ASSESSMENT OF AIR QUALITY IMPROVEMENT POTENTIALS OF URBAN TREES IN KANO METROPOLIS, KANO STATE, NIGERIA

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ABSTRACT

The study aimed at assessing air quality improvement potentials of urban trees in Kano Metropolis. Air pollutants considered include; CO, and CO_2. Temperature and relative humidity were also monitored. Sampling sites were identified and mapped out across the Metropolis using the ArcGIS software tool, the sampling sites where geo referenced using high sensitivity etrexgarmin GPS. Pollutant concentration and temperature were monitored using Air Quality kit in the sampling sites with many trees and sampling sites with few trees for a period of twice a day (morning and evening), three days a week for four weeks. Data were analyzed descriptively, while T test and ANOVA were carried out to determine if there is a significant difference between the sampling sites. The result obtained showed variations in the study area, where sites with many trees have lower concentration of pollutants and temperature than sites with few trees. The analysis indicated that there is a significant difference in the amount of air pollutant and temperature between sampling site with many trees and sites with few trees. This study has demonstrated that urban trees reduce the concentration of air pollutants and temperature in Kano Metropolis, thus improving urban air quality and consequently improve human health. The study recommends serious tree planting programme, review and enforcement of laws, harmonization and synergy between responsible authorities.

Keywords: Air, Quality, Improvement, potentials, Urban, Trees

INTRODUCTION

According to Inter governmental Panel on Climate Change 2007, two major activities through which humans have continue to increase the amount of GHG (greenhouse gases) in the atmosphere are; continuous burning of fossil fuel and deforestation (Nowak *et al.,* 2006).

Current urban development alongside increasing population density in many urban areas worldwide has raised concerns about reduced urban environmental quality and quality of life of urban dwellers as a result of road constructions, buildings and other parts of the built environment are absorbing volumes of urban vegetation, as trees and grasses often lack priority within urban planning. As a result, trees are disappearing from urban and peri urban areas (UN-Habitat 2012).

Nigeria's urban population has expanded rapidly over the past 50 years and will continue to grow relatively fast in the coming decades (Bloch *et al.,* 2015). Kano Metropolis is among the mega cities in sub Saharan zone and in Nigeria that witnessed rapid expansion of population spatially.

Studies have shown that the major factor threatening sustainability in the built environment is decreased vegetation cover, urban environmental problems associated with loss of vegetation cover include; concentration of harmful gasses usually emitted from high volume traffic and industrial activities, high rise in temperature

(Urban Heat Island) and exacerbating climate change (Newman and Kenworthy, 1999).

For the past few decades, anthropogenic activities likes urbanization, deforestation, population explosion, industrialization and the release of greenhouse gases and particulate matter (PM) are the major contributing factors to the depletion of the ozone layer and its associated global warming and climate change. Particulate matter (PM) is both a major driver of climate change and a source of toxicity for health. Most critical effects are observed in ambient air, where particulate matter degrades human health (Mukherjee and Agrawal, 2017). Therefore, urban air pollution is a major environmental concern in most major cities around the world.

Urban trees may provide several air quality benefits and, one reason for this is that compared to hard surfaces; pollutant uptake by plants is much higher. Trees remove gaseous air pollution primarily by uptake through 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 (Nowak *et al.,* 2006).

Trees also remove pollution by intercepting airborne particles. Some particles can be absorbed into the tree. However, most particles that are intercepted are retained on the plant surface. These intercepted particles are often re-suspended to the atmosphere, washed off by rain, or dropped to the ground with leaf and twig fall. Therefore, vegetation is only a temporary retention site for many atmospheric particles (Nowak, *et al.,* 2006).

Trees have the potential to reduce energy use by lowering temperatures and shading buildings during the summer, and blocking wind in winter (Killicoat *et al.,* 2002). Trees can cool buildings both by providing direct shading and through evapo-transpiration. Benefits vary based on species selection and the orientation and size of the plantings, as well as their distance from a building (US EPA, 2013).

