EFFECT OF GREENERY ON CO_2 CONCENTRATION INSIDE DWELLINGS

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Abstract

With the urbanization and the rapid development more people have been moving towards cities in search of facilities. With this, demands for dwellings in the cities have increased and more buildings have been constructed, changing the previous arrangement of the cities. The cities have turned into congested areas with less vegetation and greenery. The more the urban spaces have become industrialized, the more the air has been contaminated. This research discusses the effect of surrounding vegetation on indoor air quality of dwellings by checking the difference of CO_2 concentration based on actual measurement in Colombo, Kandy and Nuwara Eliya which are situated in three different altitudes, varying amount of vegetation and with largely varying traffic congestion.

The results obtained reveal that the effect of vegetation is very high in Colombo when compared to other two cities as the traffic congestion is very high there. In low greenery areas of Colombo, indoor CO_2 concentration increases very rapidly in the evening when there isn't much difference in other two cities. But the difference between mean indoor CO_2 levels in greenery and low greenery area is decreasing significantly amongst Colombo, Kandy and Nuwara Eliya. This research indicates that the surrounding vegetation has more impact on indoor air quality in cities with high traffic congestion and low altitudes.

Key words*:* Urbanization, Various altitudes, Traffic congestion, Indoor air quality.

1 Introduction

Urbanization and industrialization are dynamically linked with the urban environment [1]. By the middle of 2009, the number of people living in urban areas (3.42 billion) had surpassed the number living in rural areas (3.41 billion) and since then the world has become more urban than rural [2]. While the world's urban population grew very rapidly over the 20th century, the next few decades will see an extraordinary scale of urban growth in the developing world. This will be particularly notable in Africa and Asia where the urban population will double between 2000 and 2030[3].

Urban areas affect the environment in three major ways: through the conversion of land to urban use, the extraction and reduction of natural resources, and the disposal of urban waste. The impacts of these pollutions are experienced both locally and at great distances from the source. For instance, domestic and industrial emissions contaminate air, land and water much beyond the immediate vicinity. The increased levels of consumption characteristics of the population of urban areas lead to generation of many quantities of waste [4].

As far as air pollution is concerned, both developed and developing countries are at risk. The main sources of air pollution are the vehicular and industrial processes. Urban air pollution problem is reaching a crisis dimension in many cities of the developing countries. There are several endemic diseases resulting from air borne particulate materials which have drawn public attention .The latest epidemic disease outbreak occurred in April 2003, when Severe Acute Respiratory Syndrome (SARS) suddenly appeared, sending shockwaves throughout the world, disturbing public health systems and economic security worldwide. By July 2003, about 8439 cases had been reported worldwide, with 812 deaths; the economic loss was estimated to be $50 - $100 billion [5]. Chemical agents, particularly air borne ones, are considered to be major factors in causing tuberculosis, bronchitis, heart diseases, cancers and asthma. Tuberculosis, the single largest cause of death in adults from infectious diseases, was responsible for three million deaths in 1996, 95% of which occurred in the developing world. Prevalence of asthma, often exacerbated by air pollutants, has also increased among children [6].

CO_2 and other gases (water vapor, methane, N_2O, ozone) have been increasing in the atmosphere at an unprecedented rate over the past century due to human activities [7]. Continuous increase in the anthropogenic (caused by human) emissions of these chemicals could, over the next century, have implications on the earth's fragile atmosphere and create a threat of air pollution. In many large urban centers around the world, especially in developing countries, deteriorating urban air quality is a serious environmental problem. Human activities produce carbon dioxide (CO_2), primarily through the combustion of fossil fuels and its concentration in the earth's atmosphere has risen by more than 31% since the Industrial Revolution. The concentration of CO_2 in the atmosphere has risen from close to 280ppm (parts per million) in 1800 to a value of 367ppm in 1999[8] and carbon dioxide (CO_2)

concentration in 2008 was 387 ppm and was the highest on record in human history[9]. The present GHG emissions are ‘far higher than even the worst case scenario’ envisaged by the AR4 [10].

