African School on Air Quality and Pollution Prevention
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Air Quality Monitoring and Measurement Techniques

Presentation by:

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Introduction to Air Quality

- **Air pollution** may be defined as the presence of one or more contaminants like dust, mist, smoke and colour in the atmosphere that are injurious to human beings, plants and animals.




Sources of Air Pollution

- **Natural**
  - Volcanoes
  - Forest fires
  - Dust storms
  - Biogenic
- **Anthropogenic**
  - Industrial sources
  - Vehicular sources
  - Domestic sources
  - Area sources

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What is Air Quality Monitoring

- Air quality monitoring involves the systematic assessment of airborne pollutant concentrations in a specific area or directly at emission sources

- Data collected can be utilize to analyze diurnal and seasonal air quality trends that provides critical insights for the development and evaluation of pollution control strategies.

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Different Types of Air Quality Monitoring

1. Stationary or Static Monitoring

Most common practice for regulators

- where data is collected at fixed locations

2. Mobile Monitoring

- where data is collected in a moving vehicle, either on the roads or going around in a neighborhood (e.g., Hotspot monitoring)

3. Emissions Monitoring

- where PM or gaseous emissions is collected immediately next to a specific source

Image source: USEPA

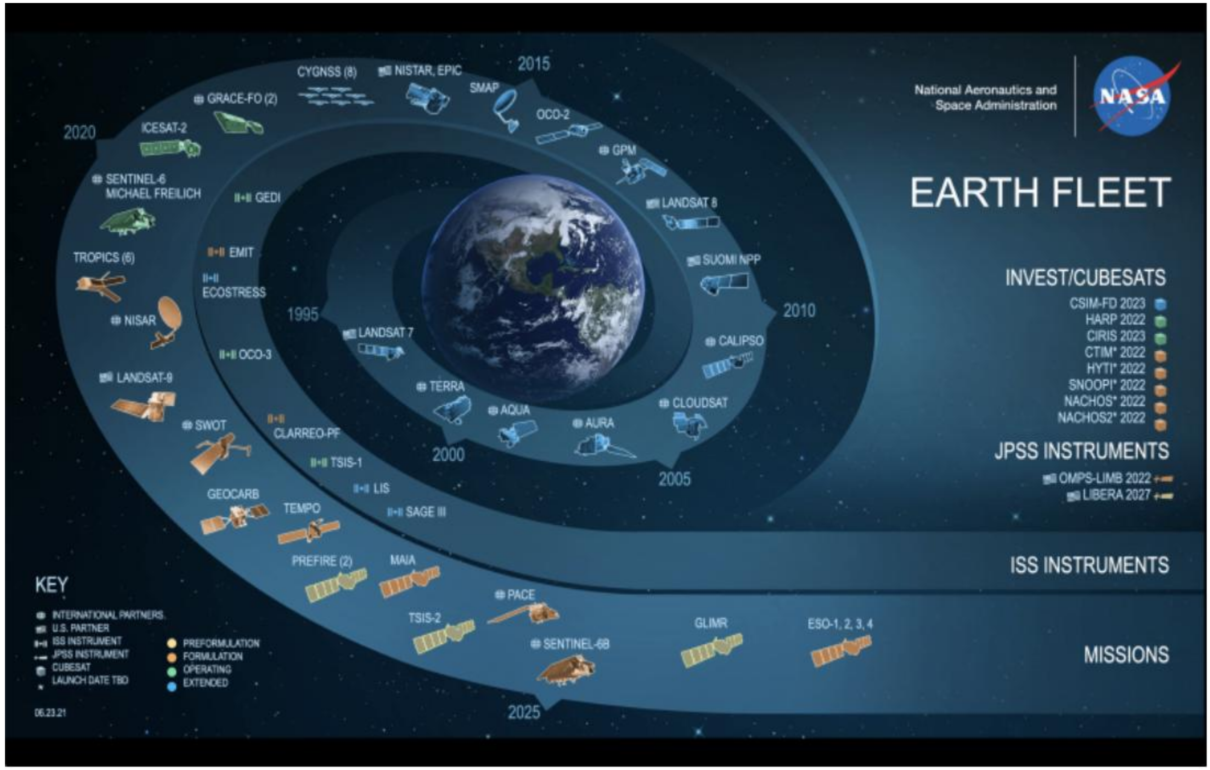
Source: https://kunakair.com/mobile-air-quality-monitors

Source: https://www.jansalgroup.com/stack-emission-monitoring

Different Types of Air Quality Monitoring

4. Remote Sensing

- Satellite which tracks pollution over large areas
- Availability of Moderate Resolution Imaging Spectro-Radiometer (MODIS) Terra, Aqua and AURA satellites across sub-Saharan Africa for air pollution assessment.
- Sentinel-5P satellite tracks global NO_2 and O_3 concentrations.
- Satellite-based remote sensing is promising but does not replace ground-based monitors