Urban vegetation can directly or indirectly affect urban air quality, by altering meteorological conditions, lowering local temperature, blocking solar radiation and by affecting wind characteristics with influences on air dispersion (Givoni *et al.,* 2003). Vegetation also influences dry deposition of gases in earth surface, enhancing removal of air pollutants by uptake via leaf stomata and cuticular surfaces. Trees also remove pollution by intercepting airborne particles in the atmosphere (Shashua-Bar and Hoffman, 2004). Urban forests have also been identified as relevant sound attenuation barriers, control erosion, mitigate flooding, reduce energy consumption, influence thermal comfort, restore and protect biodiversity, carbon sequestration, soil protection, wind breakers, significantly decreases urban heat island, access to nature and improving general human wellbeing.

Kano State is one of the megacities in West Africa with a population of about 9,383,682 (Muktar *et al*., 2010). Kano state is characterized by rapid population growth and developments, presence of atmospheric gasses and particles, noticeable rise in temperature and significant disappearance of urban forests. Deforestation, increase in air pollutants and energy consumption have been identified as the causes of rise in urban air temperature (Nurruzzaman, 2015).

A study on ambient air quality assessment in South East Nigeria reveals that the mean concentration of the air pollutants obtained exceeded the Nigerian National Ambient Air Quality Standards (NAAAQS) and the United States National Ambient Air Quality Standards (NAAAQS) except for few stations (Ibe *et al*., 2016). A study conducted in Ogbomoso, South West Nigeria on the role of mobile source emissions on air quality through well-designed studies reveals that SO2, NOx and CO pollutants concentrations were above the permissible limits set by both the Nigerian Environmental Protection Agency (EPA) and the United States Environmental Protection Agency (USEPA) for some sampling locations and within the set standards for other locations (Ojo and Awokola, 2012).

In most developing countries of the world vehicular growth has not been checked properly by environmental regulating authorities leading to increased levels of pollution as observed in a related study done in Kano, North West Nigeria that reveals that traffic emissions in Kano Metropolis produce air pollutants (NO2, SO2, NH3 etc), at some sites were above the AQI stipulated by USEPA especially during the dry seasons (Okunola *et al.,* 2012). Abam and Unachukwu., (2009) reported the AQI level of the air pollutants PM10, SO2, NO2 and CO studied in Calabar, Nigeria were significant having possible severe consequences. In a similar study at Ilorin and Lagos on air pollution, findings reveals that pollutants contribute to tropospheric ozone formation (Abdulraheem, 2009).

Most of these researches have reported the concentration of pollutants in the environment, but there has been least investigation on air quality improvement potentials of urban trees. Therefore, it is against this background that this study is set to assess air quality improvement potentials of urban trees in Kano Metropolis, with the view of providing possible recommendations so as to safeguard the Environment.

MATERIALS AND METHODS

Study Area

Kano lies between latitude 11° 57 ˈ 0ˈˈ N to 12° 2 ˈ 0ˈˈ N and 8° 29 ˈ 0ˈˈ E to 8⁰ 33 ˈ 0ˈˈ E is the capital city of Kano state in Northern Nigeria also the capital of the great Kano Emirate, in the Sahelian geographic region south of the Sahara. The Kano urban core areas covers 137km^2 and comprises six Local Government areas of Kano Municipal, Fagge, Dala, Gwale, Tarauni, and Nasarawa. Kano is 481meters above sea level. Over time the city of Kano through urbanization has witnessed rapid urban growth, swift urban expansion and complexity of urban system.

