IDENTIFICATION OF CRITICAL AND SINKING AREAS IN COLOMBO BY MEANS OF SPATIAL AIR QUALITY MONITORING

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Abstract

More and improved geographic coverage of air quality data is needed to facilitate better management of air quality. However, there can be serious local technical and other problems in obtaining and ensuring reliable data. These include training and service, power supply variability, lack of foreign exchange for equipment, consumable and replacement parts for essential equipment etc. In these circumstances, state-of-the-art automatic equipment may not be the best means of obtaining reliable monitoring data in the long term. Therefore, it is recognized that the choice of air quality monitoring methodologies needs to suit local circumstances. In recent years, relatively simple and inexpensive passive methods were developed by NBRO as an alternative to the more demanding automatic monitoring systems to develop air quality monitoring networks.

Results of 15-location passive air quality network in Colombo are discussed in this paper, and it shows that the temporal variation of weekly and monthly exposure levels of NO_2 is related to seasonal climatic conditions. However, the maximum is recorded in Northeast monsoon and minimum is at South-West monsoon. Change of air quality levels at Boralla Police Station and Thilakarathanaramaya, Boralla, which are right opposite to each other, clearly shows the climate effect. Spatial variation shows that during most time of the year, the maximum levels were recorded at Maradana Junction, a high traffic congested area. Relatively low values were recorded at Gangaramaya, Nawam Mawatha, which is close to water body and can be considered as a sinking area. Levels of air pollution were found to decrease when going away from urban areas especially at high-elevated areas.

INTRODUCTION

Gaseous and particulate emitted to the atmosphere from activities such as industrial, anthropogenic combustions etc. would change the quality of air causing air pollution. It has been a problem for a long time in many cities in the world and measures are now being taken to ameliorate a serious situation.

Colombo, the commercial capital of Sri Lanka is the most vulnerable city in Sri Lanka to air pollution, due to many reasons such as rapid growth of cities together with associated industries, transport system, power generation, domestic emissions etc. It was estimated that more than 45% of the vehicles and 80% of industries in Sri Lanka are accumulated in the area of Colombo, which is about 1 % of the total land in Sri Lanka. This may leads to make the demands the authorities to be increasingly concerned with these emissions, particularly the emission of SO_2 and NO_2.

Tendency is that the air pollution in Colombo would rise substantially as shown in Figure 01, unless some actions are taken to prevent or control it.

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However, these levels of SO_2 and NO_2 given in Figure 01, represent only the air quality levels at Colombo Fort. Situation in other urban areas in Colombo and suburban areas could be different since the emissions depend on the land use activities and terrain type. Therefore, it is very important to ascertain the air quality in such areas with a high spatial resolution to identify the critical and sinking areas in the city to develop proper planning and management strategies to control air pollution. It is an opportunity to Sri Lanka to avoid many of these problems seen in other countries through developing high-resolution air quality monitoring network for Colombo.

