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Emissions of Vehicular Traffic along Uhuru Highway Corridor in Nairobi

Jimbo Kaunda Kenneth[1], S. K. Mwea[2] & S. O. Dulo[3]

Abstract

This paper presents the results of the study on Uhuru Highway Corridor, a road segment of the northern corridor (A104) in Nairobi city. It is one of the busiest and congestion-prone highway in Nairobi, covering approximately 3.7 kilometers spanning between Lusaka roundabout and the museum hill interchange. The levels of urban air pollution correlates with vehicular emissions with the air pollutants from on-road vehicles Carbon monoxide,(CO),Nitrogen dioxide (NO), Sulphur dioxide (SOx),Total volatile organic compounds (TVOC), Hydrocarbons (HCHO) and Particulate matter of diameter 2.5 microns (PM2.5) which are a health concern that were investigated in ambient air pollutants along the corridor. A systematic study with concurrent measurements of CO, NOx, SOx, PM2.5, HCHO and TVOC in ambient air at two different locations, near Railway Underpass (NRU 01) and University of Nairobi Pedestrian Tunnel (UNPT 02) was done. Traffic Volume reduced from Monday to Saturday with an average daily traffic (ADT) of 49108 for station NRU 01 and 40723 for station UNPT 02.PM2.5. HCHO, SOx, CO and TVOC, all decreased with decrease in vehicle Volume. However, NOx which increased with decrease in vehicle volume was due to the increase of heavy commercial vehicles across the station. The ambient vehicular pollutions for the corridor were within the limits of World health organization (WHO) standards of (10mg/m3) with an exception on PM2.5which was found to be 18.39mg/m3 and 18.56mg/m3 for stations NRU 01 and UNPT 02 respectively. The government policy on vehicle emissions and pollution mitigation should be operationalized and Vehicle Traffic Emissions Policy and Regulatory framework adhered to.

Key words: Traffic emissions, Particulate matter, hydrocarbons, carbon monoxide, Sulphur dioxide, total volatile organic compounds.

1. Introduction And Study Area

Uhuru Highway Corridor, is a road segment of the northern corridor (A104) in Nairobi the capital city of Kenya situated 140 kilometers south of equator and 500 kilometers west of the Indian Ocean at 1°17'S36°49'E. It occupies 696km² at an altitude of 1,661 meters above sea level as shown in Nairobi countywebsite, (2016).
The Plate 1.2 shows the study area.

Plate 1.2: Location of the Study Area Source: (Author 2020) Google map.

[1] Department of Civil and Construction Engineering, University of Nairobi, Kenya, E-mail:kaundajimbo@hotmail.com
[2] Department of Civil and Construction Engineering, University of Nairobi, Kenya, E-mail:smwea@uonbi.ac.ke
[3] Department of Civil and Construction Engineering, University of Nairobi, Kenya, E-mail:sodulo@uonbi.ac.ke

2. Methodology

The study included review of existing information and techniques used in data collection and sample size, heavy rains were experienced during the study. Traffic data survey was conducted at the two identified sites within the study area, the first site was identified as NRU 01 road side near Nairobi railways underpass and second site as UNPT 02 near the University of Nairobi pedestrian tunnel. The peak and off-peak hours of motorized traffic counts were considered during the week at 15 minutes' interval from 11th to 16th, September 2019 from 6:00am to 6: 00pm.

2.1 Tools and Data collection

Parameters measured using the equipment and measurement of the pollutants

The PM2.5 was measured by DM 201PM2.5 Air Quality Detector, the machine had 2.8" FTF LCD Display, support 320 × 240 Pixel, high speed ARM Control Program, easy to operate with testing holes designed to provide cross ventilation and handheld design making it convenient to detect air within a short test time. The PM2.5 Particle valid range was: 0-500μg/m^3 with a charging voltage of 5V/1A, it also measured HCHO and TVOC. The TVOC test had arange:0.000-9.999mg/m^3,semiconductor sensor sample type, a diffusion concentration unit: mg/m^3 test time of 5 minutes with a test range of: 0-999μg/m^3.The BOSEAN equipment was used to measure, Nitrogen oxide, Sulphur dioxide and Carbon monoxide, it had an adjustable calibrating level, self-adjustment function, visual and audible alarm with vibration, advanced self-examination and self-renovation function. The sampling method was diffusion type with environmental condition of humidity 5% to 95% relative humidity non-condensing. The detecting range of CO was 0.1000ppm, accuracy of 3%, response time 10 seconds, repeatability 1% with 1% zero drift.

