Air Pollution (General View 3)

- Two sources of air pollutants ubiquitous in most urban areas are transportation & fuel combustion by stationary sources, including industrial heating.
- Vehicular emissions, seems to be dominant source of air pollutants especially in areas with high traffic densities & industrial activities.

Air Pollution (General View 4)

- In recent years, public concern is aroused due to wide publicity on damage to human health from inhaling of gaseous pollutants & fine particulates.
- Suggested that high incidences of respiratory health in urban areas may be associated with inhaling noxious gases & particulates in air

Air Pollution of Nairobi (1)

- Main sources of atmospheric pollution are vehicles, industries, emissions from use of charcoal & firewood, & other municipal sources such as open burning of waste.
- Increasing number of cars in city intensifies traffic & pollution problems.
- Vehicles emit significant levels of air pollutants, including greenhouse gases & precursors of smog.
- Charcoal burning, prevalent energy source in city, emits methane (CH4) & carbon monoxide (CO) & sends tiny particulates into air.

Chronic Traffic Congestions of Nairobi

Air pollution of Nairobi (2)

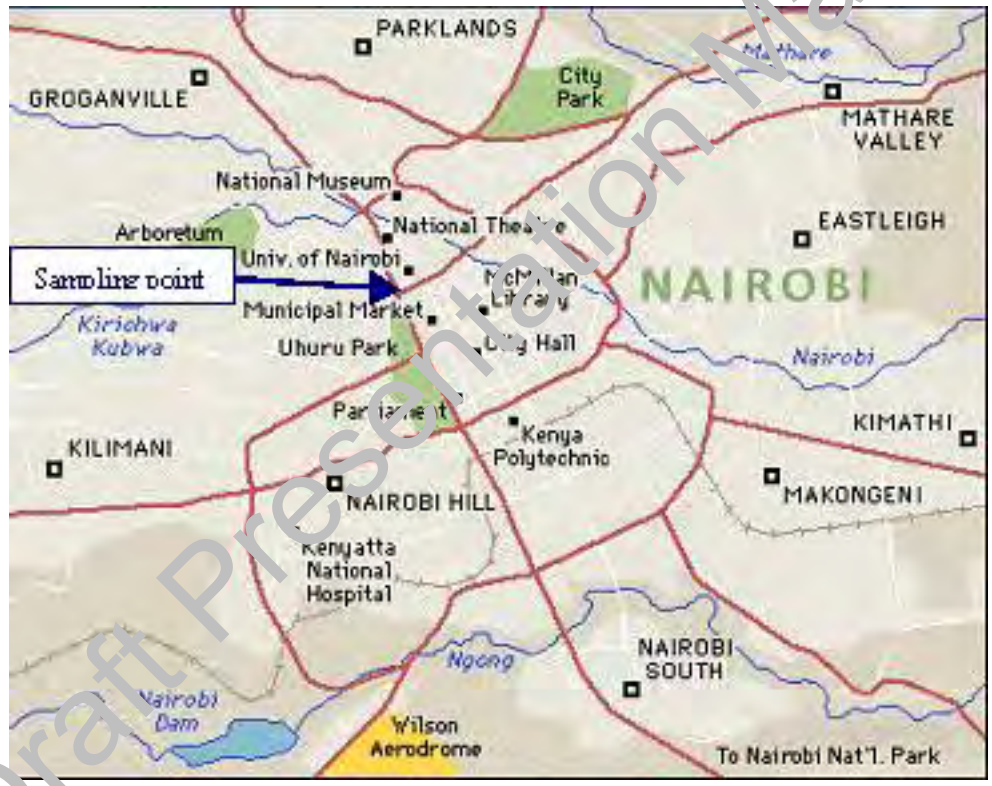
- Air Quality Survey (Odhiambo et. al.)
- Survey Period: Feb-April/03

Survey Results

- Lead (0.051 to 1.106 µg/m3)
- NO2 (0.011-0.976 ppm)
- NO (0.001-0.2628 ppm)
- PM10 levels (66.66 - 444.45 µg/m3)
- Strong correlation between fine (0.4 µm) particulates, NOx, and motor vehicle density.

