# ASSESSMENT OF DIURNAL AND SEASONAL VARIATIONS OF AMBIENT PARTICULATE MATTER (PM2.5) IN JUJA, KIAMBU COUNTY, KENYA

**MSc. Environmental Legislation and Management**


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# 1. Introduction

- Air pollution is a major environmental concern that affects human health worldwide.
- Particulate Matter pollution was estimated to cause approximately 4.2 million premature deaths annually (WHO, 2016).
- 91% of the worlds population are currently living in regions where the air quality level exceeds the WHO guideline level of 10 μm $m^{-3}$(WHO, 2016).

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- PM concentrations are also vulnerable to meteorological factors acting either individually or combined (Cheng & Lam, 2000, Buchanan et al, 2002, Khan et al, 2007)

- The India's Ministry of Earth Sciences in October 2018 attributed about 41% of $PM_{2.5}$ emissions to vehicular emissions, 21.5% to dust and 18% to industries.

- In urban areas, more than 50% of the total PM emissions are traffic generated (Wrobel et al., 2000)

# 2. Objectives

## Main Objective

- To assess the diurnal and seasonal variations of suspended particulate matter (PM2.5) within Juja, Kiambu County, Kenya

# Objectives

- **Specific Objective**

i. To determine the levels of PM2.5 in the ambient air within Juja subcounty during the dry and wet season.

ii. To assess the effects of temperature, rainfall, humidity on the levels of Particulate matter in Juja

iii. To assess the impacts of vehicular traffic on the levels of Particulate Matter in Juja.

# 3. Methodology

## Study Design

For this study, **Experimental Research Design** was used.

## Sampling Method

- Stratified Random sampling
- Sampling was done during dry and wet season

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Five sampling sites will be specifically selected within Juja area, namely:

1) **PineBreeze -Along/Close to the Highway**
2) **JKUAT - IEET building**
3) **Kroad - A Residential area**
4) **Kibariti - A rural area**

# Cont'd

**Research Instrument**

The PM levels were measured using the

**Purple Air Monitoring Sensor – PA –II-SD**

- Uses laser beam with two sensors (A and B).
- Has an internal data storage


# Cont'd

Meteorological Data Collection

- **Temperature**
- **Rainfall**
- **Humidity**

# Cont’d

- The data Analysis was done using **Excel, SPSS as well as R-programming.**
- The data is presented in **tables, charts and graphs.**
- The **daily PM levels in μg $m^{-3}$ vs time** is plotted to picture the average daily concentration in **each month**

# 4. Results and Discussion

- **4.1. To determine the levels of PM2.5 in the ambient air within Juja sub county.**
- The average mean daily PM2.5 concentration was **41**μg/$m^3$ (Pinebreeze), **15**μg/$m^3$ (JKUAT), **20**μg/$m^3$ (Residential) and **16**μg/$m^3$ (Kibariti) exceeding the WHO guidelines of 15μg/$m^3$.
- **PineBreeze** exceeded the 24hr mean USEPA National Air Quality Standards of 35μg/$m^3$ as well.
- JKUAT had an annual mean concentration of 15μg/$m^3$, exceeding the WHO guidelines of 5μg/$m^3$ annual mean.

# Cont'd

- **Collocation**
- The PM2.5 level from the low-cost Purple Air Sensors were later calibrated against a reference BAM-1022 to yield corrected PM values. A simple linear regression was used for the bias-correcting of the Purple Air data towards a Reference Monitor. The collocation of the Purple Air and the BAM-1022 monitor took place between March 2021 to July 2021 at the University of Nairobi (UoN), Nairobi.

