South Africa: Introduction to Ambient Air Quality Monitoring Course

April 3 through 6, 2006

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1

Welcoming Remarks & Important Information

- Welcoming remarks
- Introduction of course instructors, Cape Town host and local hosts; others
- Ground rules
- Coursework materials distribution
- Be sure to register/sign in each day
- Introduction of each workshop participant

2

Course Expectations from Participants

- What do you expect to learn from the course "Introduction to Air Quality Monitoring"?
- What questions do you have right now?
- What do you need to know?

3

Day 1
South Africa: Introduction to Ambient Air Quality Monitoring Course

- Module 1. Course Introduction, Objectives and Overview of Air Pollution
- Module 2. Why Develop an Ambient Air Monitoring Program?
- Module 3. Manual Active and Passive Ambient Air Sampling Devices
- Hands-on examination of passive samplers and portable particulate matter sampler

4

Day 2
South Africa: Introduction to Ambient Air Quality Monitoring Course

- Module 4. Automated Ambient Air Sampling Devices and Monitors
- Module 5. Quality Control and Quality Assurance of Ambient Air Sampling and Monitoring Operations through Calibration, Verification, and Maintenance
- Hands-on examination of automated PM and pollutant gas monitors

5

Day 3
South Africa: Introduction to Ambient Air Quality Monitoring Course

- Module 6. Ambient Air Monitoring Site Selection Procedures
- Module 7. Steps for Designing and Implementing an Ambient Air Monitoring Program
- Case Study Classroom Exercises

6

Day 4
South Africa: Introduction to Ambient Air Quality Monitoring Course

- Review Case Study Classroom Exercises and Report to the Workshop
- Module 8. Communications
- Open Discussion, Concluding Remarks, Course Evaluation, and Distribution of Certificates of Course Completion

7

Overall Course Objectives

- Answer your Questions and Needs
- Air Pollution Overview
- Involving the Public
- Air Pollution from Viewpoint of South Africa
- Air Quality Management Plan
- Monitoring and Sampling Methods (hands-on)
- Selection of Monitoring Sites

8

Course Objectives (Cont'd)

- Air Monitoring Plan
- Quality Assurance Project Plan and SOPs
- Communicating Results
- Student Presentations of Air Monitoring Plans
- Provide Additional Study Materials on CD

9

Module 1: Overview and Introduction to Air Pollution

Objectives:

- Meeting the Public; Receiving Their Ideas
- Air Quality Monitoring and its Importance to an Overall Air Quality Management Program
- Overview of Air Pollution and Monitoring

10

Definitions

- Ambient Air
- Air Pollutants
- Air Pollution Monitoring
- Personal Monitoring

11

Air Quality Management Program

- Note the importance of Air Quality Monitoring to the overall air quality management program

12

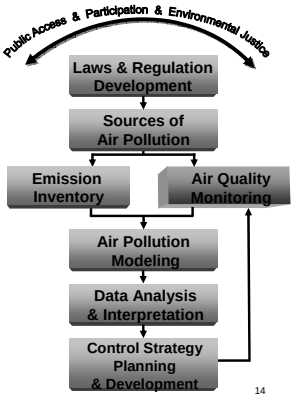
Major Components of an Air Quality Management Program

- Overview of Air Quality Management
- Laws and Regulations – US EPA Programs
- Sources of Emissions
- Measurement of Emissions
- Emission Inventory Development
- **Air Quality Monitoring**
- Air Quality Modeling
- Data Analysis and Air Quality Management Process
- Control Strategy Planning
- Public Participation and Environmental Justice

13

Role of Air Quality Monitoring in an Air Quality Management Program.

As with other components of the AQM process, stakeholder and public participation is important.



14

Public Participation…

- **Means that people should have a say in decisions which affect them**
- **Includes the promise that the public's contribution will influence the decision**
- **Communicates the interest and meets the process needs of all participants**
- **Requires that the participants seek out and facilitate the involvement of those potentially affected**

15

Fundamental Questions to Address

- How is my project impacting the local community? Are there social costs?
- How can I effectively involve the community in the decision making process?
- What are the needs of the community?