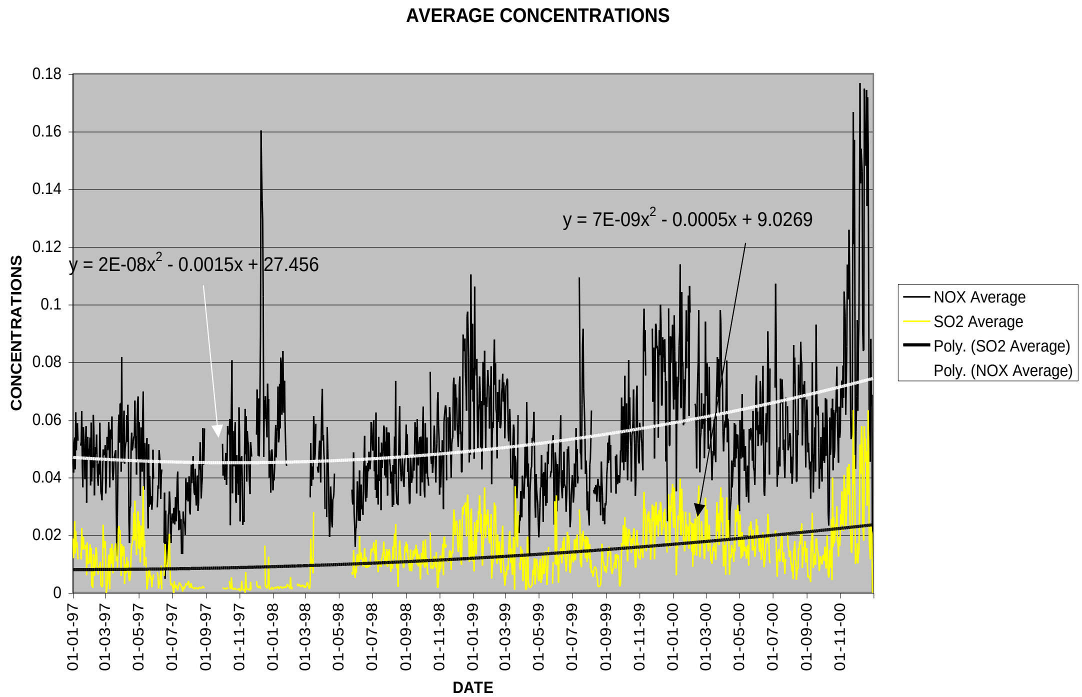


Figure 1. Change of 24-hour average concentration of NO2 and SO2 in Colombo Fort. (Source; NBRO air quality database)

Development of a monitoring network using high cost methodologies such as automated, active sampling etc. is not economically achievable in Sri Lanka. Therefore, low cost passive techniques are useful technique to achieve these targets along with the existing automated monitoring system. This paper discusses the outcome of the results of air quality monitoring network developed by using passive sampling technique in and around the City of Colombo to analyse the severity of the problem and to identify the critical and sinking areas.

METHODOLOGY.

Air quality monitoring network was developed with 15 locations to represent different environmental conditions and land use in and around the City of Colombo. The monitoring locations and their descriptions are given in table 01.

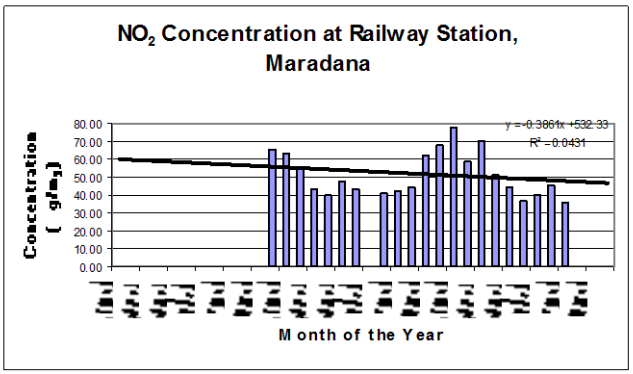
Table 01. Description of air quality monitoring locations.

