Chemistry/Environmental Studies L111:

Environmental Concerns and Chemical Solutions

Chem L111

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Chem L111

- What is this course about?

- Understanding man’s impact on our environment (Air, water, soil)
- Understanding what can be done, and what obstacles there are to implementing those solutions
- Learning how to intelligently discuss both the problems and the solutions

Chem L111

- How do we teach chemistry?
- Normally, we teach a 2 semester course on introductory chemistry
- That course has both a discussion section and a 4 hour lab each week
- Even that course sequence is only the foundation, and doesn’t specifically address environmental issues
- We need a different method, to teach people who want to understand the news stories they read, but who aren’t dedicated scientists
- That’s L111

Chem L111

- How is L111 different?

- One semester
- No lab
- We DO have a discussion, on Tuesdays
  - Sometimes that will be for discussion of concepts, of conflicts, of politics
  - Sometimes that will be for math
- We leave out a lot of chemistry, and we leave out a lot of the math… but it IS a physical science, and some of the math is unavoidable

Chem L111

- How will L111 work?
- Every Tuesday, there will be a homework assignment due – you can't do chemistry without problem solving
- Most Thursdays, there will be a short quiz – 15 minutes, multiple choice
- Three Thursdays will have Midterm Exams rather than quizzes – the full period, but still multiple choice
- There will be a cumulative Final Exam, which will also be multiple choice, and will be **optional**
- Near the end of the semester, you will be asked to write a letter demonstrating your mastery of one of our topics

Chem L111

- How will L111 work?

- The text is Chemistry In Context, by the American Chemical Society.
- The syllabus is available here today, but the syllabus and the lecture notes will be posted on the course web page:

http://alpha.chem.umb.edu/chemistry/chL111/

Chem L111

- How will L111 be graded?

Exams (each worth 20%)	60% of total
Letter	20% of total
Weekly Homework Assignments	10% of total
Weekly Quizzes	10% of total

Chem L111

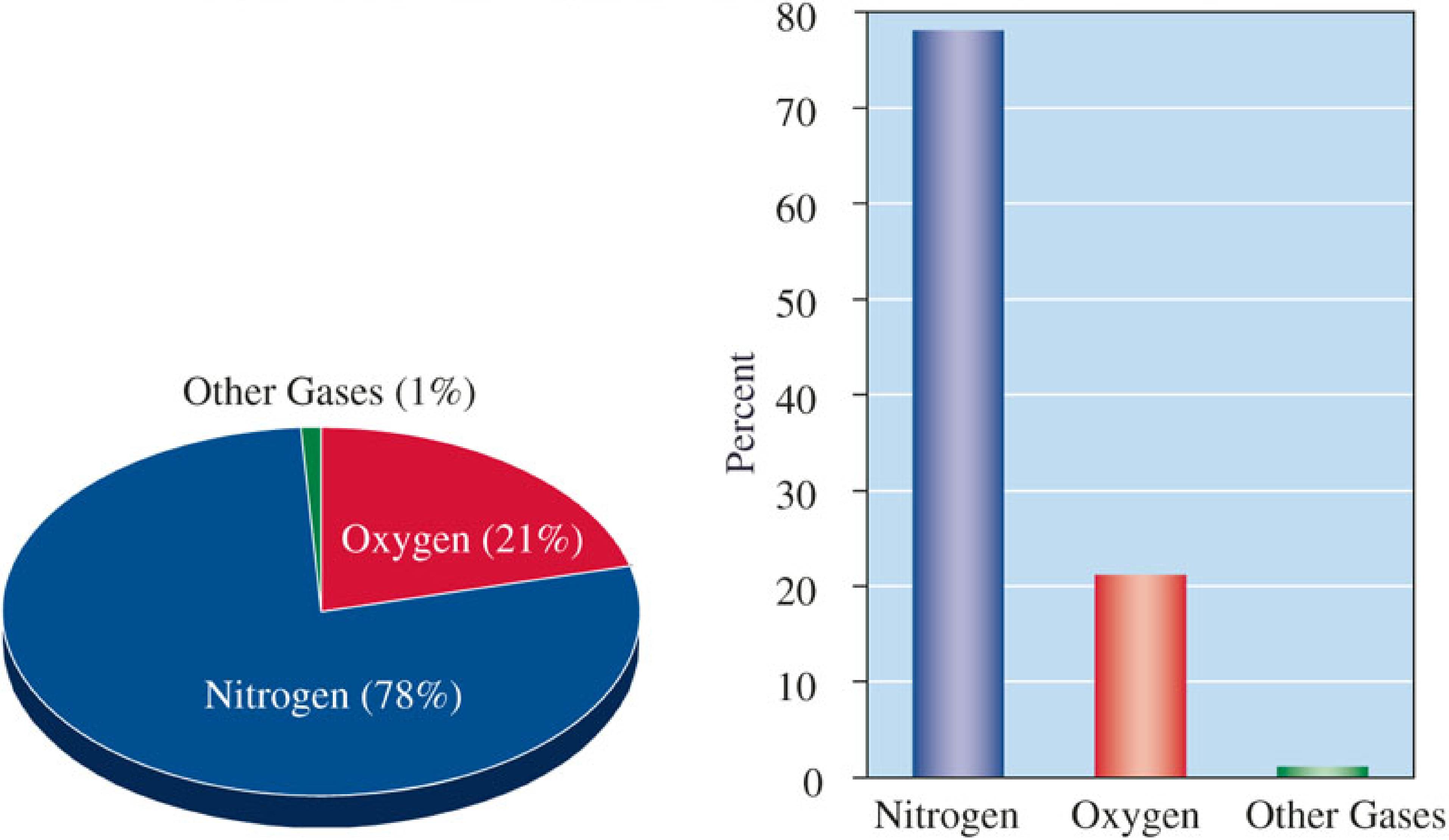
- What topics will we cover?