16

Overview of Air Pollution Monitoring

17

Overview of Air Pollution Monitoring

- Historical Episodes
- Air Pollutants in the U.S. and South Africa
- Health Effects
- Classification of Sources
- Pollutant Transportation and Transformation

18

Air Pollution Episodes

- Muese River Valley (1930)
- Donora, Pennsylvania (1948)
- Poza Rica, Mexico (1950)
- London Fog (1952)
- New York City (1953)
- Bhopal, India (1984)

19

Air Pollution Episode: London Fog (1952)

20

Air Pollution Episode: Bhopal, India (1984)

21

Has South Africa Had an Air Pollution Episode?

22

Air Pollutant Classifications

- United States ("criteria" air pollutants)
- South Africa ("priority" air pollutants)

23

U.S. EPA "Criteria" Pollutants

- Particulate Matter (TSP, PM10, and PM2.5)
- Ozone (O3)
- Sulfur Dioxide (SO2)
- Nitrogen Dioxide (NO2)
- Carbon Monoxide (CO)
- Lead (Pb)

24

South Africa "Priority" Pollutants

- Identical to U.S. Criteria Pollutants
- Also Includes Benzene and Dust

25

Review of Criteria/Priority Pollutants

- Chemical and Physical Descriptions
- Sources of Air Pollution
- Effects on Humans and Surroundings

26

Particulate Matter (PM)

Definition:

Particulate matter consists of small particles of solid and liquid substances that are released into the atmosphere by many natural processes and human activities. Some particulate matter forms in the atmosphere from precursor gases.

27

Definition of PM by Size

- Total Suspended Particulate (TSP) refers to particles with average aerodynamic diameters of submicron up to 25 to 50 μM (25 to 50 millionths of a meter).
- PM10 are individual particles have an average aerodynamic diameter less than or equal to10 μM (10 millionths of a meter). Comparatively speaking, a particle that is considered PM10 is 1/6 the diameter of a human hair.
- The PM2.5 fraction consists of individual particles having an average aerodynamic diameter less than 2.5 μM (2.5 millionths of a meter).
- Particles of 10 to 2.5 μM are the "coarse" fraction.

28

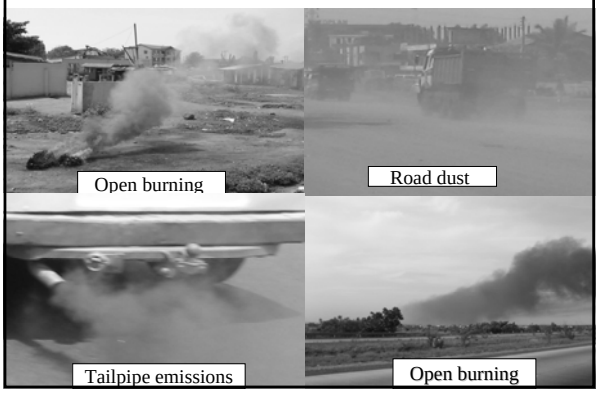
Sources of PM

Sources:

- Exhaust emissions from older, poorly maintained vehicles without catalytic converters and from diesel-operated vehicles
- Burning of wood and wood-based charcoal for cooking
- Burning of waste
- Wind-entrained dust from roads and other sources
- Chemical reactions in the atmosphere

29

General Sources of PM Air Pollution



PM10 Effects on Human Health and Surroundings

Health Effects on Humans and Surroundings:

- PM10 pollution has been shown to increase human mortality in cities associated with higher than normal particulate pollution
- Chronic effects on respiration due to particulates lodging in the lungs
- Interfere with green plant's ability to absorb carbon dioxide and release water surface due to deposits of dust

31

PM10 Effects on Human Health and Surroundings (Cont'd)

- Heavy dust may affect the breathing of animals
- Particulates from large construction projects can kill organisms and damage large areas, change species composition, alter food chains, and generally affect ecosystems
- Particulates block sunlight causing changes in the climate, resulting in changes in the biosphere

32

Ozone (O3)

Definition:

- O_3 is a colorless gas with a slightly sweet odor. It is the most common photochemical oxidant in the air.

