ELIGIBILITY OF PASSIVE SAMPLING TECHNIQUES FOR RURAL AIR QUALITY MONITORING

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Abstract

Development of passive sampling techniques originated in the field of occupational exposure monitoring. It is possible to develop them further to monitor low levels of certain pollutants in ambient air. In rural areas where pollutant concentrations are relatively low, this inexpensive technique could be successfully deployed. Added advantages are that it does not require highly skilled personnel on site, and an electricity supply since air pollutants are collected on an absorbing material without using an air pump. These advantages render the passive technique to be more suitable for rural area monitoring than other conventional sampling techniques.

In this study, ambient air quality monitored at 20 locations in rural areas of Kitulagala, Puttalam and Thihagoda (Matara) using passive sampling technique, is discussed. Results show that, in case of SO_2 and NO_2, the two-week maximum exposure levels are less than 15 $\mu g/m^3$ and 10 $\mu g/m^3$ and minimum levels are 0.33 $\mu g/m^3$ and 0.92 $\mu g/m^3$ respectively. Average levels of SO_2 recorded at three locations are 5.45 $\mu g/m^3$, 6.82 $\mu g/m^3$ and 8.00 $\mu g/m^3$ respectively.

The maximum, minimum and average weekly exposure levels of SO_2 in Colombo in $\mu g/m^3$ were 77.88, 33.15, and 57.8, and of NO_2 were 72.64, 36.43 and 53.2 respectively. In some rural locations, levels of said pollutants are found to be lower than the minimum detection limit (0.001 ppm) of conventional automated air quality monitoring equipment. Therefore, passive technique is very useful in air quality monitoring in rural areas for screening and baseline studies, site selection and determining site representatives etc.

<u>INTRODUCTION</u>

The amount of pollution in the air in most of cities has been increasing because of the industrialization. In the recent times, the combination of the growth of cities, increase in population, use of vehicles and rapid industrialization, has led to health and environmental damage in several cities in Sri Lanka. Most of studies on air pollution monitoring and management were focused only at Colombo and a few other urban towns. These studies show that the air pollution is on an increasing trend, especially in Colombo. However, no of attempts have been made to monitor the air quality in the other areas, especially in the rural areas, due to the high cost involved in monitoring.

Being a developing country, Sri Lanka cannot afford high cost monitoring techniques for extensive air quality monitoring, especially in rural areas. Active and automated methods are expensive, they use electricity to run the air pump and the detectors in instrumentation and essentially need proper maintenance.

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Passive sampler and its suitability in rural monitoring

Passive sampler is a device that collects a target pollutant by absorption to a selected chemical substrate. After exposing for a suitable sampling period (preferably one week to one month, depending on the nature of the sampling area), the sampler is returned to the laboratory and the absorbed pollutants are quantitatively analyzed. These passive samplers are particularly useful in baseline surveys, area screening or inductive monitoring. The active and automated air quality monitoring methodologies are often unsuitable for rural air quality monitoring, since they need infrastructural facilities such as electricity and transportation. Mobilization cost of monitoring with these techniques is also high. The most important factor in deciding the monitoring methodology is pollutant concentration level. Air pollutant levels in rural areas are very low. Sometimes, these levels are below the minimum detection level of active or automated monitoring equipment.

There is no constraint as for the minimum detectable level in passive sampling, and all it requires is a sufficiently long exposure time, for the pollutant to be absorbed by the substrate to a measurable level. Exposure time may be as long as one to two weeks at least, depending on ambient pollutants levels. However, long time period required may be considered sometimes as a disadvantage in passive sampling techniques. Therefore, using passive sampling techniques which have several advantages such as low cost, easy handling / sampling, minimum use of external resources (power supply, labor etc) and unaffected by weather (heavy rainfall, wind) in place of conventional active or automated monitoring is recommended for rural air quality monitoring.

EXPERIMENTAL & METHODOLOGY

In this study, following four distinct areas in Sri Lanka are considered. They are:
1. Puttalam, 2. Thihagoda – Matara, 3. Kitulgala, 4. Colombo.

Colombo was taken to be the reference city, as it has a high population, a large number of industries, and a large fleet of vehicles. It is also an air pollution affected city and more data is available.