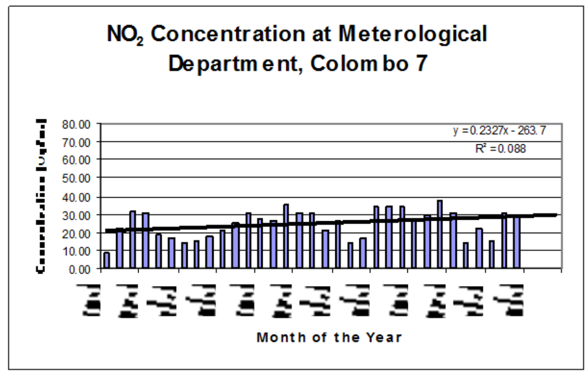
Location	Topography	Description
1. Premises of Central Environmental Authority, Battaramulla	Flat terrain, surrounded by marshy lands, neighboring a road	Background Station; vehicular emissions, domestic and open burning are the main sources of the area
2. "Ahinsakaramaya" Battaramulla	Flat terran, surrounded by water body	Neighborhood site; vehicular emission, construction activities, are main contributors to area pollution
3. Purana Viharaya, Pitakotte	25- 30m high elevated.	Neighborhood site; vehicular and domestic emission are the main sources.
4. Bandujeewa Ground, Kirulapona - (1)	About 50- 60 m elevated site	Background site; vehicles and domestic emissions, open burning, are mainly contributed
5. Child Welfare Center, Robert Gunawardana Mawatha Kirulapona -(2)	Flat terrain	Neighborhood site: domestic, open burning and wastes burning are the sources mainly contribute
6. Henry Pedris Ground, Thibirigasyaya	Flat terrain	Site representing mainly vehicular emissions from High Level road & Galle road, domestic emissions also contribute.
7. Meteorological Dept., Colombo 7	Flat terrain	Background site; represents vehicular emission, domestic power generation, green ground effect
8. Colombo Municipal Council, Town Hall	Flat terrain	Neighborhood site; represents emissions from vehicles, domestic & commercial power generation, green ground effect
9. Simamalakaya Gangaramaya temple	Surrounded by lake	Neighborhood site, represent vehicle emissions, domestic & commercial emissions and water body effect
10. Railway Station, Fort	Flat terrain	Reference point; road network, harbor activities, thermal power generation, domestic and commercial power generation, sea breeze, locomotive emission etc as a main emission contributing sources in the area
11. Railway Station, Maradana	Flat terrain	Reference site, locomotive emissions, small-scale industrial emissions, domestic & domestic power generations emissions
12. Jethawanaramaya, Colombo 1	Flat terrain	Reference site, industrial emissions, domestic, commercial & vehicular emissions, represents as main sources
13. Eli House, Mattakkuliya	High elevation	Highest elevated site in the area, domestic emissions, harbor activities, sea breeze, and vehicles can consider as main contribution.
14. Vidyalankara Pirivena, Peliyagoda	Flat terrain	Reference site which represents main road, green land, railway tracks, industries, residences, commercial premises and temple as different land use
15. Police Station, Borella	Located at southwest direction to the Borella Junction	Reference site, vehicles, industrial and commercial emissions are the main contribution
16. Tilakarathnaramaya temple, Borella	Located at Northeast direction to the Borella Junction	Reference site, vehicles, industrial and commercial emissions are the main contribution.

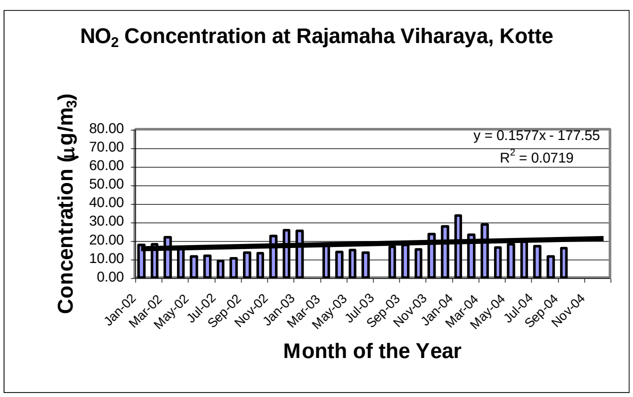
Passive samplers were installed at a height of about 3 m from the ground level to monitor exposure levels of NO_2 at all locations and sampling were collected weekly and monthly basis. The samples were analysed by wet chemical and colorimetric methods.

