



Potential of Metropolitan Greenspaces on Global Warming Abatement in Lagos, Southwestern Nigeria

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ABSTRACT: Greenspace campaign regulates urban air quality and global warming effects. Four areas with trees planting (TP: Ojota-Ketu, Anthony, Costain and Airport-Agege) and non-trees planting (NP: Mile 12, Jibowu, Ojuelegba and Iyana-ipaja) were selected considering traffic volumes. Gaseous pollutants: CO, CO₂, NO_x, SO₂, VOC; SPM and noise levels; meteorological conditions: O₂ and Temperature in the selected areas were assessed to be TP and NP were CO: 3.76 ± 1.23 and 4.70 ± 1.59 µg/ m³, CO₂: 8.39 ± 1.50 and 14.68 ± 2.62 µg/ m³, NO₂: 1.94 ± 0.84 and 2.57 ± 1.11 µg/ m³, SO₂: 0.32 ± 0.54 and 0.46 ± 0.77 µg/ m³, VOC: 2.08 ± 0.65 and 2.60 ± 1.66 µg/ m³, SPM: 101.5 ± 26.19 and 189.34 ± 48.99 µg/ m³, Temp.: 41.25 ± 6.92 and 45.38 ± 7.26 °C, O₂: 28.25 ± 2.74 and 21.73 ± 2.09 %, and Noise: 93.75 ± 37.21 and 112.50 ± 44.65 dB. Gaseous pollution levels were below the standards at the TP. Levels of SPM were generally lower but Temperature was higher than the limit. Greenspace significance to improve urban air quality and abate global warming was observed.

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Continuous growth in human population, vehicular traffic and industries had increased urban levels of gaseous and particulate pollutants over the years. One of the dominant sources of air quality deterioration is road traffic-induced (Kumar *et al.*, 2013). The effects have a direct relationship with deterioration in overall human health and account for half of the outdoor-induced problems. Another undesired and unpleasant factor that creates nuisance in the urban center is noise which affects the quality of life through ear impairment. Noise negatively has intervention on communication, productivity and social behaviour of man (Haq *et al.*, 2014). Various approaches to reduce urban and environmental pollution have considered urban tree planting areas (greenspaces) and its orientation for bio-aesthetic values, thereby making cities habitable, conducive, and contributing to human health and well-being. Vegetation and land cover removal have given way to an artificial urban landscape with concrete and tar (Olayemi and Oluwafemi, 2013). Urban heat island effect is mitigated with increase in urban greenspaces with relative contribution of evapotranspiration overall cooling effect, this in turn increases oxygen levels and lowers the average temperature of the environment below 30 °C (DoH, 2008). The study assessed mitigating effects of greenspaces on the air

quality and potential global warming in selected areas within Lagos State metropolis.

MATERIALS AND METHODS

Study area: Lagos is the most urbanized state in Nigeria with 17, 500 hectares of built up area (Oduwaye, 2006), which makes its natural land cover area witness a dramatic shift as a result of massive urban development. Lagos State is located in the southwestern coast of Nigeria between latitudes 6°22'N and 6°52'N and longitudes 2°42'E and 3°42'E. The area is characterized by a wet equatorial climate with mean annual rainfall above 1800 mm. An important part of the land resource in the state comprises saltwater and freshwater wetlands. The former covers the mangrove swamps along the coast of the study area. The greenspace areas in Lagos metropolis monitored were Ojota-Ketu;- 39, 161.30 m², Anthony;- 15, 679.34 m², Costain;- 11, 750.25 m² and Airport-Agege; 42, 900.34 m² (Olaleye, 2013) while the non-greenspaces were Mile 12, Jibowu, Ojuelegba and Iyana-ipaja.

Sampling sites and parameters: The eight selected locations for the study were four greenspaces and four non-greenspaces (Figure 1). The areas were

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chosen for population density and traffic volume. Gaseous pollutants, meteorological conditions, particulate matter and noise were assessed. The parameters were monitored with battery-operated hand-held equipment: Land-duo (Industracom, North Sydney, Australia) for CO, CO₂, NO₂ and O₂, QRAE⁺ meter (Fisher Scientific, Loughborough, UK) for SO₂, VOC and T^oC, DustTrak (TSI, Air Met Scientific, UK) for SPM and SD-200 (Air Met Scientific, UK) for noise level. According to Thomasnet (2011), the equipment were placed 2.5 m above ground level, where man is exposed to the

prevailing pollutants and the sampling was carried out for 1 hour before the fluctuated values were recorded. The equipment were gaseous sensor in-built, which identified, quantified and digitised the existing gaseous parameters in the sampling locations.