→ Indicate urban traffic as major source for both fine particulates & NOx.

Sampling Point of 2003 A/Q Survey



Air Pollution of Nairobi (3)

- Air Quality Survey (Kinney et.al., 2009)
- PM2.5 is of Concern
- Survey Period: July 2009

Survey Results

- 128.7 to 18.7 µg/m3 @ 100 m downwind of major intersection in Nairobi.
- Vertical dispersion experiment revealed decrease from 119.5 µg/m3 at street level to 42.8 µg/m3 on 3rd-floor rooftop in CBD.

WHO A/Q Guideline (2005)

- PM2.5:
  - 10 µg/m3 Annual mean
  - 25 µg/m3 24-hour mean
- PM10:
  - 20 µg/m3 Annual mean
  - 50 µg/m3 24-hour mean

Rationale of A/Q Management

- Evidence on airborne PM & public health impact is consistent in showing adverse health effects at exposures that are currently experienced by urban populations in both developed & developing countries.
- Range of health effects is broad, but are predominantly to respiratory & cardiovascular systems.
- All population is affected, but susceptibility to pollution may vary with health or age.

WHO Interim Targets for A/Q Management

- Three Interim Targets
  - IT-1
  - IT-2
  - IT-3
- Long and Short terms Exposures
  - Long Term: Annual
  - Short Term: 24-hrs
- PM10, PM2.5, O3

WHO A/Q Guidelines &interim targets for PM (µg/m3): 24-hour Conc.

	PM10	PM2.5	Basis for the selected level
Interim target-1 (IT-1)	150	75	Based on published risk coefficients from multi-centre studies & meta-analyses (about 5% increase of short-term mortality over AQG value).
Interim target-2 (IT-2)	100	50	Based on published risk coefficients from multi-centre studies & meta-analyses (about 2.5% increase of short-term mortality over AQG value).
Interim target-3 (IT-3)	75	37.5	Based on published risk coefficients from multi-centre studies & meta-analyses (about 1.2% increase in short-term mortality over AQG value).
Air quality guideline (AQG)	50	25	Based on relationship between 24-hour and annual PM levels.

WHO A/Q Interim Targets and Nairobi

- Nairobi – Maybe classified into IT-1
- This level corresponds to highest mean concentrations reported in studies of long-term health effects.
- May also reflect higher but unknown historical concentrations that may have contributed to observed health effects.
- This level has been shown to be associated with significant mortality in developed world.

Geography of Nairobi (1)

- Largest Town in Kenya (3 – 4 million population)

  → Large Exposure to People.