Methods

This study adopted purposive sampling technique to select the sample sites of the study. ArcGIS software tool was used to identify and mapped out the sampling sites across the Kano urban core, with two sample sites, (one with trees and a counterpart with fewer trees) in each of the six local government areas only for Kano Municipal that is having four sample sites (two with much trees and two with fewer trees) making a total of fourteen sampling sites, seven with trees and seven with relatively fewer trees. The ambient air pollutants; CO_2, and CO were measured continuously using the air quality monitoring kit across the fourteen sampling sites for three days a week, twice a day for one month, October 2019. During data collection, pollution sources were avoided such as busy roads, industrial sites, generators and burning sites. Environmental parameters such as air temperature and relative humidity were as well monitored with the help of the meteorological data device: AZ7755 Temp. RH. CO2. Measurements were taken within three hours in the morning (6am-9am) and within three hours in the evening (3pm-6pm) each day. The sampling sites were geo-referenced using the high sensitivity etrexgarmin GPS (Global Positioning System). The data was analyzed using the Microsoft Excel and Statistical Package for Social Sciences. The mean was determined for all the pollutants and temperature for all the sampling sites for all the days. T-test analysis and ANOVA were used to determine the significant difference between the sampling sites.

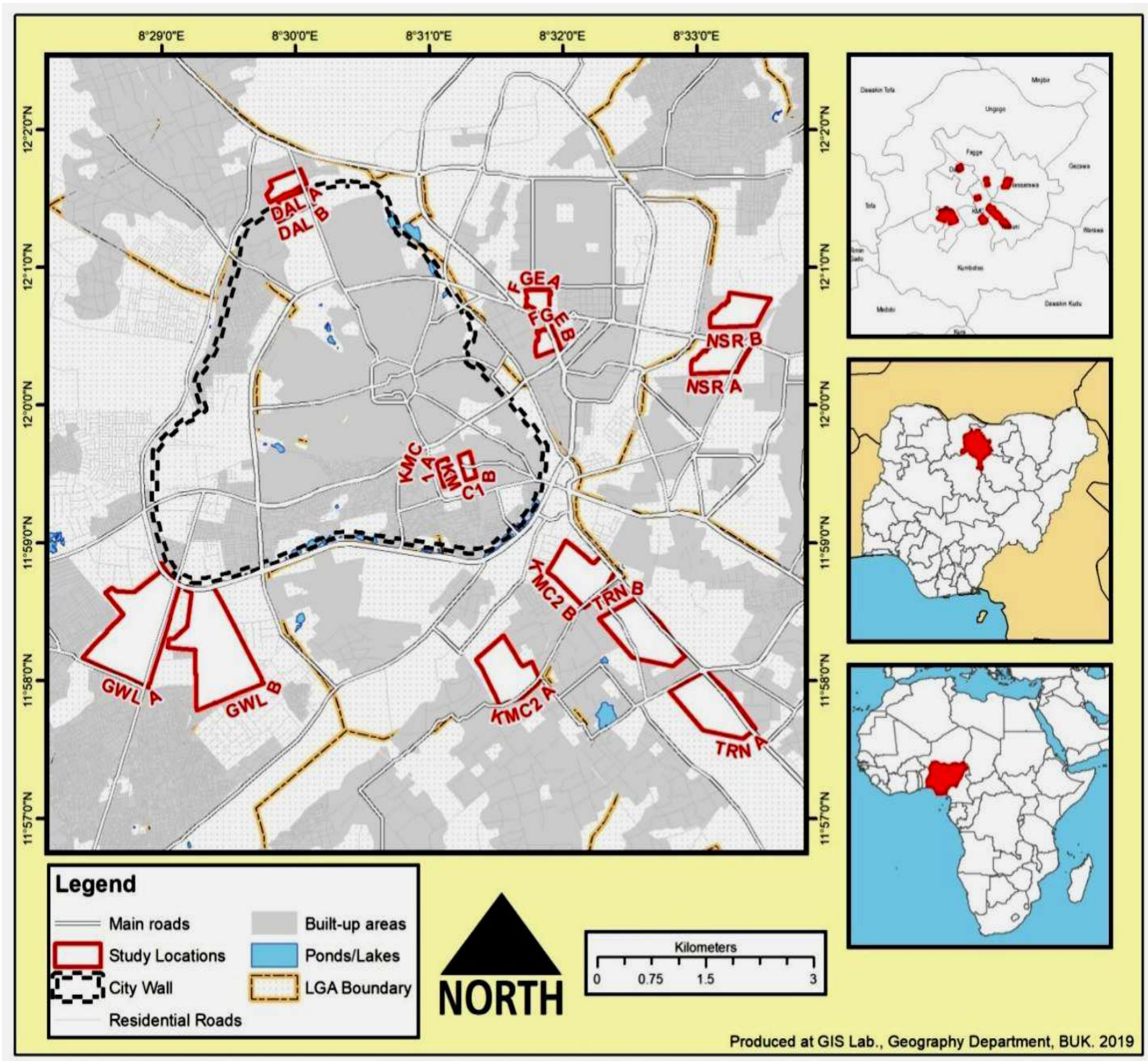

Figure 1: Map of Kano Metropolis Showing Sample sites

Source: (GIS Lab, Geography Department, BUK 2019)

Table 1: Characteristics and location of study sites

L.G.A	CO-ORDINATES		FEATURES	AREA(m2)/ NO. OF TREES	LANDUSE
KMC1					
A	N11'59.444'	E008' 31.127'	Cluster of trees	53882.8/302	Institutional
B	N11'59.576'	E008'31.251'	Few trees	53882.8/46	Residential
KMC2					
A	N11'57.954	E008'31.670'	Many trees	423635/1792	Recreational
B	N11'58.671	E008'32.190'	Fewer trees	423635/276	Commercial
TARAUNI					
A	N11'57.726'	E008'33.034'	Many trees	541067/1231	Institutional
B	N11'58.129'	E008'32.738'	Fewer trees	5410677/693	Residential
NASARA			Many trees		
WA	N12'00.402	E008'33.081'	Fewer trees	258383/522	Recreational
A	N12'00.622	E008'33.185'		258383/393	Residential
B					
FAGGE	N12'00.747'	E008'31.834'	Cluster of trees	89876.3/593	Institutional
A	N12'00.451'	E008'31.799'	Few trees	89876.3/79	Residential
B					
DALA					
A	N12'01.581'	E008'29.934'	Cluster of trees	118439/328	Commercial
B	N12'01.424	E008'30.661'	Few trees	118439/97	Residential
GWALE					
A	N11'58.682'	E008'28.681'	Many trees	1051190/1934	Institutional
B	N11'58.390'	E00.8'29.271'	Fewer trees	1051190/832	Residential/ Institutional

