USE OF PASSIVE AIR QUALITY MONITORING TECHNIQUES FOR REGIONAL AIR POLLUTION MONITORING : POTENTIAL AND LIMITATIONS

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INTRODUCTION

Out of all chemical oxides of nitrogen, nitrogen dioxide (NO_2) is the most important species with regard to human health. It is a strong oxidant with a reddish - brown colour and is very soluble in water at the atmospheric temperature.

Nitrogen Oxides in the atmosphere are formed naturally by the bacterial and volcanic actions, by lightning and by human activities. Major source of man - made emissions of nitrogen oxides into the atmosphere is considered to be the combustion of fossil fuels mainly for heating and power generation, industrial and transport sectors.

In most of the ambient situations, nitric oxide (NO) is emitted and then it is transformed into nitrogen dioxide in the atmosphere. Even at low concentrations of nitric oxide present in the atmosphere, oxidation takes place rapidly due to the atmospheric oxidants such as ozone. Non - combustion industrial processes such as the manufacture of nitric acid, the use of explosives and welding processes also contribute to the formation of atmospheric nitrogen dioxide.

Generally, annual mean nitrogen dioxide concentrations in urban areas throughout the world are in the range of 20 - 90 $\mu g/m^3$ (0.01 - 0.05 ppm). Urban outdoor levels of nitrogen dioxide vary according to the time of day and the season of the year depending mainly on meteorological factors. Indoor sources such as cooking, cigarette smoking and lighting may also be contribute to high exposure levels. For example, the tobacco smoke from one cigarette may contribute to a nitric oxide concentration of 150000 - 226000 $\mu g/m^3$ (80 - 120 ppm) and smaller quantities of nitrogen dioxide.

The biochemical studies have shown that there are direct effects of expose on long and short-term exposure levels of nitrogen dioxide. There are numerous investigations of the effect of the nitrogen dioxide on the pulmonary function of humans under various conditions like normal, bronchitic and asthmatic. Studies with animals have clearly shown that the exposure to nitrogen dioxide concentrations around 1880 $\mu g/m^3$ (1 ppm) for several weeks to months causes both reversible and irreversible lung effects including structural changes in pulmonary regions. Even low nitrogen dioxide levels as 940 $\mu g/m^3$ (0.5 ppm) increases susceptibility to bacterial infection of the lung.

When Colombo City is considered, nitrogen dioxide is an important air pollutant resulted by the vehicular traffic, high degree of industrialization and power generation in the City and suburbs. Continuous monitoring data from 1997 to 2001 clearly shows the co-existence of other air pollutants like sulfur dioxide, nitric oxide, ozone, carbon monoxide and Suspended Particulate Matter along with the nitrogen dioxide (NO_2). Since the continuous monitoring data indicated very high level of air pollution during the period of NorthEast monsoon, this programme was initiated to capture the data of NO_2 at 10 locations in Colombo starting from 02-11-01. However, it was noted that the continuous monitoring stations had not functioned during the North-East monsoon period due to the power cut prevailed.

EXPERIMENTAL

Sample Preparation

A passive sampler, somewhat resemblaning to the famous "Ogawa" sampler was fabricated with Teflon. Stainless steel wire mesh and absorbing filter pads were thoroughly washed with ASTM type-1 deionized water and then with methanol and dried in an oven before use. Dried filter pads were coated with 50 μl of absorbing reagent containing NaI, NaOH and Ethylene glycol and dried it in a dessicator. Then the samplers were loaded with coated filter pads and sealed with endcaps before sending it to the sampling site.

Sampling

Sampling sites were selected to represent both areas with high degree of pollution and neighbourhood sites. Sampling sites are indicated in Table 01. Specially designed windshield was installed at each selected site and passive samplers were fixed to the windshield using holding clips. The sealed end caps were removed at the site before installing the sampler.

Table (01) Locations of passive nitrogen dioxide monitoring within Colombo City.