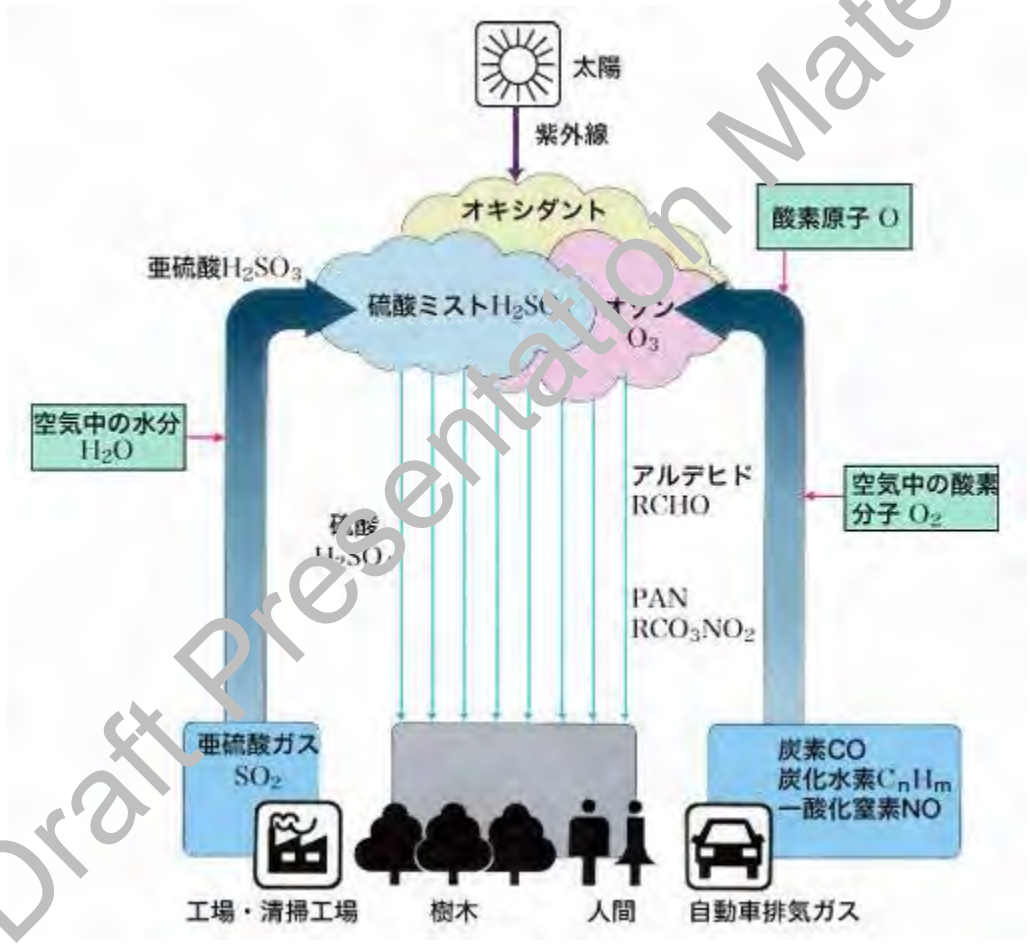
- Located at highland area (1,700 m.a.s.l)

  → Thin Air: Lean Combustion

  Strong Sunshine

  → Photochemical Rxn

Photo-Chemical Rxn



Geography of Nairobi (2)

- Partially surrounded by Great Rift Valley Mountain Ranges.

  → Prone to be trapped since Mountain Range plays as Barrier

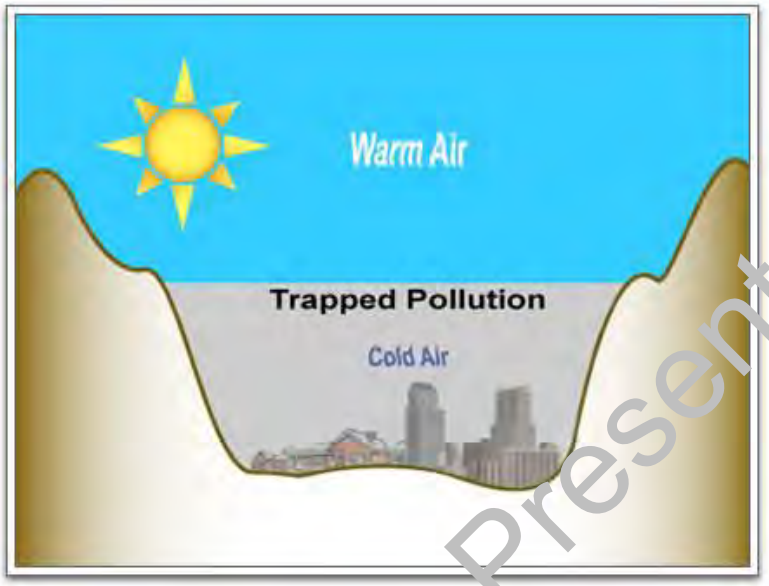
- No Strong Wind Blowing

  → No Quick Dispersion of Pollutant. Stay longer inside of City

  → Prone to Occur Thermal Inversion

Thermal Inversion

- Tend to occur sunny, windless day (Winter time).
- Not occur in night time



Pollutants are trapped and not spread.

Spreading of smoke plume is inhibited due to the barrier between hot air mass and cold one.

