

AMBIENT AIR QUALITY STUDY OF THE POLLUTION CAUSED BY  
VEHICULAR EXHAUST EMISSIONS IN THE CITY OF COLOMBO



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## ABSTRACT

The study was performed to determine the concentrations of particulate matter (total suspended particulate and fine dust), lead, polycyclic aromatic hydrocarbons, total hydrocarbons, non-methane hydrocarbons, methane, sulphur dioxide and carbon monoxide in the air on regular basis at seven selected intersections in the city of Colombo during the period from 1990 to 1993. Primary climatic data such as humidity, rainfall, wind speed were also recorded, especially during air sampling for particulate matter.

**Total Suspended Particulate(TSP)** and fine dust(FD) measured using a high volume air sampler indicated that the average TSP concentration was  $404 \mu\text{g}/\text{m}^3$  with a variation between  $100 - 960 \mu\text{g}/\text{m}^3$  for 8 hour period. More than 50% of the time TSP concentration was above  $300 \mu\text{g}/\text{m}^3$ . TSP and FD concentrations were found at higher levels exceeding the Standards of Sri Lanka and World Health Organization(WHO). The average values of TSP on Sundays were found to be  $274 \mu\text{g}/\text{m}^3$  which indicated that the TSP values were low by an average of 32% of weekdays' TSP levels. This could be due to lesser traffic moving on Sundays which was about 50% of weekdays traffic.

A linear relationship was found for TSP level and traffic densities at three sampling sites namely Maradana, Wellawatta and Borella. The correlation coefficients were 0.97, 0.84 and 0.71 respectively. A similar correlation was not seen at other four sites. One reason could be the absence of buildings and wind barriers around these sites that reduces the concentration of airborne particulate by blowing by the wind. Further the TSP concentration remained mainly at a constant average concentration in ambient air at Thunmulla and Eye Hospital Junction despite the traffic densities, where the TSP found to be an average value of  $165.5 \mu\text{g}/\text{m}^3$  per 1000 vehicles per hour and  $133 \mu\text{g}/\text{m}^3$  per 1000 vehicles/hour respectively. At the sampling site, Fort, the average TSP concentration in the evenings was about 60% less than morning averages and this difference could be due to the inland blowing of sea breeze during evenings observed.

A relationship between TSP with humidity was not observed. However a significant reduction of TSP at Fort and Wellawatta after a rainfall was recorded. Wind speeds and directions changed frequently at the sites with the moving of vehicles. The average wind speed in the city during the sampling was recorded as 3.91 km/h and it varied between 1.4 - 13.2 km/h in the city limits. The average ambient temperature recorded during the study period was  $29.5^\circ\text{C}$  and it varied between the maximum and minimum temperatures of  $24^\circ\text{C}$  and  $36^\circ\text{C}$ .

The average **FD** concentration was recorded as  $267.6 \mu\text{g}/\text{m}^3$  while the highest value  $434.6 \mu\text{g}/\text{m}^3$  was at Fort. 47% of determinations had exceeded the standard of  $300 \mu\text{g}/\text{m}^3$ . About 84% of suspended particulate were fine dust which is also named as respirable dust.

The average particulate **lead(Pb)** concentration in the air was  $0.43 \mu\text{g}/\text{m}^3$  for 8 hour. Very high concentrations were recorded from Fort, Slave Island and Maradana which were  $1.13 \mu\text{g}/\text{m}^3$ ,  $1.11 \mu\text{g}/\text{m}^3$  and  $1.00 \mu\text{g}/\text{m}^3$  respectively. The concentration obtained in Colombo have exceeded WHO standards in several occasions although the average concentration of  $0.43 \mu\text{g}/\text{m}^3$  was below the WHO standard. Therefore, the pollution by Pb could have some effect on human health. The average percentage of Pb content in TSP samples was 0.128 % and these values were less than the values recorded from other cities such as Seoul, Shin Chon(China) and Tokyo. A relationship between Pb contents and TSP contents was not observed.