Site No.	Location	Installation Date	Monitoring Frequency	Type of Site
1	Fort Railway Station, Colombo 11	Nov.02,2001	Weekly & Monthly	Reference point; parally done with automated air quality monitoring/ maximum emission impact site
2	Meteorological Dept. Bauddhaloka Mw. Colombo 07	Nov.02,2001	Weekly & Monthly	Reference point; Neighborhood site
3	Ahinsakaramaya, Battaramulla.	Nov.02,2001	Weekly & Monthly	Neighborhood site
4	Central environmental Authority,104, Robert Gunawardene Mw Battaramulla..	Nov.02,2001	Weekly & Monthly	Neighborhood / Background site
Site No.	**Location**	**Installation Date**	**Monitoring Frequency**	**Type of Site**

5	Seemamalakaya, Gangarama Temple, Colombo 02.	Nov.02,2001	Weekly from Jan. 2002 & Monthly	Neighborhood site
6	Henry Pedris Stadium, Havelock Road, Colombo 05.	Nov.20,2001	Weekly & Monthly	Site representing road emissions from High Level Road & Galle road
7	Bandujeewa Grounds, Kirullapona, Colombo 05.	Nov.21,2001	Weekly & Monthly	Background site; about 50-60m elevated location.
8	Child Welfare Centre. Robert Gunawardene Mw. Kirullapona, Colombo 05.	Nov.20,2001	Monthly	Neighborhood site
9	Rajamaha Viharaya, Pitakotte, Kotte.	Nov.20,2001	Monthly	Background site
10	Colombo Municipal Council (CMC), Town Hall, Colombo 07.	Nov.21,2001	Weekly & Monthly	Neighborhood site; maximum population exposure site.

Analysis

After exposing samplers for a particular period, (one-week or one month) the samplers were sealed with endcaps and delivered to the laboratory. The trapped NO_2 were extracted into a 10 ml of colour developing reagent (Saltzmann reagent) containing Sulfanilamide,N-(1-Naphthyl)-ethylenediamine dihydrochloride and phosphoric acid and the colour intensity were measured using a UV - Visible spectrophotometer. The concentrations of NO_2 were then calculated against a calibration plot with known quantities of $NaNO_2$.
***** ASTM type-1 deionized distilled water was used throughout.

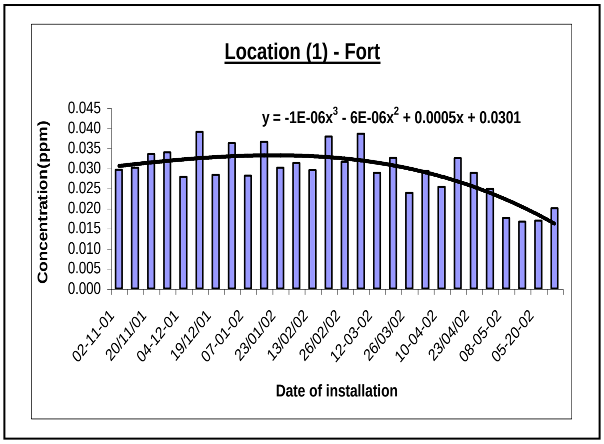
The data from reference sites was crosschecked with automated nitrogen dioxide analyzer (MonitorLab 9841 model) data obtained from Automated Air Quality Monitoring station, operated by the Central Environmental Authority of Sri Lanka.