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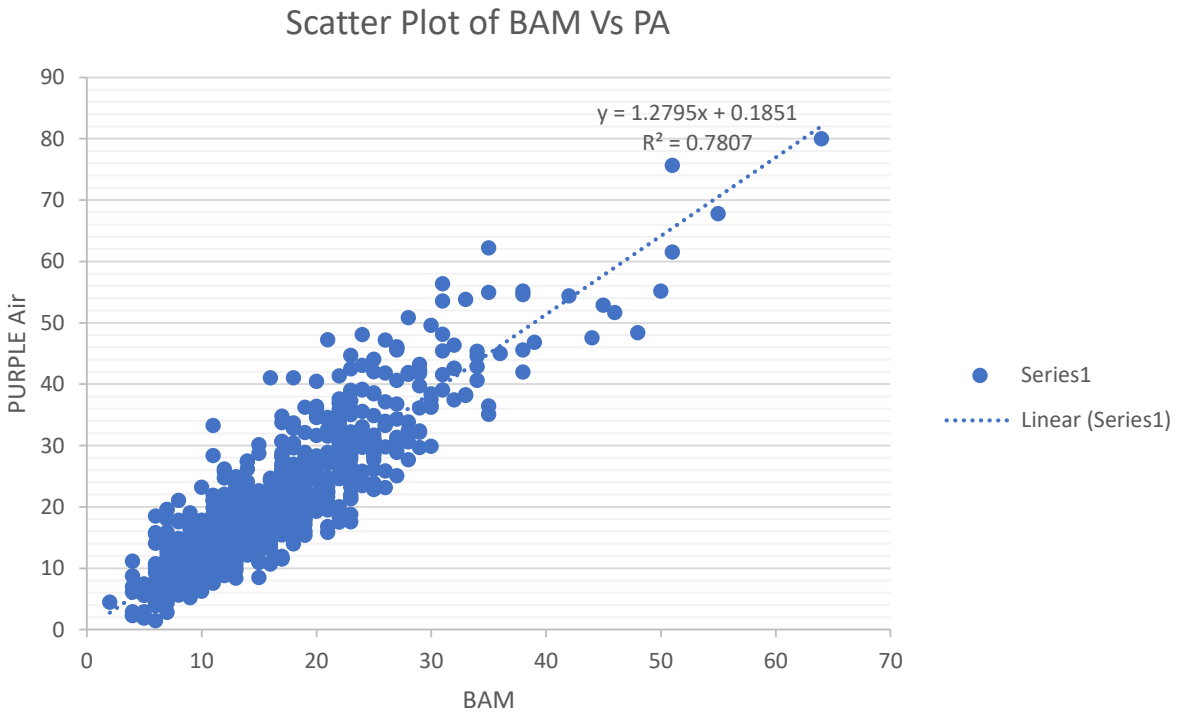
- In Fig. 2 we present a simple linear regression for the Nairobi BAM -1022 Vs Purple Air co-location. Correlation between raw PurpleAir data and the UoN BAM-1020 was high **($R^2$ = 0.78).**



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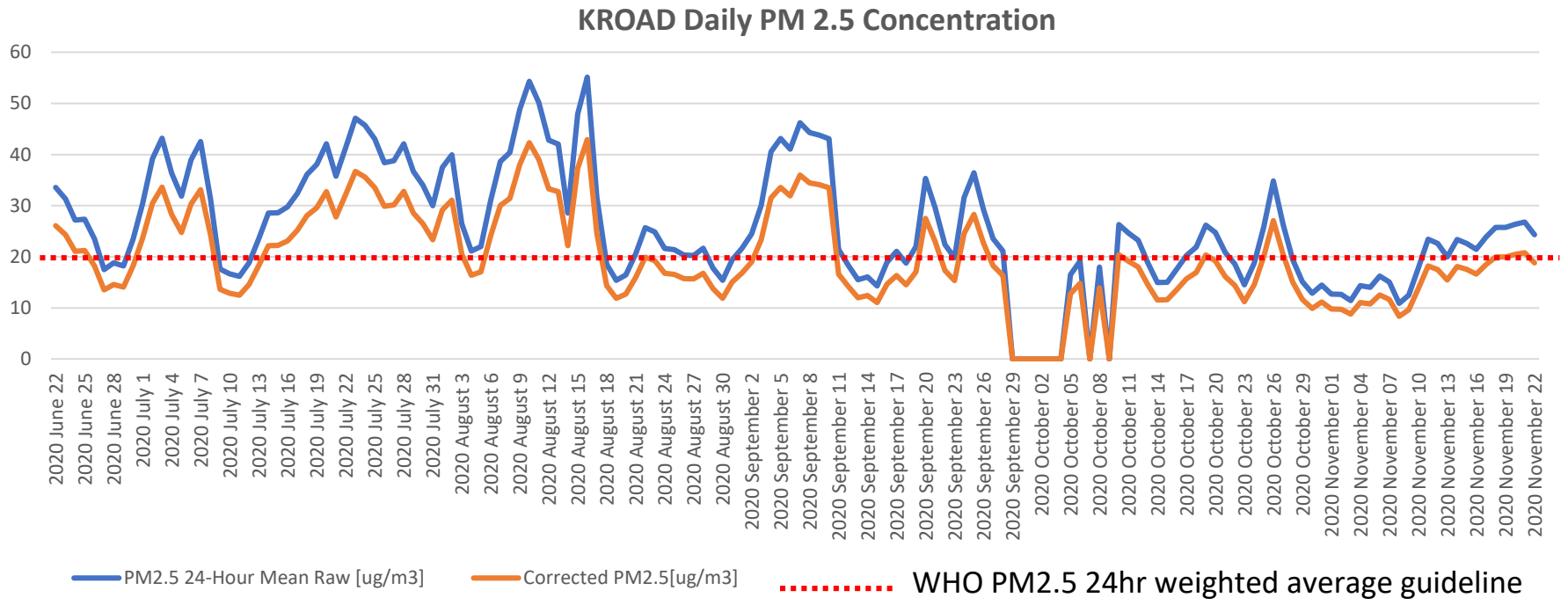
- **$PM_{2.5}$ Concentration at KROAD**




