Monitoring tropospheric airborne particles along a section of the busiest road in East and Central Africa (Thika road, Kenya) using low-cost monitors

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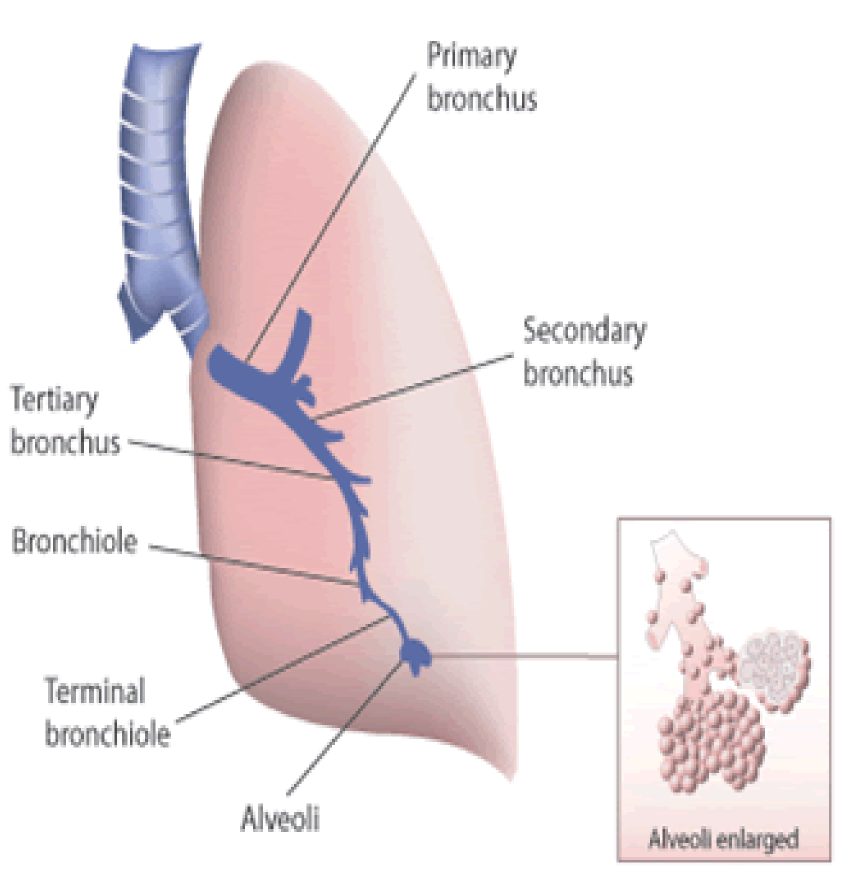
Introduction

- Air pollution – substances; gases, aerosols and particles
- Vehicular traffic, mining, residences & industrial activities (Mutua et al., 2021).
- Cancer, asthma, eye problems and respiratory problems esp. the young and elderly (Lai et al., 2016).
- Kenya - increased number of vehicles & industrial emissions (Mutua et al., 2021).
- A growing economy with a young population
  - Improved road networks
  - Increased access to car loans
  - Old vehicles – used cars
- Thika road - daily traffic load of close to 150,000 vehicles (KENHA, 2021).