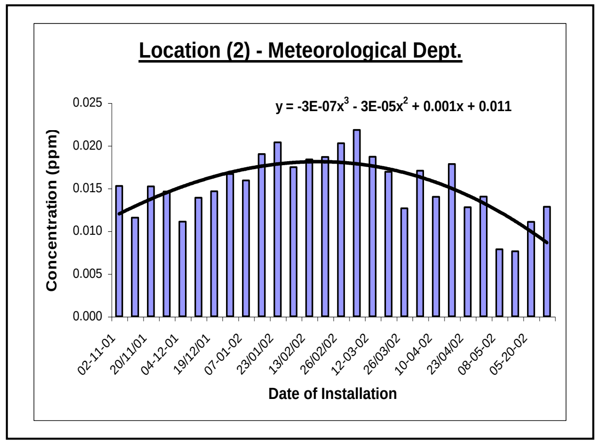
RESULTS AND DISCUSSION

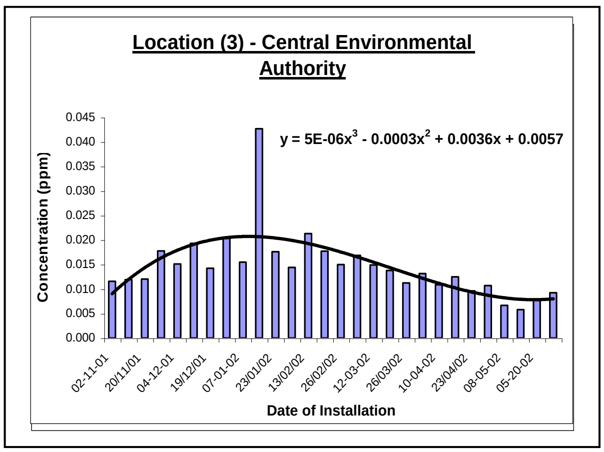
Weekly Passive Monitoring

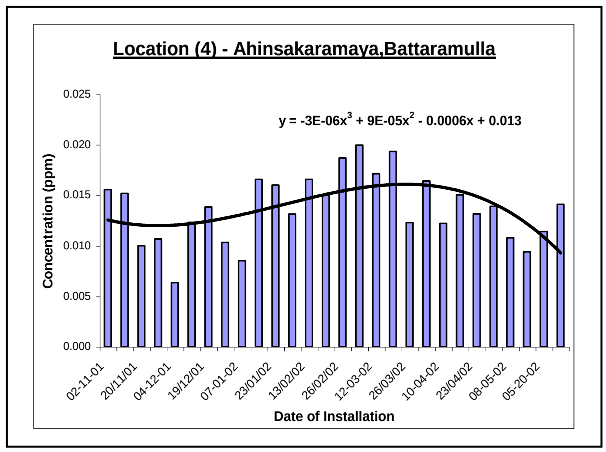
Weekly monitoring was done at 08 locations. The monitoring location at Seemamalakaya, Gangaramaya temple, Colombo was initially established as monthly monitoring site and subsequently changed to weekly monitoring site from 23rd January 2002. Averaged weekly nitrogen dioxide concentrations at each site are illustrated in figure (1).

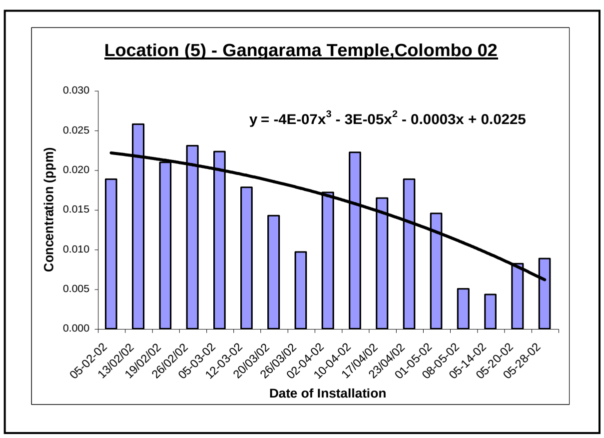
Figure (1). Weekly average nitrogen dioxide concentrations at each location