Vegetation influences urban environmental conditions and energy fluxes by selective reflection and absorption of solar radiation (Goward et al, 1985) and by modulation of evapotranspiration [11]. The absence and scarcity of vegetation in urban areas was long been recognized as a strong influence on energy demand and development of the urban heat island? [12]. Urban vegetation abundance may also influence air quality and human health [13].Trees eliminate gaseous air pollution primarily by uptake via leaf stomata, though some gases are removed by the plant surface. Once inside the leaf, gases diffuse into intercellular spaces and may be absorbed by water films to form acids or react with inner-leaf surfaces. Trees also confiscate pollution by intercepting airborne particles. Some particles can be absorbed into the tree, though most particles that are intercepted are retained on the plant surface. The intercepted particle often is resuspended to the atmosphere, washed off by rain, or dropped to the ground with leaf and twig fall [14].

Therefore, this research focuses the effect of greenery on indoor air quality in dwellings, hence motivating people on vegetation.

2 Objective

The main objective of this research is to identify the indoor CO_2 levels in three main cities of Srilanka, with three various altitudes, varying levels of vegetation and varying amount of traffic congestion. Hence identify the indoor air quality and motivate the people in retaining vegetation in all parts of the country.

3 Methodology

To achieve the objectives following methodology was carried out,

1. The CO_2 readings were taken from three different cities in Sri Lanka namely Colombo, Kandy and Nuwara Eliya.
2. In each city indoor CO_2 readings were taken once in every 15 minutes from 8.00-18.00 in two locations, where one location is surrounded by greenery in a village like environment and the another place which is closer to a main road which is surrounded with buildings.
3. Hourly average CO_2 readings were plotted and analysis was carried out.

3.1 Site Description

Colombo, Kandy and Nuwara Eliya are the three cities considered.

Among these, Colombo is the most urbanized city in Sri Lanka having an urban population of 54.6%. Altitude of Colombo is very low as it is located very close to sea. The University of Colombo premises which is surrounded with lots of greenery is considered as one location. There are a lot of government departments and schools around the University of Colombo premises though it is surrounded with lots of greenery. Traffic congestion near University of Colombo premises is very high during 7 am to 9 am, 1 pm to 3 pm and 4 pm to 7 pm. The other location is near Dematagoda railway station where there are lots of slums. The traffic congestion there is very high during 7 am to 9 am, 12 pm to 3 pm and 4 pm to 7 pm. In both the locations, the overall traffic congestion is very much higher than any other city in Sri Lanka.

Figure 1: Greenery and Low Greenery Locations of Colombo

The city of Kandy is located in the central part of the country and has an altitude of 465m. That is the second highest urbanized city among the considered cities having an urban population of 12.2%. In Kandy the amount of urban vegetation is high when compared to Colombo and the amount of vegetation is less when compared to Nuwara Eliya. One location selected is Katugastota. There are lots of car sales in both sides of the road in Katugastota and the traffic congestion is high during 6 am to 9 am, 12 pm to 3 pm and 5 pm to 6 pm. Though there are a lot of car sales and traffic, the environment is surrounded with lots of greenery and has natural ventilation throughout the whole day. The other location is ugurassapitiya where you can find lots of greenery and very less traffic. When comparing both the locations in Ugurassapitiya there is a very large amount of greenery and Katugastota less amount of greenery than ugurassapitiya, But still Katugastota is a good greenery environment.

Figure 2: Greenery and Low Greenery Locations of Kandy

Figure 3: Greenery and Low Greenery Locations of Nuwara Eliya

The third considered city is Nuwara Eliya. It is located in the central part of the country and has an altitude of 1868m and urban population of 6.1%. One location selected in Nuwara Eliya is near hill road junction with lots of small dwellings. The other location selected is near Craig-Bank Nuwara Eliya which is located at the foot of Piduruthalagala Mountain. Both locations are covered with lots of greeneries and the traffic congestion is also very low when compared with other two cities.

4 Analysis and Findings

This section describes the analysis and findings, based on the readings that were taken from greenery and low greenery locations in selected cities.