Source; Field work 2019

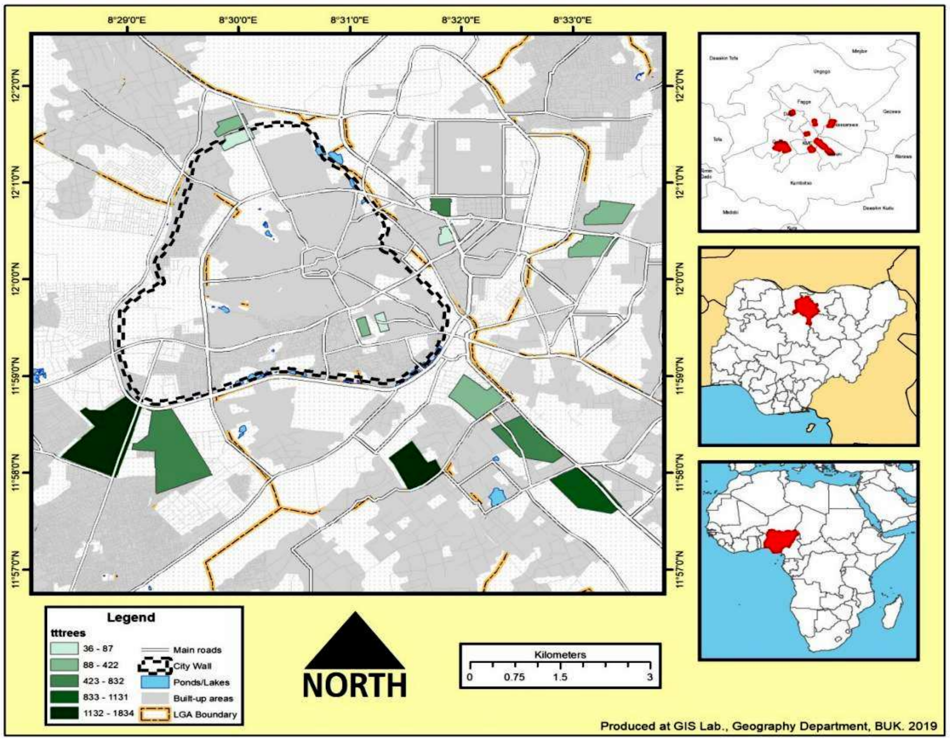

Figure 2: Map of Kano Metropolis Showing Tree Density across Sample Sites.
Source: (GIS Lab, Geography Department, BUK 2019)

RESULTS AND DISCUSSION

Table 2: The Mean Concentration of CO_2 at different Sampling Sites of the different Local Government Areas at different time of the Day

CO_2 (ppm) Local Govt	**Morning A**	**Morning B**	**Evening A**	**Evening B**
KMC1	414.5	423.6	407.4	419.1
KMC2	410.3	416.3	401.1	411.8
NSR	426.0	437.3	412.5	416.9
GWL	423.2	433.8	409.6	410.2
DAL	435.8	427.2	419.6	416.9
FGE	415.5	401.8	416.7	434.8
TRN	413.6	420.3	403.9	413.3

Source; Field work 2019

A-Sampling sites with Many tree
B- Sampling sites with few trees

Table 2 showed CO_2 level at DAL A sample site in the morning to be 435.8ppm, and it is the highest despite having much trees in site. This might probably be as the result of the market activities in the sample site. KMC2 A sample site in the evening has the lowest CO_2 level of 401.1ppm, and this can be due to the fact that it has a high tree density thus, high rate of photosynthesis. Generally, CO_2 levels are lower in sample sites with much trees than in those with few trees and lower in the evening than in the morning. However the CO_2 level in all the samplin g sites is within the 350ppm-1000ppm typically found in occupied spaces with good air exchange.

Table 3: The mean Concentration of CO at different Sampling sites of the Different Local Government Areas at different time of the day

CO (ppm) Local Govt	Morning A	Morning B	Evening A	Evening B
KMC1	2.3	2.9	2.8	3.0
KMC2	1.8	2.8	2.3	2.8
NSR	2.3	2.7	2.5	3.0
GWL	2.0	2.3	2.4	2.5
DAL	2.0	2.6	1.9	2.5
FGE	1.9	3.4	2.0	3.3
TRN	2.6	3.0	2.6	2.8

Source; Field work 2019

A-Sampling sites with much trees
B- Sampling sites with few trees

Table 3 showed that CO levels in sampling sites with many trees are generally lower than sampling sites with few trees, with FGE B morning and FGE B evening having the highest, 3.4ppm and 3.3ppm respectively. KMC2 A morning having the lowest with 1.8ppm. The CO levels in densely treed areas are low probably because of the concentration of oxygen (O_2) due to high photosynthesis activity, the CO readily reacts with the O_2 to form CO_2, consequently reducing the amount of CO in the area. The trees absorb the CO_2 and give out O_2, and the chain chemical reaction continues. This corroborate the finding done by the United States Environmental Protection Agency, 2020 that stated that trees help reduce the potential adverse health and environmental effects of CO by removing it from the air.

Table 4: The mean Temperature at different Sampling Sites of the different Local Government Areas at different time of the day

Local Govt	Morning A	Morning B	Evening A	Evening B
KMC1	29.0	33.2	30.0	35.0
KMC2	28.8	35.8	29.2	34.9
NSR	25.3	27.3	28.9	34.3
GWL	24.9	27.2	30.6	35.9
DAL	26.7	31.1	31.4	35.2
FGE	27.8	33.1	30.9	36.1
TRN	30.3	34.6	29.4	33.9

Source; Field work 2019

A-Sampling sites with many trees

B- Sampling sites with few trees

Table 4 showed the mean temperatures of sampling sites with much trees and sampling sites with few trees in the month of October. This is the warm and dry period where humidity and temperature have the highest impacts, due to the calm tropical air mass and period of transition between rainy season and dry season (Alhaji 2015). Temperatures at sampling sites with many trees are significantly lower than those of sampling sites with fewer trees.