Mean PM2.5 Concentration – 19.85[ug/m3]

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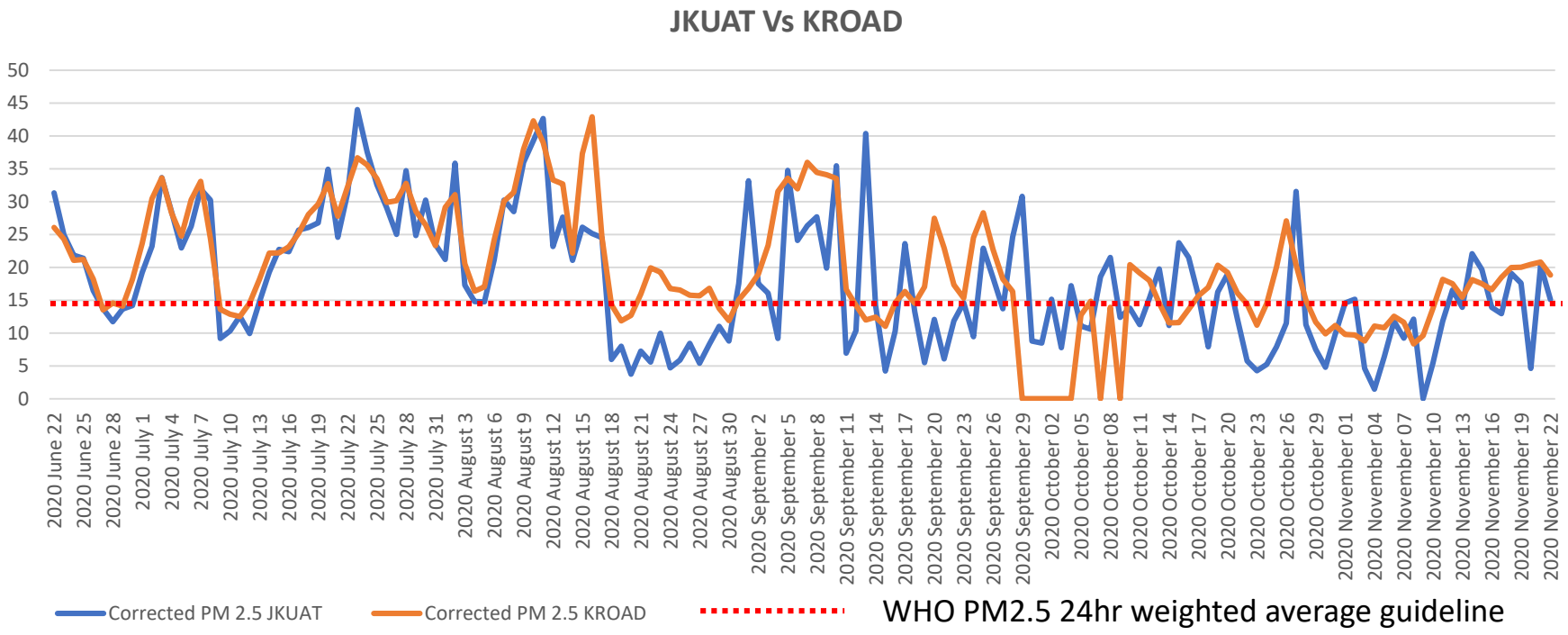
- **Seasonal Variation between PM2.5 Concentration at JKUAT Vs KROAD**