Source: https://aqicn.org/map/world/

Importance of Air Quality Monitoring

- **Support compliance with ambient air quality standards**
  - ✓ Assess highly polluted areas or large emission contributors
  - ✓ Maintain regulations of pollution levels & enforcement of standards
- **Evaluate background concentrations and health risks in population centers**
  - ✓ Provide justification for health targets through epidemiological modeling
  - ✓ Links to asthma, cardiovascular disease, respiratory issues
- **Report air quality to the public**
  - ✓ Alerts public to protect themselves against poor AQ days
  - ✓ Provides public pressure for legislation
- **Support air pollution research**
  - ✓ Collaboration with local or external research efforts

Monitoring Network Strategies

- **Human health objective**
  - Stations in population centers, near busy roads, in city centers, near schools or hospitals, background sites
- **Monitoring strategies should consider**:
  - Investment costs, operating and maintenance costs, reliability of system, staff capacity, operation requirements
- **Data management systems and databases**
  - Data storage (Cloud storage, internal memory, SD cards, etc)
  - Data retrieval (API, web-based interface, SD card, etc)
  - Data analysis (Statistical analysis, machine learning, data visualization, etc)
  - Used in conjunction with meteorological data (Temp., RH, Wind speed & wind direction, pressure, etc)

Types of AQ Monitors

- U.S. EPA formally evaluates technologies proposed to monitor compliance with the National Ambient Air Quality Standards (NAAQS)
- Federal Reference Method (FRM)
  - Provides fundamentally sound and scientifically defensible concentration measurements
  - Serve as the basis of comparison to judge other methods
- Federal Equivalence Method (FEM)
  - Provide comparable level of compliance decision making quality as FRMs

Testing and Performance Criteria	
Accuracy	Precision
Range	Detection Limit
Pollutant specificity	Noise
Drift	Multi-site measurement

AirMetrics Sampler

MiniVol Sampler

Federal Equivalency Method Monitors

TEOM Continuous Ambient Particulate Monitor

https://assets.thermofisher.com/TFS-Assets/CAD/product-images/teom-1405.jpg-650.jpg

Teledyne T640 Particulate Monitor

https://www.teledyne-api.com/prod/particulatematter/PublishingImages/T640-monitor.png

BAM 1020 Continuous Particulate Monitor

https://metone.com/products/bam-1020/

“Low-Cost” Air Sensors

Airbeam3

Airly

Modulair

Airgradient

Kunak

Clarity

Praxis

Atmos

IQAir

Airqo

SensorAfrica

Air Quality EGG

TSI-Bluesky

Factors to consider when selecting a monitoring location

- terrain and site-specific meteorology
- location of emission sources
- possible chemical or physical interferences
- area and size of the project or premises
- proximity to sensitive receptors
- availability of services (e.g. 240 V power) and site security
- whether emissions are likely to be constant or variable
- how the data collected from the monitoring is to be interpreted and used

Factors to consider when selecting a monitoring location

- ❑ Airflows are not restricted and are free from potential interferences such as buildings, trees and tall fences
- ❑ Sampling inlets have a minimum clear sky angle of 120° from nearby structures, Height Placement (1.5 m to 3 m high)
- ❑ There is a low potential for interference and contamination from localised sources such as roads and construction activities
- ❑ Adverse effects from local topographical factors are minimized
- ❑ The site is safe and secure and has a low potential for vandalism
- ❑ Reasonable access is available for people and equipment
- ❑ Reliable electricity supply is available
- ❑ Site is unlikely to be impacted by environmental factors such as extreme heat, flooding and strong winds.

Intro: Case Study of Air Quality Monitoring

- Accra-Tema and Greater Kumasi Metropolitan Areas has experienced rapid urbanization with evident urban sprawl.
- These areas fall within coastal and middle belts of Ghana respectively.
- This study objective was to analyze air pollution data in key Metropolitan cities in Ghana focusing on $PM_{2.5}$.
- Daily $PM_{2.5}$ samples were collected from 14 Low-Cost Sensor (LCS) networks deployed at eight residential, one commercial, three roadside, and two industrial locations from 1st January to 30th June 2022.