Statistical analyses: The data collected were subjected to descriptive (mean and standard deviation) and inferential statistics (one-way ANOVA and Duncan's Multiple Range Test at p < 0.05).

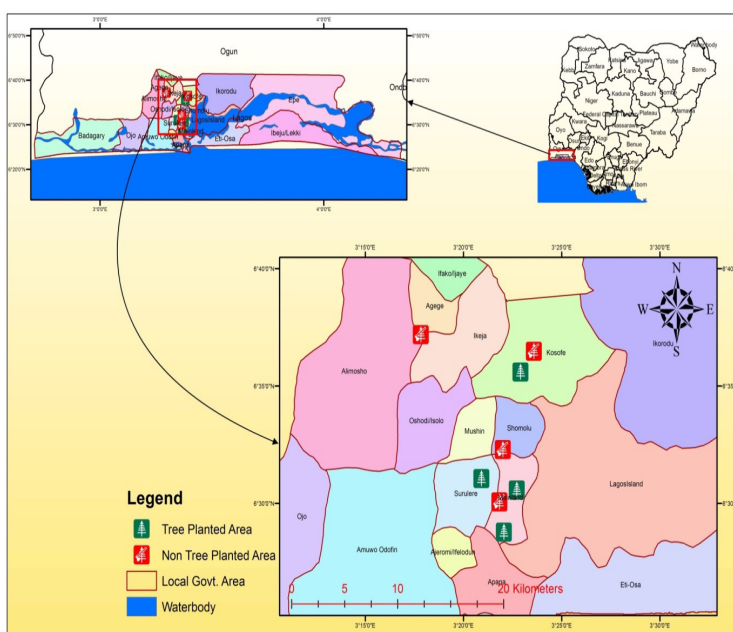


Fig 1: Map of the Study Area, Trees Planted Areas = greenspaces, Non Tree Planted Area = non- greenspaces

RESULTS AND DISCUSSION

Levels of the gaseous parameters in greenspaces: From Table 1, levels of CO ranged from 2.10 ± 0.36 along Airport-Agege to 3.03 ± 0.25 µg/ m³ along Costain. Its concentration was highly significant (p < 0.05) on the environment and the same along both Ojota-Ketu and Airport-Agege roadsides. Levels of CO₂ ranged from 5.30 ± 0.36 along Airport-Agege to 5.90 ± 0.36 µg/ m³ along Costain (p > 0.05). Levels of NO₂ ranged from 1.05 ± 0.18 along Airport-Agege to 1.52 ± 0.13 µg/ m³ along Costain (p > 0.05). Levels of SO₂ ranged from 0.12 ± 0.13 along Airport-Agege to 0.35 ± 0.10 µg/ m³ along Costain (p > 0.05). Levels of VOC ranged from 1.11 ± 0.13 along Airport-Agege to 1.58 ± 0.31µg/ m³ along Ojota-Ketu significantly (p < 0.05). The detected values from the study were compared with the EC (2016) limits for all the sampling locations within1 hr period. The CO levels were less than the limit: 40 µg/ m³. Levels of CO₂ did not exceed the limit (10 µg/ m³). Levels of

NO₂ were below the limit (191 - 200 µg/ m³). Also, the levels of SO₂ were below the limit (198.75 - 350 µg/ m³) (Table 1). It could be deduced that the levels (µg/ m³) of gaseous pollutants determined were least along Airport-Agege with the highest greenspace area of 42, 900 m² while highest along Costain with the lowest greenspace area of 11, 750.25 m². High volume of vehicle moving into and from Apapa and Island as well as industrial emissions from the area (Singh, 2004) might have been responsible for the high levels of pollution in Costain.