Chapter 1	**The Air We Breathe**
Chapter 2	**Protecting the Ozone Layer**
Chapter 3	**The Chemistry of Global Warming**
Chapter 5	**The Water We Drink**
Chapter 6	**Neutralizing the Threat of Acid Rain**
Chapter 4	**Energy, Chemistry, and Society**
Chapter 7	**The Fires of Nuclear Fission**
Chapter 8	**Energy From Electron Transfer**

Chapter 1
The Air We Breathe

What's in it?

Fig.01.04


Other Gases (1%)
Oxygen (21%)
Nitrogen (78%)
Percent
80
70
60
50
40
30
20
10
0
Nitrogen
Oxygen
Other Gases

Consider This - 1.1

What total volume of air do you exhale in a typical day?

Introduction of Dimensional Analysis

Consider This - Solution

- Amount of air in one breath
  - $\sim$500 mL/breath (~ 1 pint, or 2 cups)
- Breaths per minute
  - $\sim$15 breaths/min
- Breaths per day

$$\frac{15\text{ breaths}}{1\text{ min}} \times \frac{60\text{ min}}{1\text{ hr}} \times \frac{24\text{ hr}}{1\text{ day}} = \frac{21{,}600\text{ breaths}}{1\text{ day}}$$

- Amount we breathe per day

$$\frac{500\text{ mL}}{1\text{ breath}} \times \frac{21{,}600\text{ breaths}}{1\text{ day}} = \frac{10{,}800{,}000\text{ mL}}{1\text{ day}}$$