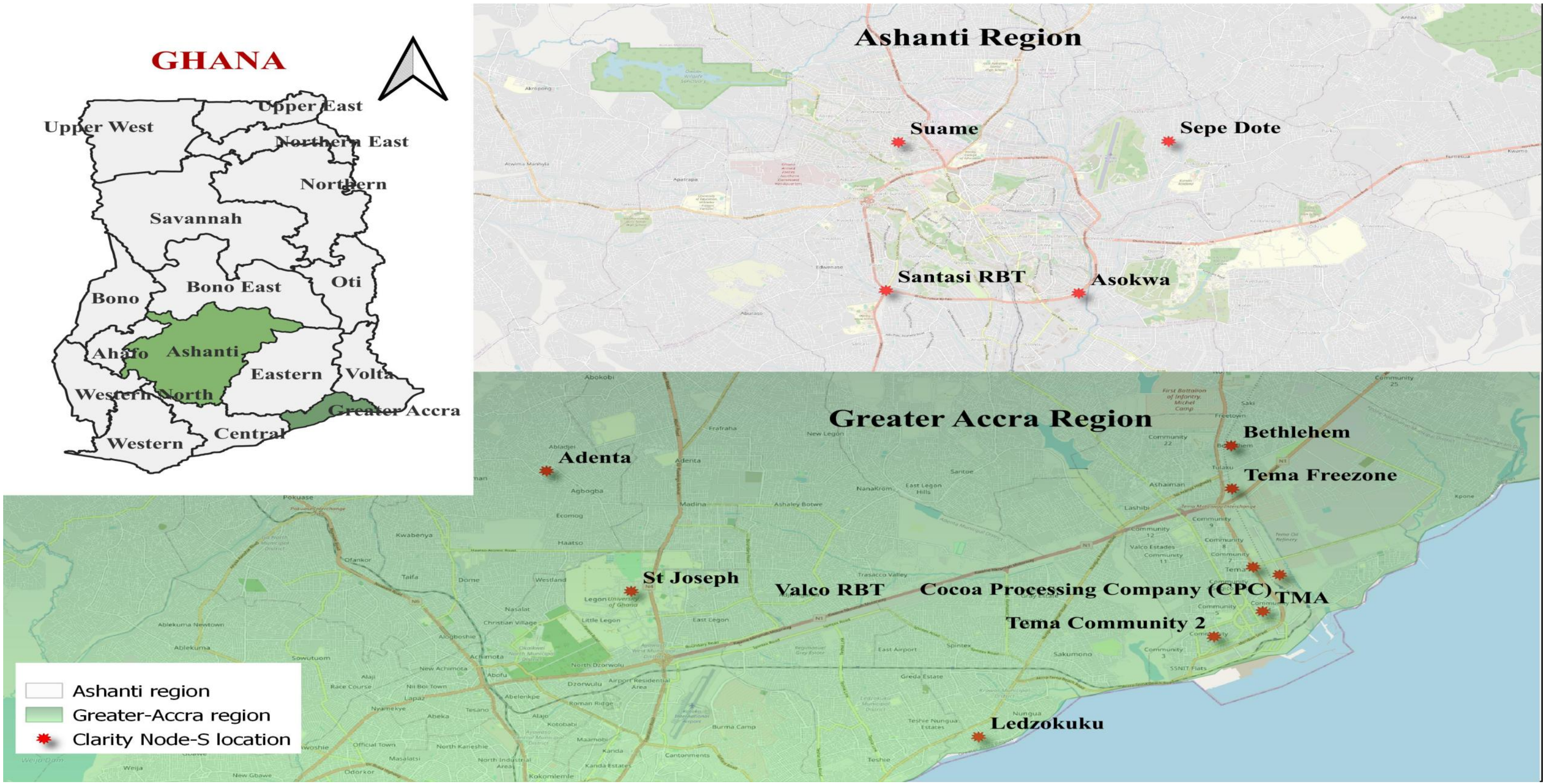


Fig. 1: Map showing the air quality monitoring locations

Methodology

- PM sensors used: Clarity Node-S air sensors at urban monitoring sites located in
- Residential sites: Adenta, Chalton Clinic, Ledzokuku, St. Joseph Basic school, Tema - Tema Community 2, Bethlehem-Tema, Suame, and Sepe-Dote
- Commercial sites: Tema Municipal Assembly (TMA)
- Industrial sites: Cocoa Processing Company (CPC) and Tema-Freezone enclave
- Roadside sites: VALCO roundabout, Santasi roundabout and Asokwa.
- The monitoring sites were identified and secured together with stakeholders from the Metropolitan, Municipal and District Assemblies (MMDAs).

