# Interventions to urban air pollution management and their impact on ambient air quality in Sri Lanka

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**ABSTRACT**: Urban air quality is deteriorated due to many reasons such as increase of vehicles emissions, industries, domestic and commercial activities with the urbanization. Colombo the commercial capital of Sri Lanka, is one of the cities with deteriorated air quality. Many researches have been conducted and found that pollution levels have rapidly increased during last few decades. Researchers, professionals, organisations and the government of Sri Lanka have opened their eyes to find solutions to this burning issue. In this regard, an action plan "Clean Air 2000 Action Plan" for the management of air quality was developed in 1992 by covering most of the sectors that are responsible for air pollution problems and this plan proposed time targeted actions to solve the problem. Most of actions identified were not implemented in the due time and therefore, Colombo air pollution problem came to a peak level in year 2000. Their after several strategic interventions were taken from time to time and only few studies have been done to evaluate the impact of these interventions. This paper presents the air quality impacts due to the interventions taken to control air pollution problem in Colombo. Air quality monitoring data at Fort, Colombo indicates that the implemented actions have positively affected to decrease the air pollutant level in Colombo. The Sulphur dioxide ($SO_2$) levels in Colombo urban area has decreased by 7% in 2001 to 2002 and 15% in 2003 to 2004 with the reduction of Sulphur level in diesel fuel. $SO_2$ and PM levels decreased by about 10 – 20% with the introduction of vehicular emission testing (VET) programme and significant decrease was observed by about 30-40% in Colombo 2009 to 2012 due to the improvement of road surfaces, removal of road obstructions and VET actions. Present data indicates that introduction of hybrid vehicles has reduced $NO_2$ level in ambient air. Therefore, with these interventions, ambient air quality levels in Colombo have improved up to a notable level. However, there will be tendency to increase air pollutant levels with the increasing of the vehicular population.

## 1 INTRODUCTION

Good air quality is essential for human health and the health of the environment as a whole. Polluted air can seriously affect the quality of life, can damage historic buildings, and kill sensitive plant life and in the long term it would adversely affect natural quality of the ambient air. Air quality can be deteriorated due to air emissions by anthropogenic activities as well as by natural phenomena. In urban areas, the air quality is deteriorated due to the anthropogenic activities such as fossil fuel combustion for transportation, power generation and industrial activities, fugitive emissions and solid waste burning etc. the factors associated with urbanisation.

As a result of rapid urbanization and infrastructure development in Sri Lanka, most urban cities are becoming victims of deteriorated ambient Air Quality. Colombo the commercial capital of Sri Lanka is one of the cities with deteriorated air quality. Several research studies have been conducted and found that pollution levels in Colombo air have rapidly increased during last few decades with the increase of vehicle density, industries, domestic and commercial activities around the city. It was identified that energy consumption for mobile sources and stationary sources are the two major sources that contribute to air pollution in Colombo and the mobile source emissions has a higher contribution.

Recognizing the growing problem of air pollution in the Colombo environmental area, researchers, pro-

fessionals, government of Sri Lanka and relevant institutions have open their eyes to find solutions to this burning issue. In 1992, a strategic action plan "Clean air 2000" was developed by National Environmental Steering Committee (NESC) though the Metropolitan Improvement Programme (MEIP) in consultation with Ministries and Agencies whose activities influence the air quality (Clean Air Action Plan, 1992).

The "Clean Air 2000" is the 1st attempt taken to control urban air pollution in Sri Lanka and it recommend 47 actions under seven categories of Vehicle Inspection and Maintenance, Fuel Reformulation, Pricing and Fleet Mix, Emission Inventory and Monitoring, Standards Setting, Institutional Framework and Regulatory Compliance, Economic Instruments and Transportation Planning and Traffic Management. However, only very few minor actions identified by the Action Plan were implemented and most of the actions were not implemented in the due time. As a result, Colombo air pollution problem came to a peak level in year 2000 by exceeding 1 hour average $SO_2$ standard levels at Colombo for several hours per day.

In 2000, the "Clean Air 2000" Action Plan was reviewed and an action plan "Clean Air 2007" and then "Clean air 2012" in 2007 were developed by identifying critical issues and recommendations to manage air quality problems in Sri Lanka (Clean Air Action Plan, 2012).

Since the major source of air pollution is vehicular emissions, most of the actions recommended in above action plans were related to fuel quality improvement and vehicular emission control. Reduction of sulphur content in diesel and introduction of unleaded petrol are the actions taken for fuel quality improvement. Vehicular emission testing program along with the inspection and maintenance, introduction of one-way transport systems, development of road surface and removing road obstructions etc. are the other implemented actions for the control of vehicular emissions. Introduction of cleaner fuel vehicles such as motivations to use 4-stork three wheelers by banding of importation of 2-stork three wheelers, promoting hybrid and electric vehicles to the fleet etc. were also the results of above action plans.