Negative Impacts due to Air Pollution

- Air pollution adversely affects human health & environment.
- Particulates are associated with respiratory & eye diseases such as asthma, lung cancer, & conjunctivitis, especially in infant & elderly.
- Air pollution is also major contributor to effects such as acid rain, which has been responsible for much damage to soil, fish resources & vegetation, often far from emission sources.

Human Health Impacts due to Air Pollution (1)

- Health effects caused by air pollutants range from subtle biochemical & physiological changes to difficulty in breathing, wheezing, coughing & aggravation of existing respiratory & cardiac conditions.
- These conditions can result in increased use of medicaments, increased frequency of doctor visits, loss of man-hours, more hospital admissions & premature death.

Human Health Impacts due to Air Pollution (2)

- Health effects of poor A/Q principally affect body's respiratory system.

  e.g., Chronic bronchitis

  Emphysema

  Asthma

  Cardiovascular disorders.

Human Health Impacts due to Air Pollution (3)

- 3 yrs reduction of Life Time Expectancy/TSP 100 ug/m3 of Increase

Note: This rule of thumb is applicable for situation where TSP concentration is above certain thresh-hold value.

(Source: Case Study of PRC, PU, 2013)

Top ten major causes of mortality (%) in Nairobi (1998- 2000)

	1998	1999	2000
Respiratory symptoms	37.0	27	35.5
Malaria	23.1	18.8	14.7
Accidents	-	14.2	10.0
Skin disease	14.4	6.6	7.7
Diarrhea	9.3	8.3	9.5
Urinary tract disease	4.6	Not indicated	6.0
Intestinal worms	4.1	Not indicated	Not indicated
Disease of puerperium & childbirth	3.9	7.3	Not indicated
Eye infections	3.2	7.9	6.7
Ear infections	-	9.4	0.8

Source: City of Nairobi Outlook,

Remarks from Nairobi Outlook (1)

- Available data show that leading cause of death is Respiratory Ailments. In 2000, Respiratory Disease &Malaria accounted for over 50 % of all deaths in city (CBS 2003d).
- Five most important causes of death in children under five include Acute Respiratory Infection (ARI), diarrhea, measles, Malaria, Malnutrition & anemia.
- All these are related to living environment.

Remarks from Nairobi Outlook (2)

- More needs to be done both to ensure better enforcement of A/Q standards, thereby reducing the prevalence of respiratory diseases, and to improve sanitation and health in Nairobi.