Some of the Sites

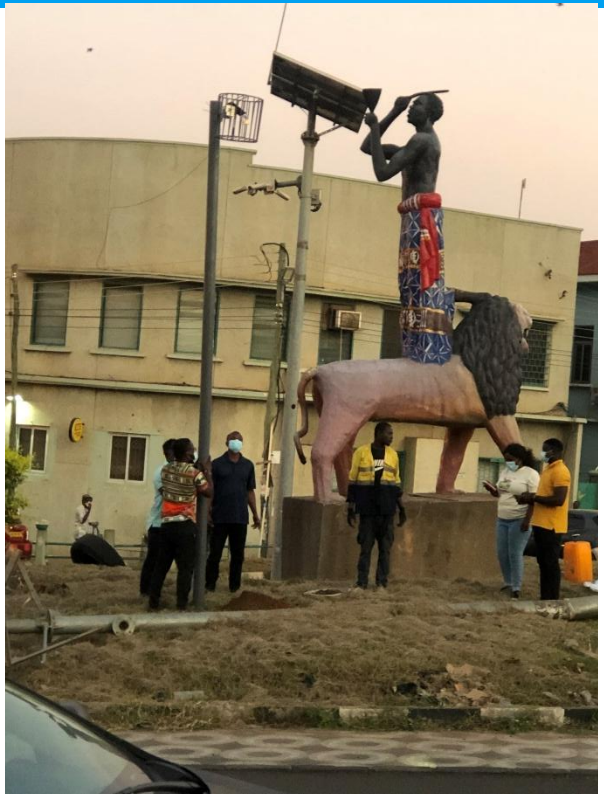


Fig. 2: Deployment of Low-Cost sensors

Results

- The $PM_{2.5}$ concentrations data were analyzed using descriptive statistics, time series plot, temporal variation plot (between wet and dry seasons) and calendar plots of AQI.

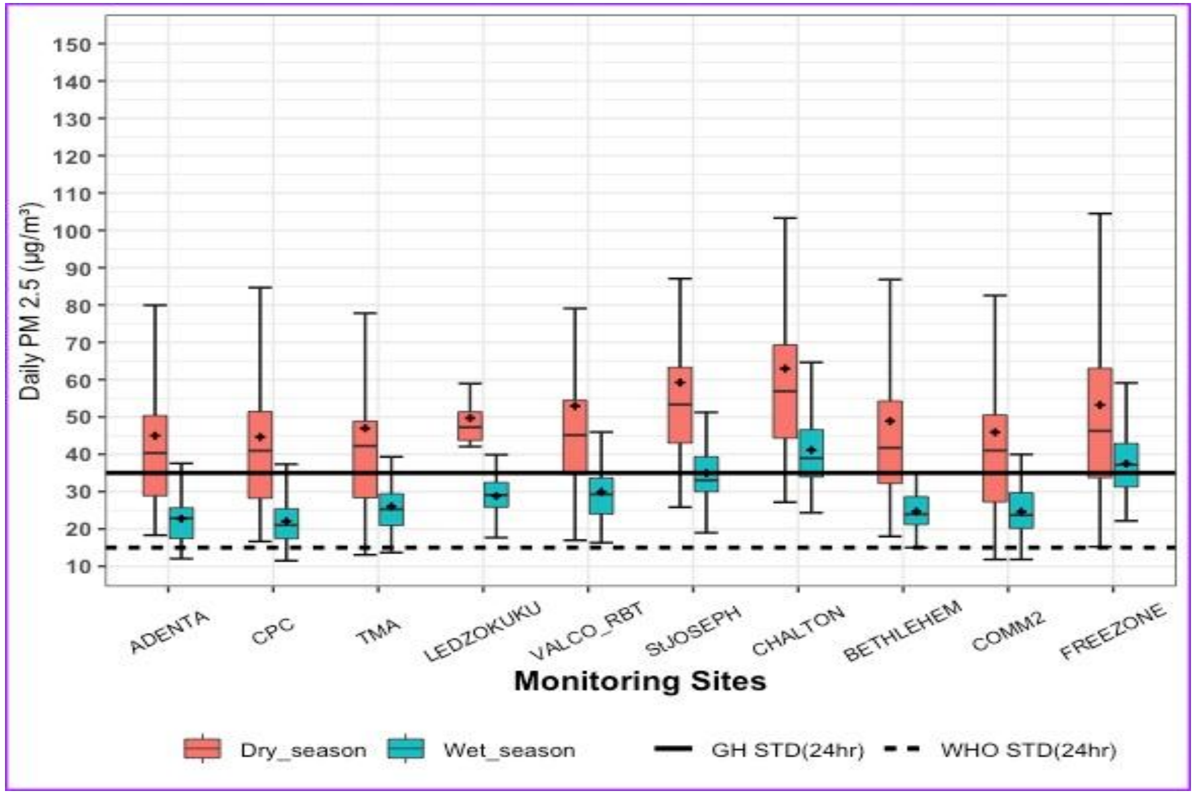


Fig. 3 : Box plot of PM2.5 levels at Accra-Tema areas

✓ Mean $PM_{2.5}$ levels measured during the dry season (January-March 2022) were twice as high as those recorded during the rainy (wet) season (April-June 2022).