Traffic along Thika Road

Literature Review

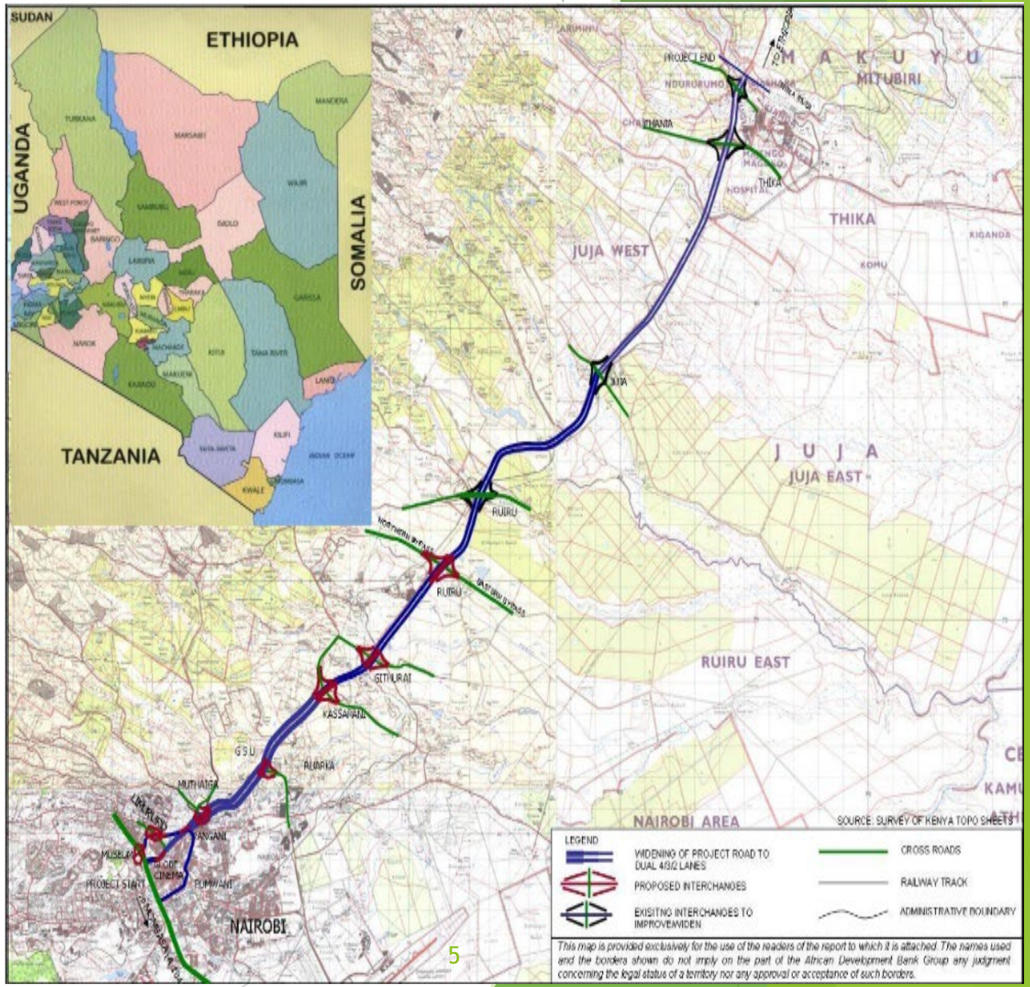
- PMs - adverse effects on human health
- Fine particles pose higher health risk compared to larger ones (Zanobetti et al., 2009; Bell et al., 2007; Lai et al., 2016).
- PMs persist in the air - reduced visibility.
- Air Quality regulations of 2014.
- Guidelines are poorly enforced
- PM_{10} – 24 hour permissible limits - WHO and GOK of 50 µg/m^3 and 100 µg/m^3 (WHO, 2021; GOK, 2014)