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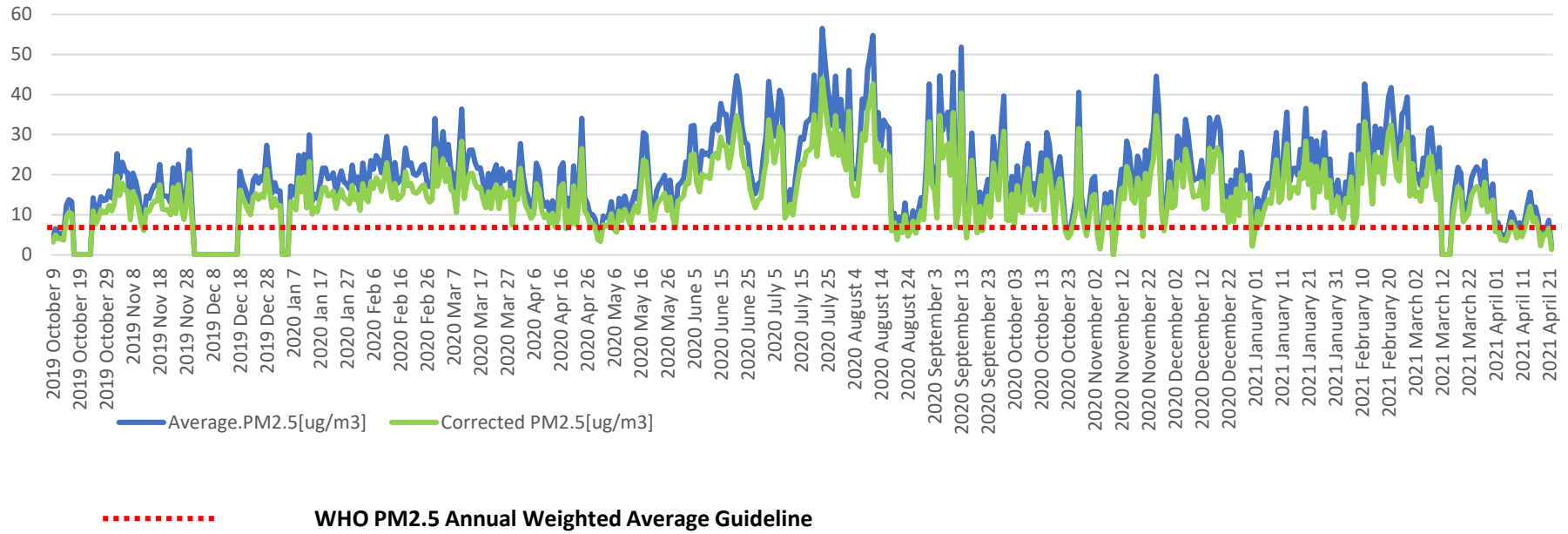
- **Annual PM 2.5 Measurements at JKUAT**




JKUAT had an annual mean concentration of 15µg/$m^3$, slightly exceeding the WHO guidelines of 5µg/$m^3$ (WHO, 2021).

# Cont'd

The results revealed that the overall $PM_{2.5}$ concentration was higher during the dry season (June - August 2020) compared to the wet season (March - May 2020) where it dropped by 5-10μg/$m^3$ on average. Our findings were in agreement with what was reported by others (*Rasa et al, 2020*, *Ramson et al*, *2016*, *Ogere*, *2002*). The higher PM levels during the dry season can be attributed to lack of wet scavenging.

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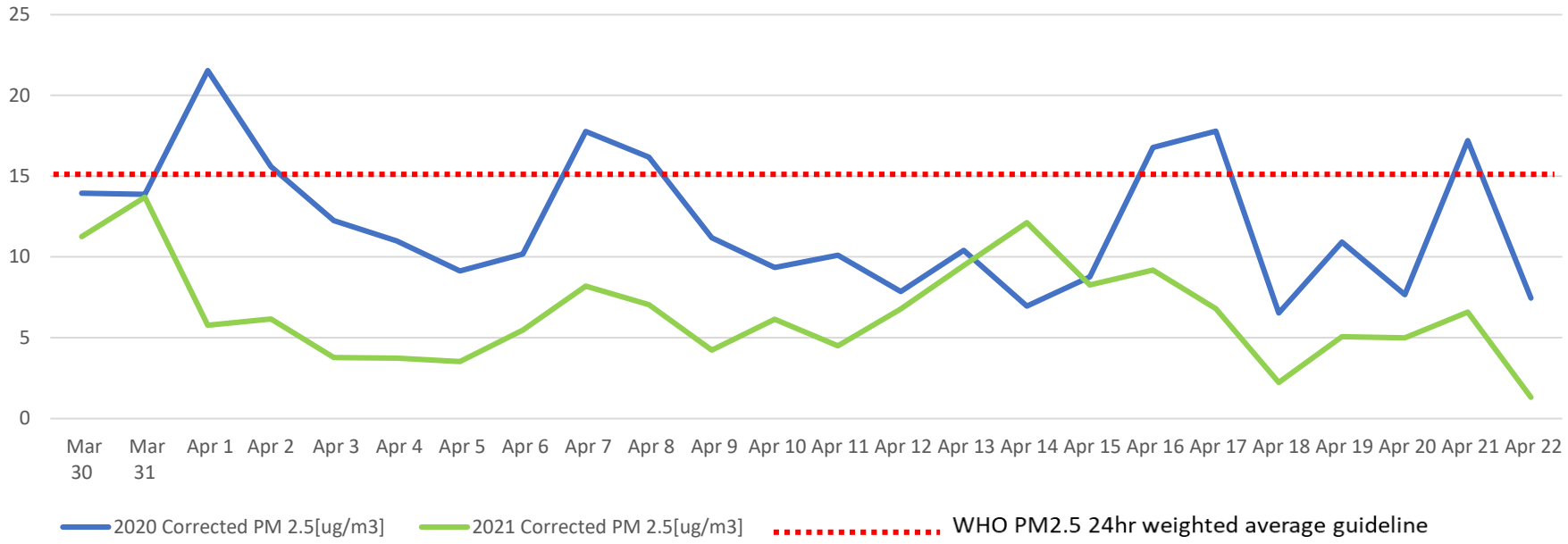
## JKUAT 2020 Vs 2021 PM2.5 in relation to the Covid 19 Lockdown