Puttalam is about 145 Km from Colombo, located in the North–Western Province and it is a dry, coastal city. The surrounding area can be considered in general as rural, having a low population density. Its transportation is mainly concentrated in the town area. Except for several salt industreis and a cement factory, other industries are rare. The Holcim cement factory is the main isolated industry in the study area. Coconut estates & Teak cultivations are widely spread in this area.

Thihagoda – Matara, is 160 Km from Colombo and located in the Southern Province. It is in the wet zone. The population density is higher and vehicular fleets are larger in Thihagoda when compared in Kitulgala and Puttalam. A 20 MW thermal power plant (that uses furnace oil as the fuel) is recorded as the only effective industry in this study area.

Kitulgala is 150 Km from Colombo and located in the wet zone of the Sabaragamuwa Province. Low humidity and high average rainfall were characteristics in Kitulgala. Evergreen rain forests are widely spread in this study area. Low population density, low vehicular fleets, negligible industrialization and agriculture-based economy are noted in the study area.

Selection of monitoring Location

Twenty (20) locations selected in each study area represent:

- Town and industrial area,
- Main road
- Rural areas, residential and non-residential

Analytical methodology,

In the study, all the samplers were installed at a height of about 3 m from the ground level. Sulfur Dioxide (SO_2) was analyzed using Pararosasnline method (colorimetry), and Nitrogen dioxide (NO_2) was analyzed using Saltzman method (colorimetry).

RESULTS & DISCUSSION

The average exposure levels of NO_2 and SO_2 at 20 locations in Puttalam area is given in Fig.1. It shows that the locations at the town area 7, 16 and 17 are relatively higher than that of other locations, from which it could be deduced that vehicular emission is the main pollution source of NO_2 and SO_2 in the area. All locations which are in the direction of North-East to the Holcim Cement Plant 9, 11, 14 and 18 show high pollutant concentration values, especially the location 11, which is the closest location to the Cement Plant monitored, since the South-west monsoons was prevailing during the monitoring period. Rest of the locations 4, 6 and 15 which show relatively high levels of pollution with respect to NO_2 and SO_2 represent the vehicular emissions by main road in the area.

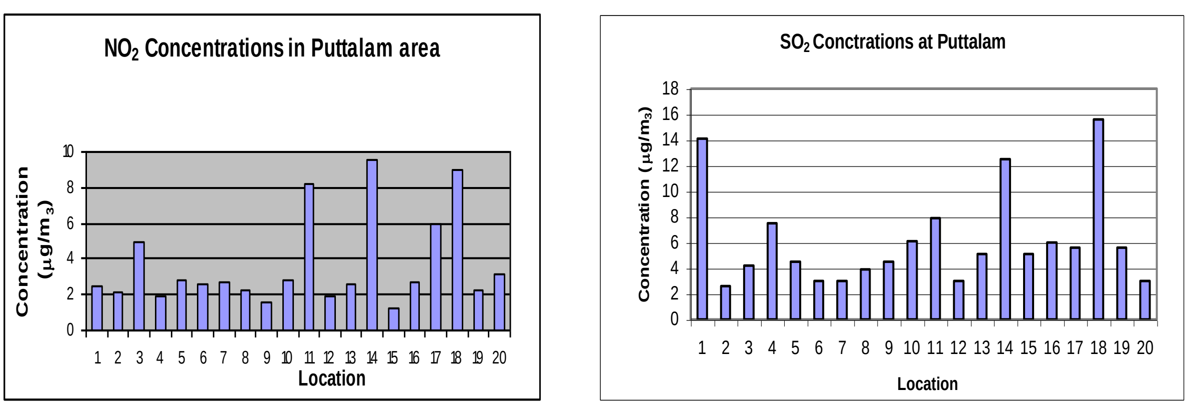

Figure 1: SO_2 and NO_2 concentrations in locations monitored at Puttalam

Two-week exposure levels of NO_2 & SO_2 in Thihagoda, Matara are given in Fig. 2. Relatively high values were recorded at the locations of 1, 2, 4, 5, 15, 16 & 17 due to industrial and vehicular emissions in the neighborhood. Locations 1, 2, 4 and 5 which are at a direction North-East to the thermal power plant give high values since South-West monsoon prevailed during the monitoring period. However, the high values at locations 15 and 17 are due to the vehicular emissions since those are close to main roads.