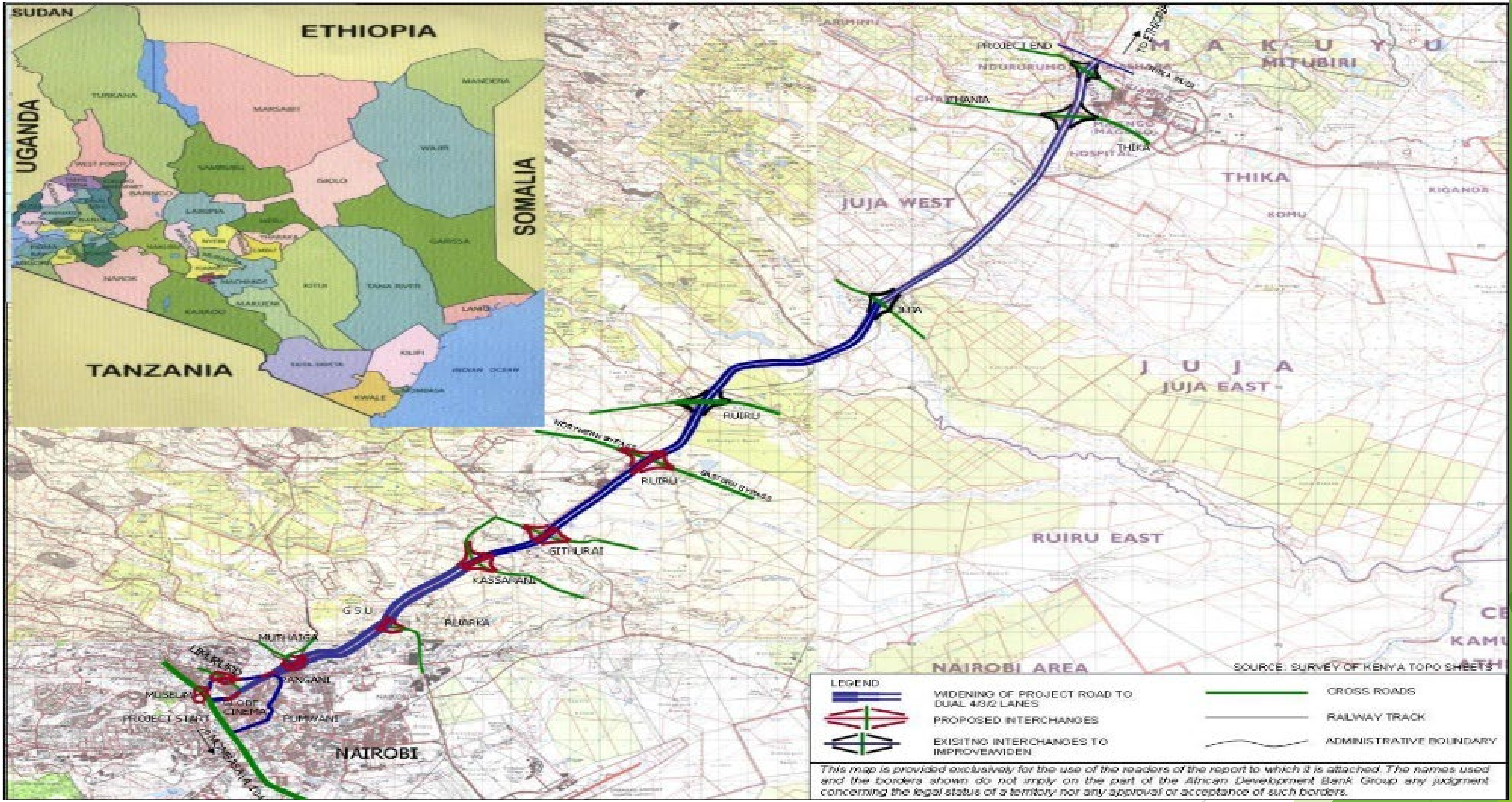


Materials and Methods

Sites and Measurement Periods

- Thika Road - 8-lane highway in Kenya
- Links Nairobi with Thika
- 50 km, A2 highway
- Area - human residences, mining, industries and institutions
- Covers 746 km^2 - population of 486,121
- Population Density of 652 people per km^2
- 244,051 males and 242,070 females (KNBS, 2019).

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NAIROBI AREA
SOURCE: SURVEY OF KENYA TOPO SHEETS
LEGEND
WIDENING OF PROJECT ROAD TO DUAL 4/3/2 LANES
PROPOSED INTERCHANGES
EXISITNG INTERCHANGES TO IMPROVE/WIDEN
CROSS ROADS
RAILWAY TRACK
ADMINISTRATIVE BOUNDARY
This map is provided exclusively for the use of the readers of the report to which it is attached. The names used and the borders shown do not imply on the part of the African Development Bank Group any judgment concerning the legal status of a territory nor any approval or acceptance of such borders.