- In addition, comparing the month of April 2021 to the previous year, the daily mean dropped by 5-10µg/$m^3$ – the period of the new Covid -19 lockdown.

- Our findings show that such efforts for a short period of time resulted in a significant reduction in PM levels. Thus, the drop in PM2.5 level cannot be explained by meteorological changes alone as it is evident that human activities also play a major role (Ju et al., 2021, Mannucci et al., 2017)

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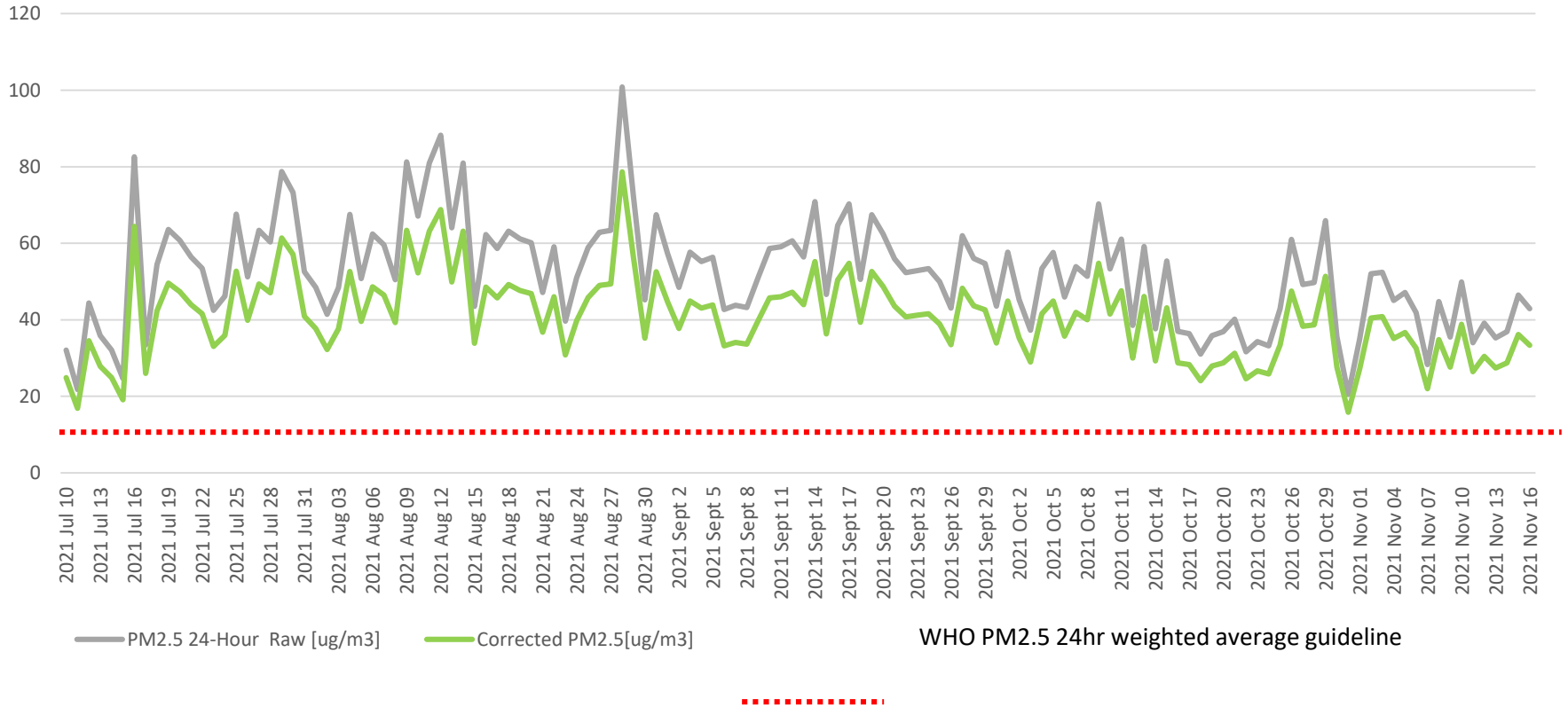
- **PineBreeze Daily $PM_{2.5}$ Concentration**