Measurements of CO, NOx, HC, PM2.5, TVOC and SOx

Air pollutants were measured at approximately 2.0 m height above the ground level. The PM2.5 was measured by DM 201PM2.5 Air Quality Detector, the machine had 2.8" FTF LCD Display, support 320 × 240 Pixel, high speed ARM Control Program easy to operate. The PM2.5 Particle valid range was0-500μg/m^3 with a charging voltage of 5V/1A.The Table 3.2 shows in summary the Geometric Characteristics of the study area.

3. Results, Analysis And Discussions

3.1 Traffic analysis

The speed and traffic flow studies included gathering data of traffic flow on a stretch of Uhuru Highway Corridor between the University Way roundabout and the Kenyatta Avenue roundabout for the speed surveys and the volume counts. The length considered was 200m. The average daily traffic (ADT) station NRU 01 was 49108and UNPT 02 40723 respectively.

3.2 Traffic Volume -versus Emissions

A summary of Vehicle Traffic Volume -versus Emissions for Nairobi railways underpass NRU 01 station in both direction - A (Approach from Nyayo Exit to CBD) and B (Approach from CBD Exit to Nyayo).

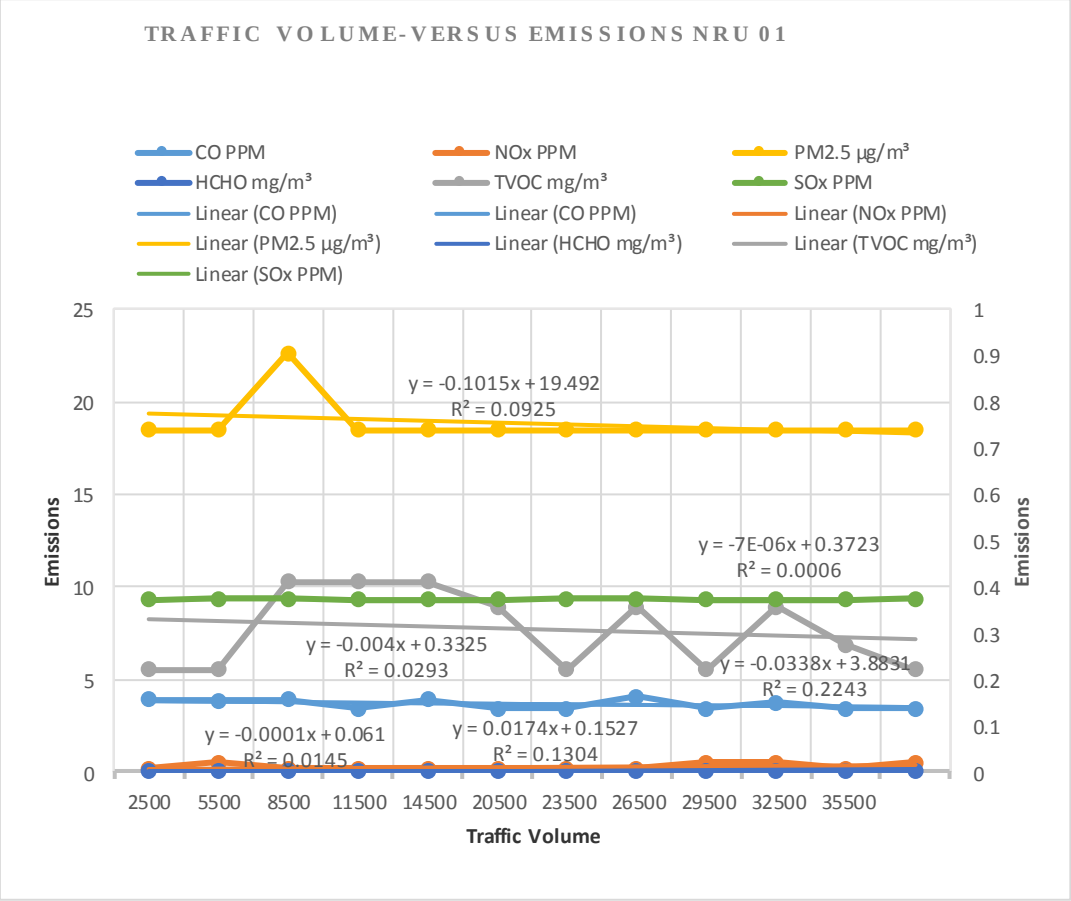

Figure 3.1: Traffic Volume - versus Emissions NRU 01 (Author, 2019).