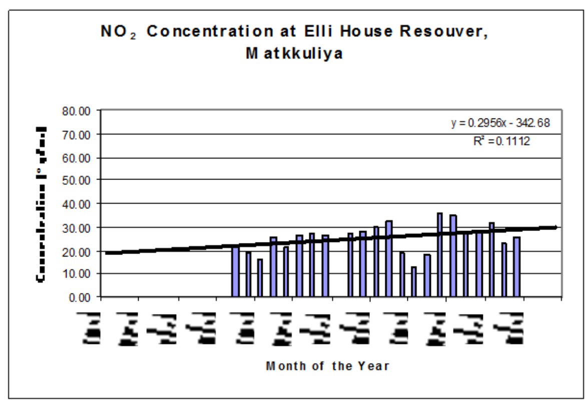
RESULTS & DISCUSSIONS

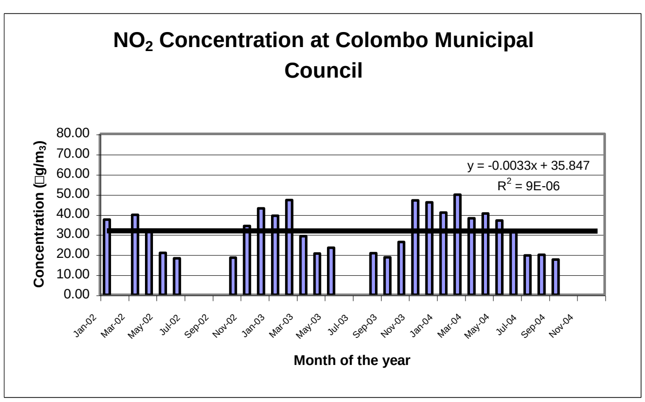
Monthly average levels of NO_2 shows that the levels are subjected to the seasonal wind pattern of the areas as shown in Fig. 2. The maximum levels were recorded during the North East monsoon and the minimum was recorded during South-west monsoon. However, the maximum monthly average at each location was recorded in different months, which reveals that not only the seasonal monsoon wind direction but also the local wind direction and terrain pattern would affect on the air quality levels in each location.