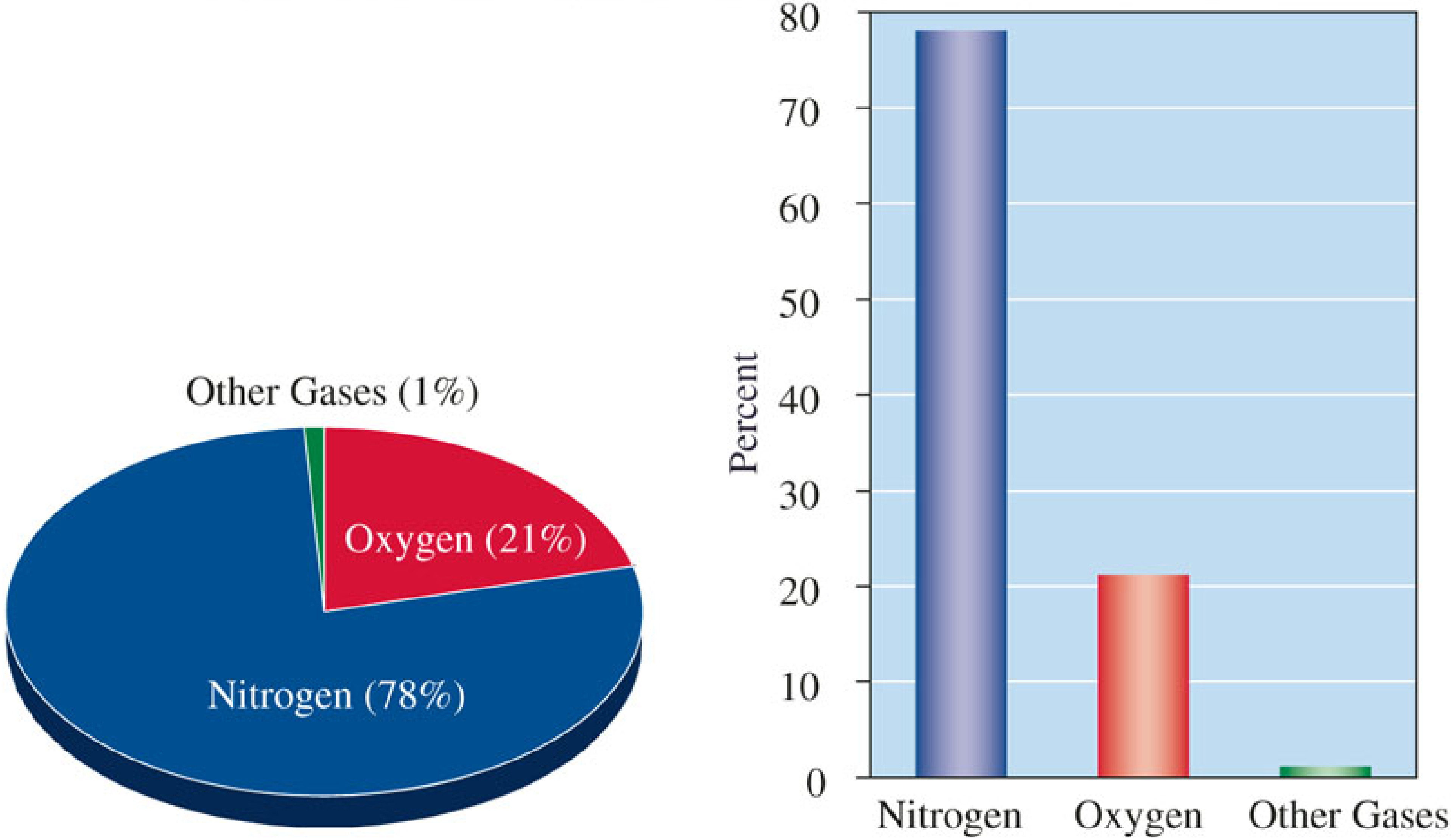
$$\frac{10{,}800{,}000\text{ mL}}{1\text{ day}} \times \frac{1\text{ L}}{1000\text{ mL}} = \frac{10{,}800\text{ L}}{1\text{ day}} \approx 10{,}000\ {}^{L}\!/_{day} = 10^4\ {}^{L}\!/_{day}$$

Tbl.01.02

Table 1.2 Typical Composition of Inhaled and Exhaled Air

Substance	Inhaled air (%)	Exhaled air (%)
Nitrogen	78.0	75.0
Oxygen	21.0	16.0
Argon	0.9	0.9
Carbon dioxide	0.04	4.0
Water	0.0	4.0

Fig.01.04


Other Gases (1%)
Oxygen (21%)
Nitrogen (78%)
80
70
60
50
40
30
20
10
0
Percent
Nitrogen
Oxygen
Other Gases