Though, these interventions taken time to time under above action plans to improve urban air quality, only few studies has been done to evaluate the effect of those interventions on urban air quality. The NBRO is one such organisation monitoring ambient air quality since 1997 up to date. The aim of this paper is therefore to present the air quality improvements due to the interventions taken to control urban air pollution problem in Colombo by studying diurnal variations of $SO_2$ and $NO_2$ levels in Colombo urban area.

## 2 METHODOLOGY

Available continuous air quality data on Nitrogen Dioxide ($NO_2$), Sulfur Dioxide ($SO_2$) and Particulate Matter (PM10) at Colombo Fort air quality measuring site was collected for a period of 1997 to 2014. The lead levels of the study conducted by NBRO before and after the phasing-out of lead in gasoline were taken for the evaluation of impact of the introduction of unleaded petrol in Sri Lanka.
Active and passive sampling data of $NO_2$ and $SO_2$ in the data base of National Building Research Organisation (NBRO) and Particulate data collected by Central Environmental Authority (CEA) were used. The data were analyzed to get the annual average pollutant concentration. However, data for several years could not be found due to the discontinuation of the mentoring programs. The annual average variation of each pollutant was studied in the consecutive years of each action implemented for the control of air pollution in Sri Lanka to identify the impact of the actions on the ambient air quality.

**WHO Annual Guideline value for NO2**

**WHO Annual Guideline value for SO2**

## 3 RESULTS AND DISCUSSION

One of the actions identified in the fuel quality improvement is phase-out of Lead in petrol. It was implemented in 2002 by introducing unleaded gasoline by replacing lead component in gasoline by organic additives. Accordingly, the lead in atmospheric particulate was drastically reduced after the introduction of unleaded gasoline as shown in figure 1 (Samarakkodi et al, 2003). With this improvement, the lead levels in atmosphere has fallen down to undetectable level and hence the national standard levels stipulated for Lead in ambient air (National air quality regulations 1994) was removed from the amendment made to the national air quality standards in 2008.

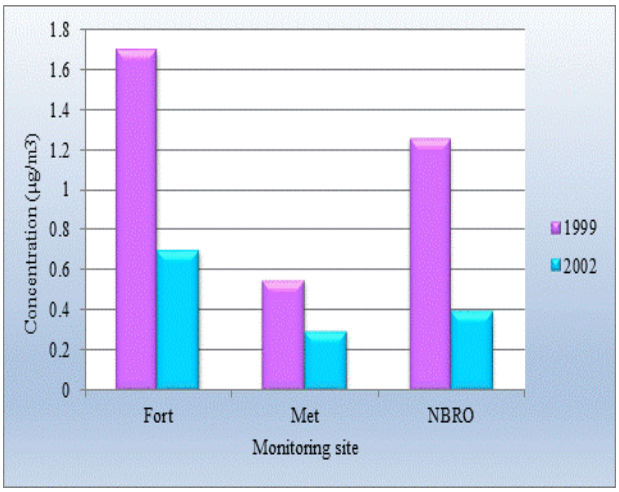



Figure 1. Particulate Lead Levels in ambient air (Source; NBRO database)

Annual average $SO_2$ levels in Colombo Fort air quality monitoring site from 1997 to 2014 are presented in figure 2 (Premasiri et al, 2009).

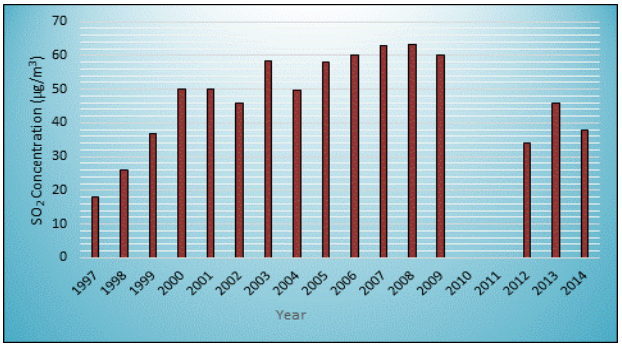
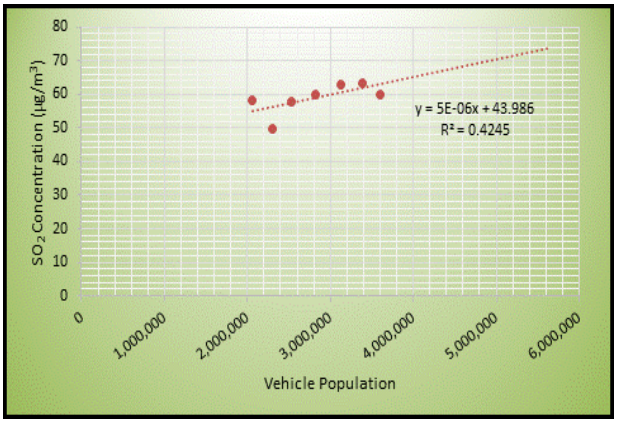