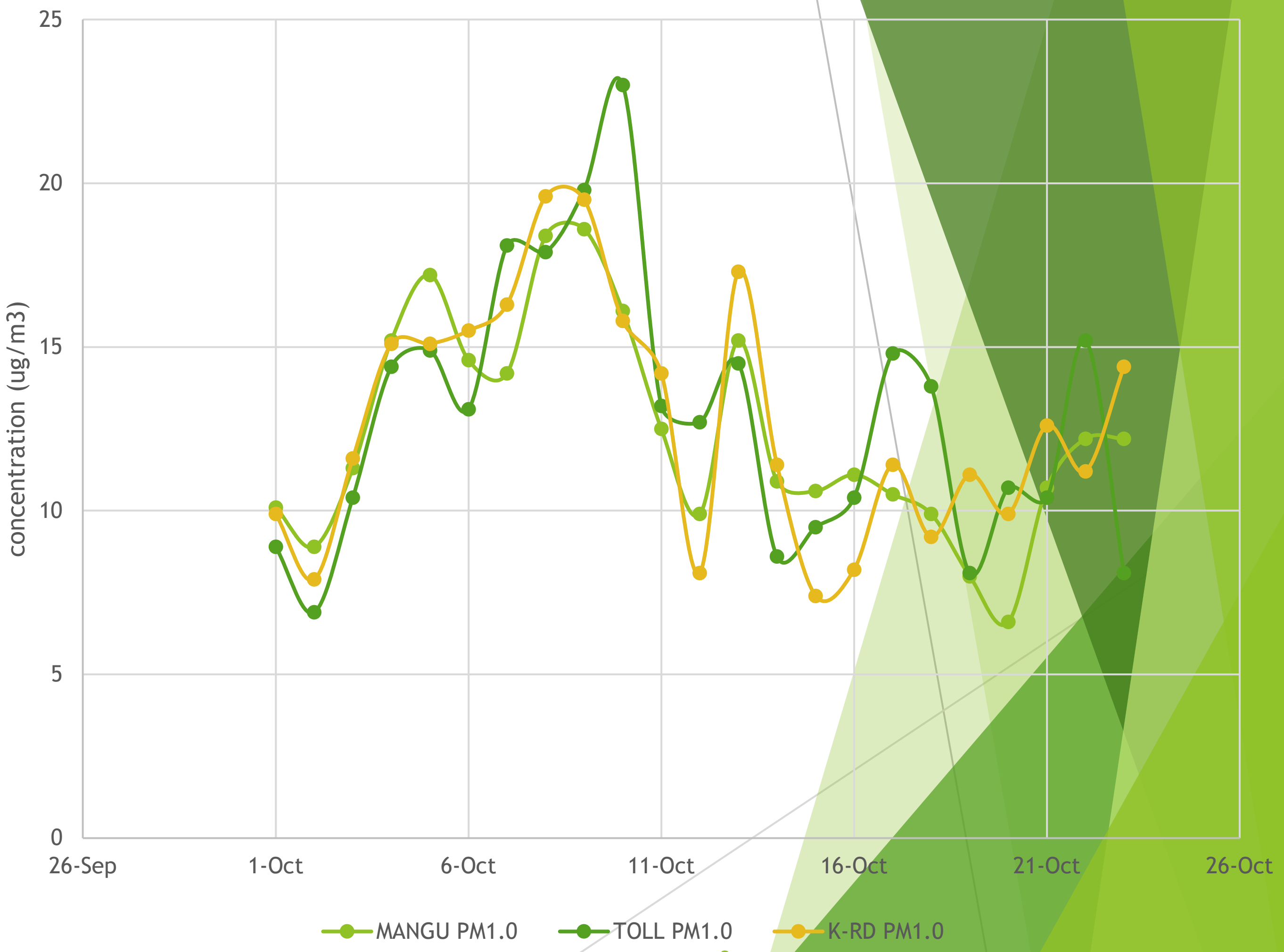
Instrumentation & Monitoring

- Purple air, PA-II monitors at three locations October 2021.
- Data from the purple air maps and SD cards
- BAM reference monitor
- The weather data was studied - rain and wind data.
- The Purple Air PA-II Low-Cost PM Monitor
  - Laser optical particle counter (OPC) sensors,
  - Temperature,
  - Relative humidity, and
  - Barometric pressure sensor,
  - Wireless network communication module.