Mortality

- Mortality Due to PM_{10}

Excess Death = $0.00112 \times (PM_{10} - 41) \times P \times c$

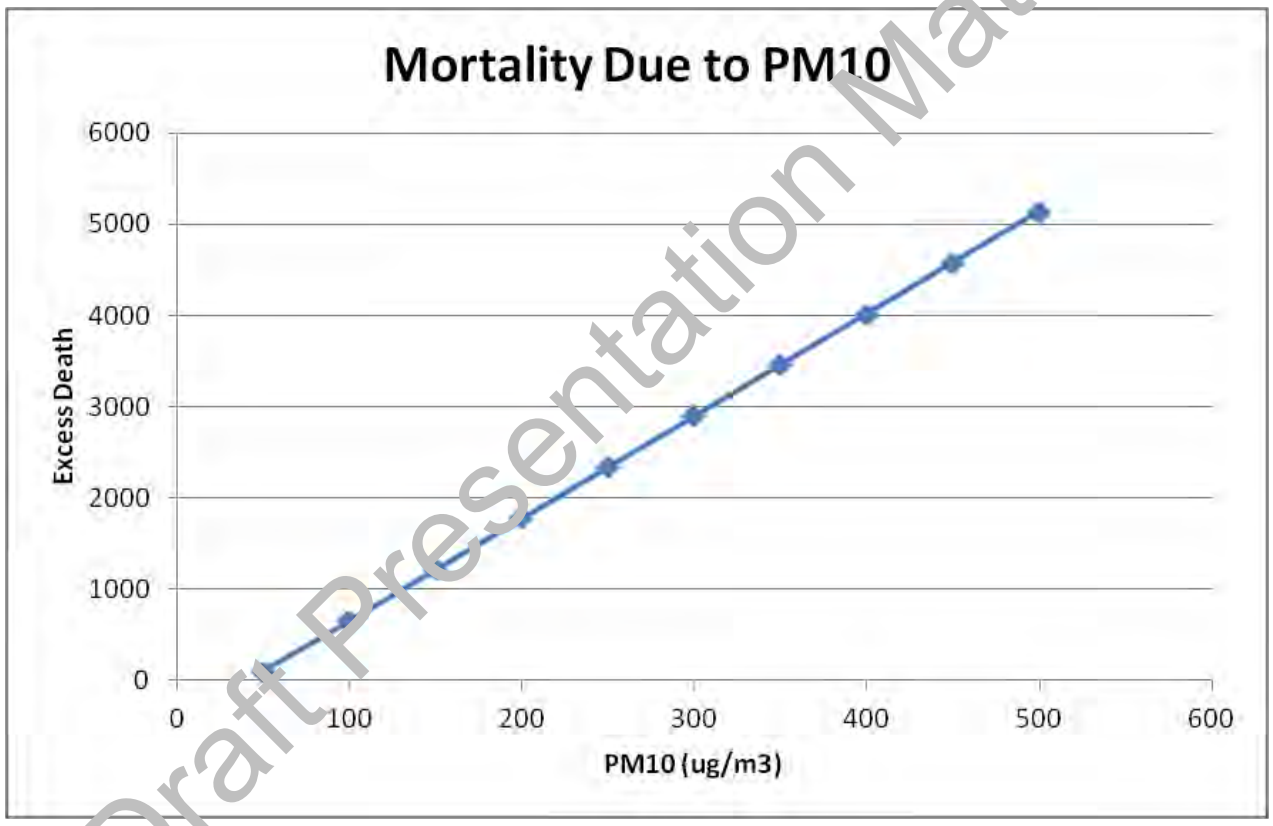
where

P : # of People exposed to specific concentration.

c: Crude Rate Mortality, the number of deaths occurring during the year, per 1,000 population (≈ 0.01 for Kenya)

PM_{10}: Annual Average Concentration [ug/m3]

Mortality Due to PM10 where, P = 1 million



Illness (Morbidity)

- Chronic Bronchitis

Total # of yearly cases/100,000 =

$6.12 \times (PM_{10} - 41)$

- RHD (Respiratory Hospital Diseases)