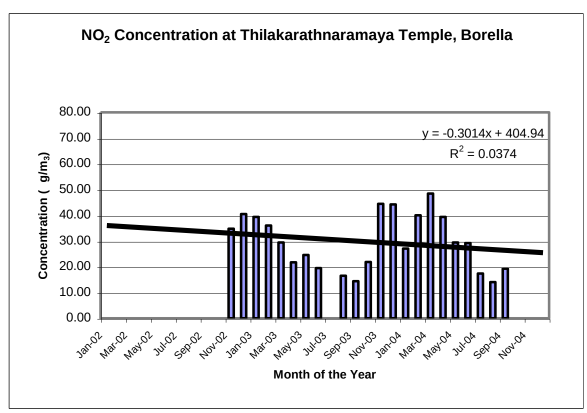


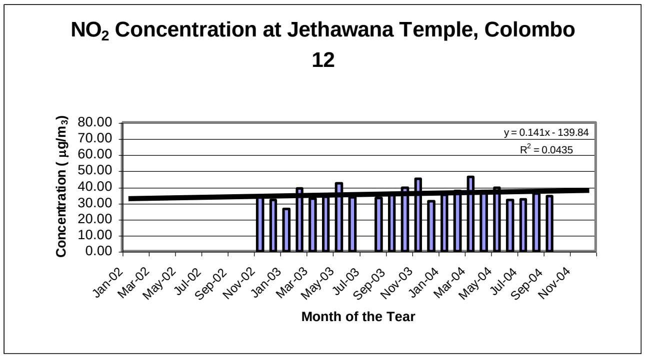


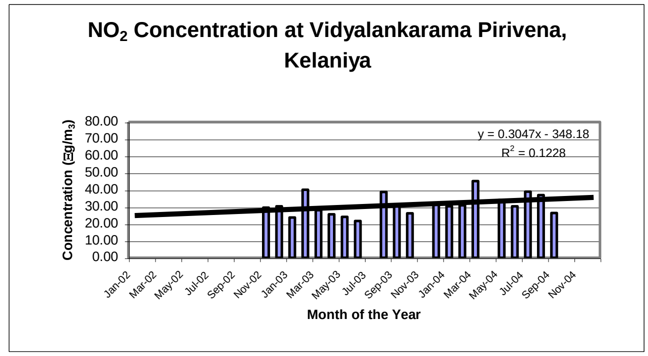


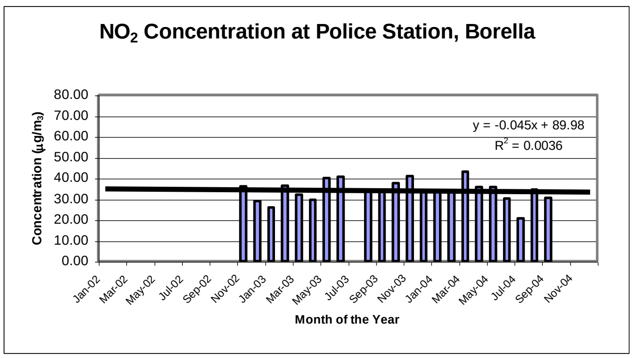


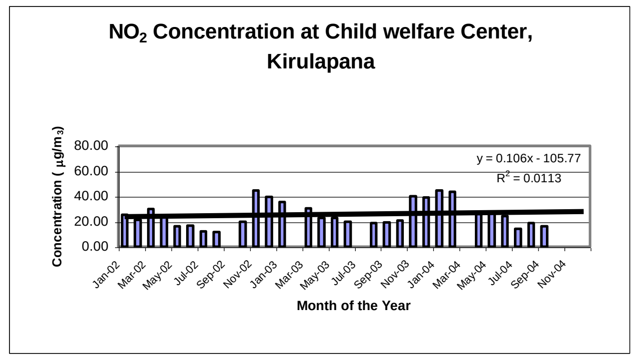


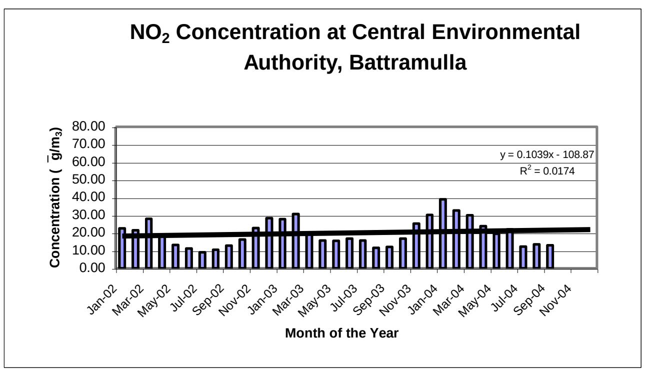


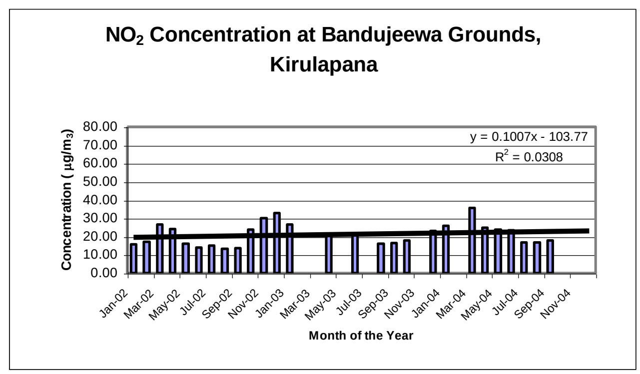

NO2 Concentration at Jethawana Temple, Colombo 12
y = 0.141x - 139.84
R2 = 0.0435
Concentration (µg/m3)
Month of the Year