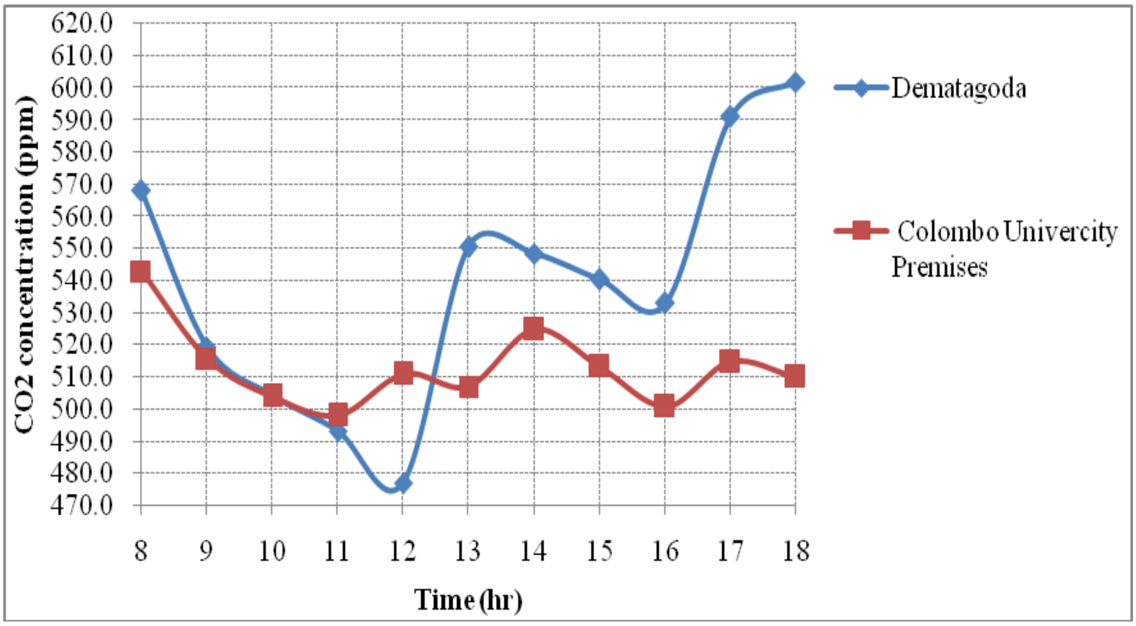

Figure 4: Time Vs CO_2 concentration curves in Colombo

Variation of indoor CO_2 levels between greenery (University of Colombo premises) and low greenery (Dematagoda) areas in Colombo is shown in figure 4. It shows that the indoor CO_2 levels in both locations decreases up to 9.00 and there is no significant difference in levels up to 11.00. Then at 12.00 the CO_2 level in Dematagoda reduces than in the greenery environment, which is very unique as far as the entire graph is concerned. Since 12.00 the indoor CO_2 level in Dematagoda increases very rapidly and reaches the peak level by 18.00. The maximum concentration of CO_2 observed in Dematagoda is 602 ppm as observed at 18.00 while the maximum observed in University of Colombo premises is 543 ppm as observed at 8.00. The curve clearly shows that there is no much of change in the shape of the curve in Colombo university premises throughout the whole day, while the graph of Dematagoda changes uniquely and rapidly. The mean CO_2 for the whole day observed in Dematagoda is 538.9 ppm while the University of Colombo premises are 512.9 ppm. And during traffic periods of 12.00 to 15.00 and 16.00 to 18.00, the indoor CO_2 concentration in Dematagoda increases very rapidly while there is less change in University of Colombo premises when compared to Dematagoda.

All the above analysis clearly shows that the effect of greenery on indoor CO_2 concentration is high when the trees are located closer to air polluting sources.