Levels of the gaseous parameters in non-greenspaces: From Table 2, levels of CO ranged significantly (p < 0.05) from 2.63 ± 0.45 along Jibowu to 3.79 ± 0.31 µg/ m³ along Iyana-ipaja. Levels of CO₂ ranged with not significant (p > 0.05) different from 9.28 ± 0.63 along Jibowu to 10.33 ± 0.63 µg/ m³ along Iyana-ipaja. Levels of VOC ranged significantly (p < 0.05) from 1.39 ± 0.16 along

Jibowu to $1.98 \pm 0.38 \mu\text{g}/\text{m}^3$ along Ojuelegba. However, its levels were not significantly ($p > 0.05$) different along both Ojuelegba and Iyana-ipaja. Levels of NO_2 ranged ($p > 0.05$) from 1.39 ± 0.24 along Jibowu to $2.00 \pm 0.17 \mu\text{g}/\text{m}^3$ along Iyana-ipaja. Levels of SO_2 ranged ($p > 0.05$) from 0.50 ± 0.15 to $0.34 \pm 0.18 \mu\text{g}/\text{m}^3$. Levels of CO were less than the limit: $40 \mu\text{g}/\text{m}^3$ along all the sampling locations for 1 hr period. Levels of CO_2 were less than the limit: $10 \mu\text{g}/\text{m}^3$. The levels of CO_2 detected at the monitoring hour indicated that its contribution would have been from the vehicle volume because one of the dominant sources of urban pollution is road-traffic-induced. Significant difference in VOC level indicated that deadly ground O_3 might also be significantly different in all the areas because VOC has directly correlated with the variation of O_3 but negative correlation with

NO_x . Levels of NO_x were below the limit: $191 - 200 \mu\text{g}/\text{m}^3$. The low levels of NO_x recorded might have increased CH_4 and O_3 to corroborate West *et al.* (2007) view that NO_x reduction increased CH_4 and long term ozone (O_3). Level of NO_x enhances the magnitude of effects observed with other pollutants, is a good indicator of traffic-related air pollution and an important source of a range of more toxic pollutants that could act in combination to produce adverse health effects. Several studies among occupational groups exposed to traffic fumes have documented adverse effects including lung cancer and lung function changes (Karita *et al.*, 2001). Levels of SO_2 were above the threshold ($198.75 - 350 \mu\text{g}/\text{m}^3$) in all the sampling locations within 1 hr sampling period (EC, 2016) with possible occurrence acid rain.

Table 1: Results of the air quality parameters at the greenspaces

| | Ojota-Ketu | Anthony | Costain | Airport-Agege | |
|--|-------------------|----------------------|-------------------|-------------------|-------------------------|
| Area covered by trees (m^2) | 39, 161.30 | 15, 679.34 | 11, 750.25 | 42, 900.34 | (Olaleye, 2013) |
| Parameters | | | | | Threshold |
| CO ($\mu\text{g}/\text{m}^3$) | 2.16 ± 0.42^a | 2.73 ± 0.2^{ab} | 3.03 ± 0.25^b | 2.10 ± 0.36^a | 40 (EC, 2016) |
| CO_2 ($\mu\text{g}/\text{m}^3$) | 5.37 ± 0.42^a | 5.80 ± 0.36^a | 5.90 ± 0.36^a | 5.30 ± 0.36^a | 10 (EC, 2016) |
| NO_2 ($\mu\text{g}/\text{m}^3$) | 1.25 ± 0.40^a | 1.37 ± 0.13^a | 1.52 ± 0.13^a | 1.05 ± 0.18^a | 191 - 200 (EC, 2016) |
| SO_2 ($\mu\text{g}/\text{m}^3$) | 0.15 ± 0.18^a | 0.23 ± 0.13^a | 0.35 ± 0.10^a | 0.12 ± 0.13^a | 198.75 - 350 (EC, 2016) |
| VOC ($\mu\text{g}/\text{m}^3$) | 1.58 ± 0.31^b | 1.37 ± 0.13^{ab} | 1.48 ± 0.08^b | 1.11 ± 0.13^a | ---- |

Values with the same superscripts along the row were not significantly ($p > 0.05$) different

Table 2: Results of the air quality parameters at the non-greenspaces

| Parameters | Mile 12 | Jibowu | Ojuelegba | Iyana-ipaja | Threshold |
|--|----------------------|-------------------|-------------------|--------------------|-------------------------|
| CO ($\mu\text{g}/\text{m}^3$) | 3.42 ± 0.31^{ab} | 2.63 ± 0.45^a | 2.71 ± 0.52^a | 3.79 ± 0.31^b | 40 (EC, 2016) |
| CO_2 ($\mu\text{g}/\text{m}^3$) | 10.15 ± 0.63^a | 9.28 ± 0.63^a | 9.39 ± 0.73^a | 10.33 ± 0.63^a | 10 (EC, 2016) |
| NO_2 ($\mu\text{g}/\text{m}^3$) | 1.80 ± 0.17^a | 1.39 ± 0.24^a | 1.65 ± 0.53^a | 2.00 ± 0.17^a | 191 - 200 (EC, 2016) |
| SO_2 ($\mu\text{g}/\text{m}^3$) | 0.34 ± 0.18^a | 0.17 ± 0.18^a | 0.22 ± 0.26^a | 0.50 ± 0.15^a | 198.75 - 350 (EC, 2016) |
| VOC ($\mu\text{g}/\text{m}^3$) | 1.71 ± 0.16^{ab} | 1.39 ± 0.16^a | 1.98 ± 0.38^b | 1.85 ± 0.96^b | ---- |