Table 5: The mean Relative Humidity at different sampling site of the different Local Government Areas at different time of the day

Relative Humidity				
Local Govt	**Morning A**	**Morning B**	**EveningA**	**Evening B**
KMC1	61.0	46.3	47.8	36.4
KMC2	54.3	39.3	57.0	37.0
NSR	77.2	68.3	48.8	39.4
GWL	76.1	63.5	48.4	35.1
DAL	66.6	49.9	43.6	34.3
FGE	62.2	45.9	44.5	34.7
TRN	59.7	39.0	51.2	38.6

Source: Field work 2019

A-Sampling sites with many trees

B- Sampling sites with few trees

Table 5 showed the mean relative humidity of sampling sites with much trees is higher than those of the sampling sites with few trees. It is one of the cooling effects of trees, the higher the relative humidity the lower the temperature and vice versa. Relative humidity and temperature are directly related to tree density. A similar study conducted by Okhakhu, (2018) in Benin reported high humidity values between 84.40% - 80.85% which is slightly higher than observed in this study.

Table 6: t-test values for sampling sites with much trees and sampling sites with few trees in the morning and evening in Kano metropolis.

Parameters	**Morning A – Morning B**	**Evening A – Evening B**
CO_2	0.449	0.033*
CO	0.208	0.019*
TEMP	0.001**	0.000**
RH	0.000**	0.000**

*Significant at = 0.05, **Significant at = 0.001
A-Sampling sites with much trees
B- Sampling sites with few trees
Source: Field work 2019

The t test values presented in table 6 revealed that there is a significant difference in the atmospheric CO_2 and CO in the evening between sampling sites with much trees and sampling sites with few trees, this might be attributed to certain factors like the light independent process of photosynthesis, carbon dioxide concentration and temperature. Temperature and relative humidity show significant difference even at higher level of significance 0.001 both in the morning and evening due to absorption and depletion of solar energy by trees, indicating the effectiveness of urban trees in lowering air temperature.

Table 7: ANOVA Comparison of pollutants and temperature levels between Sample Sites with much Trees and Sample Site with Few Trees and the time of the day (Morning and Evening) in Kano Metropolis.

Parameters	**F**	**Sig.**
Temp	16.229	.000
CO_2	2.503	.083
CO	9.010	.000
RH	16.972	.000

Source: Field work 2019

Table 7 showed that there is a statistically significant difference (since the p-value is less than 0.05) between temperature, relative humidity and CO, between sample sites with much trees and sample sites with fewer trees and also between morning and evening hours in Kano metropolis. But there was no statistical difference for CO_2 (as the p-value is greater than 0.05).

Table 8: ANOVA Results for difference in Pollutants and Temperature Levels Between the Local Government Areas in Kano Metropolis.

Parameters	F	Sig.
CO_2	1.760	.283
CO	4.143	.042
Temp	.353	.887
RH	.158	.981

Source: Field work 2019

The result indicated in Table 8 Showed that there was no statistical significant difference (since the p-value is greater than 0.05) in CO_2, temperature and relative humidity between the Local Government Areas in Kano Metropolis, this might probably be as the result of careful selection of sample sites as purposive sampling was used. Mean while there was a significant difference in CO concentration between the Local Government Areas in Kano Metropolis.