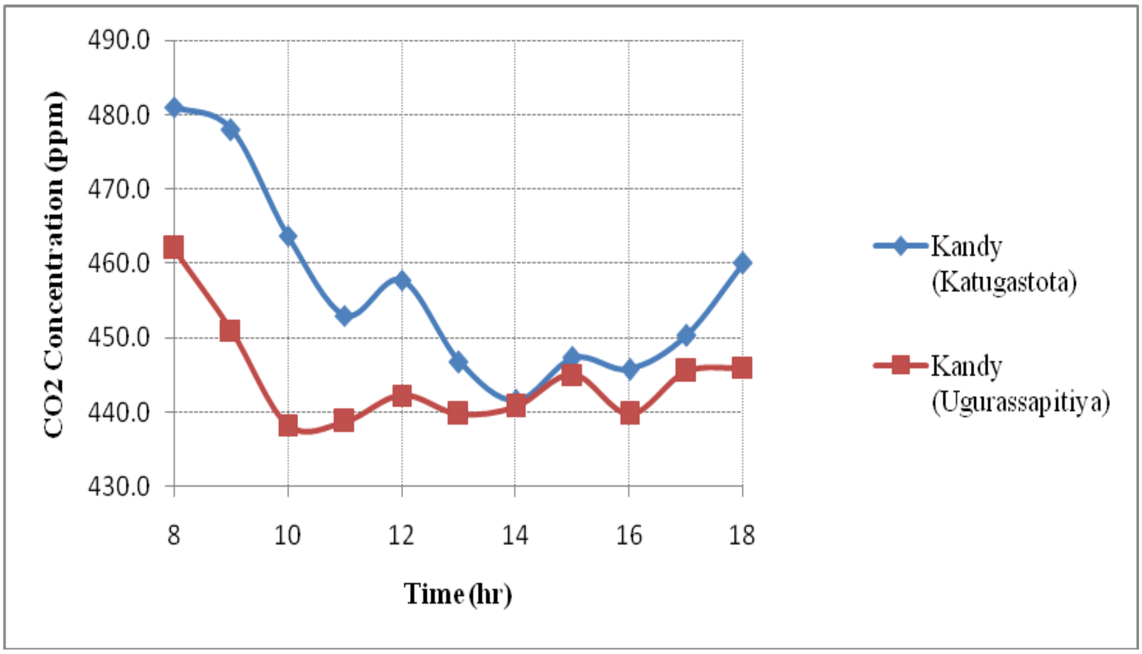

Figure 5: Time Vs CO_2 concentration curves in Kandy

The above figure 5 shows the indoor CO_2 variation graphs between greenery (Ugurassapitiya) and low greenery (Katugastota) in Kandy. Indoor CO_2 level in Katugastota reduces gradually up to 14.00 and increases gradually up to 18.00 while CO_2 level in Ugurassapitiya reduces gradually up to 10.00 and is almost unchanged after 10.00. Generally, throughout the whole day shapes of curves are almost same though there are small deviations. Highest amount of CO_2 concentration in both locations was observed at 8.00. Even during the traffic periods there is no much difference in CO_2 levels between Ugurassapitiya and Katugastota. The average CO_2 concentration for the whole day observed in Katugastota is 456.8 ppm while it is 444.8 ppm in Ugurassapitiya.

Above analysis in Kandy proves that when the trees are planted beside or closer to air pollution sources, it influences more on indoor air quality as even during traffic congestion periods there is not much of difference in indoor CO_2 between Katugastota and Ugurassapitiya.