Results and Discussion

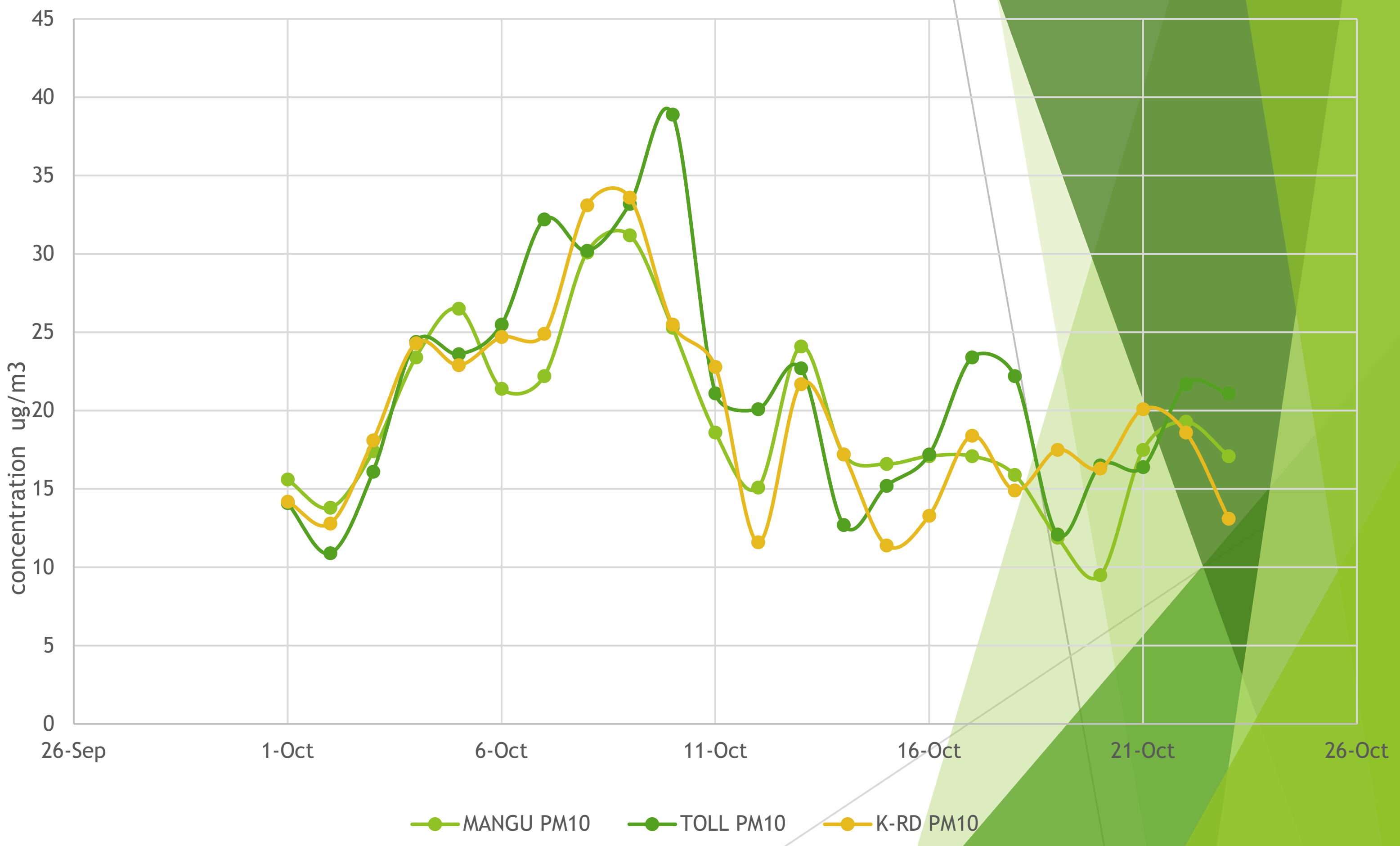
24 hr Concentrations of $PM_{1.0}$

- $PM_{1.0}$ 18.3±4.5 a range of 6.6 – 23.1 µg/m³
- Toll site - 21.4±7.1 followed by Mangu 19.3±5.3 Kroad lowest 13.1±6.1 µg/m³
- $PM_{1.0}$ varied within and between sites
- Peak values at the Toll site
- Hilly areas with several residential areas
- Speed bumps
- Acceleration traffic - increased emissions