Results

- Daily minimum and maximum $PM_{2.5}$ concentrations recorded in Accra-Tema Metropolitan Areas were 34.24 ± 27.25 μg/m³ (CPC) to 52.05 ± 44.25 μg/m³ (Chalton), while Kumasi varied from 48.90 ± 34.48 μg/m³ (Suame) to 57.30 ± 40.60 μg/m³ (Asokwa).

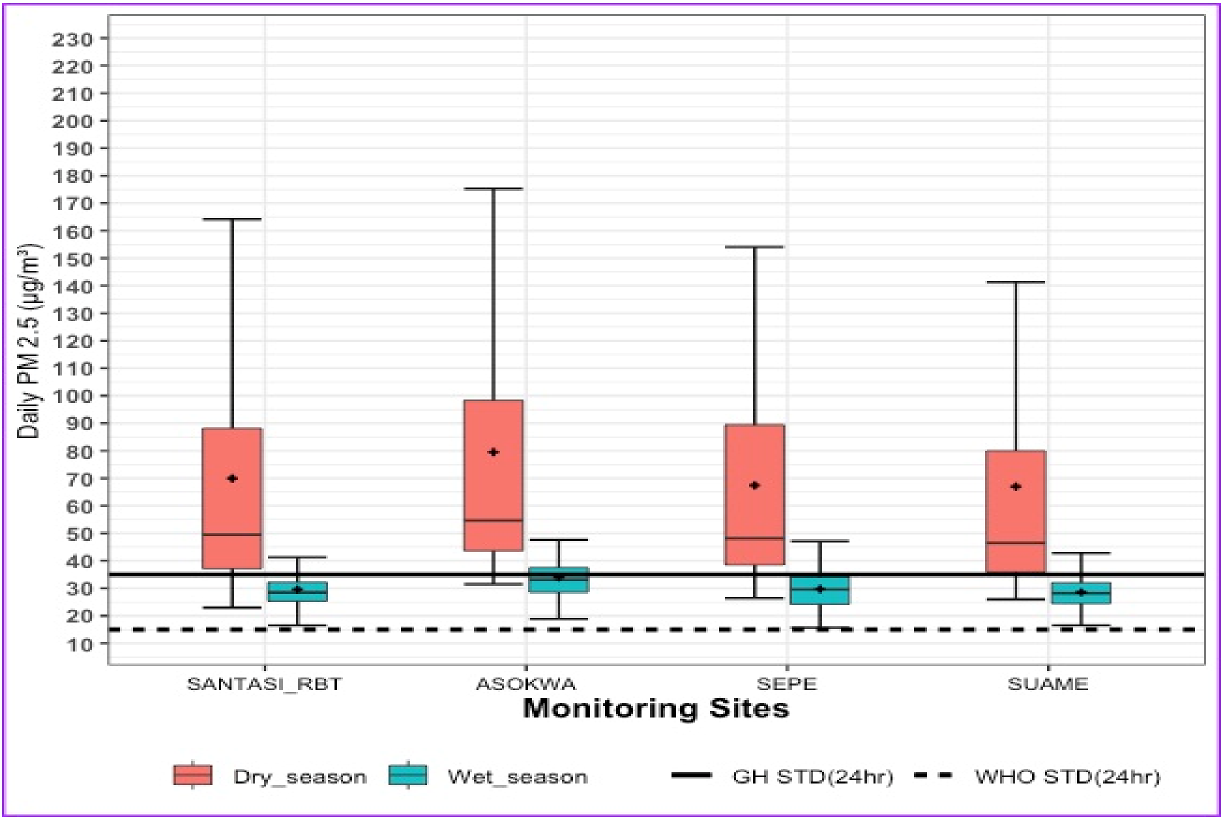