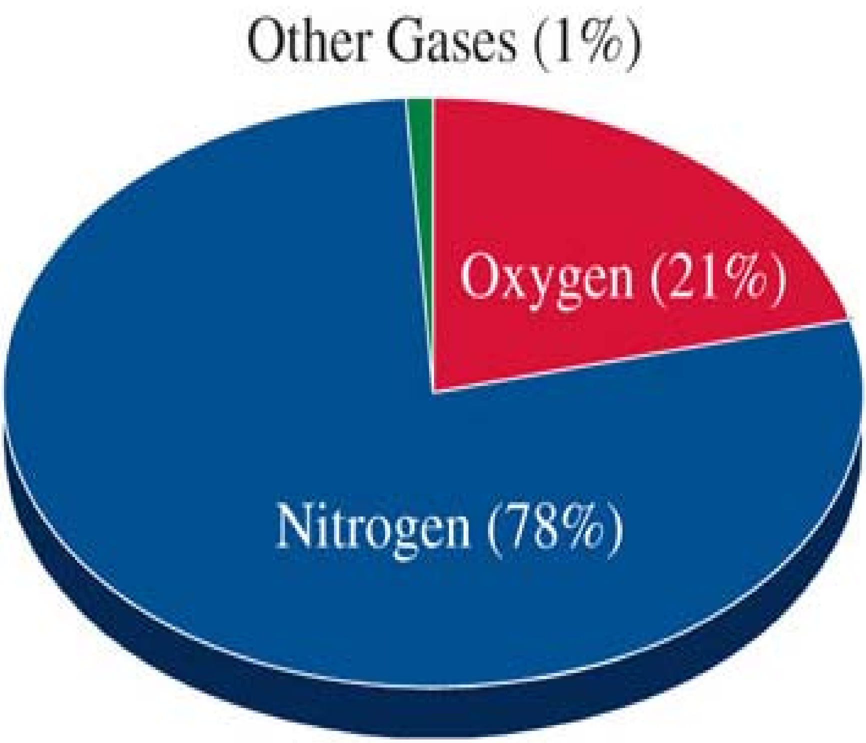
Consider This - 1.3

Humans are accustomed to living in an atmosphere of 21% oxygen where a paper match burns completely in less than a minute, a fireplace consumes a small pine log in about 20 minutes, and you exhale a certain number of times a minute.

Burning, rusting, and the rate of most metabolic processes in plants and animals depend on the concentration of oxygen.

How would life on Earth be different if the oxygen content in the atmosphere were doubled?