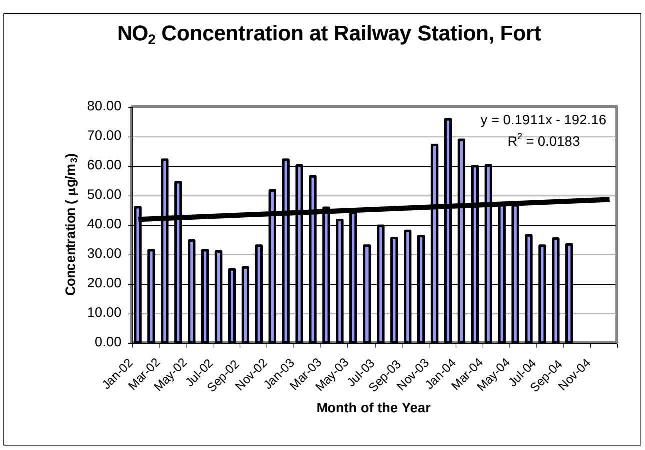

NO2 Concentration at Vidyalankarama Pirivena, Kelaniya
y = 0.3047x - 348.18
R2 = 0.1228
Concentration (µg/m3)
Month of the Year

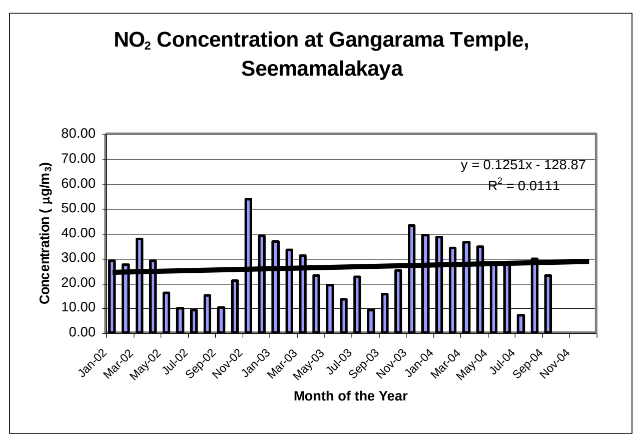

NO2 Concentration at Police Station, Borella
y = -0.045x + 89.98
R2 = 0.0036
Concentration (µg/m3)
Month of the Year

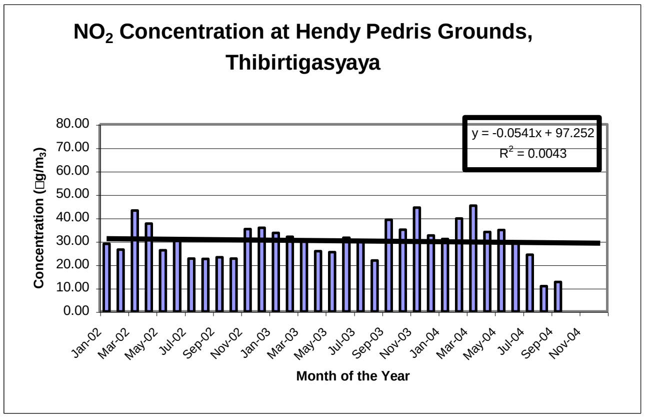

NO2 Concentration at Child welfare Center, Kirulapana
y = 0.106x - 105.77
R2 = 0.0113
Concentration (µg/m3)
Month of the Year


NO2 Concentration at Central Environmental Authority, Battramulla
y = 0.1039x - 108.87
R2 = 0.0174
Concentration (g/m3)
Month of the Year


NO2 Concentration at Bandujeewa Grounds, Kirulapana
y = 0.1007x - 103.77
R2 = 0.0308
Concentration (µg/m3)
Month of the Year