A natural layer of ozone forms high in the atmosphere (stratosphere) and protects us from the harmful ultraviolet radiation from the sun.

However, O_3 is considered a pollutant in the lower atmosphere (troposphere) when it exceeds the air quality standard.

33

Source of Ozone

Indirect Sources:

Emissions from poorly maintained older vehicles

- Burning of fossil fuels
- Industrial areas that produce NO_2 as a byproduct
- Ozone forms as a secondary pollutant from precursors

NO_2 + UV light → NO + O ·

O · + O_2 → O_3

NO_2 + VOC + O_2 + UV light → O_3 etc

34

Ozone Effects on Human Health and Surroundings

Health Effects on Humans and Surroundings:

- Eye and respiratory system irritation
- The effect depends on the dose or concentration of exposure which result in damage to plants and animals, and materials such as rubber, paint, and textiles

35

Sulfur Dioxide (SO2)

Definition:

SO_2 is a colorless and odorless gas normally present in the Earth's atmosphere at low concentrations. A significant feature of SO_2 is that it converts to particulate sulfate through complex reactions.

36

Sources of SO2

Sources:

- Fumes from diesel buses and exhaust from poorly maintained older vehicles burning sulfur-contained fuels
- Oil refineries, cement factories, aluminum plants
- Coal in power plants

37

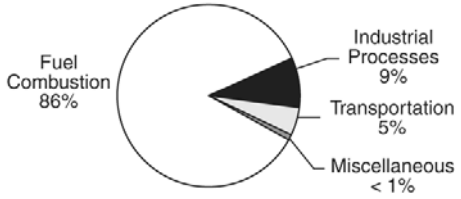
SO2 Effects on Human Health and Surroundings

Health Effects on Humans and Surroundings:

- Adverse effects depends on the SO_2 dose or concentration
- SO_2 is capable of causing severe damage to human and animal lungs, particularly in the sulfate form
- Corrosion of paint and metals
- Injury or death to animal and plants
- SO_2 is a precursor to acid rain

38

SO2 Emission Sources



39

Nitrogen Dioxide (NO2)

Definition:

NO_2 is a yellow-brown to red-brown gas that converts by complex reactions in the atmosphere to nitric acid (HNO_3) and the nitrate anion (NO_3^-).

40

Sources of NO2

Sources:

- Vehicular tailpipe emissions as nitric oxide, NO, which is oxidized to NO_2 in the atmosphere
- Burning of fossil fuels

41

NO2 Effects on Human Health and Surroundings

Health Effects on Humans and Surroundings:

- Eye, nose, throat, and lung irritation
- Long-term exposure to NO_2 increases susceptibility to viral infections, such as influenza
- NO_2 suppresses plant growth and damages leaf tissue

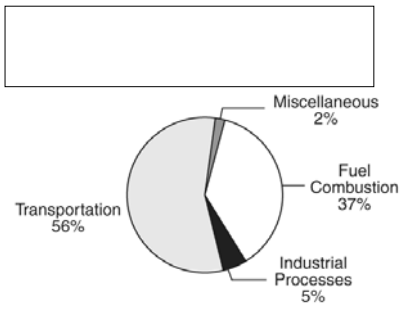
42

NO2 Effects on Human Health and Surroundings (Cont'd)

- Depresses immune systems in animals
- NO_2 has a role in the production of photochemical smog containing ozone
- Contributes to acid rain as nitric acid, leading to effects on soil and vegetation

43

NOx Emissions Sources



44

Carbon Monoxide (CO)

Definition:

CO is a colorless, odorless gas that at very low concentrations is extremely toxic to humans and animals. Many people live and have activities near major traffic routes and are thus very susceptible to CO pollution.