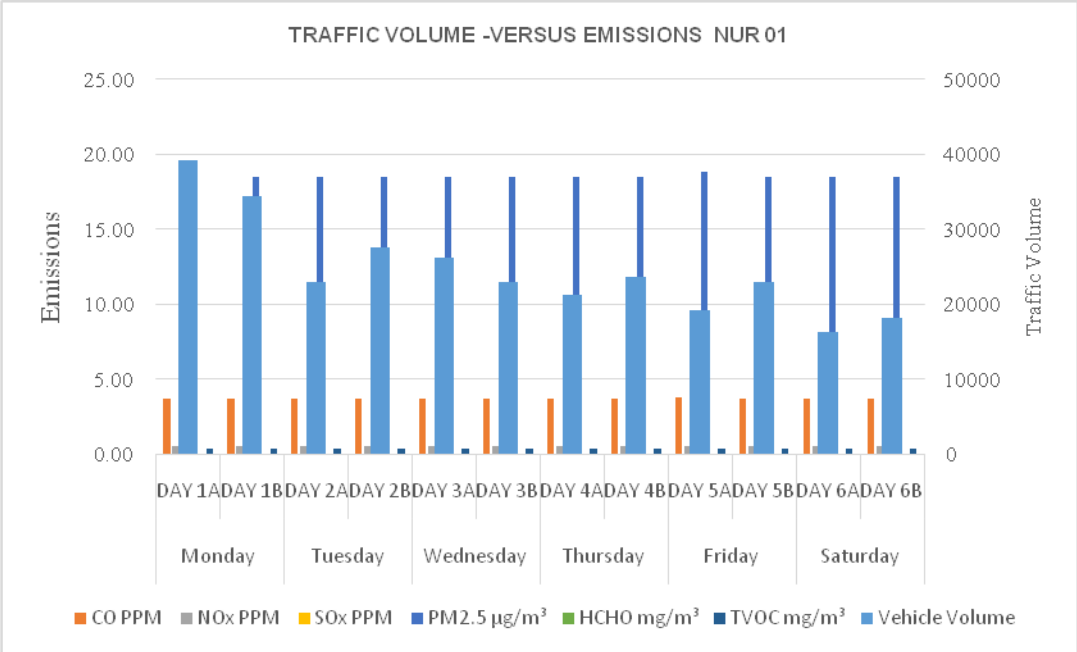

Figure 3.2: Traffic Volume - versus Emissions NRU 01 (Author, 2019).

A summary of daily Traffic Volume -versus Emissions trend for Nairobi railways underpass station NRU 01

The summary of trends for station NRU 01 indicate the followings:

1) PM2.5. HCHO, SOx, CO and TVOC, all decreased with decrease in vehicle volume. However, NOx which increased with decrease in vehicle volume. It was found out that as volume of traffic decreased from Monday to Saturday, the increase of heavy commercial vehicles across the NRU 01station contributed to increase in NOx.

2) Traffic volume may have reduced due to personal vehicle owners switching to public transport as a result of heavy rains confirmed by traffic level of service mostly at LOS F causing heavy traffic jams.
A summary of Vehicle Traffic Volume-versus Emissions for University of Nairobi Pedestrian Tunnel UNPT 02 station in both direction - A (Approach from CBD Exit to West lands) and B (Approach from West lands Exit to CBD).