Values with the same superscripts along the row were not significantly ($p > 0.05$) different

Meteorological condition in the greenspaces: As shown in Table 3, the atmospheric temperature of the areas ranged with no significant ($p > 0.05$) difference from 26.33 ± 2.31 (Airport-Agege) to 28.66 ± 1.15 $^\circ\text{C}$ (Costain). The atmospheric temperature did not exceed the limit for urban heat island during the day, 30 $^\circ\text{C}$ (DoH, 2008). The oxygen levels of the areas ranged significant ($p < 0.05$) from 17.33 ± 0.58 to 20.67 ± 0.58 %; lowest in Costain but highest in Airport-Agege areas. This oxygen level would make where it was highest (Airport-Agege) the most conducive area.

Meteorological condition in the non-greenspace: As shown in Table 4, temperature of the study areas ranged with no significant ($p > 0.05$) different from 28.97 ± 2.54 along Jibowu to 31.53 ± 1.27 $^\circ\text{C}$ along Iyana-ipaja. Oxygen levels ranged significantly ($p < 0.05$) from 13.33 ± 0.44 to 15.90 ± 0.44 % in all the areas; highest along Jibowu but lowest along Iyana-ipaja. Anthropogenic activities (mostly transportation

with vehicular emissions) in Iyana-ipaja were high, and it is where Ikotun and Agege axes traverse Ikeja and Agabado-Ijaye axes with no greenspaces at all. Atmospheric temperature of both Jibowu and Ojuelegba was lower while Mile 12 and Iyana-ipaja values were higher than the urban heat island limit: 30 $^\circ\text{C}$ (DoH, 2008). Rise in temperature levels could influence dispersion of vehicular emissions with resultant poor air quality. Temperature has been traced to be a predominant parameter that affects concentration of O_3 , which is one of the criteria of pollutants (Kumar *et al.*, 2013). This also complied with the view that SPM had positive correlation with temperature in all the seasons, especially from October to December which is equivalent to harmattan period in Nigeria. Influence of temperature on gaseous pollutants (such as SO_2 and NO_x) could be more predominantly effective in dry season than other seasons due to higher trends and variations. However, the study showed that Jibowu was the most conducive area having highest oxygen level value.

Table 3: Results of the meteorological conditions at the greenspaces

| | Ojota-Ketu | Anthony | Costain | Airport-Agege | (Olaleye, 2013) |
|---|---------------------------|----------------------------|---------------------------|---------------------------|------------------|
| Area covered by trees (m ²) | 39, 161.30 | 15, 679.34 | 11, 750.25 | 42, 900.34 | |
| Parameters | | | | | Threshold |
| Temp. (°C) | 27.00 ± 1.73 ^a | 28.00 ± 1.73 ^a | 28.66 ± 1.15 ^a | 26.33 ± 2.31 ^a | < 30 (DoH, 2008) |
| O ₂ (%) | 19.00 ± 1.00 ^b | 18.33 ± 0.58 ^{ab} | 17.33 ± 0.58 ^a | 20.67 ± 0.58 ^c | ----- |

Values with the same superscripts along the row were not significantly ($p < 0.05$) different.

Table 4: Results of the meteorological conditions at the non-greenspaces

| Parameters | Mile 12 | Jibowu | Ojuelegba | Iyana-ipaja | Threshold |
|--------------------|----------------------------|---------------------------|---------------------------|---------------------------|------------------|
| Temp. (°C) | 30.80 ± 1.90 ^a | 28.97 ± 2.54 ^a | 29.70 ± 1.91 ^a | 31.53 ± 1.27 ^a | < 30 (DoH, 2008) |
| O ₂ (%) | 14.10 ± 0.44 ^{ab} | 15.90 ± 0.44 ^c | 14.62 ± 0.77 ^b | 13.33 ± 0.44 ^a | ----- |