Fig.01.04 and http://chemincontext.eppg.com/chapter1/FiguresAlive.html



1% means 1 part in 100

Or 1 part per 100

Or 10 parts per 1,000

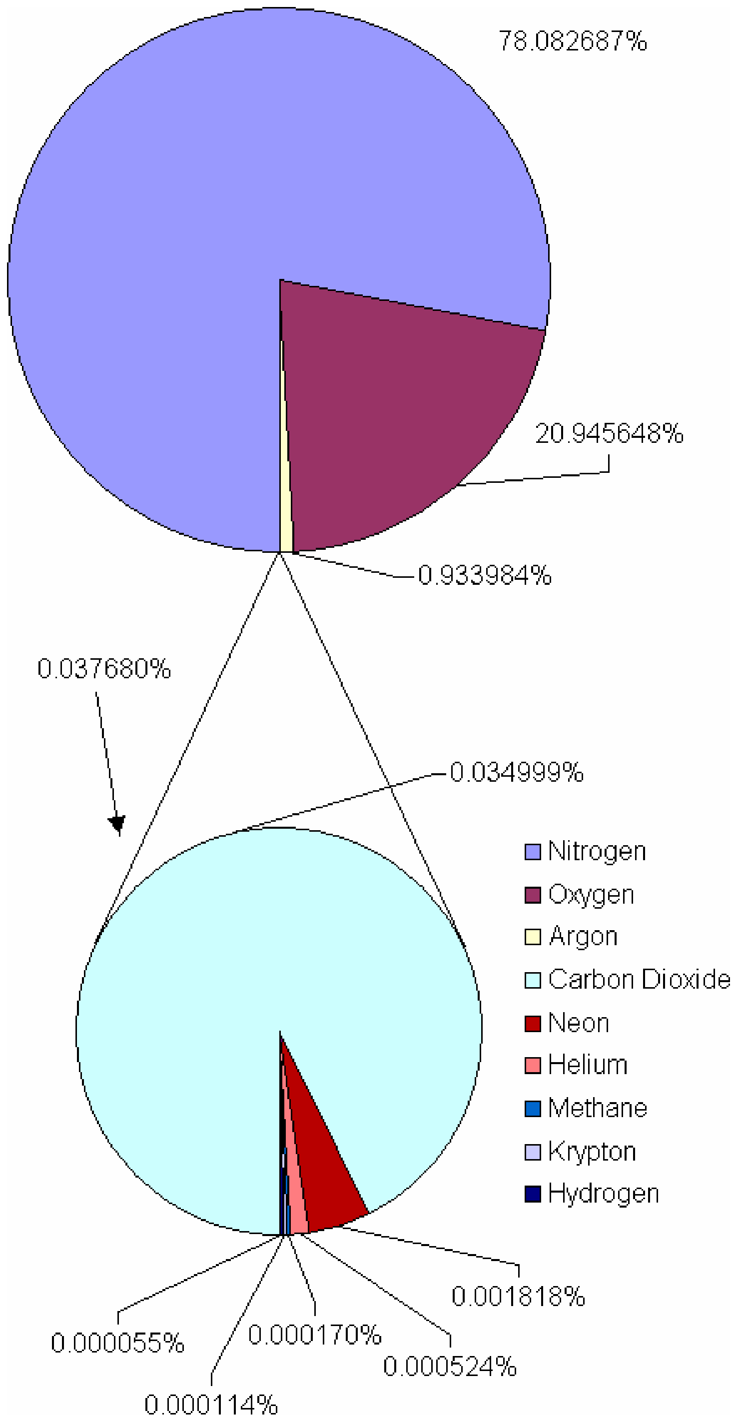
Or 100 parts per 10,000

Or 1,000 parts per 100,000

Or 10,000 parts per 1,000,000

Other gases are 1 pph

Or 10,000 ppm



- Nitrogen: 78.1%
- Oxygen: 20.9%
- Argon: 0.934%=9,340 ppm
- Carbon Dioxide: 345ppm
- Neon: 18.2ppm
- Helium: 5.24ppm
- Methane: 1.70ppm
- Krypton: 1.14ppm
- Hydrogen: 0.55ppm=550ppb

- http://en.wikipedia.org/wiki/Earth's_atmosphere

What about the water?

On a very hot and humid day, say 77°F (or 25°C) and a relative humidity of 80%, one cubic meter of air contains 18.4g of water.

This corresponds to ~3% of the air being water.

Air can range from 0% water up to 5% water.

It also varies throughout the day and at different locations, which makes it easier to discuss the contents of dry air.

Tbl.01.01

Table 1.1 Changes in Air Quality

Criteria Air Pollutant	1982–2001 (%)	1992–2001 (%)
Carbon monoxide	−62	−38
Nitrogen dioxide	−24	−11
Ozone		
1 hr	−18	− 3
8 hr	−11	0
Sulfur dioxide	−52	−35
PM_{10}	…	−14
$PM_{2.5}$	…	…
Lead	−94	−25

Source: EPA, *Latest Findings on National Air Quality, 2001 Status and Trends.* http://www.epa.gov/air/aqtrnd01/

… Trend data not available

Note: These percents represent overall changes. Changes for a particular urban area may differ.

Tbl.01.03

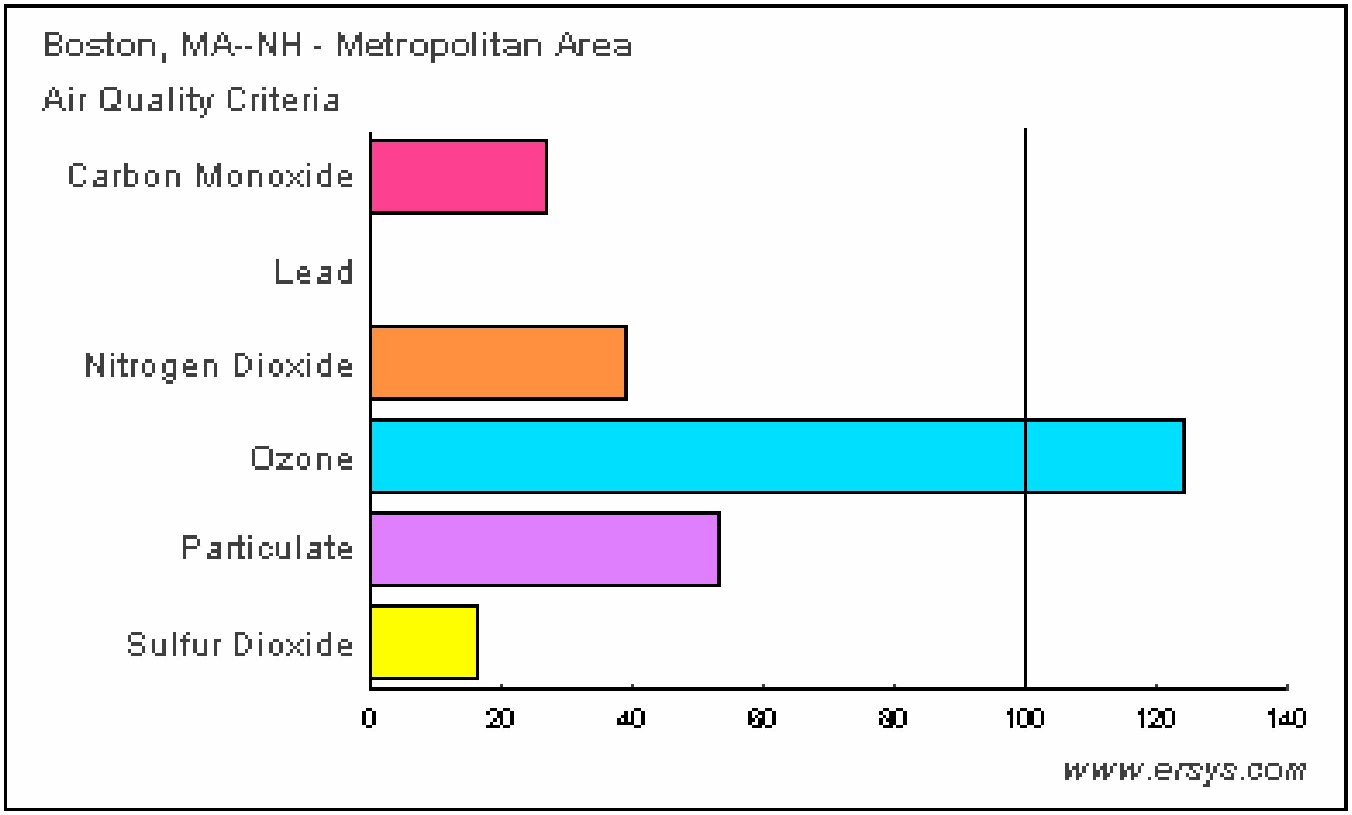
Table 1.3 Levels for the Air Quality Index