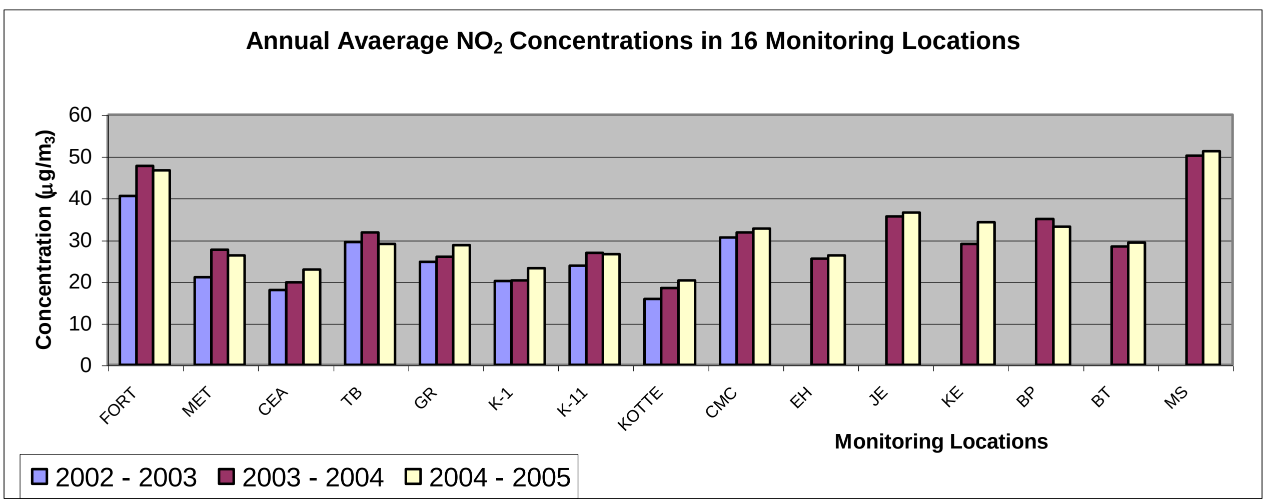

NO2 Concentration at Railway Station, Fort
y = 0.1911x - 192.16
R2 = 0.0183
Concentration (µg/m3)
Month of the Year


NO2 Concentration at Gangarama Temple, Seemamalakaya
y = 0.1251x - 128.87
R2 = 0.0111
Concentration (µg/m3)
Month of the Year



At the locations of Gangaramaya, Thibirigasyaya, Kirulapona – II and Jethawanaramaya-Colombo 12, the maximum values were recorded in November. However, at Colombo Fort, Maradana and Thilakarathanaramaya-Boralla, it was recorded in December. Maximum levels at CEA-Battaramulla and Raja Maha Viharaya-Kotte were recoded in during January. But at all other locations, the maximum was recorded in during March. These results were confirmed by the weekly concentration of NO_2 in each location.

The air quality trends indicate that the trends differ from location to location. The air quality levels at Colombo-Fort, Elihouse, Kotte, MET-Colombo 07, indicated an increasing trend, whereasother locations indicated a decreasing trend. The annual averages of NO_2 at Maradana and Fort are nearing the ceiling given by the WHO annual guideline value 40 – 50 $\mu g/m^3$. Among the rest, some locations already were exceeding 30 $\mu g/m^3$.



In addition, though values are somewhat close, Maradana shows a higher pollution levels than Fort in most of months in the year. This is mainly due to the railway emissions since the sampling site at Maradana is close to the railway track and directly exposed to engine emissions. However, both Maradana and Fort recorded values as much as 150% higher than other locations. This may be due to the contribution from on road vehicle emissions along with the railway emissions. Therefore, these two areas can be considered as a critical area with respect to air pollution. Relatively lower values recorded at Gangaramaya reveals that water body act as an air pollution sink. Lower values recorded at KP1, EH and Kotte is the effect of elevation from other locations, which have high wind speed and dilution will dominate the air pollution in those areas.

CONCLUSIONS

- Maradana and Fort can be identified as critical areas in Colombo with respect to Air Pollution.
- Borella, Jetawanaramaya, and CMC area can be categorized as moderately polluted areas in Colombo.
- Water bodies such as Bera Lake can be considered as air pollution sink.
- Air pollution levels are lower at high-elevated areas due to dilution by wind.
- The exposure levels highly depend on the wind pattern and the terrain type of the area.

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ACKNOWLEDGEMENT:

National Research Council (NRC) and Sri Lanka Government are greatly acknowledged for the financial support given in this study.