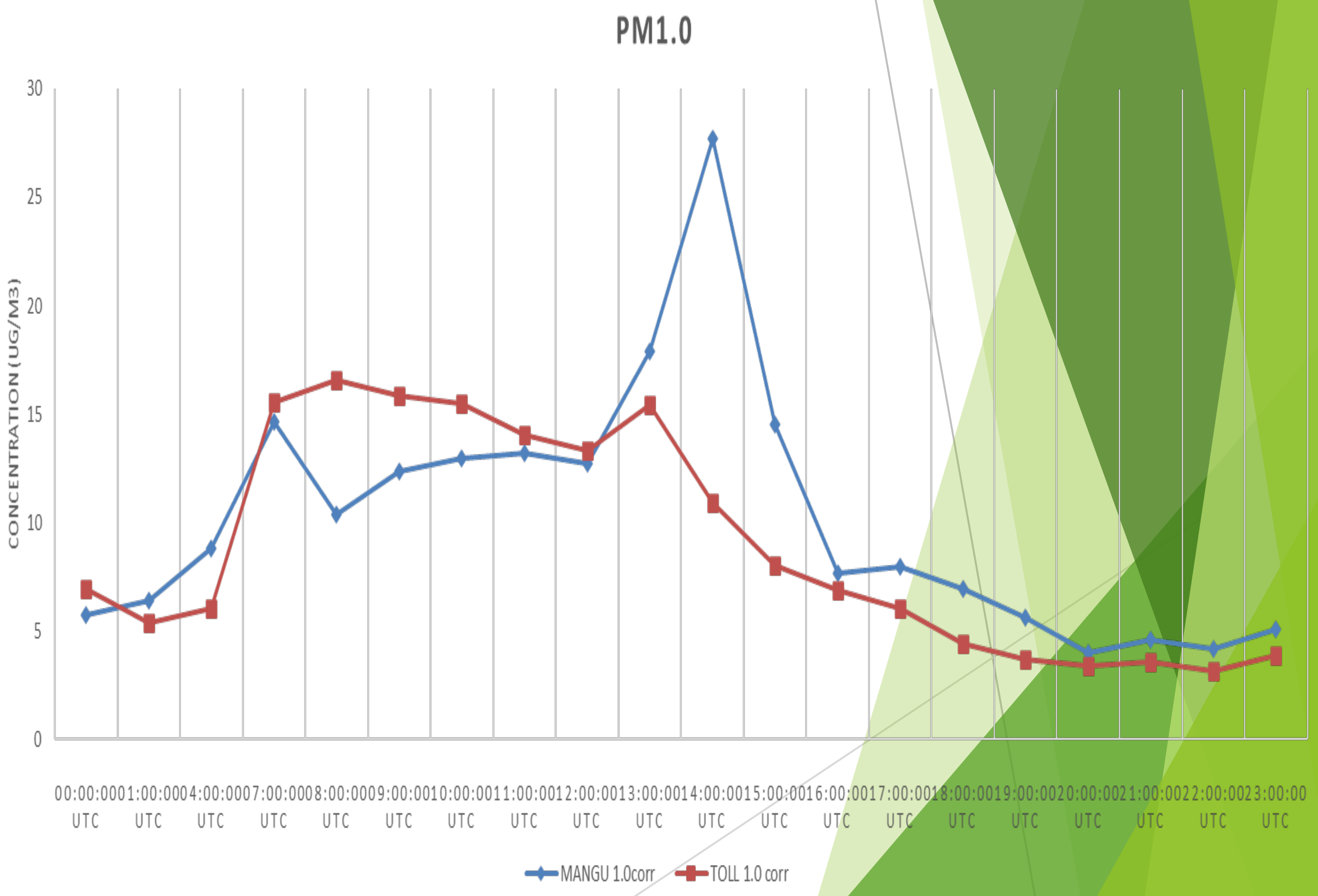
24 hr concentrations of PM_{10}

- PM_{10} mean 20.1±1.55 range 9.5 - 38.9 μg/m^3
- Toll – Mangu - Kroad
- Wide variations within and between sites attributed to;
  - traffic volumes, rainfall, wind speeds and other PMs contributing sources
- PM_{10} within permissible limits - WHO and GOK of 50 μg/m^3 and 100 μg/m^3 (WHO, 2021; GOK,