Fig. 4 : Box plot of PM2.5 levels at Greater Kumasi areas

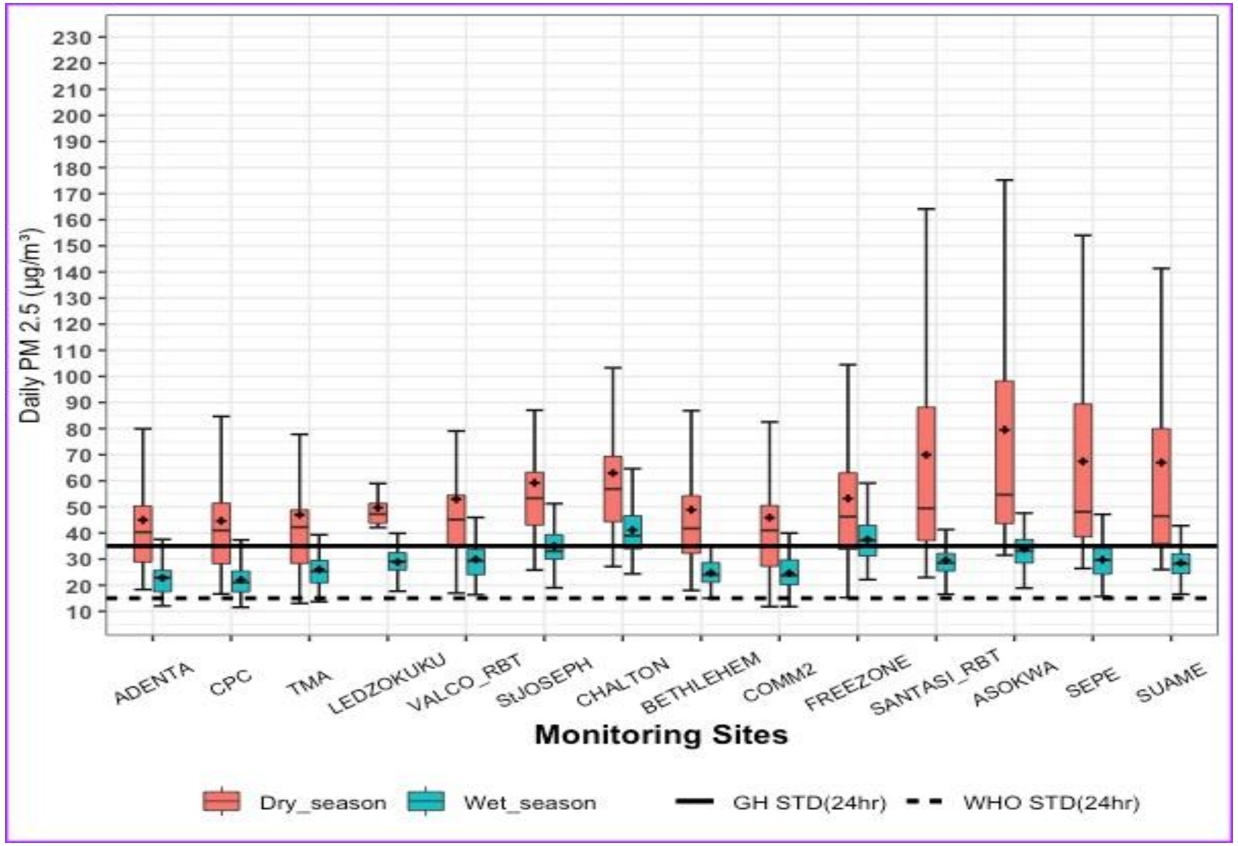


Fig. 5 : Box plot of PM2.5 levels at Accra-Tema and Greater Kumasi areas

Results

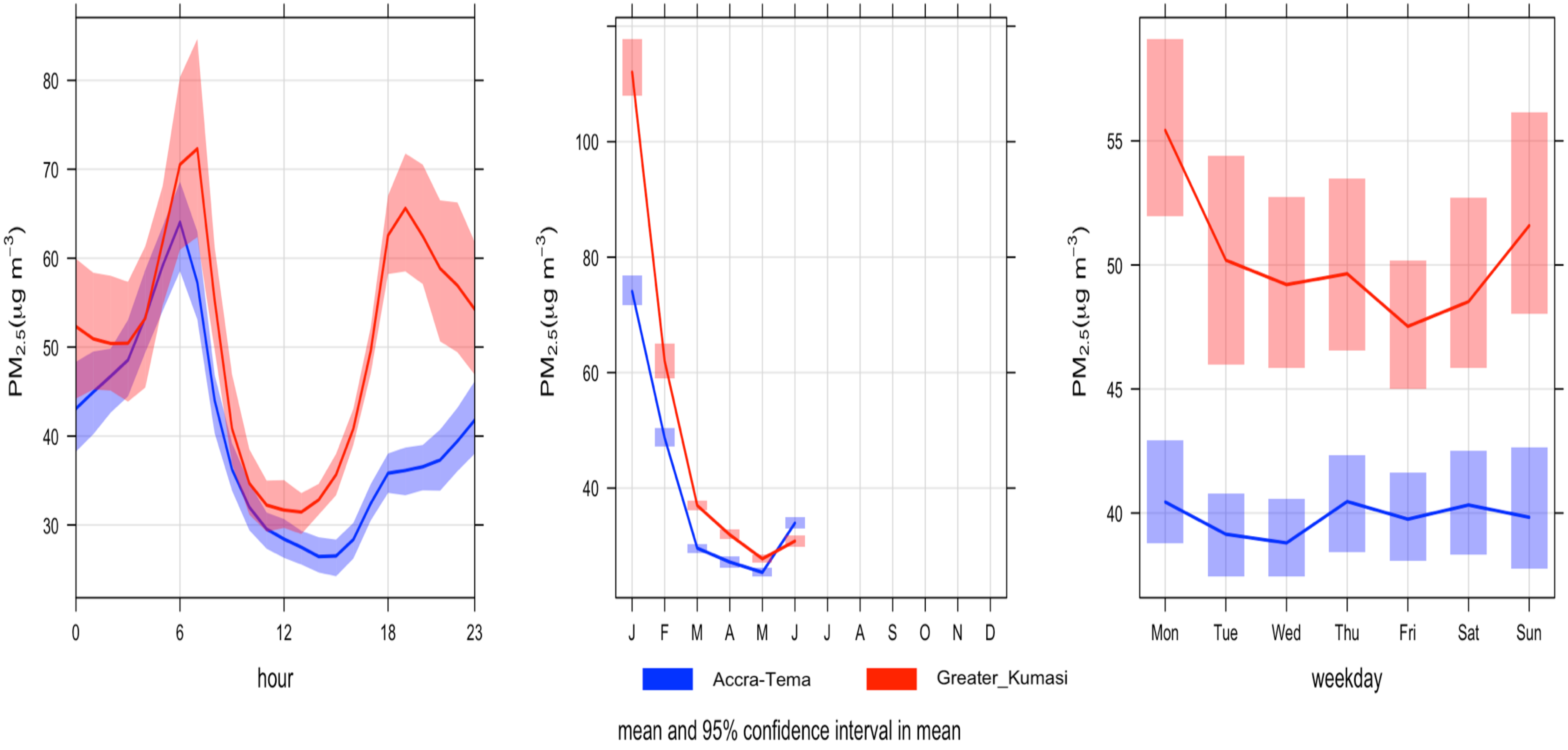
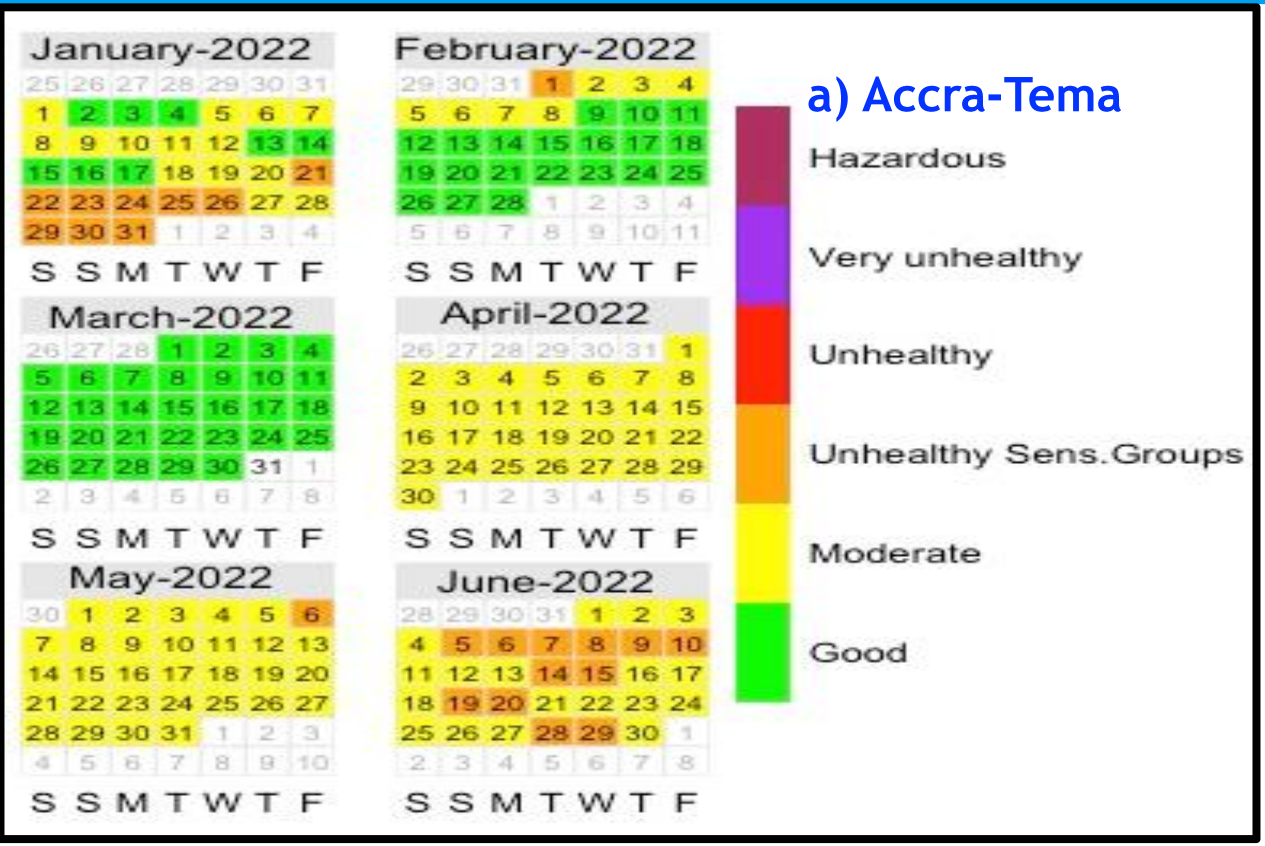
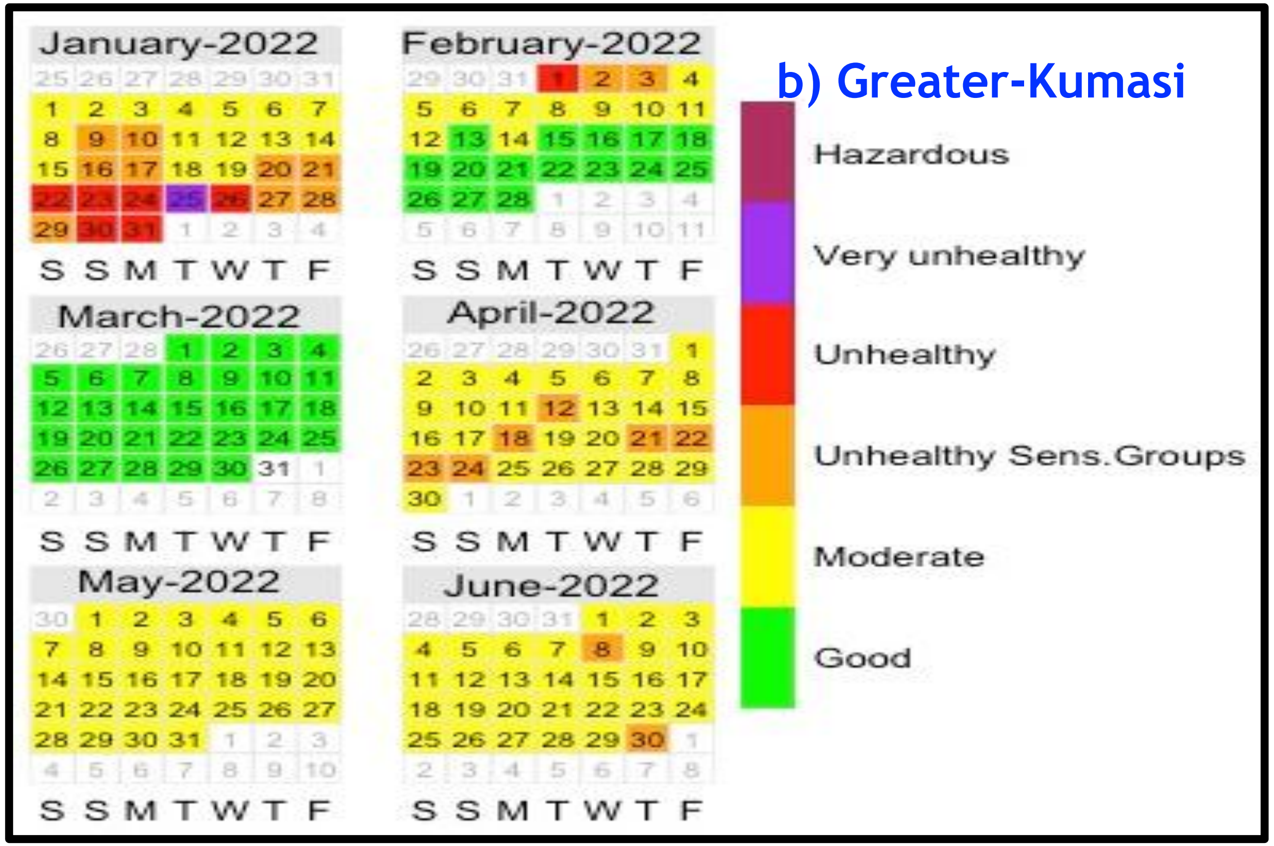


Fig. 6 : Time variation plot of $PM_{2.5}$ levels at Accra-Tema and Greater Kumasi areas

Results





- 86% of the $PM_{2.5}$ datasets exceeded the recommended limit prescribed in Ghana Air Quality Standard of 35 μg/m^3, with 57% occurring in the Accra-Tema and 29% in the Greater Kumasi areas.
- All the PM2.5 concentrations recorded in the study areas exceeded the World Health Organization guideline level of 15 μg/m^3
- The predominant AQI recorded at both Accra-Tema and Greater Kumasi Metropolitan Areas were in the moderate range (51-100)

Thank you

Comments and questions?

https://afriset.org/

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