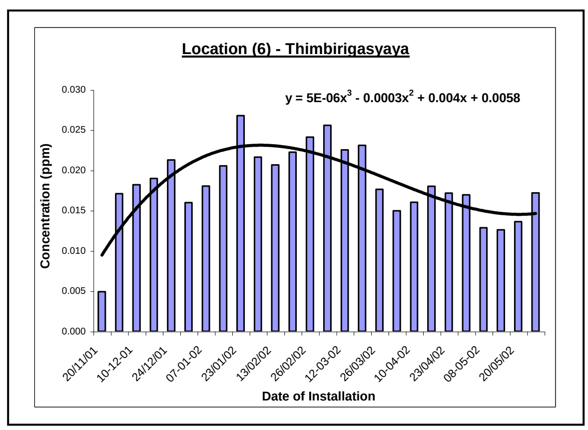


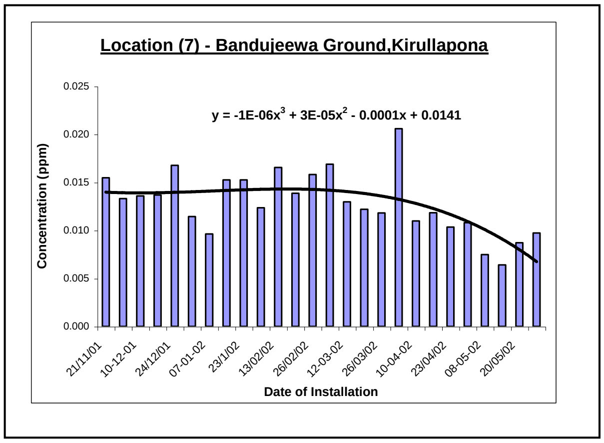


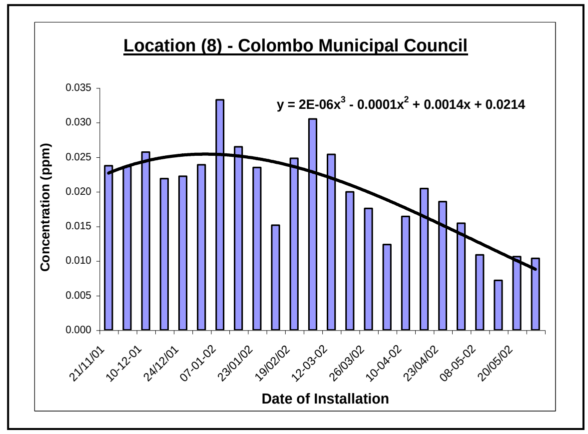












According to weekly passive sampling results, the results obtained at the beginning of this programme was very high in almost all the locations compared to the results obtained in May.

Except Ahinsakaramaya, which is North-East to the main Borella-Battaramulla road, others shows maximum exposure levels during the period starts from December to February, when the North-East monsoons prevailed.

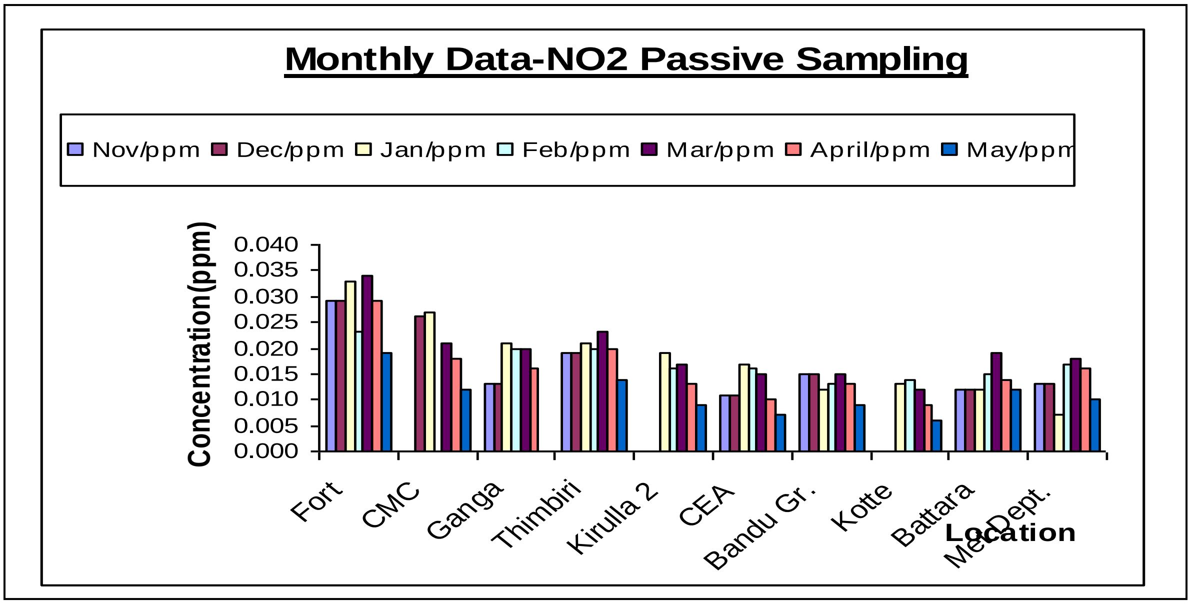
In January, most of the locations recorded the highest nitrogen dioxide concentrations with a maximum weekly nitrogen dioxide concentration of 0.039 ppm at Fort in December. After the mid March, a trend in decreasing nitrogen dioxide concentrations started at all locations except Battaramulla. The Fort, the center of the administration city, representing pollution from all transport sectors including land, sea and rail, the maximum levels of air pollution were reported, compared to other monitoring stations.