Figure 2. Variation of Annual Average Levels $SO_2$ at Colombo City (Source; NBRO database)

The results indicate that the $SO_2$ levels increased gradually from 1997 to 2008 with some reduction in certain years compared to the previous year. Then the levels drastically reduced from 2008 to 2012 by about 50%. The $SO_2$ levels are positively correlated




to vehicular population in Sri Lanka with correlation coefficient 0.65 from 1997 to 2009 as shown in figure 3.

Figure 3. Scatter Plot of annual $SO_2$ Concentrations Vs Vehicular Population in Sri Lanka from 1997 to 2009 (Source; NBRO & RMV database)

When analyzing these changes in sulfur dioxide levels in atmosphere with the action implemented to improve the fuel quality in Sri Lanka, it was revealed that reduction of $SO_2$ levels from 2001 to 2002 and from 2003 to 2004 were due to the reduction of sulfur content in diesel from 8000 ppm to 5000 ppm in 2001 and then from 5000ppm to 3000 ppm in 2003 as shown in the figure 4 (Rodrigo, 2015).

The significant deduction of 40% ambient $SO_2$ was observed from 2009 to 2012 could be due to the strategic actions taken for air pollution control along with the urban development activities. The vehicular emission testing program implemented within the Western Province in 2008 with stringent standards, improvement of road surface and removal of road obstructions in Colombo and introduction of one-way traffic management are some of the actions implemented within the Colombo city. The ambient $SO_2$ measurement results clearly revels that the above implemented activities have positively affected to reduce ambient $SO_2$ levels by 40% in Colombo atmosphere.

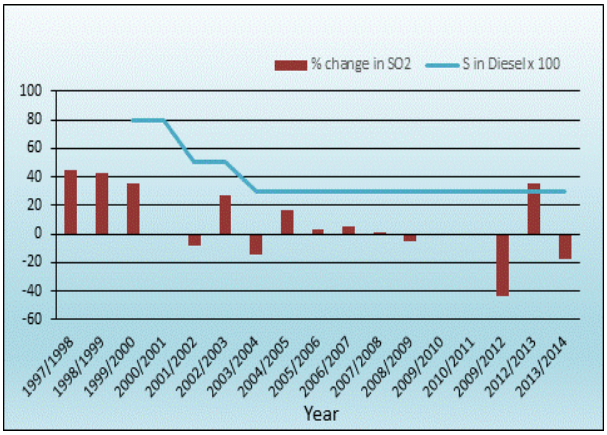



Figure 4. Reduction of maximum Sulfur content in diesel fuel in Sri Lanka and % reduction of annual average $SO_2$ in atmosphere (Source; NBRO & RMV database)

Annual average $NO_2$ levels in Colombo Fort air quality monitoring site from 1997 to 2014 are presented in figure 5.

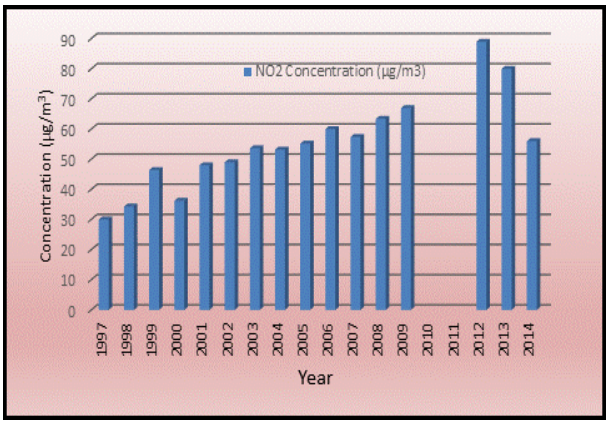



Figure 5. Variation of Annual Average Levels $NO_2$ at Colombo City from 1997 to 2014 (Source; NBRO database)

The results indicate that the $NO_2$ levels have increased gradually from 1997 to 2012 and exceeded the WHO annual guideline value in 1999 onwards. The $NO_2$ levels positively correlated to vehicular population with 0.98 correlation coefficient as shown in figure 6. This clearly indicates that, the implemented actions to improve fuel quality has no significant impact on ambient $NO_2$ levels.