All the 16 priority pollutants of the type **poly aromatic hydrocarbon (PAHs)** were found in 75% of samples. Further 82% contained the important carcinogenic compounds like

benzo(a)pyrene, benzo-anthracene, dibenzo anthracene and benzo(b)fluoranthene. The computed mean concentration of the PAH compounds in the air was  $730 \text{ ng/m}^3$  with a variation between  $270\text{-}2270 \text{ ng/m}^3$  for 6 hourly samples. It was found that B(a)p concentration varied in the range of  $10\text{-}60 \text{ ng/m}^3$  with an average concentration of  $20 \text{ ng/m}^3$ . There was a significant correlation ( $r = 0.80$ ) between the quantity of PAH and B(a)p but a less positive relationship ( $r = 0.27$ ) was observed for PAH with TSP. The average percentage of PAH in TSP was 0.29% and the average percentage of B(a)p in PAHs was 3.5%. In TSP, the average percentage of B(a)p was 1.0. This percentage is less than the 10% of the value reported in the ambient air in Beijing. Most of the PAH and B(a)p are found in fine particulate matter rather than in coarse particles.

**Sulphur dioxide ( $\text{SO}_2$ )** was measured by Ambient  $\text{SO}_2$  monitor. The mean  $\text{SO}_2$  concentration was obtained as  $0.0119 \text{ ppm}$  ( $30 \text{ } \mu\text{g/m}^3$ ) for 8 hour period which was below the Standards of WHO and Sri Lanka. During the measuring, the highest concentration was found at Thunmulla which was  $0.0548 \text{ ppm}$  ( $137.0 \text{ } \mu\text{g/m}^3$ ) and the lowest was at Eye Hospital Junction which was  $0.0029 \text{ ppm}$  ( $7.4 \text{ } \mu\text{g/m}^3$ ). It was observed that  $\text{SO}_2$  was effectively removed from the air during precipitation. The removal of  $\text{SO}_2$  was about 90%.

The ambient concentrations of  $\text{SO}_2$  and **total hydrocarbons (THC)** were positively correlated ( $r = 0.426$ ) during dry climatic conditions. The mean concentration of THC in the city was  $2.74 \text{ ppm}$  ( $\pm 0.36$ ) and the value had been varied between a range of 2 and 5 ppm for 8 hour period. During Sundays, the concentration had been 2.49 ppm which is about 9% of the weekdays value. This could be due to decrease of the passing traffic on Sundays.

The average concentration of **non methane hydrocarbons (NMHC)** was  $0.834 \text{ ppm}$  ( $\pm 0.40$ ) for 8 hour period with a variation between 0.07 - 3.00 ppm. The highest value was at Slave Island site and the lowest was at Fort site. These NMHC levels were above the standards of USEPA of 0.24 ppm and therefore the contribution to pollution by NMHC was considerably high. According to the studies carried out in China, it could be envisaged that in the presence of NMHC in the air at levels found at sites in Colombo is adequate to cause the formation of photochemical smog (PAN) and  $\text{O}_3$ . The maximum concentration of methane ( $\text{CH}_4$ ) recorded from the study was 2.11 ppm and the lowest reading was 1.80 ppm. The average concentration of  $\text{CH}_4$  was 1.906 ppm with a standard deviation of  $\pm 0.12$ . The measurements of  $\text{CH}_4$  indicated that  $\text{CH}_4$  was uniformly distributed in the ambient air of the city.

The average **carbon monoxide (CO)** concentration was  $4.0 \text{ ppm}$  ( $4.52 \text{ mg/m}^3$ ) with the highest value at Maradana site which was 25 ppm. The high concentrations did not last for a longer time and decreased to a low value within a few seconds. The above CO levels in Colombo air were well below the WHO standards.

At major roads like Maradana road, Reid Avenue, Galle road and Lotus road the average traffic densities were about 41770, 38800, 37700 and 34650 respectively. The average vehicle volume per hour was about 3100. On Sundays the value was about 50% of the weekday value. The ratio of petrol to diesel vehicles would be about 63: 37. The active vehicle population in the country is about 811,143 and it is increasing annually by about 11%. With regard to the fuel use, diesel consumption is higher than petrol consumption over the last decade which has an average ratio of 3:1. Therefore, for a unit segment of an urban highway, emissions from diesel vehicles are higher than petrol emissions. Although a relationship between the consumption of diesel of passing vehicles and related TSP concentrations was not found, the high level of diesel consumption could be one of the main reasons for the existence of high level of suspended particulate matter in the ambient air.