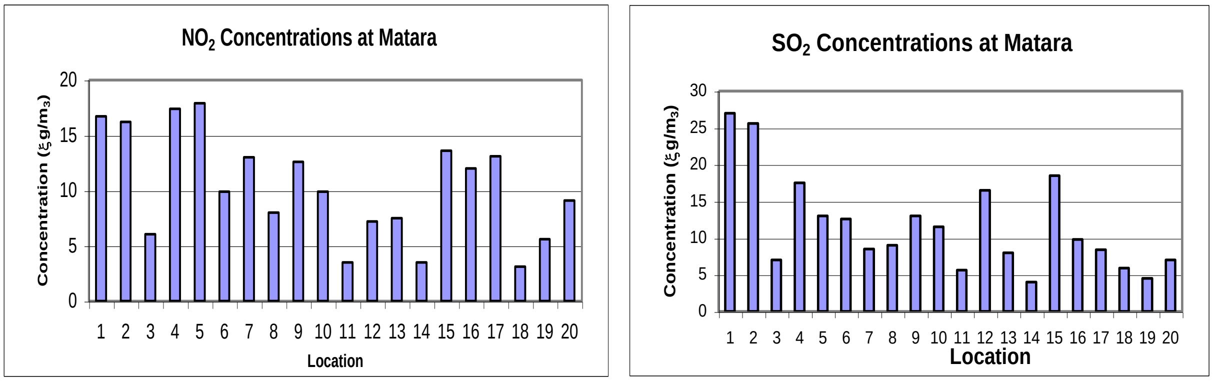

Figure 2: SO_2 and NO_2 concentrations in locations monitored at Thihagoda

NO_2 & SO_2 levels at Kitulgala which shown in Fig.3. indicate that the 2-week concentration levels lie within a range from 0.5 to 14 $\mu g/m^3$ for SO_2 and from 1.0 to 11.8 $\mu g/m^3$ for NO_2. The higher values recorded are at locations 9, 10, 19 and 20 are due to vehicular emissions from nearby main roads.

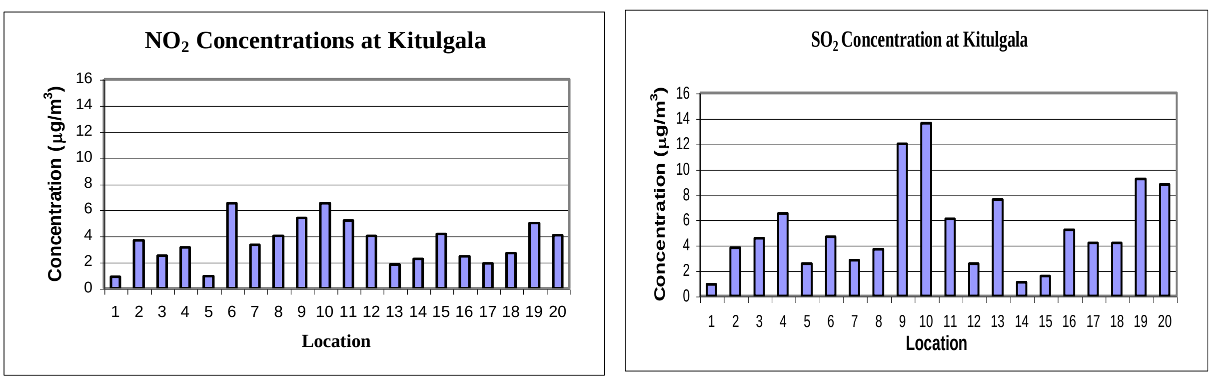

Figure 3: SO_2 and NO_2 concentrations in locations monitored at Kitulgala

The comparison of NO_2 and SO_2 levels in three areas as shown in Fig .4, and the maximum, average and minimum concentration at each area is given in Table 01. This clearly indicates that Kitulgala is the lowest pollution and Colombo Fort is the highest. Also it indicate that the minimum NO_2 level recorded at Kitulgala was about 0.9 $\mu g/m^3$ which is well below the minimum detection limit (2.0 $\mu g/m^3$) and minimum SO_2 level recorded about 0.9 $\mu g/m^3$ which is well below the minimum detection limit (2.5 $\mu g/m^3$) of automated air quality monitoring systems available in Sri Lanka.

