port of the country and several high polluting industries such as thermal power plants, iron smelting plants etc are also located close to the boundary of the Colombo Metropolitan City. Air pollutant emissions from sources such as domestic, commercial, transport and industrial activities etc leads to an increase in air pollution levels in the city area. As a result, the air pollution levels in the area exceeds the WHO guideline values and it is in the increasing trend with some fluctuations due to implemented air quality managements strategies (Premasiri *et al*, 2009, Samarakkody *et al*, 2001, Jayawardana *et al* 2004). Out of above air pollution sources vehicular emission is identified as the major pollution source in the area since the air quality monitoring results indicate high pollution levels in traffic congested areas and hourly variation of air pollutant levels are closely linked to the traffic fleet in the city (Premasiri et al 2012).

In addition to about 250,000 registered vehicles within the CMC area more than 200,000 other vehicles are coming from the main six corridors of Colombo - Nittambuwa (AA001), Colombo - Gampaha (AA001& AA033), Colombo - Kalutara (AA002), Colombo – Negambo (AA003), Colombo - Avissawella (High Level,AA004), and Colombo - Horana (BB084) roads and other by roads operating within the area (Jayaweera et al, 2013). Air emissions from these vehicles are directly affecting the people who use the roads and those living by the roadside. In addition, passengers traveling in these roads with open windows are also exposed to high air pollutant levels associated with automobile emissions.

Since many Government & Non-government institutions, commercial centres, leading schools, higher educational institutions, public & private hospitals etc. are located within the Colombo Metropolitan Area (CMA), large fraction of community including office staff, school children etc in the surrounding areas travel to the Colombo city for their day to day necessities. Majority of these people use non-AC public transport system as well as private buses with open windows. Therefore, they are exposed to air pollutants emitted by vehicles for a considerable time period while they reach Colombo in high traffic jams especially through the main corridors. The estimates show that the average speed within Colombo roads is below 17 km/hr and the situation is worst during peak hours of the day (SPTMICMR, Ministry of Transport, 2014). Therefore, exposure levels of the people when reaching Colombo during peak hours are higher since they spend considerable time to reach the destination.

Although, many research activities were done on urban and roadside air pollution in Sri Lanka, no study was conducted to study the exposure levels of vehicular passengers and drivers to air pollutants. Therefore, the main objectives of this study is to estimate the air pollutant exposure levels with respect to NO_2, SO_2 and SPM of passengers who use public transport to reach Colombo from suburban cities using six main corridors.

2 MATERIALS AND METHODS

For the study of air pollutant exposure levels, Colombo - Nittambuwa (AA001), Colombo – Gampaha (AA001 & AA033), Colombo - Kalutara (AA002), Colombo - Negambo (AA003), Colombo-Avissawella (High Level, AA004), and Colombo - Horana (BB084) bus routes were selected. They represent the main corridores to reach the Colombo city. The travel distances were limited to about 50 km away from Pettah Central Bus Station, Colombo. The selected routes were the highly used public transportation routes among the corridors use to reach Colombo Metropolitan Area. Fig.1 present the map of Western Province showing the selected routes.

Private & public buses with diesel engines and half open windows in the above routes were selected for the sampling of air pollutants since these are the commonly used transport mode that represent approximately 47.6% of passenger transport sector in Colombo area.

Samplers were installed to capture the NO_2, SO_2 and SPM levels to determine the pollutant exposure levels of passengers in the breathing area inside the buses in selected routes. Sampling time was selected to cover one way travelling from Colombo to other destination cities and from selected city to Colombo. In addition, samples were installed to cover both way traveling to estimate the exposure levels of the driver and the conductor. Two sets of samples were collected per day to cover high traffic times of morning and afternoon. The same sampling procedures were repeated for one day per month for four months. In each set of sampling, blank samplers were treated similarly and kept in shield without opening the plastic cap.

Air pollutant exposure levels with respect to NO_2 and SO_2 were measured using passive sampling techniques developed by NBRO and active sampling method was used for particulate matter (SPM) sampling with low flow personal air samples. As sample collection period for each route depended on the traffic condition in the route, driver's behaviour and the distances, sampling period for one way traveling varied from 90 minutes to 120 minutes.