Total # of yearly cases/100,000 =

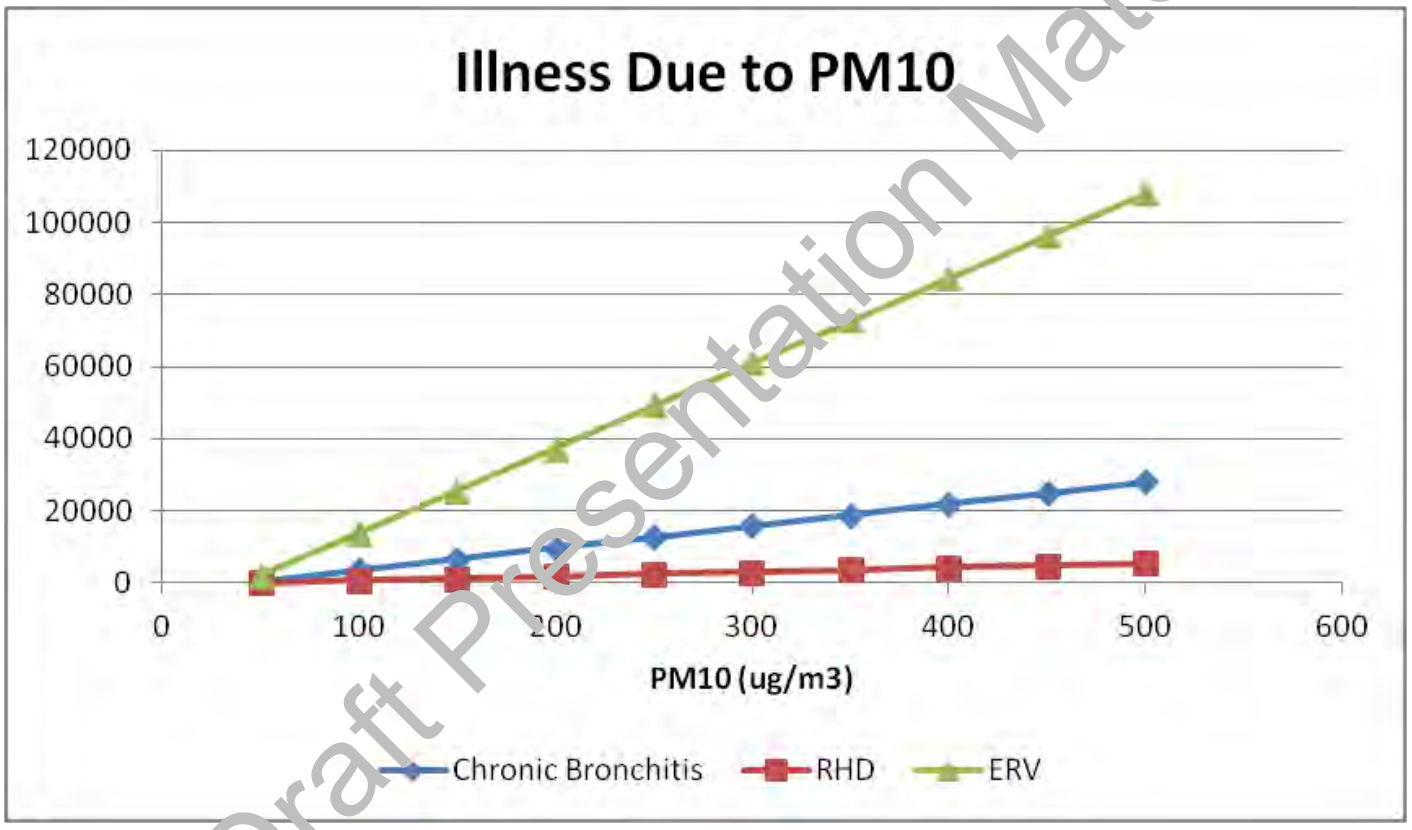
$1.2 \times (PM_{10} - 41)$

- ERV (Emergency Room Visits)

Total # of ER Visit/100,000 = $23.54 \times (PM_{10} - 41)$

Excess Illness due to PM10

where, P = 1 million



Summary 1

1. Continuous A/Q Monitoring (or establish city-wide A/Q Monitoring Network)

- Important to continue long-term A/Q monitoring.
- Establish stationary monitoring points across city.
- TSP, PM10, PM2.5, Ozone, NOx, Sox

2. Epidemic Study

- Continue epidemic study to study effects of vehicular emission on human heath

Strategies to Improve
(1) Vehicular Emissions

- Passenger Cars

  No vehicle I/M Regulation

- Public Cars

  Need One-Time Inspection/year for Registration

- Import of many used cars.

Strategies to Improve Vehicle Inspection for Import of Use Cars

Quality Assurance of Imported Used Cars (1)

- KEBS (Kenya Bureau of Standards)
- Legal Notice 78 of 15/07/2005
- KEBS has signed contracts with M/s Auto Terminal Japan Ltd (ATJ), M/s Japan Export Vehicle Inspection Center Co. Ltd (JEVIC) & M/s Quality Inspection Services Inc Japan (QISJ) for pre-export verification of conformity to standards for used road vehicles.
- Companies will provide inspection services in following countries:

  Japan, UAE , UK, Singapore, SA

Vehicle Inspection
Quality Assurance of Imported Used Cars (2)

- KEBS, KS 1515 of 2000

Critical parameters of Used Car Import.

(1) Age Limit – Less than 8 years from year of first registration.

Difference between date of manufacture & date of first registration shall be < one year.

(2) Right Hand Drive – (RHD)

(3) Road-worthiness

Shall be determined by compliance to requirements specified in standard.