Mean PM2.5 Concentration – 40.57[ug/m3]

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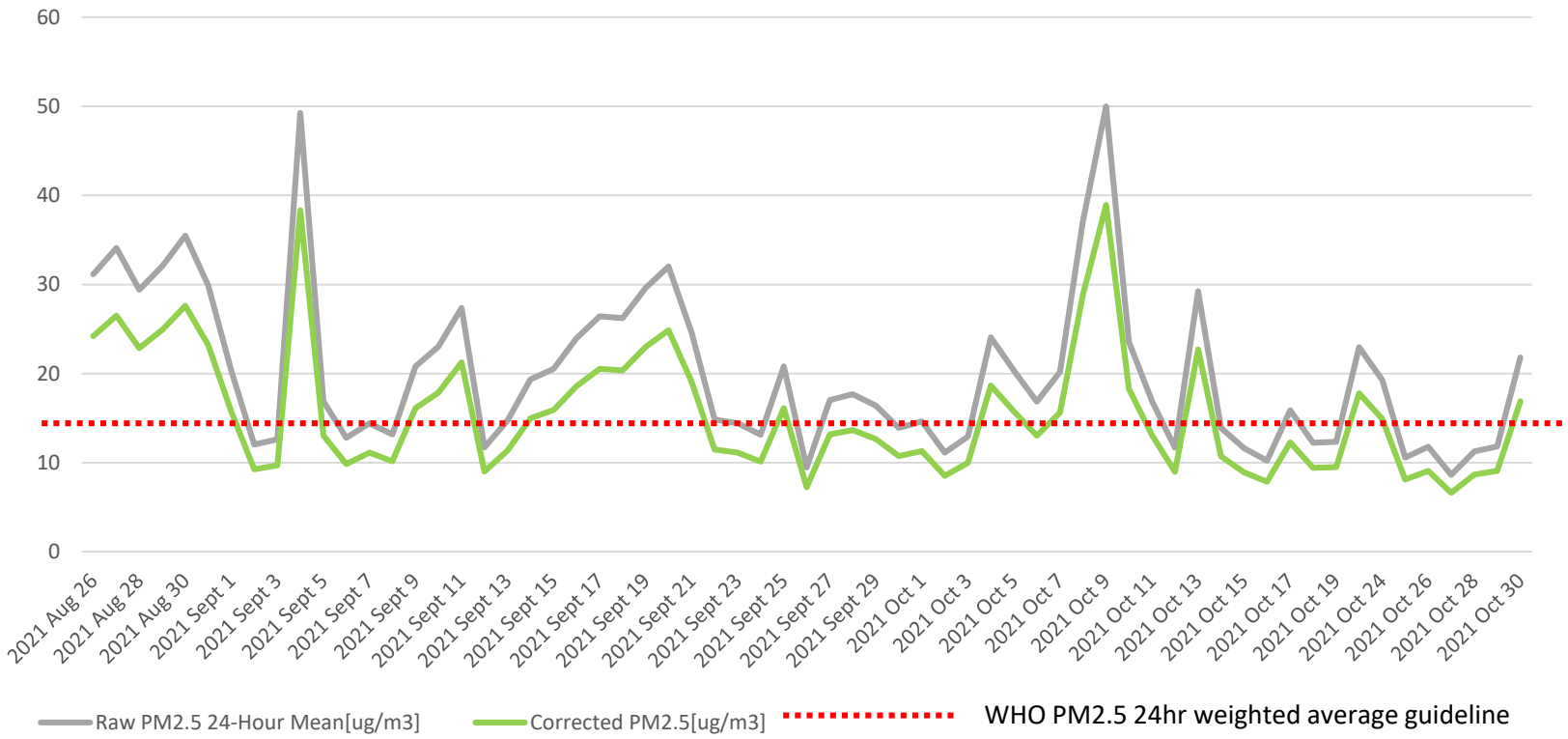
- **Kibariti Daily $PM_{2.5}$ Concentration**