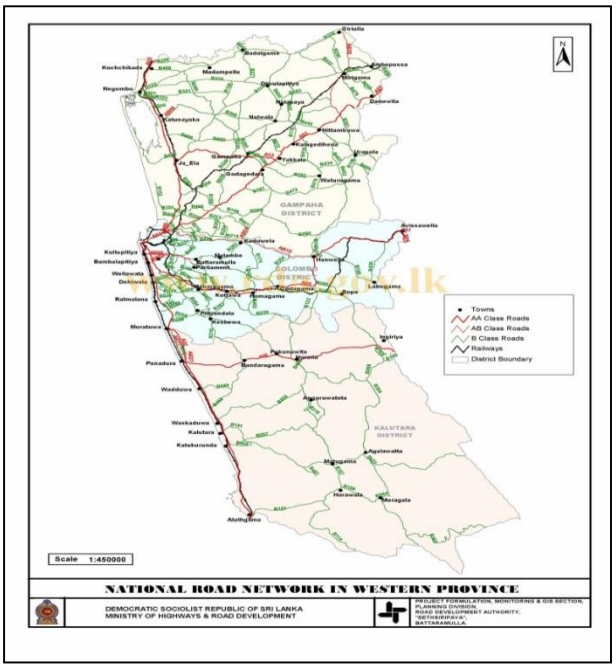

Figure 1. Map Indicating Selected Bus Route

3 RESULTS & DISCUSSION

Average exposure levels of particulate (SPM) levels inside the buses starting from Colombo to the destination in each road are presented in Fig.2. SPM levels inside the bus traveling in Colombo - Horana, Colombo - Gampaha and Colombo - Nittambuwa routes were higher than that of the 1 hour SPM concentration (500 µg/m^3) stipulated in Ambient Air Quality Regulations, 1994. The highest SPM concentration was recorded in the Colombo – Gampaha route and the second highest is for Clolombo – Nittambuwa route where part of both routes represent the AA001 road which passes through several suburban centres having heavy traffic. Lowest SPM levels were recorded in Colombo - Awissawella (AA003) road which passes suburban areas up to Homagama with traffic and then goes through relatively rural areas where low traffic conditions prevail. Similar exposure pattern can be observed in NO_2 and SO_2 concentrations as presented in fig. 3 & 4 respectively. However, the NO_2 levels do not exceed the national standard values for 1 hour average whereas SO_2 levels at all routes exceeded 1 hour national standard value for SO_2.

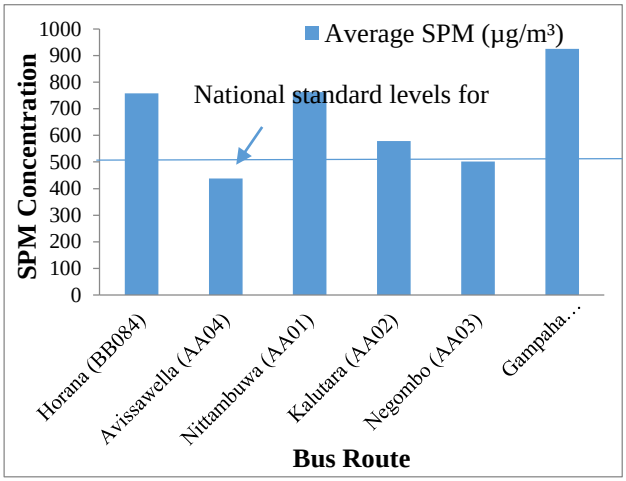

Figure 2. Average SPM concentration in each route

When comparing the morning and evening results, exposure levels of SO2 show lower values during evening time when compared to that of morning time. Whereas, no significant difference between the morning and evening levels of NO2.

Average exposure levels of NO2 and SO2 inside the buses start from each suburban to Colombo (return way) traveling in each road are presented in Fig. 5 & 6 respectively.

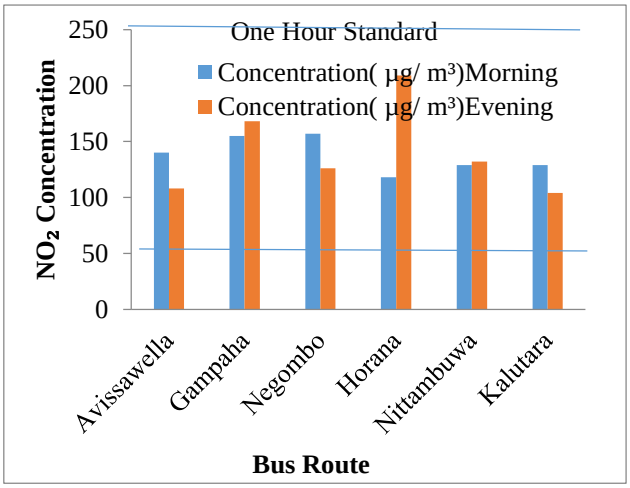

Figure 3. Average one way NO_2 concentration in each route (Started from Colombo to each city)

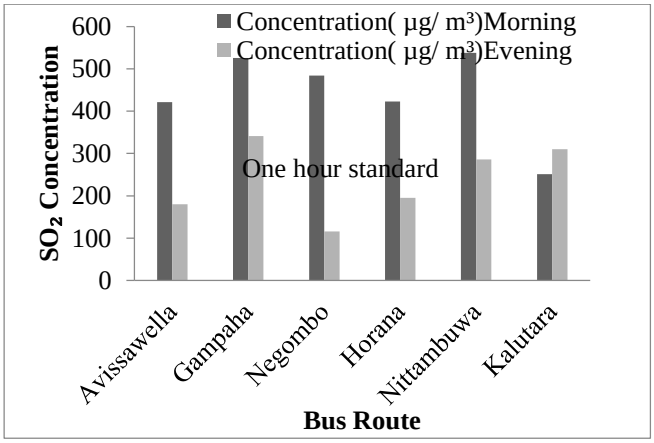

Figure 4. Average one way SO_2 concentration in each route (Started from Colombo to each city)

The results indicate that NO2 levels inside the buses when reaching to Colombo from suburban areas (return way) were higher than that of travel from the Colombo to suburbs. However, no significant change in SO2 exposure levels when traveling both sides. The results also show that the exposure levels are highly dependent on traffic conditions in the routes, and levels in some roads were high in morning than the evening (Avissawella – Colombo & Negambo - Colombo) and vice versa in other roads.