Vehicle Inspection
Quality Assurance of Imported Used Cars (3)

- KEBS, KS 1515 of 2000

  Critical parameters of Used Car Import.

(4) Radioactive contamination inspection

(5) No emission of black or dense blue colored smoke (by observation)

(6) No vehicles made before 1960

(7) Less than 0.5 % of CO in vehicular emission.

(8) Less than 0.12 % of HC in vehicular emission.

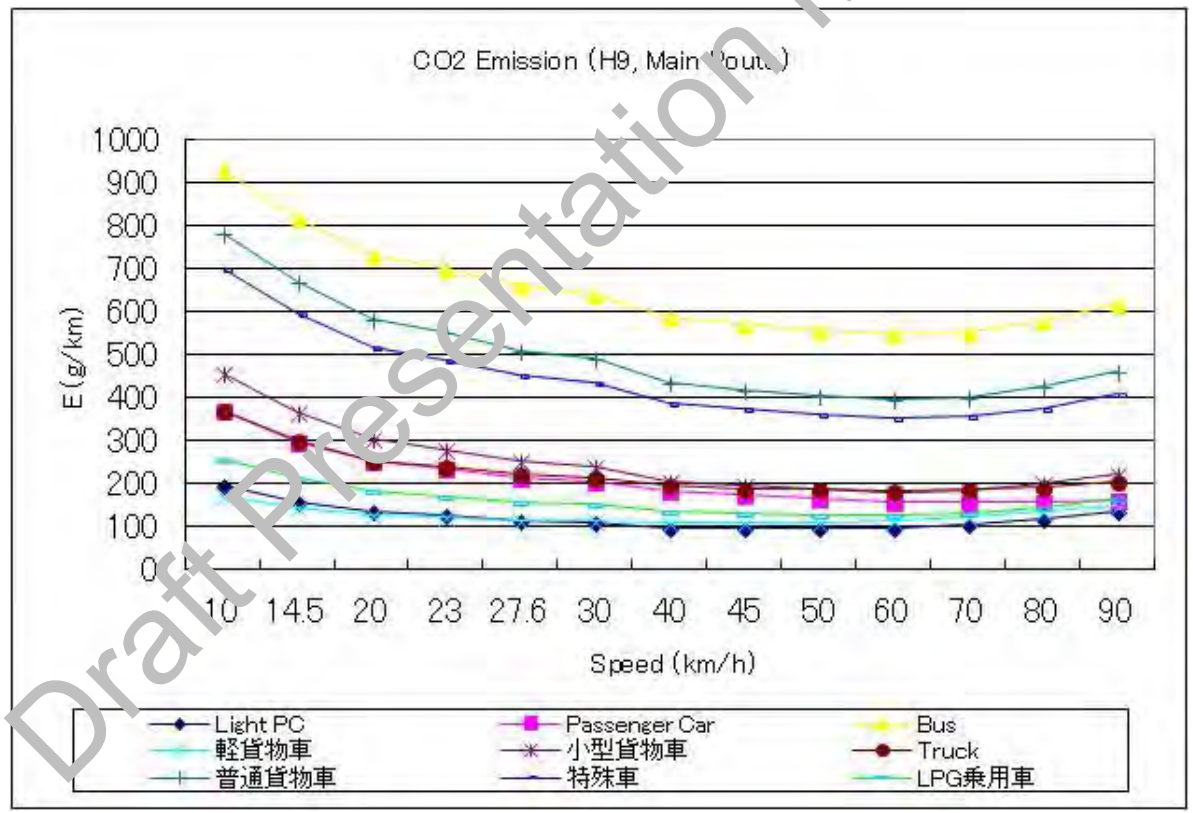
Vehicle Inspection

Summary of Issues to be addressed.

- Vehicle inspection of imported used cars is satisfactory.
- However, vehicle I/M in Kenya after its purchase is not mandatory and/or comprehensive.
- Tons of poor-conditioned vehicles circulating across Nairobi City.
- Need to establish legal framework for proper vehicle I/M (enforcement & compliance)

Strategies to Improve
(2) Traffic Congestion and Emission Loading

Vehicular Emission Loading will be decreased as traffic congestion be solved to some extents.