Monthly Passive Monitoring

Monthly exposure levels data and the average monthly data taken from weekly exposure levels at eight sites indicates the precision of the methodology (paired t- test, d.f. = 48, t = 0.995) further.

Monthly average nitrogen dioxide concentrations at all 10 locations (figure 2) also show that the maximum polluted location is the Fort Railway Station site with a maximum of 0.036 ppm in December, and then the pollution concentration of other sites decreases with distance. Locations of Colombo Municipal Council and Thimbirigasyaya, showed the same pattern as weekly concentrations. Monitoring sites at Kotte - Rajamaha Viharaya and Kirullapona - Child Welfare Center functioned as monthly exposure sites representing neighbourhood sites. Minimum monthly concentration recorded at Kotte with 0.006 ppm in May. Monthly data also shows a high level of air pollution in North-East monsoons in Colombo.

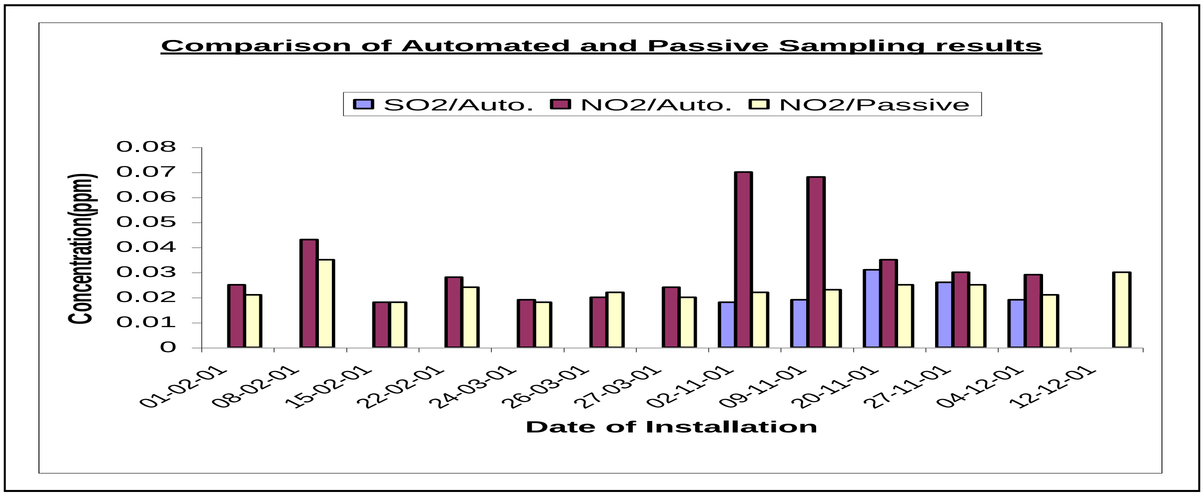
Figure (2) Monthly average nitrogen dioxide concentrations at each location