Values with the same superscripts along the row were not significantly ($p < 0.05$) different

Levels of SPM and noise in greenspaces: Levels of SPM ranged significantly ($p < 0.05$) from 58.33 ± 4.73 along Airport-Agege to 78.33 ± 7.23 µg/ m³ along Costain while noise levels of the areas ranged with no significant ($p > 0.05$) different from 59.00 ± 10.00 along Airport-Agege to 67.00 ± 7.21 % along Costain (Table 5). Levels of SPM along the areas were below the limit (150 - 250 µg/ m³) set by EC (2016) while noise level along Costain was lower than threshold for human health: 70 dB (WHO, 2000).

Levels of the SPM and noise in non-greenspace: The levels of SPM ranged significantly ($p < 0.05$) from 109.08 ± 8.84 along Jibowu to 146.48 ± 13.53 µg/ m³ along Iyana-ipaja while noise ranged with no significant ($p > 0.05$) different from 70.80 ± 12.00 along Jibowu to 80.40 ± 8.65 dB along Iyana-ipaja (Table 6). Levels of SPM were lower than the limit: 150 – 250 µg/ m³ (EC, 2016). Lung function growth rate had been reported to change with relocation of children to areas with higher or lower levels than

before. Exposure to pollutants such as SPM and O₃ (ozone) had been found associated with increases in hospital admissions for cardiovascular and respiratory disease, as well as mortality in many cities in Europe and other continents (Ezzati, 2002).

Comparison of average levels of the assessed parameters in both areas: To compare levels of air quality and climate change possibility around both greenspaces and non-greenspaces, average value of each parameter was computed (Tables 7-9). Levels of average gaseous parameters were lower at the greenspaces than the non-greenspaces (Table 7). The greenspace areas had lower average temperature levels than non-greenspace (Table 8). Levels of the SPM were relatively high (Table 9). Average levels of all the parameters were observed to be higher around the non-greenspaces (Figure 2). From Table 7, the average levels of all the gaseous parameters were lower than the limits except CO₂: 14.68 ± 2.62 µg/ m³ which exceeded the limit: 10.00 µg/ m³.

Table 5: Results of the SPM and noise at the greenspaces

| | Ojota-Ketu | Anthony | Costain | Airport-Agege | (Olaleye, 2013) |
|---|----------------------------|----------------------------|---------------------------|----------------------------|----------------------|
| Area covered by trees (m ²) | 39, 161.30 | 15, 679.34 | 11, 750.25 | 42, 900.34 | |
| Parameters | | | | | Threshold |
| SPM (µg/ m ³) | 65.00 ± 7.00 ^a | 68.33 ± 7.23 ^{ab} | 78.33 ± 7.23 ^b | 58.33 ± 4.73 ^a | 150 – 250 (EC, 2016) |
| Noise (dB) | 61.00 ± 10.00 ^a | 63.00 ± 10.00 ^a | 67.00 ± 7.21 ^a | 59.00 ± 10.00 ^a | 70 dB (WHO, 2000) |

Values with the same superscripts along the row were not significantly ($p > 0.05$) different

Table 6: Results of the SPM and noise at the non-greenspaces

| Parameters | Mile 12 | Jibowu | Ojuelegba | Iyana-ipaja | Threshold |
|---------------------------|------------------------------|----------------------------|-----------------------------|-----------------------------|----------------------|
| SPM (µg/ m ³) | 127.78 ± 13.53 ^{ab} | 109.08 ± 8.84 ^a | 121.55 ± 13.09 ^a | 146.48 ± 13.53 ^b | 150 – 250 (EC, 2016) |
| Noise dB | 75.50 ± 12.00 ^a | 70.80 ± 12.00 ^a | 73.20 ± 12.00 ^a | 80.40 ± 8.65 ^a | 70 dB (WHO, 2000) |

Values with the same superscripts along the row were not significantly ($p > 0.05$) different

Average levels of SPM which serve as travelling medium for other related pollutants were high, though within the limit in both areas (Table 9). Levels of noise in both study areas were higher than the limit for human health: 70 dB (WHO, 2000).