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
When the AQI is in this range:	*...air quality conditions are:*	*...as symbolized by this color.*
0–50	Good	Green
51–100	Moderate	Yellow
101–150	Unhealthy for sensitive groups	Orange
151–200	Unhealthy	Red
201–300	Very unhealthy	Purple
301–500	Hazardous	Maroon

Source: EPA, http://www.epa.gov/airnow/aqibroch/aqi.html

AQI Levels of Health Concern	Numerical Value	Meaning
Good	0-50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51-100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101-150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151-200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201-300	Health alert: everyone may experience more serious health effects.
Hazardous	> 300	Health warnings of emergency conditions. The entire population is more likely to be affected.

The following chart shows the ranking of the 5 major air pollutants monitored by the EPA. The chart shows the quantity of pollutant as a percentage to the minimum allowed (before it is considered a serious health risk) by the EPA. It is interesting to note that in the majority of cases Ozone is the major pollutant facing most cities. Sources: EPA - Air Quality Trends 2001



http://www.ersys.com/usa/25/2507000/air.htm

Boston Air Quality

Clear Day
June 16, 1999

This is a typical clean, clear day in Boston.
Note the crispness of the features on the horizon.
These days will have low pollution levels and low humidity.

$PM_{2.5}$ = 4.8 ug/m^3
RH = 19%

Boston Air Quality

Hazy Polluted Day
June 7, 1999

Hazy Polluted Day June 7, 1999
This is a typical hazy polluted day in Boston. Note the relatively uniform white haze that obscures the horizon. The haze tends to diminish slightly at higher elevations. These events tend to occur on hot and humid summer days and are affiliated with high ozone, $PM_{2.5}$, and RH levels.

$PM_{2.5}$ = 16.7 ug/m^3
RH = 45%

Boston Air Quality

Brown Cloud Polluted Day
January 21, 1999

This is a typical "brown cloud" polluted day in Boston. Note how the brown cloud appears to envelop the city but quickly thins out at higher elevations. These events tend to occur on calm winter mornings during rush hour traffic. $PM_{2.5}$ and black carbon levels may be high; ozone will be low; RH may vary.

$PM_{2.5}$ = 40+ ug/m^3
RH = 69%

Boston Air Quality

Foggy Day
June 13, 1999

This is an example of a foggy day in Boston.
It appears similar to a hazy polluted day, but note how the fog tends to be more grey than the white haze and how it does not thin out near the top of the picture. Fog is most common in the fall and spring. RH will be very high; ozone will be low; $PM_{2.5}$ may be moderate or high since the fog may trap local pollutants.

$PM_{2.5}$ = 15 ug/m^3
RH = 98%