Therefore, using passive sampling techniques, it can be monitor very low levels of air pollutants in which the technique can be used for air quality monitoring in rural areas especially for baseline surveys, area screening or inductive monitoring.

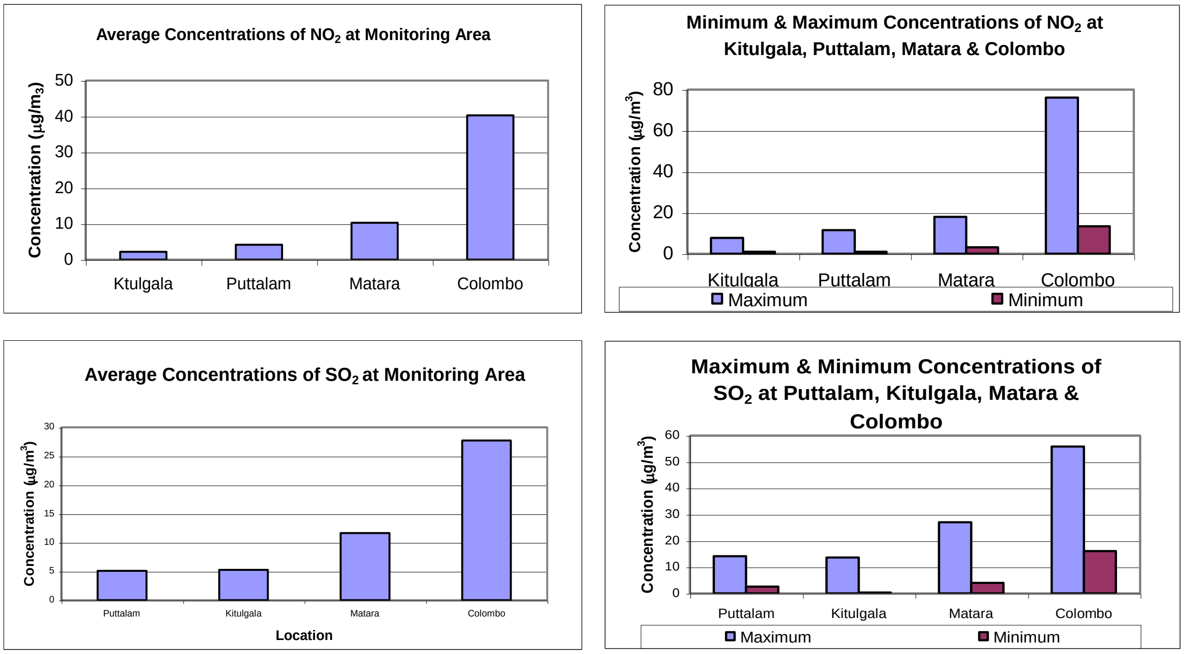

Figure 4: Average, minima, & maxima of pollutant concentrations in study area

Table 1: Average, minima, & maxima of concentrations pollutant in study area

Location	NO_2 Concentration ($\mu g/m^3$)				SO_2 Concentration ($\mu g/m^3$)			
	Maximum	Minimum	Average	Standard Deviation	Maximum	Minimum	Average	Standard Deviation
Puttalam	9.5	1.2	3.6	2.51	15.8	2.6	6.2	3.78
Kitulgala	6.5	0.9	3.5	1.64	13.6	0.9	5.3	3.47
Matara	17.9	3.1	10.3	4.74	25.6	4.0	11.6	6.51
Colombo	76.7	13.3	40.3	17.48	55.8	16.1	27.7	10.92

CONCLUSION

- Exposure levels of SO_2 & NO_2 at roadsides in rural areas are high due to vehicular emissions
- Passive sampling technique is more suitable for rural and urban air quality monitoring with a high resolution with low cost.
- It can be apply in rural areas for baseline surveys, area screening or inductive monitoring and to study the transboundary pollution movements etc.

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