Mean PM2.5 Concentration – 15.54[ug/m3]

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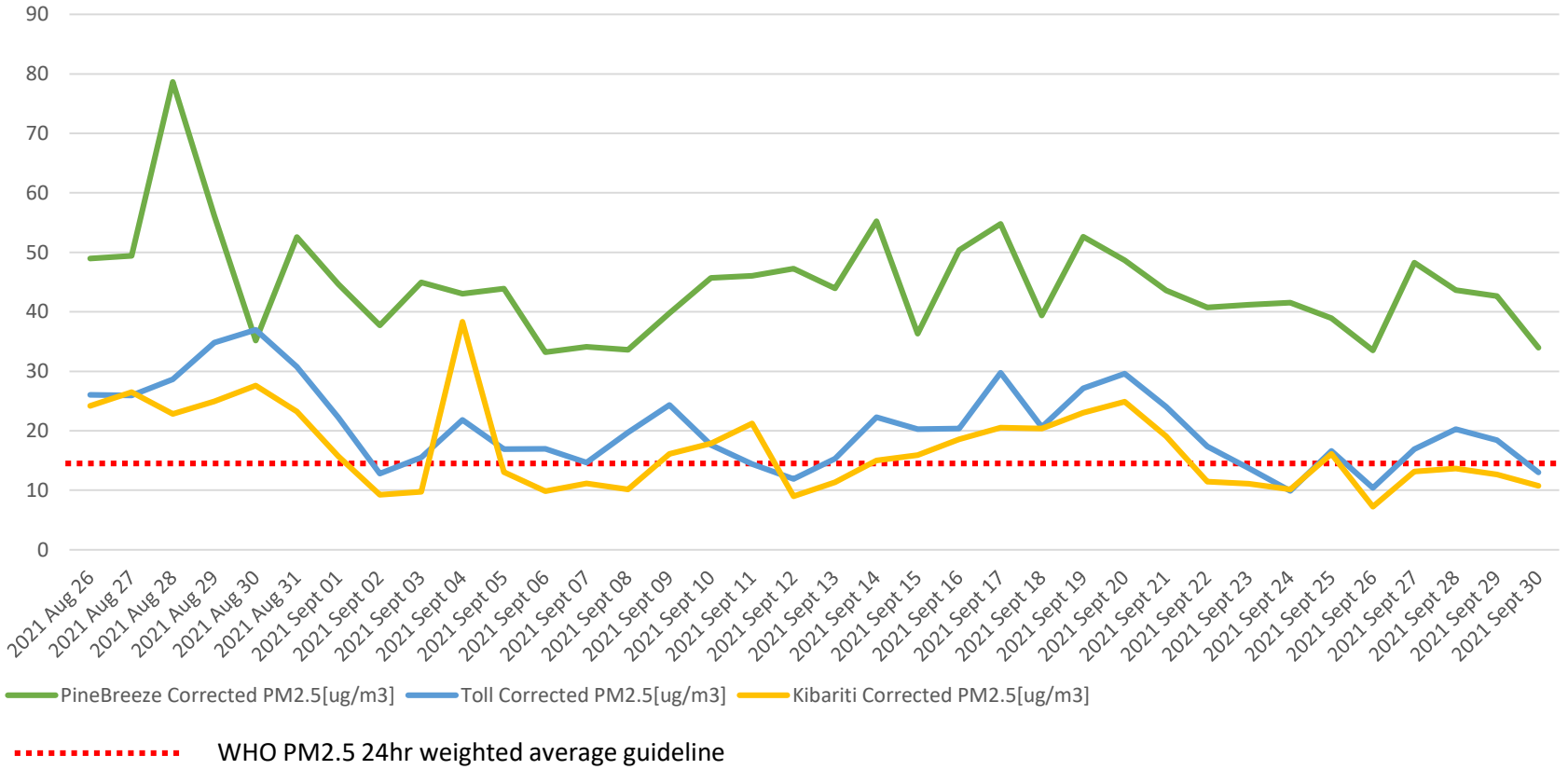
- **Comparison of PineBreeze, Toll and Kibariti Daily $PM_{2.5}$ Concentration**




Despite the sites being in different area, they all had the same pattern indicating the are all influenced by weather conditions in the same way. With the Highway site (PineBreeze) leading, followed by residential site near the highway (Toll) and lastly a residential area further away from the highway (Kibariti)

# Cont'd

- **4.2. To assess the impacts of vehicular traffic on the levels of Particulate Matter in Juja.**

✓The highest mean daily $PM_{2.5}$ concentration was recorded at **79**μg/$m^3$ (PineBreeze), a site in close proximity to the busy traffic along Thika Super Highway.