Vehicle Emission Loading (2)

- So, vehicular emission loading can be reduced by mitigating chronic city-wide traffic congestion.
- Example:

If there is improvement of city-wide vehicle moving speed such as,

15 km/hr ⟶ 30 km/hr

Then, we may expect to have 20 % – 25 % reduction of emission loading.

Strategies to improve
(3) Fuel Policy

- Partnership for Clean Fuels & Vehicles (PCFV) by UNEP
- Launch transition to low-sulfur diesel.
- Low-sulfur fuels reduce levels of air pollutants emitted by vehicles, including sulfur oxides, soot & smoke particles, which can trigger respiratory & cardiovascular diseases & increase risk of lung cancer.
- Kenya's new standard of 500ppm is lowest in East Africa & has been followed by Tanzania

Strategies to improve
(3) Fuel Policy

- Elimination of lead in gasoline (done)
- Phase down of sulfur in diesel & gasoline fuels, concurrent with,
- Adoption of cleaner vehicle technologies,
- Development of Automotive Fuel Efficiency policies & strategies.

Strategies to improve
(3) Fuel Policy

- Fuels and vehicles work together as a system
- Low emission, fuel efficient vehicles
- New technologies: hybrid, hydrogen etc
- Retrofit vehicles: can reduce emissions by 40-95%
- Catalytic Converter: can reduce emissions up to 90%

(3) Fuel Policy
Other Energy Choices for Africa

- Biofuels (energy security, economy, environment, improve fuel quality, sustainability)
- Compressed Natural Gas (CNG)
- Liquefied Petroleum Gas (LPG)
- Electric trams/light rail

Strategies to Improve
(4) Legal Framework for A/Q Management

- Air pollution legislation in Kenya is contained in various legislative documents which include

  Penal Code (Cap 63), Public Health Act (Cap 242),
  Traffic Act (Cap 365), Grass Fibres Act (Cap 327),
  Occupation Health and Safety Act, 2007,
  Mining Act (Cap 306),
  Local Government Act (Cap 265),
  Chiefs Authority Act (Cap 128),
  Air Quality Regulations under EMCA, 1999, and
  Building Code Adoptive Bylaws, 2000.

Weaknesses exist in enforcement & compliance practices.

Strategies to improve
(5) Enforcement and Compliance 1

- Legislations are fairly comprehensive.
- However there are two contributory factors that impede full implementation.
- First, penalties in older laws are too low to deter contraveners. This calls for review of these laws.
- Other weakness is inadequate & inconsistent enforcement & compliance.
- Improvement in enforcement & public awareness will lead to more compliance which will have multiplier effect resulting in reduced disease burden on both government & households.

Strategies to Improve
(6) Combined Strategies and/or Policies

Specific policy interventions will however further improve policy implementation landscape:

- **Full exploration of environment & health inter-linkages**

Health & Environment Strategic Alliance (HESA) as envisaged & recommended in Libreville Declaration (WHO & UNEP, 2008) should be established.

Other inter-sectoral strategic partnerships with lead agencies on weather & climate change monitoring, finance, agriculture as well as water & sanitation should also be established, strengthened & operationalized.

Strategies to Improve
(7) Human Health and Environment

- **Established link between cost of healthcare & state of environment must also be articulated to policy makers.**

Relevant & well articulated health- environment indicators &other advocacy instruments should be developed, monitored &communicated to policy makers.

Strategies to Improve
(8) Targeted Capacity Building

- **Targeted capacity building interventions are also needed & should include focused & needs-driven human resource & technical capacity development within all institutions with health & environment mandates.**

Special emphasis must be made for specific areas & levels where known gaps exist for instance, environmental health, environmental engineering & integrated environmental management.

Strategies to Improve
(9) Enforcement and Compliance 2

- **Need to strengthen environmental health enforcement & compliance practices** in order to achieve required standards in health & environment.
- There is also need to domesticate & implement all relevant regional & international multilateral environmental agreements.

End of Presentation

Thank you!