Higher levels of pollution were observed around the non-greenspace than the greenspace areas (Figure 2). This might result from the anthropogenic activities, emissions from the increasing number of automobiles, time of the day when anthropogenic

activities were high coupled with the sunrise which influences urban heat island effects, an evidence of global warming. The risks of urban heat island are possibly high in large metropolis (DEFRA, 2002), with non-greenspace areas. The intensity of the urban heat island is typically at peak several hours after sunset and in the absence of greenspaces which would have provided cooling effects. Thus, there

would be higher levels of the criteria air pollutants (CO, SO₂, NO₂, O₃ and SPM) in the non-greenspaces. This in turn would increase levels of greenhouse gases and possible global warming effects. Therefore, this should create concern to general public that greenspaces mitigating measures which started in Lagos State before 2009 should be extended for its cooling effects.

Table 7: Average values of gaseous parameter in both study areas

| Gaseous parameter | Greenspaces | Non-greenspaces | Threshold |
|---------------------------------------|-------------|-----------------|-------------------------|
| CO (µg/ m ³) | 3.76 ± 1.23 | 4.70 ± 1.59 | 40 (EC, 2016) |
| CO ₂ (µg/ m ³) | 8.39 ± 1.50 | 14.68 ± 2.62 | 10 (EC, 2016) |
| NO ₂ (µg/ m ³) | 1.94 ± 0.84 | 2.57 ± 1.11 | 191 – 200 (EC, 2016) |
| SO ₂ (µg/ m ³) | 0.32 ± 0.54 | 0.46 ± 0.77 | 198.75 – 350 (EC, 2016) |
| VOC (µg/ m ³) | 2.08 ± 0.65 | 2.60 ± 1.66 | |

Values with the same superscripts along the row were not significantly (*p* > 0.05) different

Table 8: Average values of meteorological conditions in both study areas

| Meteorological conditions | Greenspaces | Non-greenspaces | Threshold |
|---------------------------|--------------|-----------------|------------------|
| Temp. (°C) | 41.25 ± 6.92 | 45.38 ± 7.26 | < 30 (DoH, 2008) |
| O ₂ (%) | 28.25 ± 2.74 | 21.73 ± 2.09 | |

Values with the same superscripts along the row were not significantly (*p* > 0.05) different

Table 9: Average values of SPM and noise in both study areas

| Parameters | Greenspaces | Non-greenspaces | Threshold |
|---------------------------|---------------|-----------------|----------------------|
| SPM (µg/ m ³) | 101.5 ± 26.19 | 189.34 ± 48.99 | 150 – 250 (EC, 2016) |
| Noise dB | 93.75 ± 37.21 | 112.50 ± 44.65 | 70 dB (WHO, 2000) |

Values with the same superscripts along the row were not significantly (*p* > 0.05) different

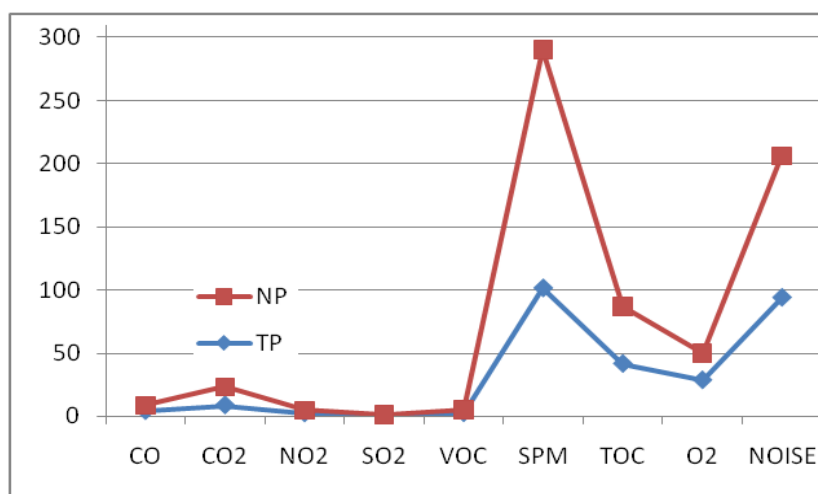


Fig 2: Graph of average values of the assessed parameters in both study areas NP = non-greenspaces, TP = greenspaces

Conclusions: Levels of CO₂, noise and temperature in Mile 12 and Iyana-ipaja (non-greenspaces) exceeded the limits. Pollution levels in the non-greenspaces were not only related to vehicle volume, human population and commercial activities but also attributed to pollutants not being sequestered. Tree planting activities to increase greenspaces should be seen as responsibility of every individual to improve aesthetic values of and care for the environment. Creation of greenspaces will make environment safe

and healthy through fresh and clean air, and abate possible effects of the global warming.

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