✓The PM2.5 concentration exceeded the WHO $PM_{2.5}$ 24hr weighted average guideline of **15**μg/$m^3$ in all the days measured as shown in the next graph. Our findings were in agreement with what was reported by others (Kinney et al., 2011, Gaita et al., 2014, Ramson et al, 2016,).

✓The high PM levels at these site can be attributed to traffic congestion (Gachanja, 2015), quality and quantity of fuel consumed (Ndegwa, 2017) - fuel consumption is bound to increase due to the old vehicle technology (Ebinger and Vergara, 2011), poor maintenance practices and deteriorated road conditions.

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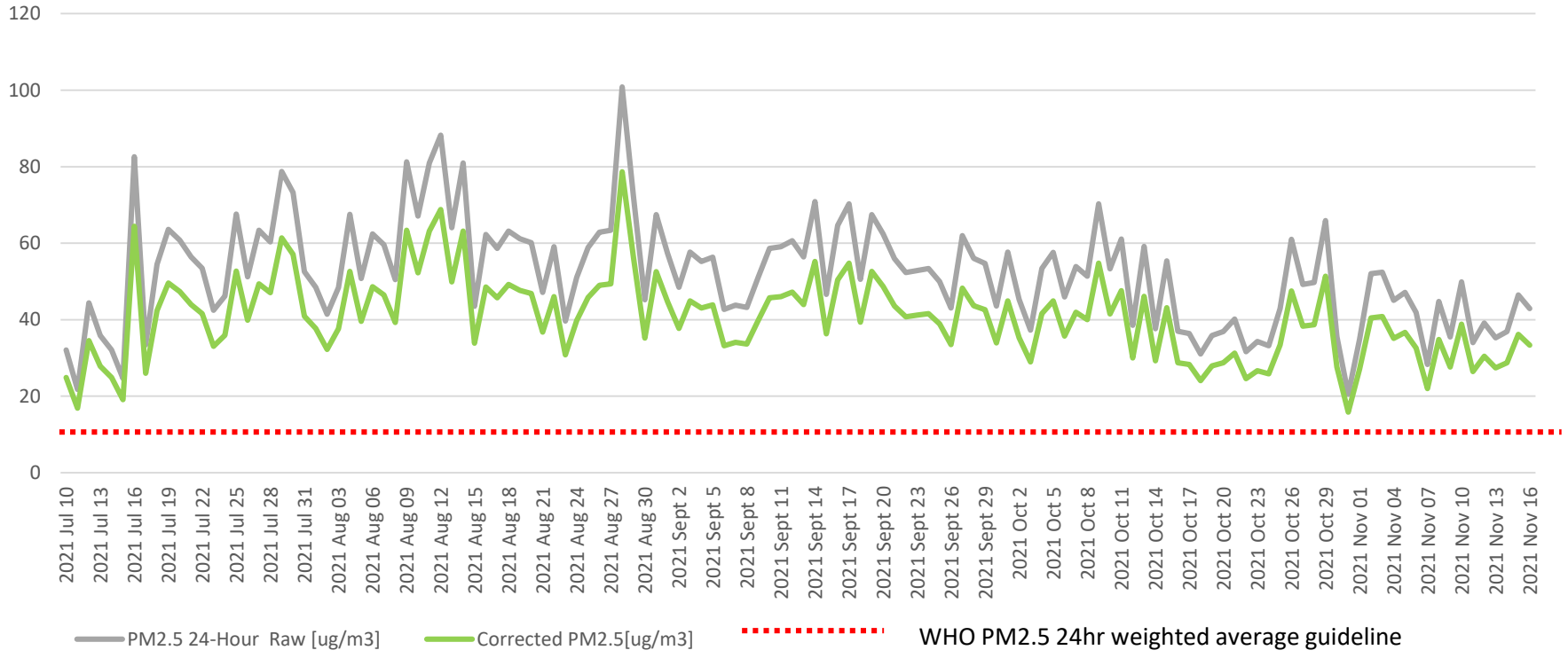
- **PineBreeze Daily $PM_{2.5}$ Concentration**




Mean PM2.5 Concentration – 40.57[ug/m3]