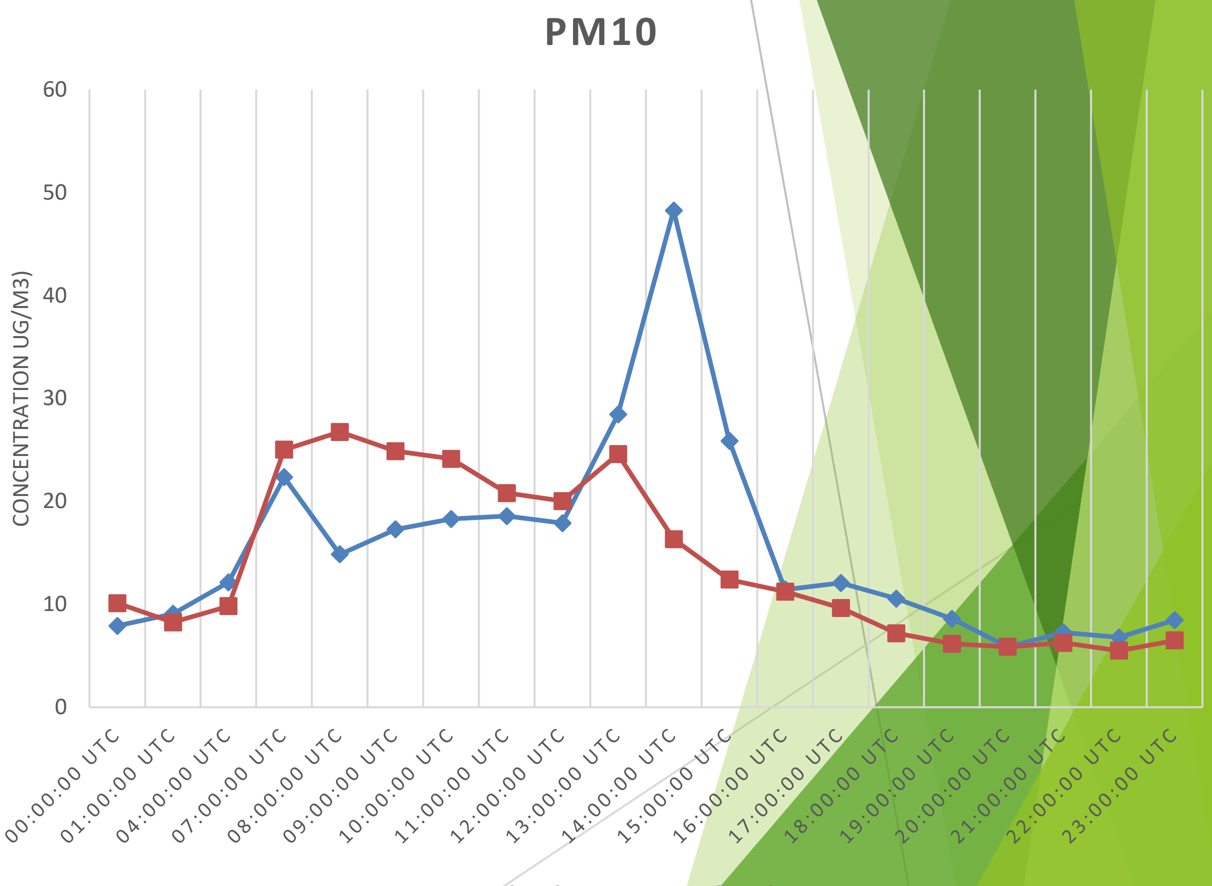
Diurnal variations of $PM_{1.0}$

- $PM_{1.0}$ range of 3.2 – 27.7 μg/m³ for Toll
- 10.2±5.8 and 8.93±6.9 μg/m³ for Mangu
- Two peaks at 0600 to 0900 hrs; attributed traffic volumes
- Peak 1800 hrs attributed to heavy traffic
- Peak at 1400 hrs attributed quarry mining
- Mining is dust intensive & windblown dust.
- The wind speeds low at 1400 – 1500 hrs.
- Lowest concs. 1900 - 2300 hours; attribute to lack of sources that emit them.

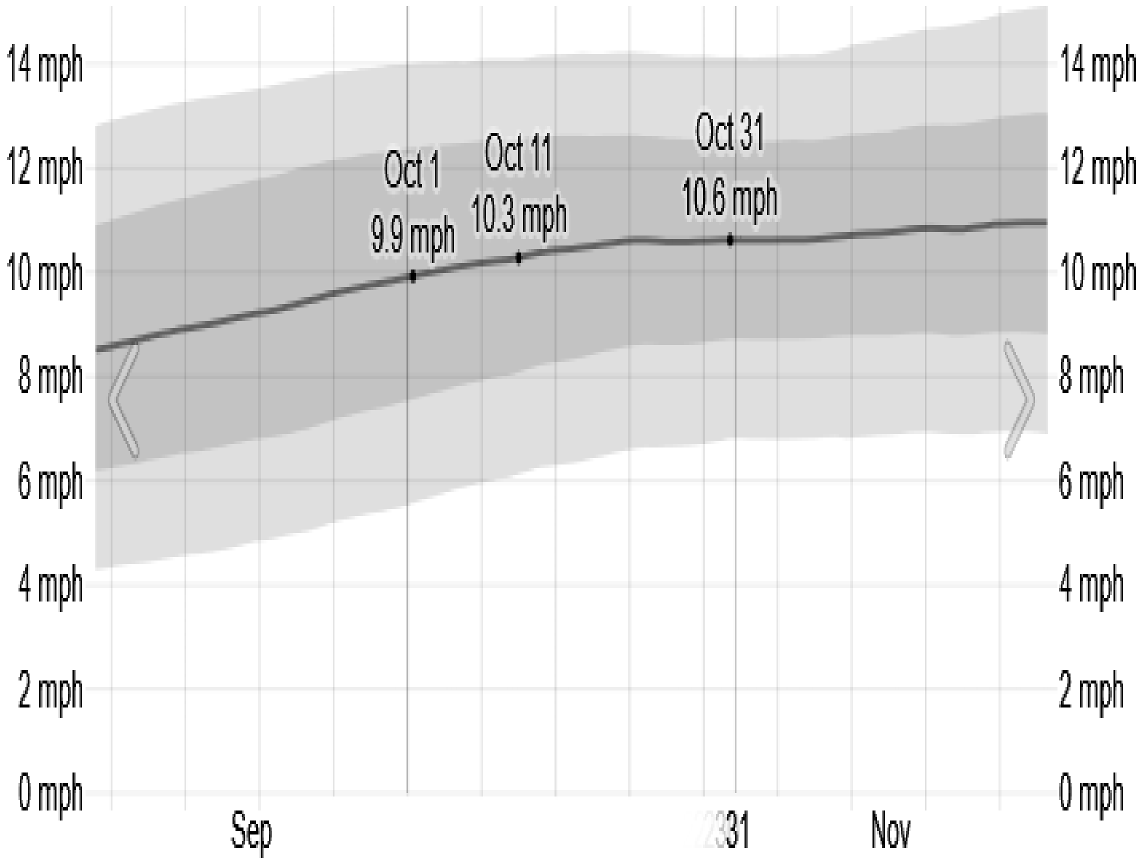


Diurnal variations of PM_{10}

- PM_{10} was 15.5±7.9 Mangu
- 14.01±10.1 µg/m^3 and Toll
- Range of 5.5 – 48.3 µg/m^3.
- Diurnal PM_{10} same profiles as $PM_{1.0}$
- Higher PM_{10} levels than $PM_{1.0}$.
- Lowest 20.00 - 23.00 hrs; - reduced traffic and settling of particles.
- Finding agrees (Gatari et al., 2005; Mutua et al., 2021; Gatebe et al., 1996).
- October wet month with rains - late afternoon to evening - wet deposition