45

Sources of CO

Sources:

- Emissions from all motor vehicles; larger concentrations from poorly maintained older vehicles
- Open pit wood burning (incomplete combustion)
- Burning of charcoal for cooking (incomplete combustion)
- Natural occurrence in the atmosphere

46

CO Effects on Human Health and Surroundings

Health Effects on Humans and Surroundings:

- CO bonds with hemoglobin in the blood more readily than oxygen (250 times faster) and is not readily released
- The effect of CO inhalation depends on the dose or concentration of exposure and ranges from dizziness and headaches to death

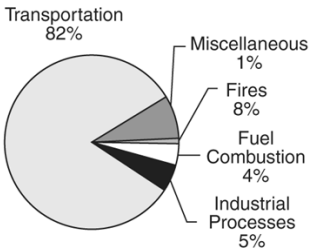
47

CO Effects on Human Health and Surroundings (Cont'd)

- People with heart disease, anemia, or respiratory disease are extremely susceptible to the effects of CO
- Causes birth defects, including mental retardation and impairment of growth of the fetus

48

CO Emission Sources



49

Lead (Pb)

Definition:

Lead, a heavy and soft metal, is a major constituent of automobile batteries and is an anti-knock additive for gasoline. Found in exhaust from vehicles using leaded fuels. Also once used in paints.

50

Sources of Lead

Sources:

- Road and roadside dust (from vehicle exhaust when leaded gasoline is used)
- Erosion of lead-containing paints

51

Lead Effects on Human Health and Surroundings

Health Effects on Humans and Surroundings:

- Disrupts normal neurological development
- Can cause learning difficulty, reduced intelligence and attention span, and permanent damage to a child's brain and nervous system

52

Benzene (C_6H_6)

Definition

Benzene is an aromatic organic chemical compound. It has a 6-carbon ring structure. When evaporated, it is a colorless gas with a slightly sweet odor.

53

Sources of Benzene

Sources:

- Natural sources include volcanoes and forest fires
- Benzene is a natural part of crude oil and gasoline
- Industrial processes and motor vehicles are major sources.
- Benzene can come from burning of coal
- Benzene is emitted from coal gasification process
- Benzene is found in cigarette smoke

54

Benzene Effects on Human Health and Surroundings

Health Effects on Humans:

- Acute exposure to benzene (less than 14 days) at high levels causes drowsiness, dizziness, headaches, and skin/eye/lung irritation
- Chronic exposure to benzene (more than a year) can cause cancer, leukemia, damage to immune system, and reproductive problems.

55

Hazardous Air Pollutants (HAPs)

- Hazardous air pollutants or toxic air pollutants are pollutants known to cause or are suspected of causing cancer or other serious human health effects, or ecosystem damage.
- In the U.S., HAPs are not considered criteria pollutants. They are categorized under other regulations:
  - National Emissions Standards for Hazardous Air Pollutants
  - Hazardous Air Pollutants Regulations

56

HAPs (Cont'd)

- Hazardous air pollutants are emitted from literally thousands of sources including large stationary industrial facilities or major point sources (such as electric power plants or utilities), smaller area sources (such as dry cleaners), and mobile sources (such as automobiles).

57

Hazardous Air Pollutants (HAPs) Basis for Standards in the U.S.

- Health Based Standards (1970 CAA)
  - NESHAPs
- Technology Based Standards (1990 CAA)
  - MACT
  - Major Sources

58

Hazardous Air Pollutants in the U.S.

- Benzene
- Toluene
- Vinyl Chloride
- Naphthalene
- Phenol
- Nitrobenzene
- Heptachlor
- Chromium VI
- Formaldehyde
- Acrolein
- 179 other HAPs

59

Classification of Air Pollutants Sources

- Mobile Sources
- Stationary Sources
- Biogenic Sources
- Fugitive Sources
- Area Sources
- Point Sources

60

Two Main Sources

- Anthropogenic
- Biogenic

61

Anthropogenic Sources

- Mobile
- Stationary
- Fugitive
- Area

62

Mobile Sources

- Automobiles
- Diesel Engines
- Off-Road Vehicles and Equipment
- Airplanes
- Railroad Locomotives and Marine Engines

63

Mobile Source

64

Air Pollutant From Stationary Sources

Air pollutant from stationary sources are produced by two primary activities:

- Combustion of fuel such as coal and oil at power generating facilities; and
- Industrial processes that release pollutants into the air