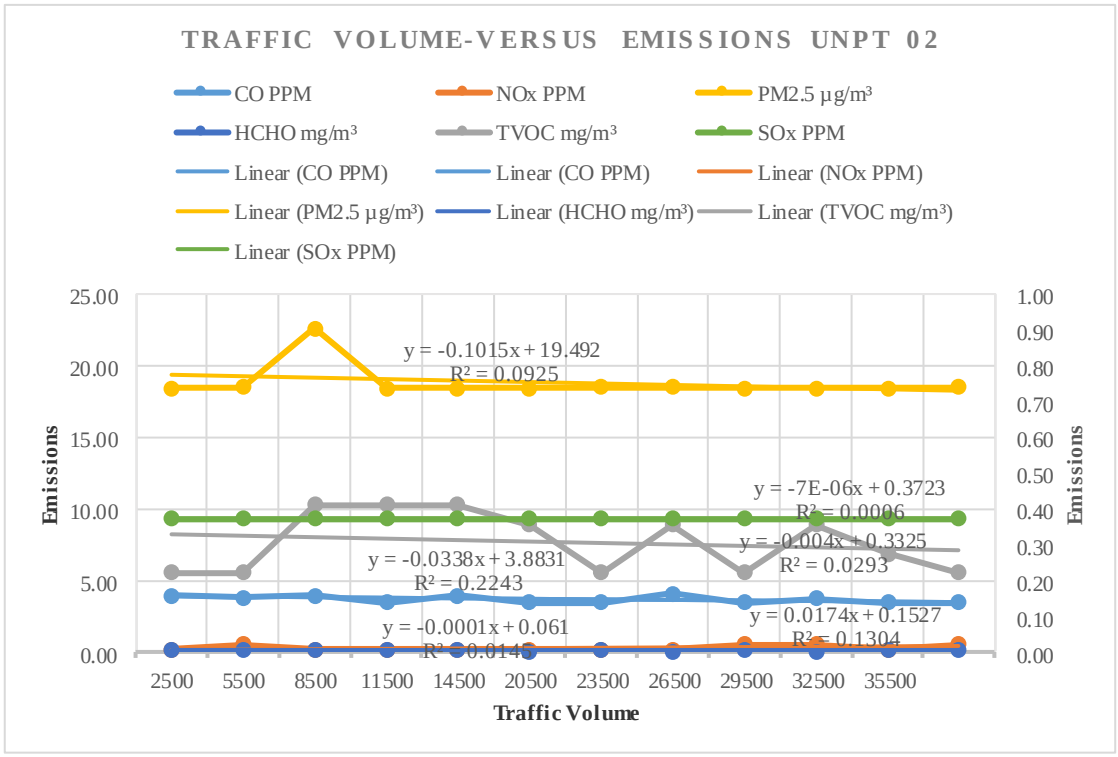

Figure 3.3: Traffic Volume -versus Emissions UNPT 02 (Author, 2019).

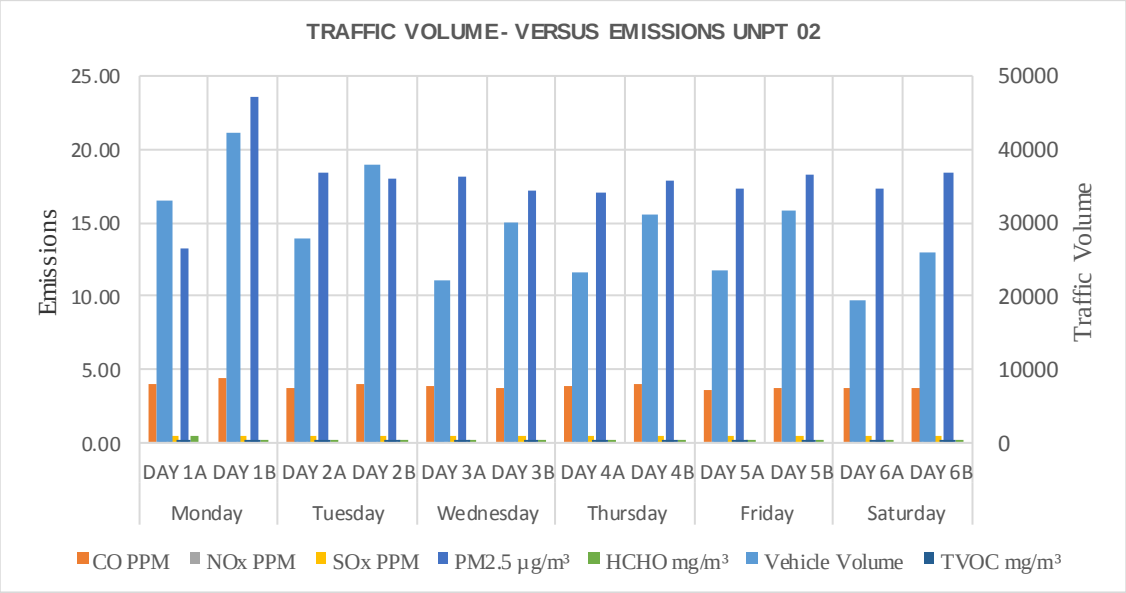

Figure 3.4: Traffic Volume - versus Emissions UNPT 02 (Author, 2019).