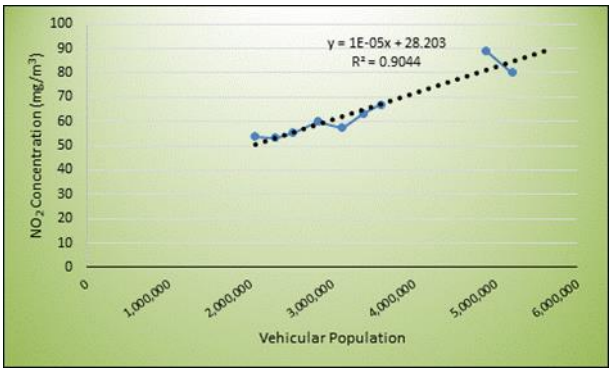



Figure 6. Scatter Plot of annual $NO_2$ Concentrations Vs Vehicular Population in Sri Lanka (Source; NBRO & RMV database)

However, the $NO_2$ levels have slightly reduced by 3 % from 2012 to 2013 and significantly changed by 40% from 2013 to 2014. This change from 2012 to 2014 would be due to the introduction of cleaner fuel vehicles such as hybrid and electrical vehicles as shown in figure 7 to the fleet especially in Colombo area while replacing used vehicles. In addition, improvement of road surface and removal of road obstructions could also be positively contributed to this change in $NO_2$ levels.

The ambient particulate matter (PM10) levels at Colombo Fort air quality Sampling Site is presented in figure 8 (Samaraweera, 2011). The results indicate PM10 levels higher than 70 µg/m$^3$ from 1998 to 2008, and the levels reduced to 60 µg/m$^3$ level from 2008 onwards. This changes of PM10 levels would be due to the implementation of vehicular emission testing program, improvement of road surface and remove of road obstruction etc.

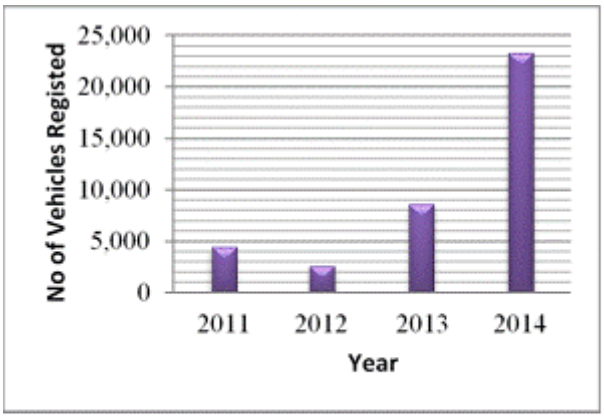



Figure 7. Registrations of Hybrid vehicles during 2011-2014 (Source; RMV database)

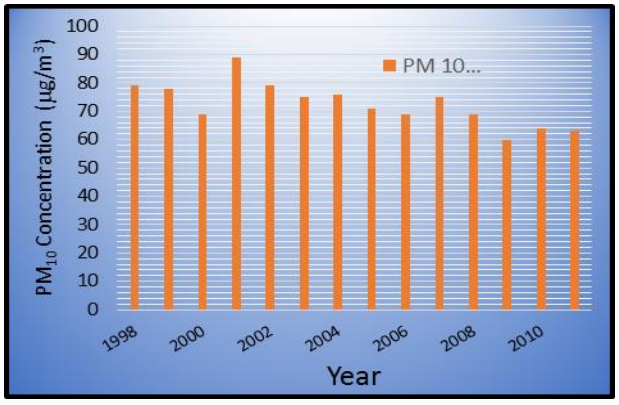



Figure 8. Particulate Matter (PM10) levels in Colombo atmosphere (Source; Central Environmental Authority)

## 4 CONCLUSION

Interventions to fuel quality improvements by reducing sulfur content in diesel and vehicular emission testing show improvement in air quality with respect to $SO_2$ whereas no significant improvement with respect to $NO_2$ levels.

Interventions such as improvements of road surface and removal of road obstructions, introduction of effective one-way transport system etc have reduced all type of pollutants related to vehicular emissions.

Introduction and promotion of cleaner fuel vehicles have effectively reduced the air pollutants in urban areas.

Establishment of continuous air quality monitoring data base along with other databases are very important in trend analysis and to evaluate the effectiveness of actions implemented as well as to develop new actions plans in urban air quality management.

## 4 REFFERENCES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