65

Biogenic Source

66

Fugitive Sources - Types

- Open burning of trash / waste
- Open land masses
- Chemical storage piles
- Open vats and chemical containers
- Road-side dust
- Agriculture and farming
- Natural emissions

67

Area Sources – Pollutants Emitted

- Fugitive dust containing total particulate matter (TPM), PM-10 and PM-2.5 particles
- Volatile organic compounds (VOCs) containing various chemicals including hydrocarbons and hazardous air pollutants (HAPs)
- Crustal earth metals found within fugitive particulate matter

68

Point and Area Sources

69

Major Pollutants of Interest To Air Management Programs

- Particulate Matter Consisting of PM10 and PM2.5
- Particulate Matter Containing Lead
- Carbon Monoxide
- Ozone
- Oxides of Nitrogen
- Oxides of Sulfur
- Others
  - Benzene &Volatile Organic Compounds/Hydrocarbons
  - Ammonia

70

Transport and Transformation of Air Pollutants

- Meteorological Factor
- Topographical Factors
- Chemical and Physical Changes

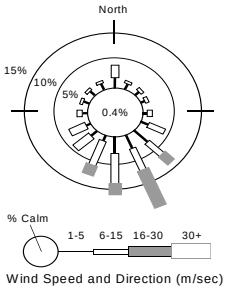
71

Meteorological Factors

- Wind speed and direction
- Atmospheric stability
- Temperature inversions

72

Wind Speed and Direction—Wind Rose



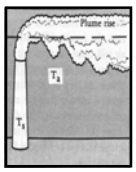
73

Atmospheric Stability

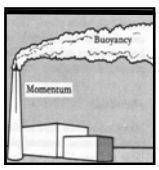
- Vertical Movement of Air
- Differential Heating
- Conduction vs. Convection
- Turbulence
  - Thermal
  - Mechanical
- Adiabatic/Environmental Lapse Rates

74

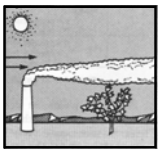
Plume Rise



T_s and T_a



Momentum and Buoyancy



Atmospheric Conditions

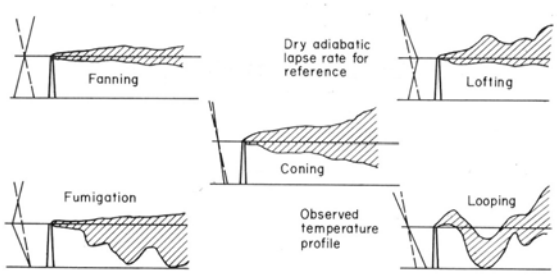
75

Plume Types Transformation Vertical Movements of Air

- Looping
- Fanning
- Coning
- Lofting
- Fumigating
- Trapping

76

Plume Type Diagrams



77

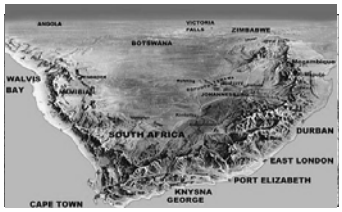
Temperature Inversions

- What is a temperature inversion?
- How would a temperature inversion affect air pollution?

78

Topography Factors

- Oceans, Rivers
- Valleys
- Mountains



79

Chemical and Physical Changes of Pollutants

- Photochemical and oxidation reactions
  - Ozone formation $NO_2 + h\nu \rightarrow NO + O\cdot$ | $O_2 + O\cdot \rightarrow O_3$
  - Oxidation of S to SO_2 to SO_3 | $SO_3 + H_2O \rightarrow H_2SO_4$
- Particulate formation
  - Ammonium nitrate haze | $NH_3 + HNO_3 \rightarrow NH_4NO_3$ (solid)
- Acidic deposition and precipitation
  - Components of "acid rain" from NO_x and SO_x precursors

80

Module 1 Review

Objectives:

- Air Quality Monitoring and its Importance to an Overall Air Quality Management Program
- Importance of Involving Stakeholders and Public Leaders
- Overview of Air Pollution and Monitoring
- Overview of Environmental Acts in the U.S. and in South Africa

81