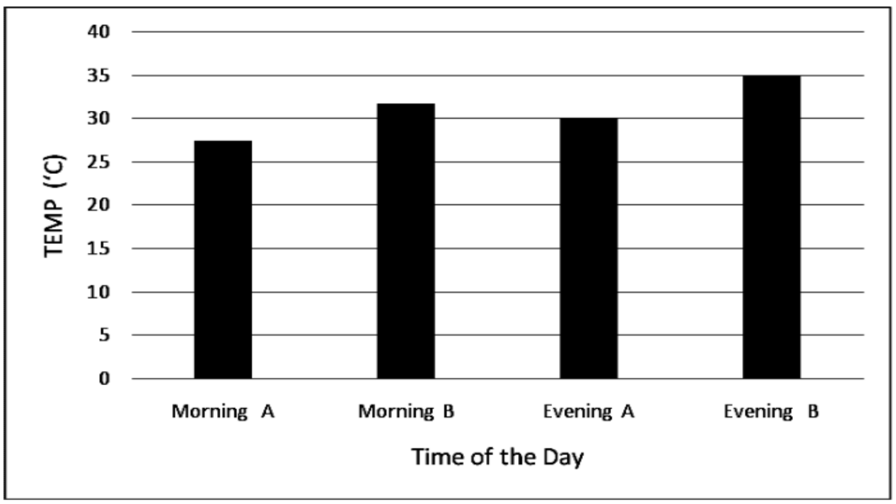

Figure 3: Temperature levels in Kano Metropolis

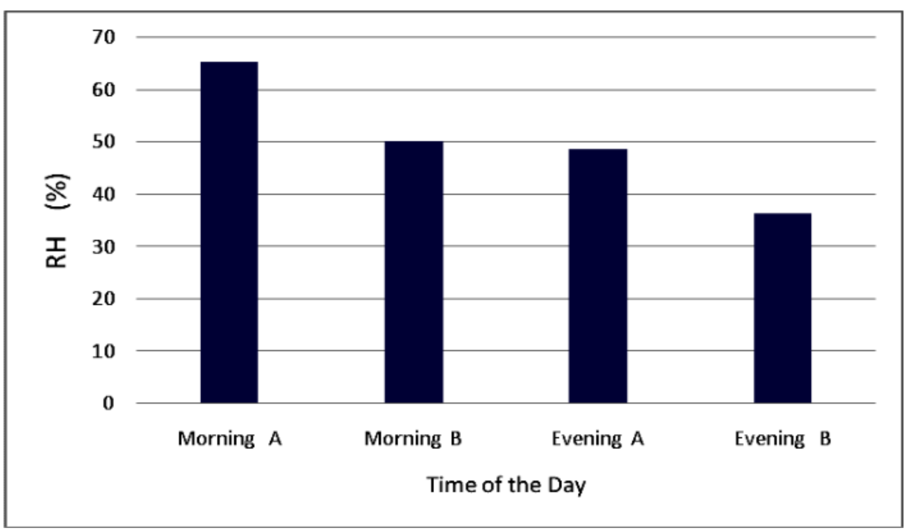

Figure 4: Relative humidity levels in Kano Metropolis

The Figures above showed the comparison of the levels of pollutants and temperature in Kano metropolis The figures show the physical and statistical difference between trees vegetated areas and areas with few trees in Kano metropolis. The study reveals that CO_2, CO, and temperature are generally lower at tree vegetated areas than area with fewer trees, that is to say air quality of tree area are relatively higher than areas with few trees, thus trees have a significant role in improving air quality

CONCLUSION

In this study, there is an over whelming evidence that urban trees reduce air pollutants in an urban environment and significantly reduce urban temperature. The findings from this study showed that the concentration of these air quality parameters were higher in places with fewer trees when compared to places with much trees. Moreover, it was observed that the concentration levels of these pollutants are within normal range. Result from this study showed no significant effect in absorption of CO and CO_2 from the atmosphere by trees, but it has shown relatively significant effect in temperature reduction. Urban trees therefore deserve and require attention in the urban planning realm to ensure environmental protection, restoration and promotion of sustainable use of urban ecosystem. The study recommends the need for continuous public enlightenment on the air quality of their environment, how it relates to their health and the important role of trees or vegetation in improving the air quality of their environment. Through which individual residents will be encourage to plant and care for trees in their homes and places of work, and avoid unnecessary destruction of existing trees.

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