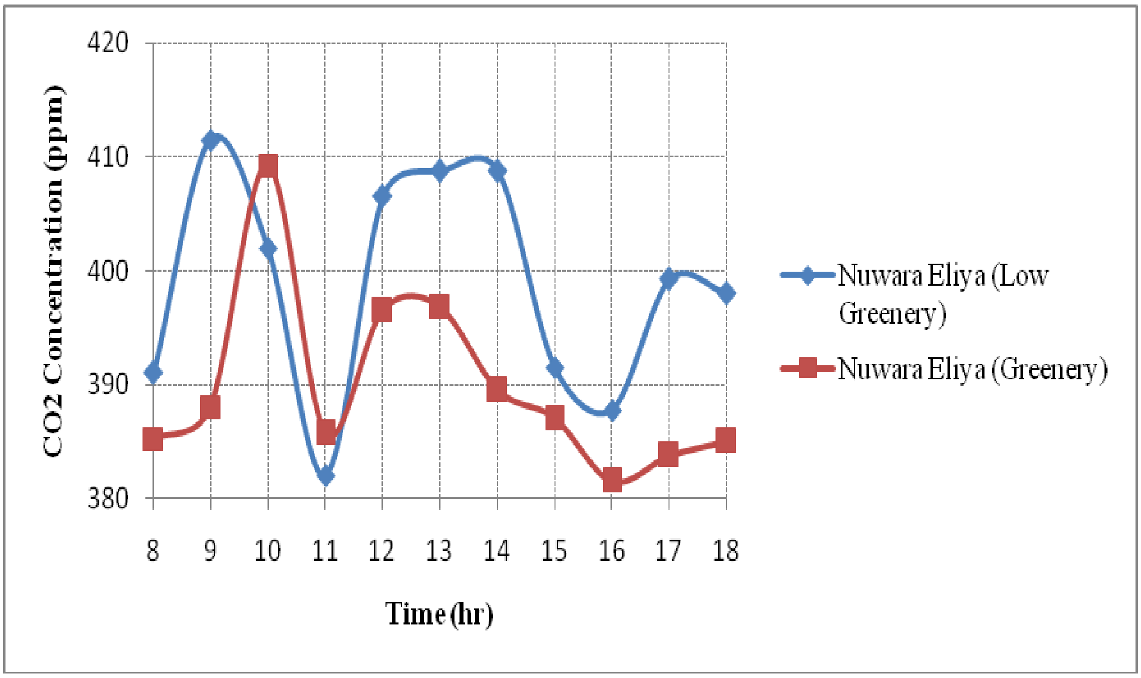

Figure 6: Time Vs CO_2 concentration curves in Nuwara Eliya

Figure 6 illustrates the indoor CO_2 variation curves in Nuwara Eliya. The shapes and readings of the curves are almost the same in both the locations. Maximum difference in indoor CO_2 level is observed at 14.00 and the difference is 12 ppm. The average indoor CO_2 level for the whole day in Hill Road Junction is 398.8 ppm and in Craig Bank it is 389.8 pm CO_2 ppm. So it is very clear that in Nuwara Eliya the indoor CO_2 concentration is almost the same in both the conditions as the amount of greenery is very high in both environment as well as the traffic congestion is very low when comparing with other two cities.