Reliability of Passive results with Automated method

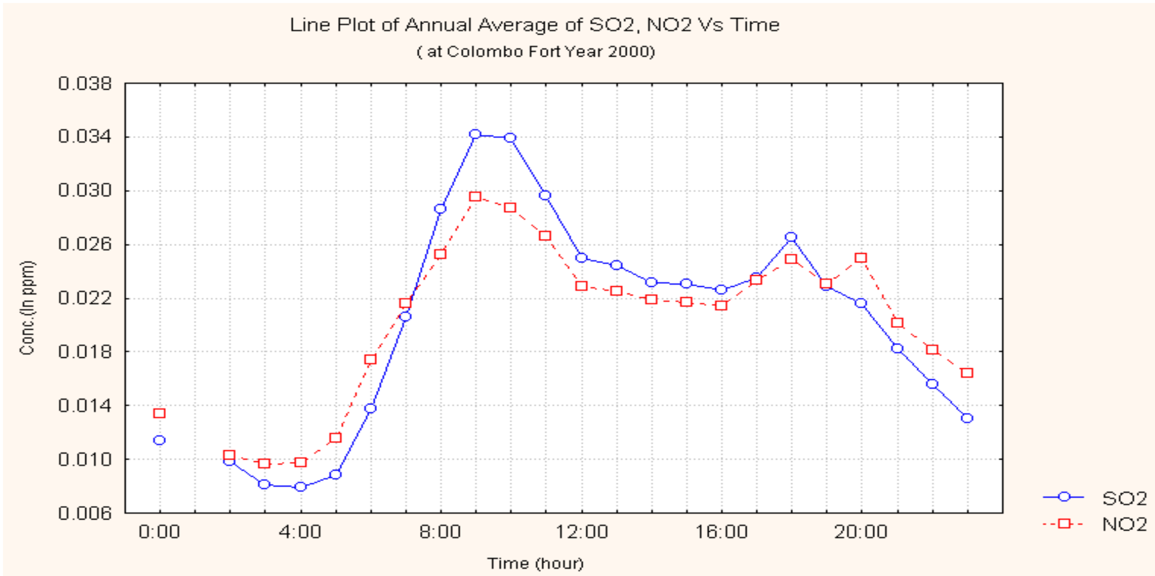
Passive sampling was carried out in parallel to automated nitrogen dioxide analyzer (Monitor Lab 9841 model) operated at Continuous Air Monitoring Automated Site at Fort Railway Station. However, limited data is available from automated systems from November 2001 due to the power cut prevailed during that period. The obtained data were compared with those of passive monitoring. (Figure 3)

Figure (3) Comparison of Automated and Passive monitoring results.



Note: Automated systems, owned by the Central Environmental Authority were operated by the Environmental Division of NBRO until March 2001 from the inception.

Figure 04. Diuranal variation of SO_2 & NO_2 at Fort automated monitoring station based on the annual average in year 2000.



source; NBRO Database

Figure 04 indicates that there is a direct relationship of ambient SO_2 and NO_2 at Fort may be due to the fact that the sources of emissions are mainly from burning of fossil fuels from various sectors. High levels of NO_2 from automated data set started from 2nd November 2001 and 9th November 2001 do not support this may be due to some technical problems of the automated monitoring unit. If we ignore those two sets of data, the both methods are found to be equally precise (paired t- test d.f.=7, t=0.995). This indicates the reliability of passive monitoring methods in continuous monitoring. It is very much relevant to run passive monitoring in parallel to automated monitoring systems to calibrate the total monitoring system and hence to optimize the reliability of the total outcome of the monitoring programmes.

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- Automated data from the Central Environmental Authority of Sri Lanka from November 2001.

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