A summary of daily Traffic Volume - versus Emissions trend for Nairobi railways underpass station UNPT 02
The summary of trends for station UNPT 02 indicate the followings:

1) PM2.5. HCHO, SOx, CO and TVOC, all decreased with decrease in vehicle volume. However, NOx which increased with decrease in vehicle Volume. It was found out that as volume of traffic decreased from Monday to Saturday, the increase of heavy commercial vehicles across the UNPT 02 station contributed to increase in NOx.

2) Traffic volume may have reduced due to personal vehicle owners switching to public transport as a result of heavy rains confirmed by traffic level of service mostly at LOS F causing heavy traffic jams.

Table 3.1and 3.2 presents the results of ambient emissions of CO, SOx, NOx, HCHO, TVOC, and PM2.5 at two measuring sites namely road side near Nairobi railways underpass NRU 01 and near the University of Nairobi pedestrian tunnel UNPT 02. On the basis of 1 hour measured observations the lowest value of PM2.5 at NRU 01 site was at 18.39μg/m^3 and the highest being UNPT 02 site at 18.56μg/m^3 which were found to be above the tolerable level of 10mg/m^3. It was additionally found that CO values were 3.72ppm for NRU 01 and 3.76ppm for UNPT 02. SOx for the two sites NRU 01 and UNPT 02 was 0.37ppm.Volatile Organic Compounds (TVOC) for the sites were highest at NRU 01 at 0.36ppm and least at UNPT 02 at 0.32ppm. Nitrogen dioxide (NOx) was least at UNPT 02 at 0.32ppm and highest at NRU 01 at 0.50ppm. 10). Sulphur dioxide (SOx) was 0.37ppm for the two sites NRU 01 and UNPT 02.

Table 3.1: Air Quality PM2.5 (Particulate Matter Levels)

Sampling Location	Dust Concentration Levels PM2.5 (Mg/m^3)	Tolerable Levels PM2.5 (Mg/m^3)	Remarks
Near railways underpass NRU 01	18.39	10	Above the Limit
University of Nairobi pedestrian tunnel UNPT 02	18.56	10	Above the Limit

Table 3.2: Air Quality (Emission Level)

Location	Carbon Monoxide (CO)	Sulphur Dioxide (SOx)ppm	Volatile Organic Compounds (TVOC)	Nitrogen Dioxide (NOx)ppm	Comments
NRU 01	3.72	0.37	0.36	0.50	Within the limit
UNPT 02	3.76	0.37	0.32	0.32	Within the limit
TLV	10ppm	0.125mg/m^3	70ppm	0.150mg/m^3	Within the limit

3.3 Discussion

From the obtained results at the two sites of data collection, there was an indication of an averagely values of pollution. It can be deduced that the site NRU 01, had the lowest value of ADT 49108 followed by, UNPT 02 with ADT 40723. The highest levels of CO measured for the NRU 01 and UNPT 02 could be attributed to the high traffic flow of vehicles of different types with reduced speeds (Vo = 26 Kph and Vmax = 2Vo = 52Kph leading to high ambient air pollutants.

4. Conclusions And Recommendations

4.1 Conclusions

1) The trends determined that, the ambient vehicular pollutions within Uhuru highway corridor (NRU 01 and UNPT 02) depended on the vehicle Volume. PM2.5. HCHO, SOx, CO and TVOC, all decreased with decrease in vehicle volume, with an exception of NOx.
2) The ambient vehicular pollutions for the corridor were within the limits of WHO standards of (10mg/m^3) with an exception on PM2.5 which was found to be 18.39mg/m^3 and 18.56mg/m^3 for stations NRU 01 and UNPT 02 respectively.
3) The stationsNRU01 and UNPT 02had ADT of 9108 and 40723 respectively, Traffic Speed was averagely 52Kph with most of its stretch operating at LOS F.

4.2 Recommendations

The pollution control should be managed from source by improving vehicle design and maintenance, patronage of public transportation system, alternatives means of transportation, staggering working hours to reduce the number of vehicles and traffic congestions, restraining parking areas within the central business districts and stopping engines from running during traffic congestions.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.