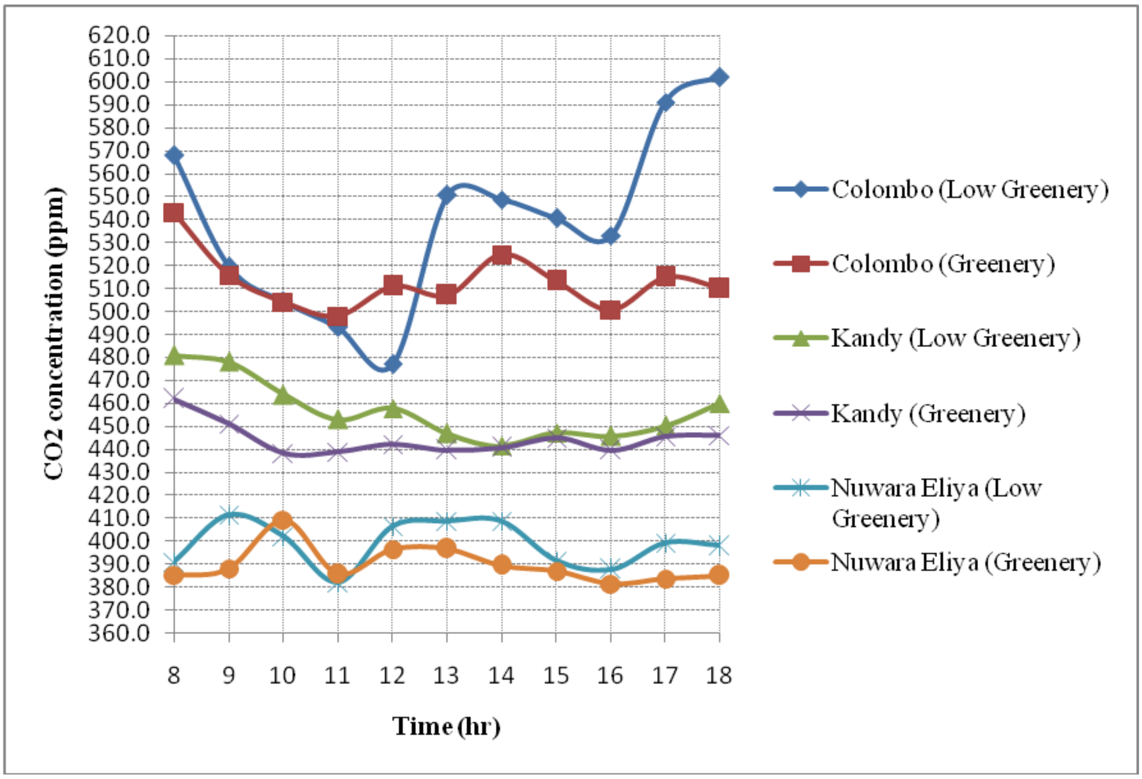

Figure 7: Time Vs CO_2 concentration curves in Colombo, Kandy and Nuwara Eliya

The variations of indoor CO_2 in greenery and low greenery areas with time in Colombo, Kandy and Nuwara Eliya are shown in figure 7. It is clear that the indoor CO_2 in low greenery area of Colombo is increasing very rapidly in the evening while there would not be difference in other two cities. The change of shape in curves between greenery and low greenery is very unique in Colombo compared to other two cities. As we look at the graph at a glance we can identify that the indoor CO_2 concentration from Colombo to Nuwara Eliya is reducing. This means that with the increasing altitudes, the indoor CO_2 concentration is decreasing in both greenery and low greenery environments. This graph gives a more precise and clear idea as to how the indoor CO_2 concentration is being transformed by greenery in cities with various levels of vegetation and varying altitudes.

5 Main Findings and Conclusion

Following are the main findings of the thorough analysis of collected data:

1. In high urbanized city (Colombo) indoor CO_2 concentration in dwellings surrounded by very low green area is decreasing up to 12 noon and increasing rapidly after 12. And the indoor CO_2 concentration is very high in the evening.
2. In high urbanized city (Colombo) indoor CO_2 levels are low even during high traffic congestion periods when they are covered with vegetation.
3. In Kandy as the amount of vegetation is very high even in the town area, there would not be much difference in indoor CO_2 concentration between town and greenery environment during traffic congestion period.
4. In less urbanized area (Nuwara Eliya) where there would not be much difference between vegetation between town area and rural areas, the difference of indoor CO_2 concentration is also low.
5. With the altitude increases, the indoor CO_2 concentration decreases in both cases and also the mean difference of indoor CO_2 concentration would also decreases.

The findings of this research clearly show the the effect of greenery on indoor air quality in various cities. Though the trees affect the indoor air quality in all kinds of environments, the effect of greenery on indoor air quality is very high in high urbanized cities with low altitudes. So formation and management of green spaces has been gaining importance as urbanization becomes the most significant reason for human migration in the world. Urban Green Spaces provide town and city dwellers with significant environmental, recreational, and material benefits. They are also home to a vast diversity of flora and fauna and are recognized as important repositories of biodiversity. Although the main climatic benefits of green spaces are cooling and shading, vegetation and soils, particularly trees, can counter poor air quality by absorbing greenhouse gases such as carbon dioxide and other air pollutants, i.e. green spaces can act as ‘carbon sinks’. Trees take in carbon dioxide during photosynthesis and store carbon until they are burnt or dead. This can be especially effective if trees are located closer to pollution sources.

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