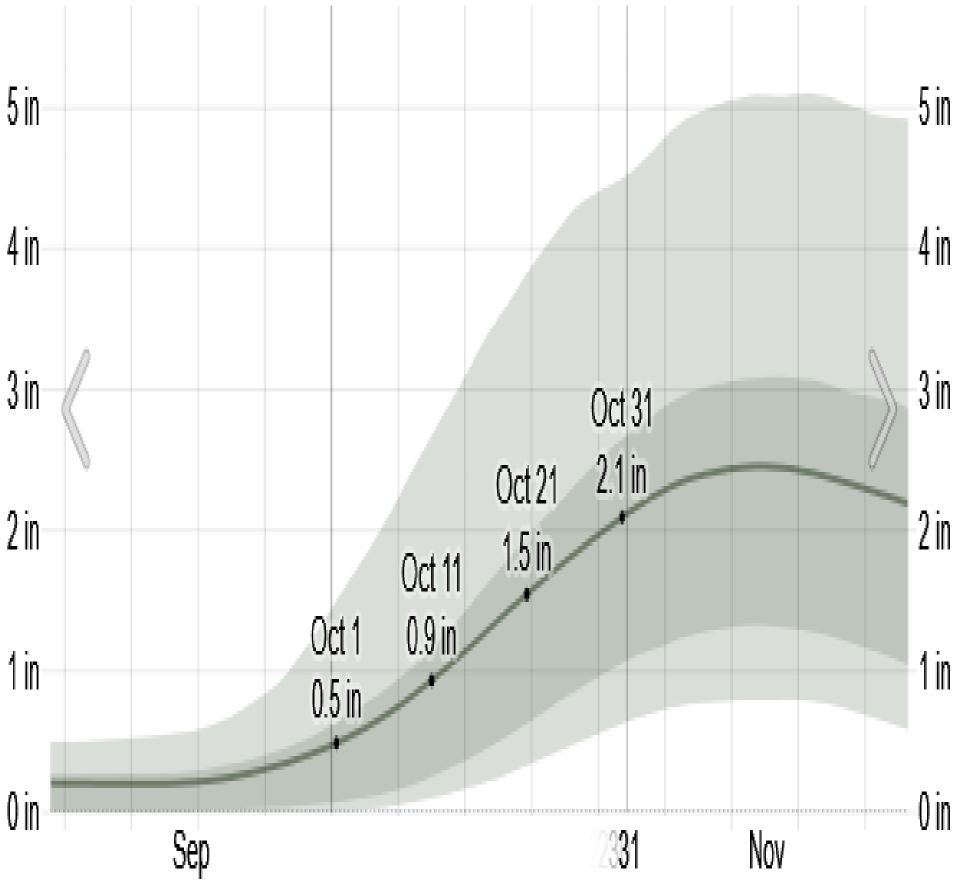


Effect of Wind speed PM levels



- Wind speeds increased in Oct - stable range of 9.9 to 10.6 mph
- Mean 10.3±0.3 mph
- Wind & profile of PMs
- Windspeed increase at Oct. 11, sharp decline in PMs
- Greatest decline in PM_{10} - dispersion
- Decrease of PM_{10} - effect of wind
- This agrees - earlier study conducted in Nairobi City (Mutua et al., 2021).

Effect of Rainfall on PM levels



- Rainfall abundance in OCT
- Range 0.5 to 2.1 mean of 1.25±0.61 in
- Rainfall - wet deposition
- Increase rain and decline of PMs.
- The highest decline observed in PM_{10} from October 11 2021
- As rainfall from 0.5 to 0.9 inches - sudden decline in PM_{10} from 38.9 to 11.6 $\mu g/m^3$

Conclusions

- Air quality with respect to PM10 for the section studied is within acceptable limits
- LCMS can improve air quality monitoring in developing nations
- Rain and wind improve the air quality
- Bumps and hilly areas have higher concentrations than areas with smooth vehicle flow

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