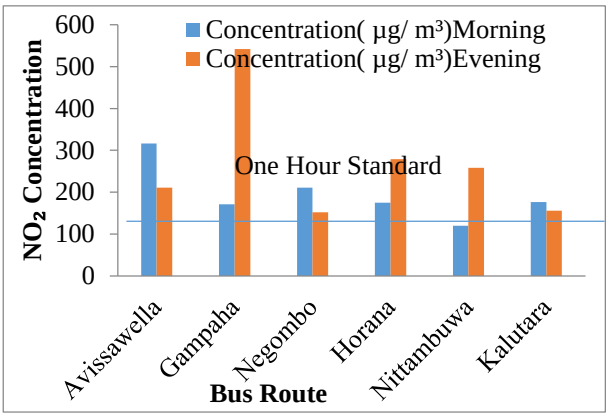

Figure 5. Average one way NO_2 concentration in each route (Started from each city to Colombo)

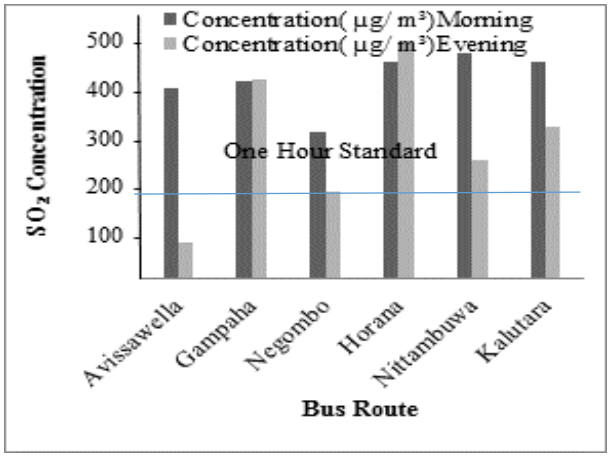

Figure 6. Average one way SO_2 concentration in each route (Started from each city to Colombo)

The high level of SO_2 recorded in both ways could be due to the air emiission contribution by same bus since they use auto diesal which contain some sulfure (S).

The data presented in Fig.7 represent the comparision of SPM data with the traffic data in each routee. The results indicates that the exposure level are higher where the number of vehicles in the road is high except in one case on Colombo-Horana road.

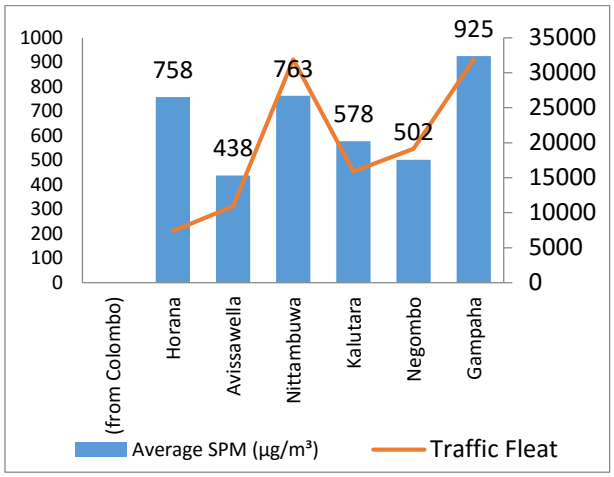

Figure 7. Average SPM levels and traffic counts in each route

4 CONCLUSIONS

Study indicates that exposure levels of NO_2 and SO_2 by travelling to one direction are in the range of 96-550 µg/m^3 and 30-700 µg/m^3 respectively. SPM exposure levels are in the range of 400-850 µg/m³. SPM and SO_2 exposure levels were noticeably higher than that of the concentrations in ambient air in the study area. The bus route from Colombo to Gampaha was observed as the highest polluted route compared to other routes where the highest concentrations (SD) of SO_2, NO_2 and SPM were 716 (119) µg/m^3, 542(40) µg/m^3 and 832(28) µg/m^3 respectively.

The results also shows that the exposure levels are highly dependent on traffic conditions and therefore traveling time in the routes and levels in some roads were high in morning than the evening and vice versa in other roads.

This emphasizes that the variability between buses were relatively high and therefore with the small number of buses studied, the findings of this research should not be viewed as inherently typical for all types of public & private buses travel along the concerned routes under all conditions. However, considering the findings of the study it could be recommended to minimize the the travel duration and unneccesory idling times with good traffic management and use of high quality public transport system to reduce passenger exposure to air pollutants since exposure to high pollutant levels could lead to decrease in the working capacity, intelligence and cause health problems etc.

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